CODE	SPECIFICATION DESCRIPTION
09700_THESS_II	**TRAINS PERFORMANCE SPECIFICATION_SERIES II**

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1.0 GENERAL REQUIREMENTS

1.1 INTRODUCTION

The Performance Specification covers the supply of fifteen (15) trains, which shall run in the Thessaloniki Metro system, and which are hereinafter designated as Series II trains for Thessaloniki Metro.

These trains shall be automatic driverless trains. (Grade-of-Automation 4 GoA4) according to IEC 62290-1.

The trains shall be physically and functionally compatible with the existing Thessaloniki Metro system, i.e., with the Base Metro Project, its extension to Kalamaria, Pylea Depot, the existing rolling stock maintenance equipment and with the existing rolling stock.

The trains shall operate in the Network, simultaneously with the series I trains, using the Signaling system being implemented by the Base Project Contractor for the Base Project and by an independent Contractor (using the same basic supplier) for the extension the Communications system, the Platform Screen Doors, etc., without the need to make changes to the existing operating structure of Thessaloniki Metro.

The Contractor shall cooperate, as required, with all contractors involved in all projects of the Thessaloniki Metro (Base Project and Kalamaria Extension), through ATTIKO METRO S.A., in view of ensuring the flawless technical and functional coordination of the designs and the manufacturing of the trains that he will supply with the civil works and all involved or related electromechanical and railway systems of the Base Project and the Extension to Kalamaria (trackwork, signaling, traction, telecommunications, etc.) and in order to ensure the required operation, safety, availability and maintainability of the new trains.

Moreover, the trains shall be suitable for operation in a surface (at grade) Metro network, enabling them to meet the requirements related to future planned extensions.

The Contractor shall perform all required designs, the appropriate calculations and required tests to demonstrate compliance of the trains with the requirements of this document.

1.1.1 Reason for the Supply

The network of Thessaloniki METRO consists of:

- The main line S1 (9.6 km. 13 stations) which extends from the New Railway Station to Nea Elvetia Station – Depot
- The extension line S2 to Kalamaria (4.8 km, 5 stations) which extends from the Patrikiou crossover (March 25thstreet) to the forestation and the terminal shafts of Mikra station.

In order to cover the operational needs with smaller headways in the Base Project, as well as the needs of the extension to Kalamaria, ATTIKO METRO S.A. decided to procure an additional fifteen (15) trains, 6 of which are required for covering the shorter train headways in the Base Project and 9 for serving the additional requirements of the Kalamaria extension.

1.2 SCOPE

This Performance Specification covers the principles and requirements relating to the design, manufacture, supply, factory testing, loading, on-site delivery, installation, on-site testing, preparation for operation, commissioning, training, 3-year warranty and fault rectification period, of fifteen (15) trains Series II.

The scope of the supply does not include:

- The on-board signalling equipment (ATC on board) to be supplied by an independent Contractor for signalling.
- The TOD Screen, which shall be placed by an independent Contractor for signaling in specially configured spots at the train driver consoles.

1.2.1 Design

The Contractor shall be responsible for planning, designing and documenting associated with the manufacturing of the trains and its equipment.

The basic guidelines for the design of the 15 new trains shall be:

- Modern, attractive, highly aesthetic, aerodynamically shaped design for the carboby exterior and vehicles interior, with maximized functionality. The carboby exterior and vehicles interior design shall be compatible and matching each other. The design may be assisted by an experienced and reputable design firm or designer.

- Maximized passenger safety through optimized structural and fatigue strength for the carbody and the bogies, as well as through the implementation of the proven energy management system in case of collision involving the new series II or series I trains. State of the art FEM calculation tools shall be utilized, supported by tests where and if necessary.

- Optimized train acceleration and deceleration, complying with the lines' present signaling and traction power supply systems characteristics, and able to follow future upgrading of the line signaling and traction power supply systems, leading to reduced travel times and increased passenger riderships.

- Maximized passenger ride comfort through advanced bogie and suspension design.

- Low noise generation and stringent noise management provisions, using low noise equipment and components and advanced noise absorbing technologies and materials.

- Detailed analysis of fire loads and maximized fire safety through the use of fire resistant materials, minimizing the production of toxic fumes in the case of fire, and maximizing the flame resistance of the floor design.

- Minimised overall train weight, leading to energy saving and minimizing wheels, rails and brakes wear.

- High performance, high efficiency and high reliability traction equipment, Including VVVF/PWM inverter technologies, motors and transmission systems, leading (in combination with the above requirement) to overall minimized energy consumption.

- Braking system with intelligent brake control management and optimised EP and ED brake blending, leading to slip/slide control, improved stopping accuracies and minimized brakes wear.

- Design and space provisions for the installation of the train-borne signaling systems to future technologies.

- Modern power electronics with innovative software control for the Auxiliary Power Supply System, leading to high redundancy of the power converters and optimal load sharing.

- Maximizing the selection and use of recyclable materials for the vehicles, minimizing the environmental impact.

- Wireless transmission of train operation data to the train maintenance – depot facilities.

- Optimal reliability, availability, maintainability and safety characteristics.

- Total compatibility with the permissible gauges in stations and tunnels, as well as with the existing trackwork, traction, 3rd rail, signalling, telecommunications systems and their technical and operational characteristics, and with the Depot equipment for train maintenance.

When designing the trains, the Contractor shall take into account the available information that will be provided by ATTIKO METRO S.A., or by other involved contractors (via ATTIKO METRO S.A.). This information shall include the following items:

- Corresponding signalling and ATS systems and subsystems of the Base Project implemented by the Base Project contractor and those of the extension to Kalamaria implemented by an independent Contractor for signalling. These systems also include the Data Communication System (DCS) for signalling.

- Interfacing systems and subsystems of the Base Project (e.g. Platform Screen Doors (PSD), Data Transmission System (DTS), Passenger Information System (PIS), Earthing System, Intrusion Detection System (IDS), CCTV, PA etc.) implemented by the Base Project contractor.

- Interfacing systems and subsystems of the Kalamaria extension (e.g. Platform Screen Doors (PSD), Power Supply System, Traction System, Earthing System, etc.) implemented by the Main Contractor of the Kalamaria extension.

- Interfacing low voltage systems and subsystems of the Kalamaria extension that are not included in the scope of the Main Contractor of the Kalamaria extension (e.g. DTS, wireless telecommunications system (TETRA), CCTV system, PA, IDS, PIS, etc.) and shall be implemented by independent contractor(s).

- Detailed Final Designs and operating principles of the central Train Signalling and Control systems and all other control systems, as applicable in relation to their extension, in the framework of the Kalamaria extension project, in the Operation Control Center (OCC) of the Base Project.

- Planning Manual of the Kalamaria extension (in priority over the Planning Manual of the Base Project which is older).

- Designs and information data related to the initial Rolling Stock provided by the Contractor of the Base Project (18 trains).

At the design phase, the Contractor shall also submit the following:

- The required Table, as indicated in Annex C, regarding the manufacturers/suppliers of systems or sub-systems of the trains.
- The required Table, as indicated in Annex A, regarding the Standards to be utilized, as regards the trains to be manufactured, organized per unit.
- The required Table, as indicated in Annex E, regarding the passengers capacity.

1.2.2 Manufacturing

The Contractor shall be responsible for manufacturing the trains and its equipment in accordance with this Performance Specification.

1.2.3 Factory Testing

The Contractor shall test the trains and all hardware and software as described herein to ensure its suitability for the intended purpose.

1.2.4 Delivery

The Contractor shall deliver all trains, spare parts, special tools and diagnostic equipment to AM's Pylea Depot in Thessaloniki.

1.2.5 Commissioning

The Contractor shall commission all trains on the network to ensure their readiness to enter revenue service.

1.2.6 Mockup

The Contractor shall deliver the mockups defined in this Performance Specification - article 6.12 – or shall comply with the alternative proposal on demonstrating real trains at the factory or in another Metro system located at any part of the world.

1.2.7 Spare Parts

The Contractor shall deliver all capital spare parts to the warehouse at AM's Depot.

The Contractor shall provide and maintain stocks of all warranty period spare parts and consumable spare parts to be required during the three year warranty period.

In addition, the Contractor shall provide the equipment indicated in Annex A.

1.2.8 Special Tools

The Contractor shall provide all special tools required to maintain and overhaul the trains in the Depot.

1.2.9 Diagnostic Test Equipment

The Contractor shall provide diagnostic test equipment to ascertain in the Depot the functionality of all discrete pieces of specialized equipment.

1.2.10 Manuals and Illustrated Parts Catalogues

The Contractor shall provide all manuals, e.g. Operation, Training, Maintenance manuals, and illustrated parts catalogues necessary for the maintenance and overhaul of the trains.

1.2.11 Training

The Contractor shall train all pertinent AM staff (Instructors for Operators and Instructors for maintenance staff) to ensure full familiarity with the operation, maintenance and overhaul of the trains.

1.2.12 Representation in Thessaloniki

The Contractor shall provide in Thessaloniki, technical support services commensurate with the requirements of the Contract. These services shall be provided by the Contractor's personnel in the Pylea Depot at Thessaloniki, and shall include, but are not limited to:

- Design certification, drawings and documentation, manuals and illustrated parts catalogues
- Acceptance tests
- Warranty service,
- RAMS monitoring services
- Training programs,
- Technical support for the acceptance of systems, spare parts and trains.

1.2.13 Operation Warranty

The Contractor shall make available at a Depot in Thessaloniki the required personnel and tools, test equipment, spare parts (including consumables), etc., required to repair or replace defective hardware and software, so as to ensure that all trains are fully available for revenue service during the warranty period.

1.3 CONTRACTOR'S RESPONSIBILITIES

The Contractor shall be fully responsible for the scope of the supply of the rolling stock covered by this Performance Specification. Design details that were not submitted along with the Offer and which - when finally submitted by the Contractor for approval - do not satisfy the reasonable requirements of ATTIKO METRO S.A., shall be amended to meet these requirements without ATTIKO METRO S.A. incurring any costs.

Any approval given by ATTIKO METRO S.A. at any stage of the Contract, does not release the Contractor from his contractual obligations.

1.4 CONTRACTUAL DOCUMENTS

This Performance Specification shall apply in conjunction with the Conditions of the Contract and the all other documents that form the Contract.

In case of a conflict between requirements expressed in other contractual documents and requirements expressed in this Specification, the requirements in the Performance Specification shall prevail.

References in this document to AIASA-… concerning Contract CON-06/004 of the Thessaloniki Metro Base Project or references to AKTOR-002/13 concerning Contract CON-002/13 of the main contractor of the Extension to Kalamaria are made in an effort to facilitate the traceability of the information to be delivered to the bidders and the Contractor.

2.0 SYSTEM REQUIREMENTS

2.1 GENERAL

Fifteen (15) trainsets shall be delivered. Trainsets shall consist of four (4) cars.

Each train-set shall accommodate a minimum number of 450 passengers. The minimum percentage for seated passengers shall 20%.

The trains shall be fully automatic (Grade-of-Automation 4 - GoA4), with an Emergency Driving Position (EDP) at both ends of the train and with bi-directional drive capability.

The Contractor shall submit to AM for approval three alternative artistic creations in color, representative of the interior and exterior of the vehicles.

The new trains shall have a total length of 50 to 55 meters (the 18 trains of the Base Project have a length of about 51.5 m, while the 15 new trains are expected to have a similar length with a possible small deviation from the original 18 trains, within the tolerances of the signaling system).

The attached drawing presents the key dimensions of the series I trains, namely:
A2-1: Rolling Stock - General Layout - AIASA-16766 - 0GS1RS0110100D

The overall length of the station platform is 60m.
A2-2: Platform length AIASA-16151 - 1S12AR419C114

The horizontal distance between the track axis and the platform edge is 1410^{+5}_{-0}mm.

The vertical distance between the platform edge and Top of Rail (TOR) level is 940^{+0}_{-5}mm.

Under no circumstances is the platform height permitted to exceed the nominal height of the floor of a stationary vehicle, Attached Drawing A2-3:

A2-3: Platform / Train Section Plan View AIASA-16151 - 1S12AR419C306A

There shall be eight (8) doors on each side of the trainset.

The dimensions of the Platform Screen Doors shall be as follows:

- Distance between the axes of adjacent PSDs 5,50 m
- Clear width 2,20 m
- Headroom 2,00 m

The attached documents present the drawings and dimensions of PSDs:

A2-4: PSD_Dimensions AIASA 15757 - Drawings 1, 2, 3 1G00LV950C800C

The axes of the train doors shall be aligned with the axes of the PSDs.

- Train door clear width: not less than 1600 mm
- Train door headroom: 1950 mm

The seats arrangement can be of longitudinal / aisle-facing type. In this case, the back of the seats shall be parallel and tangential to the sides of the train. The seats shall cover the entire

length of each side of the train, interrupted by the doors and the seats of the PSN. The seat base can be located above an equipment box, as long as the box does not extend more than half the length of the seat base, so that there is free space for the (bent) legs of the seated passengers.

The transverse type of seats arrangement (transverse / forward-facing seats) is also permitted. Mixed arrangement is also accepted.

The Contractor shall submit the proposed seat arrangement(s) to AM for approval.

In order to calculate the number of standing passengers:

- the area of a 300 mm wide floor strip, in front of the projection on the floor of each seat base, shall not be taken into account.
- the floor of the gangways between cars can be taken into account.

A space for two (2) wheelchairs shall be provided in each train, destined to be used by PSNs. This space shall be fitted with folding seats, in case there is no wheelchair (see Article 6.13 of this Performance Specification).

It shall be possible to securely fasten bicycles in the aforementioned space for the PSN.

2.2 TRACK STANDARDS AND CLEARANCES

The Contractor shall take into account all the parameters, in order to confirm the compatibility of the new train with the requirements of the train gauges that have already been applied in Thessaloniki Metro.

Moreover, the Contractor shall also take into account all parameters, in order to mitigate the difference between the values of the end and the center throws, in order to maximize the Static Load Gauge - and therefore the capacity of the train –respecting, however, all requirements in this Performance Specification and in other Contractual Documents

The trains must be fully compatible with the characteristics of the alignment and with the track and third rail systems in all areas of Thessaloniki Metro network (including the Depots).

The trains shall be compatible with the track alignment standards of the Thessaloniki Metro and shall meet all the requirements related to the gauges which are mentioned in the Planning Manual. Consequently, the gauges of the new vehicles (on a straight track), but also augmented with the corresponding throws (in curved tracks), shall be identical or contained in the corresponding gauges for the Series I Trains, in all areas of the existing network (including the Depots). All relevant information related to existing train gauges, is presentwedin the attached AM drawings as follows:

A2-5: Gauge in Tunnel / Station- AIASA 13669

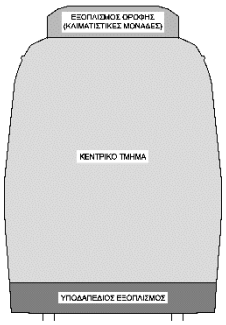
High Speed Gauge_ 90kph 1T00CW225C316A

Low Speed Gauge_ 50kph in Platforms 1S00CW225C305B

Gauge in Stations _3 Drawings 1S00CW225C304C

A2-6: Gauge for ballasted tracks AIASA-14195-1D00CW225B317B

The throw values for the Series I vehicles are calculated on the basis of the following mathematical formulas:

<table>
<tr><td rowspan="4"> 
</td><td>Area</td><td>Curve radius [m]</td><td>Center Throw [mm]</td><td>End Throw [mm]</td></tr>
<tr><td>Roof-mounted equipment</td><td>50 ÷ ∞</td><td>$15625/R$</td><td>0</td></tr>
<tr><td>Center section</td><td>50 ÷ ∞</td><td>$15625/R$</td><td>$11248/R$</td></tr>
<tr><td rowspan="2">Underfloor equipment</td><td>50 ÷ 200</td><td>$15625 \times \left(\frac{1}{R} - \frac{1}{200}\right)$</td><td rowspan="2">0</td></tr>
<tr><td>200 ÷ ∞</td><td>0</td></tr>
</table>

The maximum value of the throw (calculated according to the above table) is kept constant along the circular curve.

Application of the throw value - from zero to maximum - is performed linearly at locations where the straight and the curved track meet, regardless whether a clothoid intervenes or not. Similar application of throw values - from maximum to zero - is performed at the exit of the curve. These variations of the throw values are applied linearly at distances (calculated according to the layout and dimensions of the Series I trains of Thessaloniki Metro) as shown in the table below:

	Location where throw value starts increasing from zero	Location of maximum throw value
Center Throw	11m before the start of the transition curve (if any, otherwise from the beginning of the circular curve)	Start of the circular curve
End Throw	10.85m before the start of the transition curve (if any, otherwise 12,7m before the beginning of the circular curve)	1,85m before the beginning of the circular curve

The Contractor shall provide the Kinematic Load Gauge of the train, i.e., the Static Gauge enlarged to contain the greatest possible displacement of the train vehicles relative to the rails, when stationary or moving, taking into account the characteristics of the suspension and leaving room for the maximum permissible tolerances for the construction and maintenance of the train vehicles. The Kinematic Load Gauge shall include, but not limited to, the following elements:

- The car static outline,
- Car body sway (roll plus lateral displacement) on bogies,
- Construction tolerances of components, including their wear,
- Omni-directional bogie rotation,
- Displacement induced by the permissible passenger loads,
- Suspension system failure,
- Wheel gauge tolerances,
- Indirect effects of the track construction and maintenance tolerances.

Subsequently, the Dynamic Clearance Envelope of the Train, which is the extension of the Kinematic Load Gauge, shall take into account the direct effect of the maximum permissible tolerances of the installation, the width and the cant of the track, including the wheel wear effects. The effect of throw at curves is not included. Therefore, the Dynamic Clearance Envelope includes the entire cross-section of the vehicles and their loads, under any operating and maintenance conditions, both of the vehicles and of the track

Finally, the Structure Gauge of a train is defined as the envelope not to be infringed upon by any part of any structure or fixed equipment. There shall be special provisions to permit infringement of the Structure Gauge by the platform edge, the Third Rails and the Platform Screen Doors. The Dynamic Clearance Envelope, enlarged by the following dimensions (additional tolerances, clearances and unforeseen items) defines the Structure Gauge of the vehicle:

Clearance in Tunnel Sections	**Ballasted track**	**Un-ballasted track**
Horizontally, minimum unforeseen	150mm	100mm
Vertically, only in TBM and NATM Tunnels	125mm	100mm
Vertically, only in C&C Tunnels	225mm	200mm

Moreover, in order to take into account future design requirements, a 50 mm thick easement is added, enclosing the entire Structure Gauge, except for the points vertically below it.
In areas with curves, the Structure Gauge shall be enlarged by the corresponding throws.

Provisions shall be made in the design to minimize the horizontal gap between the edge of the train door sill and the platform edge. A maximum horizontal gap of 60mm is required

The underfloor equipment shall be placed so as not to violate and to respect the envelope of the trackside equipment in all areas of the existing network and the Deports of Thessaloniki Metro, including the components of the Third Rails System. Consequently, in areas with curves, the associated induced throws shall also be taken into account.

Information on the existing track alignment and the standard tunnel cross-sections for the Base Project and the extension to Kalamaria is included in the attached drawings:
A2-19: Base Project sections track alignment
A2-20: Base Project sections track alignment

The Contractor shall carry out tests in accordance with the requirements of IEC 61133 to demonstrate that the trains shall operate satisfactorily and always within the above-mentioned gauges, throughout the metro network, including the Depots.

2.3 ENVIRONMENTAL CONDITIONS

The general environmental conditions in the Thessaloniki area are as follows:

Minimum ambient temperatures:	-10°C (absolute)
	+ 6.5°C (monthly average)
Maximum ambient temperatures:	+ 48°C (absolute)
	+ 33°C (monthly average)

Table 2.4.1 Environmental Conditions

The Contractor's attention is drawn to the fact that because of solar load, track bed temperatures out of tunnels (e.g., in the Depot) will reach 55°C, and that the design of under floor equipment must account for this.

The Contractor shall take into account that since Thessaloniki is located in the Thermaikos Gulf of the Mediterranean Sea, the air is sufficiently modified by the saltwater to provide a mildly corrosive atmosphere.

The Contractor shall ensure that all equipment will operate satisfactorily when the above conditions are modified by heat or other emissions from train borne equipment, both at grade and in tunnel sections.

The Contractor's attention is drawn to the fact that during the operation, there will be high levels of metallic dust in the tunnel and that the Contractor should provide suitable equipment or equipment protection. Where filters are installed, the Contractor should employ a filter change policy as required to accommodate these high levels of dust.

The temperature in the tunnels and stations are quite stable, not exceeding 39 ° C and 40 ° C respectively in the summer months.

2.4 WEIGHT LIMITS

The Bidders and then the Contractor shall declare and guarantee the maximum weight of each car type and of a train, using the following designations, complying with the requirements of standard EN 13452-1, paragraph 5.2:

Load	Description
EL E	Train fully equipped and ready for service operation, with no driver
EL S	EL E + all fixed and folding seats occupied
EL 5	EL S + standing passengers at a density of 5/m^2
EL 8	EL S + standing passengers at a density of 8/m^2

where,
EL: European Load
E : Empty
S : Seats (fixed and folding)
X : Standing passengers (X/m^2)

Table 2.4.1 Weight Limits

Passenger weight shall be assumed to be 70kg per person.

Load conditions, as specified in Article 8.5.2 of standard IEC 61133, shall be taken into account in the calculations and the tests. Therefore:
ELE corresponds to "Minimum load"
EL5 corresponds to "Normal load"
EL8 corresponds to the maximum load "Exceptional/crush load".

The maximum allowable load per axis is 14 tn under a load condition of EL8.

2.5 TRAIN PERFORMANCE

2.5.1 Train life cycle

The trains shall be designed and constructed for a life of not less than 30 years when operating in a safe and reliable manner under the conditions described herein. Trains shall be assumed to travel 120,000 km per year. The Contractor will provide documented evidence of the ability to meet this requirement.

2.5.2 Running performance

For the purpose of calculating and submitting train performance figures, the following shall be taken into account:

- Full traction performance shall be available at supply voltages between 650Vdc to 900Vdc. At supply voltages below 650Vdc down to 500Vdc, traction performance shall be decreased linearly in proportion to the reduction in supply voltage.

- Full electrodynamic brake performance shall be available at supply voltages between 750Vdc to 900Vdc. At supply voltages below 750Vdc down to 500Vdc, electrodynamic brake performance shall be decreased linearly in proportion to the reduction in supply voltage.

- In the framework of the calculations, wheels shall be assumed to be in the half-worn condition, unless otherwise specified.

- The track-wheel adhesion coefficient may be assumed in the calculations as up to 0.18.

- Jerk limit for the performance calculations under all acceleration and service braking conditions: 0.60 – 0.65m/sec^3.
  It is noted that the jerk limit shall be possible to be separately software adjustable in both acceleration and braking between 0.4 and 1.2m/s^3. It shall be initially set to 0.6m/s^3, and the final value will be determined by AM during vehicle performance testing in Athens. All vehicles shall then be adjusted by the Contractor to the accepted value.

The Contractor shall state the train rolling resistance formula used, and shall provide the calculations in order to determine in his Offer the rolling resistance values at various speeds, in line with standard IEC 61133: Testing of Rolling Stock on completion of construction and before entry into service.

The Contractor shall perform tests in line with Standard IEC 61133 to verify the values of his Offer. The calculation method in the existing network shall be agreed upon with AM.

The traction and brake performance of trains stated below are the minimum acceptable ones. If higher performance values are required for ensuring the required revenue service speed, then the Contractor should comply with this requirement.

2.5.3 Speeds

Speed values concern all load conditions between ELE and EL8 under any wheel wear conditions.

- Maximum operational speed: 80km/h

The design speed shall ensure the performance of the train, while performance tests shall be carried out at the maximum operation speed and up to +10%.

- Revenue service speed: 30km/h

2.5.4 Accelerations

Average acceleration on level, straight track from standstill 0 to 40km/h under load conditions EL E to EL 5 shall be at least 1.11m/sec^2.

Time to reach 80km/h from standstill on level, straight track, with half worn wheels, under EL 5 loading condition shall not exceed 36 s.

The 80km/h speed shall be possible at 2.5% uphill gradient under a load condition of EL5.

2.5.5 Brake Performance

2.5.5.1 Electrodynamic brake performance

The average electrodynamic braking deceleration from 70km/h to 10km/h on level, straight track under load conditions EL 5 shall be at least 1.20m/sec^2.

2.5.5.2 Service brake performance

The following service brake performance concerns service deceleration on level, straight track.

Under load conditions EL E – EL 5, the equivalent service deceleration from 80km/h to 0km/h shall be 1.20m/sec^2. This deceleration for the range of 70km/h to 10km/h shall be achieved only through electrodynamic braking for a minimum load of EL E. For speeds outside the speed range (70-10km/h), deceleration shall be achieved through the assistance of trailed and motor bogies friction brake.

Under load conditions EL 8, the equivalent service deceleration of 1.20 m/sec^2 shall be achieved through the assistance of the friction brake of trailed and motor bogies in the entire speed range.

2.5.5.3 Security brake performance

Equivalent security braking deceleration by application of the friction brake only from 80km/h to 0km/h and under load conditions EL 5 shall be 1.42m/sec^2 $\pm$ 15%.

2.5.5.4 Holding brake performance

Holding brake shall obstruct train movement with 25% of the bogies out of operation under the following conditions:

- Maximum load: EL8
- 4% maximum gradient

Holding brake shall be calculated and tested, so that it keeps the train still under the aforementioned conditions for 1 hour.

2.5.5.5 Parking brake performance

Parking brake shall obstruct train movement with 25% of the bogies out of operation under the following conditions:

- Maximum load: ELE

- 5.4% maximum gradient (on lines 2 and 3)
- indeterminate duration.

The Contractor shall confirm through calculations and tests the performance of the holding brake.

2.5.6 Downgraded traction operation

Under downgraded traction power due to a fault of a motor car, the train shall be capable:

- under load conditions EL5 to execute at least one complete trip with return on Line 4 by making all stops at stations
- start with an acceleration of at least 0.18 m/sec^2 from any point of Line 4 (maximum gradient 4%) under load conditions EL5.
- start with an acceleration of at least 0.10 m/sec^2 under load conditions ELE at the maximum gradient of 5.4% of Lines 2 and 3.

2.5.7 Downgraded friction brake operation

Under downgraded friction brake operation due its car bogies fault, the train shall be capable:

Irrespective of the initial speed, the deceleration of the train, by applying security braking and with its car under load condition ELE-EL8, shall not be less than 0.7m/sec^2.

2.5.8 Train trailing capability

Under emergency conditions, the train shall be capable of pushing or pulling another train. The Contractor shall confirm by calculation and tests that an empty train (ELE) can push or pull another train under an EL 5 load, whose traction system is out of service from any location of the network until the next station for the passengers to disembark and then to carry the empty train to the Depot.

The start up on grade at a maximum gradient of 4% shall be at least 0.10m/sec^2.

2.5.9 Performance Characteristics

Performance curves shall be provided for the EL 5 loading condition. The corresponding traction motor characteristics shall be in accordance with standard IEC 60349-2.

2.5.10 Performance Calculation

The Contractor shall develop a computer model to simulate the performance of a train undergoing a round trip between terminal stations (New Railway Station and Micra Station).

Assumptions:

- Train load underload conditions EL 5
- Dwell time at terminal stations: 120 s(applied once during simulation)
- Dwell time at stations: 20s
- Line voltage 650 Vdc and 750Vdc
- Average wheel wear on all axles
- Dry rail with sufficient friction
- Jerk limit: 0.6 m/sec^3
- Maximum service speed: 80km/h
- Line receptivity: 25% in scenario S1 and 0% in S2
- Friction coefficient: 0,18

The following running conditions shall be modeled:

S1. The train utilizing on the line the maximum acceleration and braking permitted by the existing train control systems (ATC), to achieve the shortest possible round trip time.

S2. The train utilizing maximum on the line the acceleration and braking permitted by the existing train control systems (ATC), to achieve the maximum possible speed in the shortest possible time, but coasting between accelerating and braking for sufficient time to increase the round trip time by 5s per km.

The results of the simulations to be submitted containing the following data:

2.5.10.1 Trip diagrams

Speed diagrams, acceleration diagrams, time, line power, line current rating, RMS rated current and motor mechanical power in correlation with travelled distance and time.

2.5.10.2 Values included on a table

- Station name
- Inter-station distance: d [km]
- Inter-station running time: t [s]
- Total trip time
- Inter-station traction energy: W_{line} [kWh]
- Inter-station regenerated energy: W_{reg} [kWh]
- Inter-station specific energy consumption: W_{SEC} [kWh] = W_{line}- W_{reg}
- Inter-station rheostatic braking energy: W_{rhe} [kWh]
- Inter-station auxiliary systems energy W_{aux} [kWh]
- Round trip journey time, including intermediate station stops and terminus stations: t_{total} [s]
- Round trip traction energy: $W_{line\ total}$ [kWh]
- Round trip regenerated energy: $W_{reg\ total}$ [kWh]
- Round trip rheostatic braking energy: $W_{rhe\ total}$ [kWh]
- Round trip auxiliary systems energy $W_{aux\ total}$ [kWh]
- Round trip specific traction energy consumption: W_{SEC} [kWh] = W_{line}- W_{reg}
- Round trip final energy consumption:
- $W_{FIN\ total}$ [kWh] = $W_{line\ total}$ +$W_{aux\ total}$ - $W_{reg\ total}$
- Round trip RMS Line current: I_L [A]
- Round trip RMS motor current: I_M [A]

2.5.10.3 The following characteristic curves for the motor in traction and braking:

- Tractive Effort (kN) - Speed (km/h)
- Braking Effort (kN) - Speed (km/h)
- Acceleration (m/sec^2) – Speed (km/h)
- Deceleration (m/sec^2) - Speed (km/h)
- Line Current (A) - Speed (km/h)
- Motor Current (A) - Speed (km/h)
- Motor Voltage (V) - Speed (km/h)
- Motor Slip Frequency (Hz) - Speed (km/h)
- Motor Speed (rpm) - Speed (km/h)
- Motor Efficiency (%) - Speed (km/h)
- Gearbox Efficiency (%) - Speed (km/h)
- Inverter Efficiency and Frequency (Hz) - Speed (km/h)
- Train Resistance (at 0%, 2.5%, 4%, 5.4%) - Speed (km/h)

2.5.10.4 Additional data such as:

- Gear ratio
- Train resistance formula
- Rotational mass allowance
- Etc.

2.6 ENERGY MEASUREMENT

The Contractor shall provide means on all trains to measure energy in kWh for traction, regeneration and auxiliaries separately and independently.

2.6.1 Energy Consumption Demonstration

At the design stage, the Contractor shall measure by simulation a train's energy consumption on the Base Project Line and on the extension in accordance with the running condition ItemsS1, S2 and the assumption in paragraph 2.5.10.

The following data shall obtained from the simulation:

- Round trip journey time t_{total} [s]
- Round trip final energy consumption: $W_{FIN\ total}$ [kWh]

After the completion of the commissioning stage, the values shall be verified by means of tests on the network. The Contractor shall demonstrate by test that the actual energy consumption does not exceed by more than 3% the consumption foreseen in the Design.

2.7 SAFETY OF RUNNING

The safety of running shall be evaluated as per IEC 61133.

Safety shall be tested with respect to the guideline drawn in EN 14363 "*Testing for the acceptance of running characteristics – Testing of running behaviour and stationary tests*" and based on the simplified acceptance method described therein. New wheel profile and track geometry quality QN 2 in accordance with EN 14363 shall be considered for the assessment.

2.8 RIDE COMFORT

The ride comfort of the cars shall be evaluated and tested in accordance with the mean comfort-simplified method of EN 12299. The comfort index N_{MV} shall be less than or equal to 2.5 for new wheel profile and track geometry quality QN 1 in accordance with EN 14363.

The Contractor shall measure the ride comfort in each car type, in accordance with an ATTIKO METRO S.A.-approved procedure.

The Contractor shall provide a vibration analysis for ATTIKO METRO S.A.'s review and acceptance, which demonstrates compliance with the comfort quality requirements of this Performance Specification.

2.9 MAINTENANCE REQUIREMENTS

2.9.1 Existing Maintenance Facilities/Equipment

At the beginning of the project, the Contractor shall check and confirm the compatibility and adequacy of the basic maintenance facilities/equipment that already exist in the depot facilities to carry out the Preventive and Corrective maintenance of the new trains. ATTIKO METRO S.A. shall provide as of the tender stage the description of the basic maintenance units, as required.

It shall be ensured as a minimum that the maintenance requirements for the new series trains shall be compatible with the maintenance facilities / equipment mentioned below, without the need to make any additions / changes to them, which could impede the efficiency and effectiveness of maintenance procedures for trains already in:

A2-07: AIASA-11299
Item 114 – Underfloor wheel lathe
A2-08AIASA-09656
Item 016 – Bogies washing plant
A2-09: AIASA-13325:
Item 064 Paint booth
A2-10: AIASA-16060:
Item 109 Automatic washing equipment
A2-11: AIASA-10591: - Lifting Jacks-
Item 054Γ – Lifting Jacks
A2-12: AIASA-14261
Item 073 – Re-railing equipment
A2-13: AIASA-16811
Item 007 –Battery electric vehicle for bogies transfer
A2-14: AIASA-15752
Item 017–Bogie deflection test rig
A2-15: AIASA-14176
Item 018–Bogie frame measuring platform
A2-16: AIASA-10610
Item 055– Lifting plant, underfloor, bogie
A2-17: AIASA-10970
Item 056 – Train Lifting plant, underfloor

A complete list of all items in the Depot is contained in annex:
A2-18-PyleaDepotItemsList

The Bidders shall examine the above equipment, the maintenance areas, shall confirm its suitability in terms of type, location, size and efficiency / performance and shall ensure that the maintenance of vehicles can be carried out entirely in the Depot. To this end, the Bidders shall include in their technical offer a Declaration of Compatibility of the new series trains with the equipment and the aforementioned maintenance facilities, as well as the respective methods of achieving compatibility as required. In no case shall the aforementioned methods of achieving compatibility hinder the efficiency and effectiveness of the maintenance procedures for the trains already in operation.

Should it be determined that the maintenance of the new trains requires additional equipment - which is not included in the existing equipment of the Depot - or requires a change / modification of the spatial arrangement of the existing equipment, the Bidder shall include this equipment/changes/modifications in his offer.

It shall be possible for the Bidders to visit the Depot during the Tender procedure.

2.9.2 Periodic Inspection Intervals

In addition to the requirements specified elsewhere in this Performance Specification, the cars shall be designed to meet the following criteria:

- No Nominal Maintenance Examination shall be required on any component at more frequent intervals than 5,000 km.
- No Limited Inspection shall be required on any component at more frequent intervals than 20,000km.
- No General Inspection shall be required on any component at more frequent intervals than 120,000km.
- No item of equipment shall require Partial Overhaul until it has accumulated at least 360,000km of operational service.
- No item of equipment shall require Major Overhaul until it has accumulated at least 720,000km of operational service.

All units or sub assemblies requiring frequent maintenance or off-train adjustment shall be arranged for easy unit replacement.

To the extent possible, all under floor and roof-mounted equipment enclosures shall be readily accessible from the sides of the vehicles for normal maintenance and repair.

The design of the vehicles shall be suitable for cleaning in ATTIKO METRO S.A.'s automatic washing plants.

To the extent possible, vehicles shall be maintainable by those members of the user population who fall between the 5^{th} percentile female and the 95^{th} percentile male without special tools.

Equipment that will be obsolete or out-of-date during the 30 year life of the train (e.g., electronic equipment, etc.) shall be configured such that it will be easily plugged in and out.

2.10 WEIGHT CONTROL PROGRAM

The outset of the design, the Contractor shall state or confirm (if this value is foreseen to be included in the Bidder's Offer) the tare weight of the train.

The Contractor shall put into place a Weight Control Program to ensure that the weight of the finished vehicles is no greater than that guaranteed in the tender. The Contractor shall tabulate the weight of all major systems and all ancillary equipment for each vehicle type, and shall provide this information to ATTIKO METRO S.A. in a Monthly Report during the design and manufacturing phases of the project.

Should the tabulations indicate that the weight of any piece of hardware will exceed the predicted value, the Contractor must immediately advise AM of the steps to be taken to achieve the overall guaranteed weights. During the manufacturing phase, estimated weight must be replaced in the tabulations by actual measured weights.

The Contractor shall also provide ATTIKO METRO S.A. with the locations of the center of gravity of the completed car bodies, completed bogies, and completed cars.

The final weight of the car shall be tested in line with IEC 61133.

The weight of every car and all wheel loads on every car shall be measured and recorded.

This data shall be provided in the Car History Books.

2.11 TRAIN CONTROL AND MANAGEMENT SYSTEM

The specification is given in Chapter 23.

2.12 EQUIPMENT SHOCK AND VIBRATION REQUIREMENTS

All equipment, sub-components, supporting framework and all fastening devices (bolts, welds, rivets, vibration isolators, etc.) shall be designed to withstand the periodic, random impact loads and vibrations associated with a rugged railcar environment without sustaining damage or malfunction. Such equipment shall comply with the requirements of IEC standard 61373, IEC standard 60077, or related EN standard, whichever is the more stringent.

Prior to being subject to these requirements, the equipment shall have passed all inspections and electrical tests required, including High Potential and Insulation Resistance tests. After successful completion of all shock and vibration tests, the component shall again meet the requirements of the aforementioned inspections and electrical tests.

The tests shall be performed in the vertical, lateral, and longitudinal directions. Unless otherwise stated, the unit shall be tested in the de-energized state. The contacts shall not break contact during all phases of the testing. The method for detecting contact discontinuity shall be approved by ATTIKO METRO S.A.

Should the equipment fail any part of the testing, it shall be subject to complete retesting. Failure is defined as the equipment requiring adjustment or redesign at any point during a test, in order to fulfil the test requirements.

All data and observations taken during the testing shall be included in a Test Report, and shall be subject to ATTIKO METRO S.A.'s review and acceptance.

Following satisfactory completion of the tests required, the unit shall be dismantled and inspected for physical damage. Any variance shall be recorded and findings communicated in the form of a written report.

2.13 TRAIN NOISE AND VIBRATION REQUIREMENTS

2.13.1 General

2.13.1.1 Noise

The trains shall be designed and tested to meet the following noise levels. Interior testing shall be performed in accordance with ISO Standard 3381. Exterior testing shall be performed in accordance with ISO Standard 3095, with microphones 7.5m from the center of the track. Testing in tunnels shall be performed on Thessaloniki Metro line system.

ITEM	REQUIREMENTS

1	**Interior noise**
1.1	**Stationary Condition on Open Section of Track**
	The interior noise level Lp,A,eq,T in any car, while stationary on an open section of track, but with all auxiliary systems running simultaneously, shall not exceed 68dB(A)
1.2	**Running Condition in Tunnel**
	The interior noise level Lp,A,eq,T in any car, with the train running at 65km/h, on straight, level, clean, smooth track, with all auxiliary systems running simultaneously and in any normal mode of acceleration, coasting or braking, shall not exceed 72dB(A). The mean coefficient of absorption in the tunnel shall be measured by the Contractor.
1.3	**Running Condition on Open Section of Track**
	The interior noise level Lp,A,eq,T in any car, with the train running at 80km/h on an open section of straight, level, clean, smooth track, with all auxiliary systems running simultaneously and in any normal mode of acceleration, coasting or braking, shall not exceed 70dB(A). Since there is no open section in the Base Project or in the Kalamaria Extension with a train running at 80km/h, this requirement can be covered by the pertinent declaration of the manufacturer or by a previous measurement/ test carried out on a similar train
2	**Exterior noise**
2.1	**Stationary Condition on Open Section of Track**
	The exterior noise level Lp,A,eq,T in any car, while stationary on an open section of track with all auxiliary systems running simultaneously, shall not exceed 70dB(A).
2.2	**Running Condition on Open Section of Track**
	The exterior noise level Lp,A.Fmax (for acceleration and braking) and TEL (for coasting) in any car, with the train running at 80km/h on an open section of straight, level, clean, smooth track with all auxiliary systems running simultaneously and in any normal mode of acceleration, coasting or braking, shall not exceed 84dB(A). Since there is no open section in the Base Project or in the Kalamaria Extension with a train running at 80km/h, this requirement can be covered by the pertinent declaration of the manufacturer or by a previous measurement/ test carried out on a similar train.

ATTIKO METRO S.A. will allow the interior noise levels in the gangway areas of the train to be slightly higher than the aforementioned values.

These specified noise levels shall be reduced by 3dB(A) if significant pure tones in the range between 300Hz and 4000Hz are present. Pure tone noise shall be considered significant in this regard if any 1/3-octave band sound pressure level is 5dB or more higher than the average of the two adjacent 1/3-octaves containing no pure tone or tonal noise.

2.13.1.2 Vibration

With the train stationary and with all auxiliary equipment operating at rated capacity, no portion of the interior of the vehicles shall exceed the following levels of vibration:

- 2.54mm peak-to-peak amplitude for frequencies less than 1.4Hz,
- 0.01g peak acceleration for the frequency range 1.4Hz to 20Hz and
- 0.762mm/second peak velocity for the frequency range above 20Hz.

Or alternatively, with the train stationary and with all auxiliary equipment operating at rated capacity, no portion of the interior of the vehicles shall exceed the following levels of vibration in accordance with EN 12299:

- N_{MVx} = 1.0
- N_{MVy} = 1.5
- N_{MVz} = 1.0.

2.13.2 Noise and Vibration Control

Any equipment (bogie or car body mounted) which may become a source of noise and rotating or reciprocating equipment and inductive electrical equipment (such as transformers, inductors, etc.) mounted to the car body which may become a source of vibration shall comply with the following requirements.

2.13.2.1 Requirements for Noise Control

In order to be assured that the complete vehicle will meet the noise requirements of Clause 2.13.1.1 of this Performance Specification, the Contractor shall supply all design information, together with an analysis showing that the overall noise targets will be achieved.

It shall be the responsibility of the Contractor to take all reasonable precautions to minimize noise radiation and transmission by using up-to-date design techniques and proper acoustic attenuation materials where required.

The Contractor shall provide for review all pertinent details of the acoustic attenuation and any special noise reduction techniques used.

2.13.2.2 Requirements for Vibration Control

Unless otherwise specified, the Contractor's equipment, when installed and operated through its normal operating range, shall impart vibrations into the vehicle mounting brackets no greater than the following RMS levels at any discrete frequency in any axis:

- 0.05g for frequencies less than 14 Hz,
- 1-5 mm/s for frequencies greater than 14 Hz.

Or alternatively, the Contractor shall propose for ATTIKO METRO S.A.'s acceptance the values in accordance with the requirements of EN 12663 and EN 61373.

Any equipment with levels greater than these values shall be provided with a resilient suspension.

The resonant frequency of the suspension system shall be designed to avoid coupling with the vehicle structure.

Resilient mounting systems must be designed to withstand, without damage or interruption of equipment function, the periodic momentary impact loads specified in this Performance Specification, as may be associated with the hard coupling of cars, impacting large rail debris, etc.

Also, resilient mounts must be arranged in a manner such that the equipment will be retained safely on the vehicle, and may continue operation, under all conditions stated in this and any other applicable specification, in the event of a complete failure of the elastomeric material. Under such circumstances the equipment must remain within the clearance envelope.

2.14 WHEEL PROFILE

The wheel profile currently in use by existing vehicles (Series I).

A2-19: AIASA-11308-Wheel-rail contact study.

At the early design phase, the contractor shall submit to ATTIKO METRO S.A. for approval a complete rail / wheel interface study, specifying the appropriate wheel profile to be finally applied, so as to increase passenger comfort, satisfy the noise requirements described in paragraph 2.13 and minimize wheel / rail wear, taking into account the overall rail layout, vehicle speed profile and the load.

2.15 GENERAL ELECTRICAL REQUIREMENTS

2.15.1 Electromagnetic Compatibility (EMC)

2.15.1.1 General Requirements

Trains shall be electromagnetically compatible within themselves, from train to train, with other trains in operation on the metro, with ATTIKO METRO S.A.'s signalling systems, with ATTIKO METRO S.A.'s communications systems and with adjacent installations. The trains shall not be capable of carrying out any operation that causes an unsafe condition in the signalling systems.

The Contractor shall conduct a program which achieves and documents electromagnetic compatibility, and the program requirements shall be applied to all subsystems and to subsystem suppliers. The Contractor shall ensure that all equipment, both individually and together, complies with the EMC requirements. The Contractor shall ensure that each train complies with the EMC requirements in all possible modes of operation, including modes of downgraded performance and failure modes.

As part of the above, the Contractor shall ensure that electromagnetic interference (EMI) complies with the limits described herein, and the Contractor shall be required to demonstrate by test that EMI levels comply with the requirements of the European Committee for Standardization (CEN), standards EN 50121-3-1 and EN 50121-3-2 in particular.

Cars shall comply with all the requirements of the European Directive 2004/108/EC on Electromagnetic Compatibility. All necessary documentation shall be made available by the Contractor to prove compliance with the above.

The Contractor shall demonstrate by test that the vehicles do not interfere with any of the wayside equipment on AM's existing system. Should testing prove that the vehicles interfere with any of the wayside equipment, as judged by the wayside signalling system supplier, the Contractor shall make all appropriate modifications to the vehicles to bring the vehicles into compliance with this requirement. As part of this, the Contractor shall perform laboratory testing on all power units according to EN 50121-3-2 and EN 50125 to ensure a high probability of compliance. In addition to discrete tests, the Contractor will be required to confirm the electromagnetic compatibility of the propulsion and auxiliary power supply systems during a combined laboratory test.

The Contractor shall submit compliance certificates with the aforementioned Standards for the entire train, which is considered as one single unit, by a Notified Body.

2.15.1.2 EMC Plan

The Contractor shall submit an EMC Plan for AM's approval that describes the Contractor's overall approach to achieving compliance. The plan shall include all activities, activity schedule, personnel and their qualifications, procedures and methods, etc..

2.15.1.3 Emissions Tests in AM's System

The Contractor shall demonstrate through specified conducted, inductive and radiated emissions tests that the worst-case emissions from the trains are electro-magnetically compatible with all of ATTIKO METRO S.A.'s systems.

Conducted emissions tests (compatibility with signalling system) shall be performed according to EN 50238 for normal and degraded modes.

Inductive and radiated emissions tests shall be performed according to EN 50121-3-1.

As a minimum, the following worst case failures shall be considered:

- One defective propulsion package
- Two defective propulsion packages.

Testing shall include various combinations of maximum and minimum acceleration, regenerative braking (with various levels of line receptivity), auxiliary equipment operating at maximum and minimum power, running in forward and reverse directions, running under failure conditions, failures under which the train can continue running at reduced performance, etc.
The Contractor shall submit compliance certificates with the aforementioned Standards for the entire train, which is considered as one single unit, by a Notified Body.

2.15.1.4 Emission Limits

The applicable train emission limits line related to signalling shall be specified by the Contractor of the Signalling system.

2.15.1.5 Electromagnetic Fields

The Contractor shall ensure that any static or alternating fields generated by the train's electrical systems shall not interfere with the correct operation of cardiac pacemakers, customer goods or any magnetic media (disks, etc.).

The Contractor shall comply with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, the European Union Directive 1999/519/EC, as well as with EN 45502-2-1 requirements.

At a minimum the magnetic flux density in any car shall not exceed:

- 1 X 10^{-3}T at 0 Hz frequency between floor level and 600mm above floor level, and
- 5 X 10^{-4}T at 0 Hz frequency elsewhere under any mode of operation, including failure modes.

The Contractor shall submit compliance certificates with the aforementioned requirements for the entire train by a Notified Body.

2.15.1.6 Safety Provisions

The Contractor shall submit an EMI Safety Analysis (as part of the safety analysis of chapter 15 of this Performance Specification) for AM's approval which demonstrates that the trains' EMI emissions are safe under normal conditions, and that the train equipment provides adequate detection, annunciation and response to failures which could cause EMI to increase above tested levels. The analysis shall include a Hazard Analysis; a Fault Tree Analysis; a Failure Modes, Effects and Criticality Analysis of all appropriate equipment.

The safety analysis shall clearly identify the actions taken to prevent the occurrence of a hazard, and shall demonstrate that the equipment and the actions are adequate to prevent an EMI hazard.

The safety analysis shall distinguish between failures affecting EMI that are automatically protected, those which are announced for action by maintenance technicians, and those that are un-announced. The aforementioned worst-case tests shall include all announced and non-announced failures.

The safety analysis shall consider all relevant train equipment failures, including line filter components, EMI detection and annunciation systems, and any other components that can affect the level or frequency of the generated EMI. The safety analysis shall also consider unusual operating conditions and the failure of any wayside equipment affecting trains. The analysis shall cover train movements on mainlines equipped by ATP and audio frequency track circuits and movements in Depots equipped with 50 Hz AC track circuits.

Trains shall incorporate an EMI detection system, properly tested (on condition that the operation frequencies of the traction system could affect the signaling system), which shall protect against signalling EMI hazard, which is caused by return currents. The detection levels, response times, frequencies and bandwidths shall be compatible with the safety analysis. The software shall ensure that no EMI hazard exists, while maximizing train availability. Positive measures shall be taken to prevent the accidental or intentional tampering with the detection's characteristics. The Contractor shall analyze and document the interactions and responses of all EMI detections on a train, to detect failure on one or more cars and failure of any wayside equipment affecting trains.

2.15.1.7 EMC Design Report

The Contractor shall submit an EMC Design Report to AM for approval which documents the design provisions to achieve electromagnetic compatibility. This shall include equipment arrangement, enclosure design, wire and cable routing, electrical interface connections (single wire, double wire, twisted pair, shield, shield grounding, etc.), voltage segregation, frequency coordination and stability, filters, shielding, normal and fault paths for ground currents, etc. The report shall also provide a description of all power units with a rating greater than 10kW, which shall include emissions characteristics versus operating mode, voltage and loading, as well as line filter, output filter, line impedance and circuit and operating mode characteristics. Also included shall be a thorough description of the EMI detection.

The report shall include the simulated or calculated emissions for a complete train together with the simulated or calculated emissions under full load conditions.

The EMC Design Report shall also document that train equipment is adequately protected against radio frequency emissions from mobile and hand-held radios and mobile telephones.

2.15.2 Low Voltage DC Control Power

Rated performance shall be provided at nominal voltage, and all equipment connected to the low voltage power supply (e.g. 110Vdc and lower) shall not be damaged by continuous

operation within the specified minimum and maximum voltage range. In addition, equipment shall not be damaged by continuous voltages down to 0Vdc.

2.15.2.1 Operating Voltage Range

Unless otherwise specified, equipment connected to the low voltage power supply shall operate over a power supply voltage range from 0.7 x (nom Vdc) to 1.25 x (nom Vdc), according to EN 50155.

The peak-to-peak ripple voltage from a static power supply not to exceed three percent (3%) of the nominal specified power supply output voltage, unless otherwise allowed by ATTIKO METRO S.A.. It is recognized that if a transformer-rectifier unit is used to generate the low voltage DC, the ripple voltage will be substantially greater than the three percent (3%) limit. In this case, the allowable ripple voltage will be as agreed upon with ATTIKO METRO S.A.

2.15.2.2 Resistance of equipment at Voltage variations

Equipment connected to the low voltage power system shall be capable of withstanding variations of voltage supply, supply over-voltages and surges as stipulated in EN 50155.

Low voltage power supplied equipment shall not be damaged by under-voltage of any magnitude or duration. Recovery of connected equipment from the under-voltage condition shall be automatic or by train-line reset. Train line and battery supplied relays shall not drop out for under-voltages as low as 0.4 x (V_{nom}), with a duration of up to 50ms.

2.15.2.3 Reverse Voltage

Equipment which may be powered from the battery bus shall not be damaged by reverse polarity voltage of the same magnitude and duration as the specified positive voltage conditions.

2.15.2.4 Transients Generated by Equipment

Equipment connected to the low voltage power supply, including battery and train lines, shall not generate transient voltages in excess of $\pm$ 200V_{pk}, with an energy content not to exceed 0.3 joules.

The equipment shall be designed such that the rate of change in voltage in any transient conducted from the equipment to the electrical interface shall not exceed 10V/msec.

2.15.2.5 Third Rail Supply System

The nominal line voltage is 750Vdc, with a range of 500V to 900V, as per the requirements of EN 50163.

At a minimum, equipment powered directly from the third rail power network shall withstand transient voltages as required by IEC 61287-1.

All equipment shall be designed to withstand frequent disruptions to the third rail power supply caused by third rail gaps.

2.16 GENERAL INSTALLATION REQUIREMENTS

2.16.1 Equipment Accessibility and Installation

All gauges, adjustment points, switches, etc., shall be easily accessible and clearly identified with permanent identification markings. The device identification system shall be approved by ATTIKOMETROS.A.

All relays and contactors shall be installed within enclosures, in the manufacturer's recommended orientation, and the car wiring shall not be connected directly to the device terminals. Where the device is rail mounted, the Contractor shall demonstrate that the arrangement will withstand the shock and vibration requirements of this Performance Specification. All devices used in safety critical circuits shall be mounted such that in the event of a collision, their contacts shall not momentarily change state and enable an unsafe condition to exist.

2.16.2 Device Reference Designators

All electrical devices shall be identified with their alphanumeric designation corresponding to that used on the relevant schematic diagram. The methodology shall be presented to ATTIKO METRO S.A. for approval.

The device reference designators shall be indelibly marked or engraved on labels and shall be installed:

- on the equipment and
- above or below the equipment.

2.16.3 Safety Grounding and Grounding of Return Current

All equipment on the vehicles, except the battery boxes, shall be safety-grounded to the car body structure. The safety grounding shall be distinct from power return grounding. Safety grounding points shall be of tinned copper, clean, free from paint and of a sufficient area to ensure proper electrical contact for the grounding cable fasteners. Un-tinned bronze grounding points and austenitic grade stainless steel grounding points are also considered acceptable. In the case that aluminum body shells are used then grounding points shall be aluminum with suitable precautions taken to prevent galvanic action. The area of any weld joining the grounding pad to a surface shall be at least equal to the cross sectional area of the grounding cable.

Grounding points will have either a tapped hole or, preferably, a clearance hole (with access to both sides) suitably sized for the lug attachment fasteners.

Minimum grounding cable size will be 6mm^2, unless otherwise approved by AM, and the size will be equal to, or larger than, that of the largest power wire connected to that equipment.

All grounding wires and cables shall:

- either be blank (diameters greater than 16 mm^2),
- or utilize longitudinally striped green and yellow insulation (diameters up to 16 mm^2),
- or heat shrinkable tubing applied over the conductor insulation.

In circuits where a ground fault could result in current levels, which are excessive, but below the operation of over current protection devices, ATTIKO METRO S.A.-approved ground fault protection shall be provided.

2.16.4 Electrical Interface

Wire and cable interface connections, both power and control, shall be made by quick coupling (preferable 1/4-turn) waterproof, with positive locking and visual indication of mating. These shall be subject to ATTIKO METRO S.A.'s review and approval. Vacant pins shall be plugged using the manufacturer's recommended plugs.

Terminal blocks, where used, shall be of a high quality, with proper creepage and clearance provisions for the voltage used. Cage clamp type also can be used. Terminal blocks shall each be given a unique identification number, and each "point" on the block shall be numbered. The numbering scheme shall be presented to ATTIKO METRO S.A. for approval.

Wherever possible, terminal blocks shall be mounted vertically to prevent dropped foreign objects from bridging terminals.

2.16.5 Wire Identification

All equipment wires shall be marked with a unique wire identification number by means of marker sleeves located within approximately 50mm of each end of each wire. The wire identification number may also be printed directly onto the wire insulation. In addition, the wire insulation shall be indelibly marked with the wire identification number at intervals not to exceed 0.5m. The Contractor shall be required to demonstrate the permanence of the inking system.

If in the standard train manufacturing process it is foreseen that installed cables must be identified through marker sleeves/ plates placed at specific locations along the cables (at least at their beginning and at their end) and if the Contactor provides the maintenance employee with the possibility to identify (through unique identifiers) the cabling routing through the train, this is also acceptable.

The identification numbering system will correspond to the wire identification numbering system used on the schematic drawings and wiring diagrams, and shall be approved by ATTIKO METRO S.A.

2.16.6 Suppression

All relay coils, contactor coils, solenoid valve coils and other inductive devices shall be furnished with coil suppression. Contact suppression shall be provided where necessary or specified.

2.16.7 General Circuit Protection Requirements

All input power circuits shall be individually protected by circuit breakers, and no circuit breaker shall protect more than one circuit, unless specifically approved by ATTIKO METRO S.A.. Circuit breaker terminals shall not be used as junction points. All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum wire size used for power distribution within the protected circuit over the expected ambient temperature range.

Fuses shall only be used where specifically required by this Performance Specification or where the use of circuit breakers is not technically feasible. The use of fuses requires the express approval of ATTIKO METRO S.A.

Under no circumstances shall either the main or auxiliary contacts of contactors or relays be wired in parallel for the purpose of carrying a load at or above the manufacturer's tip rating.

Under no circumstances shall poles of switches be wired in parallel for the purpose of carrying a load at or above the manufacturer's contact pole rating.

2.17 FAIL SAFE DESIGN

All equipment and systems, including software, affecting train safety and the safety of train crew and passengers, and/or identified as being "vital", "safe", or "fail safe", shall be designed according to the following principles. (Couplers, door system, Automatic Train Protection (ATP) system, emergency braking, shall be included, as a minimum).:

- Only components having a high reliability and predictable failure modes and that have operated in similar service conditions to those in Thessaloniki shall be used.

- Components must be utilized in such a manner that ensures that a restrictive, rather than a permissive condition will result from a component failure. (E.g., train will decelerate, rather than accelerate).

- All vital circuits not totally within the system apparatus enclosure shall be double wire, double break, with the exception of connections to non-vital circuits.

- Circuits shall be designed such that when a normally energized electric circuit is interrupted or de-energized, it will cause the controlled function to assume its most restrictive condition. (Broken wires, damaged or dirty contacts, a relay failing to respond when energized, etc., shall not result in an unsafe condition).

- Component or system failures shall cause the train to stop or to run at a more restrictive speed than that permitted with no failure.

- System safety equipment design must be such that any single independent component or subsystem failure results in a restrictive condition. Failures that are not independent, those failures which, in turn, always cause others, must be considered in combination as a single failure and must not cause a permissive condition.

- Any component or wire becoming grounded, or any combination of such grounds, shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to or greater than, 75% of the release value of any device in the circuit.

- Alternatively, redundancy may be included, which shall include not less than two entirely independent, parallel channels to perform each function. If only two channels are provided, a permissive decision shall be required from both for the system not to enter a more restrictive mode of operation. If more than two channels are provided, a more permissive decision shall be required from the majority for the system not to enter a more restrictive mode of operation.

During the Design Review process, the Contractor shall submit analyses for ATTIKO METRO S.A.'s review and approval, which demonstrate compliance with these safety principles. These analyses shall address the following issues:

- Circuit design
- Hardware design (Failure Modes, Effect and Criticality Analysis)
- Electrical Interference
- Software errors
- Short circuit analysis (ground, other conductors, etc.)
- Open circuits
- System failures.

2.18 ENGINEERING CALCULATIONS

In addition to other specific requirements specified herein, ATTIKO METRO S.A. reserves the right to review and approve all designs and documentation pertaining to components and systems where failure of such would lead to any of the following:

- A service delay
- A significant incident, such as a derailment
- Injury or death of passengers, operating personnel or maintenance staff
- Substantial maintenance costs or equipment damage.
- The Contractor shall provide a detailed listing of all equipment falling into these categories, which shall be updated as necessary throughout the course of the contract.
- All such calculations shall comply with the following requirements:
- The objective of the analysis and the design philosophy used shall be clearly stated.
- The calculations shall only use the International System of Units (SI) and abbreviations (SI).
- The analytical method used and its origin (i.e., industry standard, published technique, Code of Practice, etc.) shall be stated.
- Should more than one analytical technique be available, the reasons for choosing the technique to be used shall be described.
- All assumptions used shall be clearly delineated.
- Conclusions shall be drawn for each subset of data and presented in summary form.
- Each calculation sheet shall be titled, numbered and dated. Drawings/documents to which the calculations refer shall be noted. The name of the Engineer performing the calculations shall be identified on each sheet.

3.0 VEHICLE BODY

3.1 GENERAL

The design of each type of car body shell shall be as identical as possible.
Cars shall be designed and constructed to withstand the rigors of a normal railroad environment for a period of 30 years, without repair. The Contractor shall provide documented evidence of the ability to meet this requirement.

The traverse cross section to be proposed shall maximize the amount of interior space and shall maximize the occupation of the permissible envelope. The proposed alternative transverse cross-sections require the approval of ATTIKO METRO S.A.

The carbody outside aesthetic appearance is considered as a very important factor in the train design. Smooth and flat or mildly curved outside surfaces with uniform joints in continuous width, rounded transitions of the carbody exterior with no untoward protrusions in evidence, door and window shapes, car to car joints with a minimized void between the train and the station platforms and windshield dimensions and shape, and the selection of colors shall all be integrated in a modern, aerodynamically shaped, high quality appearance product.

The Contractor shall provide suitable repair procedures for both light and structural damage, as well as to vandal attack (impact, graffiti, etc.).
Moreover, he shall submit procedures for graffiti removal and appearance reinstatement which shall be approved by ATTIKO METRO S.A..

Also, the Contractor shall provide recommended car body shell cleaning procedures.

3.2 MATERIALS AND CONSTRUCTION

The car body shells shall be of integral construction, and shall be manufactured in their major part of aluminium alloy. All material grades used shall be approved by ATTIKO METRO S.A.

The end sections of the car bodies may be equipped with glass reinforced polyester (GRP), but this requires the approval of ATTIKO METRO S.A.

Car body shells shall generally be constructed of wide and large size extrusions joined by longitudinal welds.

All car body assemblies and sub-assemblies shall be assembled to ensure build uniformity and component interchangeability.
Care shall be taken to avoid sections being produced which might retain dirt and moisture, and which might become a source of corrosion.

In addition, the construction of car body shall allow all portions and areas to be readily painted (by spray gun or brush) and protected from corrosion.

Particular care shall be taken when joining other materials to the aluminium alloy, to prevent untoward electrolytic action and corrosion.

The car body shall be designed and tested to be watertight, including the requirement to pass through AM's car washing facilities without allowing any water ingress. Also, prior to the installation of acoustic and thermal insulation and interior finish panels, each car shall be

given a complete test for water tightness. The water tightness test procedures shall be approved by ATTIKO METRO S.A.

The car body exterior of the vehicles shall be painted. The sides and ends of the car body, including the doors, shall incorporate a finish acceptable by AM. The finish shall be vandal resistant (impact, graffiti, etc.) and shall have a proven record in rail transit service. The Contractor shall submit samples of such for ATTIKO METRO S.A.'s approval.

All body panels shall be free from wrinkles and other imperfections and shall be flat within maximum 0.25mm in any 1m span.

3.3 STRUCTURAL REQUIREMENTS

3.3.1 General

The car body shells shall be designed, constructed and tested in line with Standard EN 12663 "Structural Requirements of Railway Vehicle Bodies: Part -1 Locomotives and Passenger Rolling Stock - Category P-IV. In addition, in order to ensure compatibility with the existing 18 trains, the car bodies must be able to bear an axial load of at least 800 kN at the front and rear buffers level and 400kN at the couplers.

To provide confidence in the design, the Contractor shall submit a Stress Analysis for the review and acceptance of AM. The stress analysis shall include the use of a suitable Finite Element Model (FEM) supported by classical hand analysis for detailed components. The FEM, analyses and all results shall be approved by ATTIKO METRO S.A.

The Contractor shall submit a table of compliance with the articles of Standard EN 12663-1 clause by clause in terms of category P-IV and with the additional requirements of the Specification.

3.3.2 Proof Loads

3.3.2.1 General

Stress levels induced as a result of the following load cases shall not exceed 87% of the material's lower yield stress (minimum safety coefficient 1.15) for values calculated on the basis of EN12663.

Unless otherwise stated, the EL 8 load shall be used.

The calculation shall be validated by a test, where applicable on the basis of EN12663. (Refer to Article 3.3.3.1 of this Performance Specification).

Floor beams shall be designed and tested not to deflect more than 1/250 of the span between supports under EL 8 passenger loading conditions, plus the loading due to interior equipment, such as linings, equipment boxes, etc.

3.3.2.2 Jacking and Lifting

Jacking and lifting pads shall be provided:

- at the extreme ends of the car bodies and
- adjacent to the car body bolsters.

The car body shell shall be designed and tested to allow an empty car, with bogies attached, to be lifted:

- at the extreme ends pads,
- the car body bolsters pads
- or any combination thereof (particularly during re-railing operations).

Specifically, the following shall be taken into account:

- The car body shell shall be designed and tested to be capable of being lifted at one extreme end, with the opposite bogie supporting the opposite end. The tare mass of the car body and the mass of one suspended bogie shall be multiplied by 1.1g.
- The car body shell shall be designed and tested to be capable of being lifted at its extreme ends. The tare mass of the car body and the mass of each suspended bogie shall be multiplied by 1.1g.
- The car body shell shall be designed and tested to be capable of being lifted at four lifting pads adjacent to the car body bolsters. The tare mass of the car body and the mass of each suspended bogie shall be multiplied by 1.1g.

The locations of all jacking and lifting points shall be clearly marked on the car body.

3.3.2.3. Car body Twist

This load case shall simulate the amount of twist in the car body resulting from one bogie having derailed with the other remaining on the track. The suspension system on the bogie on the tracks shall be in its normal condition, while that on the derailed bogie shall be in its most disadvantageous condition (deflated airbags). One wheel on one side of the derailed bogie shall be on the track, while the other wheels shall be on the track bed.

3.3.2.4 Equipment Attachments

All equipment attachments shall be fully capable of withstanding longitudinal accelerations of ± 3g, lateral accelerations of ± 1g, and vertical accelerations of ± 3g at the ends of the car falling linearly to ± 1.5g at the center of the car. These load cases shall be applied individually.

In addition, the loads resulting from the longitudinal and lateral accelerations shall be applied separately in combination with the load due to 1g vertical acceleration and the maximum loads which the equipment itself may generate.

The body to bogie connection shall sustain independently the maximum loads arising from:

- the maximum bogie longitudinal accelerations of ± 3g,
- the maximum lateral accelerations of ± 1g of the car body
- the vertical loads arising by lifting the body with the bogie attached.

3.3.3 Fatigue Loads

3.3.3.1 General

During the static load testing, strain gauges shall be placed in all areas where the stress analysis has predicted stress levels greater than 100/1.15) = 87% of the yield or 0.2% proof stress (R_{P02}).

Additional static loads shall be applied to enable the stresses from the fatigue loads to be established and the fatigue damage calculated.

The car body structure and attachments shall be designed for a probability of failure of less than 2.5% under the loads defined herein. Unless otherwise specified, EL 5 loading conditions shall be used.

The partial fatigue damage resulting from the individual load cases shall be calculated, and their sum shall not exceed unity.

3.3.3.2 EL 5 Passenger Loading

10 million cycles at ± 10% of the stresses resulting from EL 5 passenger loading.

3.3.3.3 Lateral Loading

0.1 million cycles at a lateral acceleration of ± 0.1g under EL S loading conditions.

3.3.3.4 Passenger Loading/Unloading

2 million cycles caused by passenger loading/unloading comprising the load range below:

% EL 5 Load	Cycles (x 10^6)
33	1.00
50	0.50
66	0.30
83	0.12
100	0.08

Table 3.3.3.4 Passenger Loading/Unloading

Alternatively, passenger loading/unloading can be taken into consideration in the design and manufacturing of the train with a 100% EL5 load for 500,000 cycles.

3.3.3.5 Loading from Track Twist

The torsional loading resulting from a car negotiating the following track twist spectrum during its life, in combination with the EL 5 passenger loading.

Twist Range (mm)	Applied Cycles (total 5 x 10^6)
10	4.739×10^6
15	0.174×10^6
25	0.063×10^6
39,7	0.024×10^6

Table 3.3.3.5 Loading from Track Twist

The track twist is defined as the amount by which one point out of four is out of plane at the bogie air springs.

3.3.3.6 Traction and Braking Forces

4 million maximum acceleration and braking actions under EL 5 loading condition.

3.3.3.7 Body/Bogie Connection

The loads resulting from body/bogie interaction as a result of the aforementioned fatigue load cases shall be taken into account and presented for ATTIKO METRO S.A.'s review and approval.

3.3.3.8 Equipment Attachments

All equipment attachments shall be fully capable of withstanding the loading caused by longitudinal accelerations of ± 0.2g, lateral accelerations of ± 0.15g, vertical accelerations of 1 ± 0.15g, plus any additional loading resulting from the operation of the equipment itself. Relevant calculations will be carried out for equipment attachments weighing more than 100kg.

3.4 CRASHWORTHINESS REQUIREMENTS

3.4.1 General Requirements

The design, calculations, construction and testing regarding crashworthiness shall comply with the requirements of Standard EN 15227, category C II.

The car body structure shall be designed and constructed as a relatively “rigid” compartment housing the passengers, incorporating features at each end of the vehicle to absorb impact energy. Crashworthiness shall not entail excess of the yield stresses at some parts of the car body.

The car body design shall also incorporate anti-climbers, to prevent one car from climbing over another in the event of a major collision.

The philosophy of the entire train crash energy management system and its detailed design, which shall utilize a time-dependent FEM (Finite Element Model), while the relevant design shall be submitted to ATTIKO METRO S.A. for review and approval. The crashworthiness analysis report shall include a video representation of the reaction of the car body structure under dynamic loading, and which shall clearly demonstrate stable crushing.

For a possible collision with a series I vehicle, an energy management study shall be prepared, which shall be submitted to AM after the study’s approved by the system Safety Certification agency (ch. 15).

3.5 CAR ROOF

The roof finishing shall be a metal sheet covering the cables or another electrical equipment. Roof construction shall be sufficiently robust as to allow three maintenance personnel (weights of 75kg, 1m apart from each other) to walk over the roof at one time, without causing undue deflection or permanent deformation.

3.6 EQUIPMENT MOUNTING

3.6.1 General

Equipment arrangement on all cars shall be such that under EL E loading conditions, the weight distribution is as even as possible and complies with the requirements of IEC 61133.

To the extent practicable, all equipment shall be installed in such a manner that the car body mounting brackets will retain the equipment in the event of failure of the mounting fasteners.

Equipment shall be logically grouped into enclosures, which shall meet the requirements of Chapter 18.7 of this Performance Specification.

Care shall be taken to ensure that the equipment within the enclosures is readily maintainable, taking into consideration the required maintenance interval.

The electrical equipment located in the under floor area shall be protected against moisture and dust according to IEC 60529, class IP55.

3.6.2 Under floor/Roof Mockup

In order to evaluate the efficacy of the under floor/roof equipment layout, the Contractor shall install all equipment, wiring, piping, etc. on the car mockup. As the design progresses, replicated hardware shall be replaced with production components. (Enclosures need not be equipped). The layouts shall be approved by ATTIKO METRO S.A. Alternatively, the Contractor shall demonstrate the above on a real train at the factory or in another Metro system located at any part of the world.

3.7 SIGNS

The following signs, as a minimum, shall be provided in both the Greek and English languages.

Operations Company-related signs:

- Reserved areas for Persons with Special Needs
- Vehicle number
- Identification of jacking and lifting points
- Identification of dangerous voltages
- Identification of maintenance requirements
- ATTIKO METRO S.A. logo.

All signs shall be vandal and graffiti resistant, and shall be edge-sealed. The artwork shall be approved by AM prior to manufacturing. The number, content and location of the signs and the materials used shall be approved by ATTIKOMETROS.A.

The signs to identify the car number, the locations of lifting and jacking points, dangerous voltages, ATTIKOMETROS.A. logo, etc., shall be of paint-filled, etched stainless steel, permanently fixed in position (as approved by AM), unless otherwise accepted by ATTIKOMETROS.A..

3.8 EXTERIOR LIGHTS

3.8.1 General

All lamps shall be of LED type and of proven service in Metro systems. The colour of the lighting fixtures and the lens transmittance shall not be altered throughout their service life.

On each end of the train end one set of white headlights shall be provided.

Similarly, at each train end one set of red taillights shall be provided.

The headlight and taillight units shall be mounted flush with the exterior surface of the car body in an aesthetically pleasing manner.

The lights shall be fully adjustable.

When one direction of the train is activated, the headlights on that side will be illuminated and the taillights shall switch off. (The taillights on the opposite side shall remain illuminated).

All lights shall be powered from the low voltage DC power supply system. Should the Auxiliary Power Supply Equipment not be operational, the lights shall be powered from the batteries. Each set of lights of each color shall be powered from individually protected separate circuits. All lights shall be constructed to allow easy cleaning of lenses and reflectors, where used. The beam pattern and alignment shall not be affected by the cleaning process. Lenses shall not be affected by graffiti or by car cleaning agents.

Lamps shall be easily changed by one person within two minutes.

3.8.2 Headlights

The headlights shall aid the forward vision of the Operator and shall act as a warning to maintenance staff on the track of the imminent arrival of a train.

Two headlights shall be installed on the extreme end of the driving cars. The location of the lights shall be subject to ATTIKO METRO S.A.'s approval between sole bar level and the bottom of the windshield. Each shall be mounted between 1,400mm and 1,750mm from running rail level, equally spaced about the centreline of the car, and on 1,300mm minimum centers.

Headlight beam pattern shall be elliptical and shall have low and high beams. Each headlight low beam shall be inclined downwards, so that with the train located on straight, level track the beam pattern horizontal centerline intersects the running rails 40m in front of the train. The headlight full beam shall have a minimum light intensity of 1lux in a distance of 160m.

Each headlight assembly shall be provided with means to finely adjust the beam alignment, and the aforementioned pattern shall be readily achieved. The adjustment shall accommodate a minimum of ± 2 degrees of adjustment beyond that necessary to achieve the required beam pattern, to allow for vehicle construction and headlight assembly installation tolerances. The equipment shall be tolerant to in-service shock and vibration and shall not require adjustment during routine maintenance activities or at periods less than once per year.

3.8.3 Taillights

Two red taillights shall be installed on the train end at the same height from rail as the headlights.

On driving cars the taillights shall be directly adjacent to the headlights (inboard).

The taillights shall be clearly visible from a distance of 200m in daylight. The beam pattern shall be circular, with a viewing angle of at least 15 degrees. The lighting intensity at a distance of 2m shall be no less than 6.5 lux.

3.9 BARRIERS AND GANGWAYS

The gap between cars shall be closed off by barriers and gangways.

The gangways shall allow passengers to readily move from car to car and also to be used by standing passengers in peak hours. Therefore, grab rails shall be provided in the gangway area for the potential standees.

Also, the gangways:

- shall have such internal dimensions, in order to maximize the width available for the movement of the passengers between cars and
- shall be covered, if possible, with panels identical to the side panels of the train
- shall have the necessary means (e.g. eye bolts) for lifting and removal.

The width available for the movement of the passengers between cars shall be greater or equal than 1200mm.

The barrier and gangway configurations must allow for full buff under curving conditions of Thessaloniki Metro network:

- Vertical curves R= 625 m
- Horizontal curves in the Depot R=50m
- Horizontal curves in the Network R=150m

The barriers shall be suitable for train circulation throughout the revenue service network, with no speed restriction (80 Km/hr).

The Contractor shall demonstrate by means of a study (Movement Study) and test the efficacy of the barrier and gangway design under all service conditions.

The barrier and gangway configuration shall be based on proven reliability design, as per EN 16286-1.

The bellows shall be Double corrugated bellow loops type

All materials, bellows, gangways, sliding edges, etc., shall be service-proven and they shall be submitted for approval to AM

The constant operation temperatures shall range between -15 C^0 to +80 C^0.

The service life of the bellows shall not be shorter than 8 years.

Strength designs shall be submitted for all metal components and supports.

Barrier installation shall be waterproof.

Particular attention shall be paid to moving parts to ensure that passengers' body parts, baggage, etc., are not pinched or trapped.

The barrier and gangway configurations shall comply with the noise and vibration requirements of Clause 2.13.1 of this Performance Specification.
Especially, for the noise requirements of Clause 2.13.1 of this Performance Specification, the Contractor shall take all the necessary precautions in the design of the gangway area (e.g., doubling of the gangway rubber at the lower part) and shall carefully select the material of the

gangway and the barriers to minimize the difference between the higher values in the gangway area and the values on the Table 2.13.1.1.1. Test Certificates shall be submitted.

The behaviour of the material to fire shall comply with EN 45545 HL2 R1 for the inner ring and EN 45545 HL2 R7 for the outer ring. Test Certificates will be submitted

The cleaning procedure shall be submitted. Detergents for cleaning the outside of the train shall also be suitable for the Barriers.

The equipment shall be resistant to graffiti cleaning processes.

The barriers and gangways shall be readily separated in depots for maintenance purposes. The Barrier coupling / uncoupling time shall be subject to approval by ATTIKO METRO S.A.

The Contactor shall provide easily assembled and disassembled covers for the gangway openings. These covers shall offer protection against adverse weather conditions when cars are stored.

Tests shall be in accordance with Standard EN 16286-1.

3.10 MISCELLANEOUS EXTERIOR EQUIPMENT

Horns

One transit-proven high-intensity air horn shall be provided on the end of train, which shall be capable of being isolated by means of a cut out cock.

In addition, one transit-proven electric horn shall be installed on the end of the train, which shall have a softer tone than that of the air horn.

The air horn shall emit a sound level of 110 ± 3dB(A) at a distance of 2m.

The desired sound level of the electric horn shall be the same with one for the air horn. Therefore, the Contractor must locate and provide commercially available electric horns meeting as close as possible to the above value.

The horns shall only sound on the leading car in the direction of movement. If “manual reverse” position is selected via the use of the Operator’s Desk and the operator presses the electric horn pushbutton, the horns on the last car shall sound.

4.0 BOGIES

4.1 GENERAL

The bogies shall be of service-proven design. Bogie frames shall be designed and constructed to provide service for a period of at least 30 years without modification or repair. The Contractor shall provide documented evidence of the ability to meet this requirement.

The Contractor shall detail the arrangement of the motor and trailer bogies.

Motor bogies shall utilize an individual motor driving each axle, and the motors shall be mounted on the bogie frame.

Bogies will be designed and manufactured such that as many components as practicable are interchangeable. All bogies shall be fully interchangeable with adaptations in regard of bogie mounted components like antennas or similar equipment.

Bogies will be as light as possible, commensurate with meeting the requirements of this Performance Specification.

The entire bogie design will be subject to ATTIKO METRO S.A's approval.

The wheels of the bogies shall be capable of being machined on ATTIKO METRO S.A.'s existing under floor wheel truing machines, without the need to disassemble any car equipment.

The train shall be equipped with the appropriate device to allow the bogie to be safely lifted with the car body. The device shall not prevent normal movements between the bogie and the car body, nor affect suspension parameters. The device shall meet statutory requirements for lifting equipment. All bogies shall have provision for safe lifting. All bogies shall have provision for safe towing, both with and without the car body installed.
Wheel sets shall be easily disconnected from the bogie to allow the bogie to be lifted from the wheel set, leaving the wheel set as a free-standing assembly.

The bogies shall be capable of being jacked to facilitate derailment.

Based on the experience of the Contractor in similar applications in Metro Systems worldwide, the pneumatic, hydraulic and electric connections, between bogie and car body, following adequate justification in writing, may be made with quick disconnect couplings, in order to minimize the disconnection time of the bogie from the car body.

There will be no need to remove the bogies from the car, for any type of maintenance, prior to the Major Overhaul.

4.2 SUSPENSION SYSTEM

4.2.1 General

Bogies shall be equipped with a primary and secondary suspension system, the characteristics of which shall provide a low transmissibility of vibration to the car body and minimize impact and vibration noise. It is preferred that the primary suspension utilizes proven elastomeric springs and that air springs be used for the secondary suspension. Any other type is subject to ATTIKO METRO S.A.'s approval.

The bogie design shall minimize weight transfer during acceleration and braking, and shall provide good curving performance to minimize wheel noise and wheel/rail wear.

The suspension system shall be designed to provide the degree of ride comfort demanded in the Performance Specification, while providing adequate vibration isolation with all bogie-mounted equipment, the car body, and car body-mounted equipment.

The suspension system shall be such as to ensure that the train remains within the static clearance diagram under all conditions of passenger loading, track super elevation, etc., and within the dynamic clearance diagram under all combinations of passenger loading, train speed and track curvature, consistent with the system's track curvature/ speed restrictions.
The train must remain within both clearance diagrams under the conditions of deflated air springs, over-inflated air springs, broken primary springs, etc.

The rotational resistance of the bogie/car body interface and the bogie suspension elements shall be such as to minimize excessive wheel flange contact and, hence, minimize wheel squeal and wheel/rail head wear, while preventing yaw instability (hunting) throughout the train's speed range.

The primary and secondary suspension systems shall be designed and constructed, in order to have a maintenance-free service life of at least 6 years or 1,200,000km, whatever comes first.

4.2.2 Primary Suspension System

The primary suspension shall be designed to provide the axle with the possibility to move in the direction of the three axles to minimize wheel flange wear. However, wheel set yaw stiffness and damping shall not be such as to allow a yaw instability condition throughout any portion of the vehicle speed range. Also, primary suspension system vertical stiffness shall not be so great as to impart undue forces on the rail under dynamic conditions, and shall be sufficiently flexible to prevent the degree of wheel unloading that would cause a derailment, under all conditions of track irregularities, curvature, super elevation, etc., consistent with train speed. The Contractor shall provide calculations confirming that these requirements have been met.

It is preferred that the primary suspension system utilizes proven elastomeric springs, details of which must be provided for ATTIKO METRO S.A.'s review and approval. However, any other type is subject to ATTIKO METRO S.A.'s approval, provided the Contractor provides a suitable rationale for such.

The primary suspension system shall be designed to incorporate dampers or damping characteristics limiting the wheel speed, when falling at worn crossing "V" gaps.

The primary suspension system units shall be securely mounted for the safety of maintenance staff. The wheel sets shall be restrained to the bogie frame without the need to fit additional restraints at the time of lifting.

4.2.3 Secondary Suspension System

The secondary suspension system shall preferably consist of air springs supported directly on the bogie frames, controlled via the required quantity of leveling valves per car, which shall provide a relatively constant car floor height. However, any other type is subject to ATTIKO METRO S.A.'s approval, provided the Contractor provides a suitable rationale for such.

Leveling valve arms shall be securely fastened, that even if they break, they will not fall down.

Vertical and lateral dampers may be installed, to control bogie to car body oscillations. Visual means shall be provided to readily ascertain if the air springs are at their working height.

The air spring pressure shall also be used to provide a signal to the load weigh system to control vehicle tractive effort and braking forces under all car loading conditions.

Emergency secondary springs shall also be provided to support the car body in the event of ruptured air springs. To prevent excessive car body lean should one air spring rupture or leak, the air springs on each bogie shall be interconnected using a pressure differential valve. The Contractor shall provide an analysis for ATTIKO METRO S.A.'s approval, which demonstrates the correct sizing of the valve.

It shall be possible to adjust car body height for wheel wear without having to remove the bogie from the car.

4.3 SAFETY OF RUNNING AND RIDE COMFORT

The bogies shall be designed to allow the complete cars to meet the safety of running and ride comfort requirements of Clauses 2.7 and 2.8 of this Performance Specification.

Safety against derailment must be proven by a calculation according to EN 14363.

4.4 WHEEL UNLOADING

The bogie suspension system shall be designed and tested such that under the most adverse track conditions (or the values according to EN 14363 method 2) and in the EL E and EL 5 loading conditions, the maximum reduction in load of any wheel shall not exceed 55% for a car with inflated air springs, and 65% with deflated air springs. This criterion is applied to a stationary vehicle.

4.5 BOGIE FRAME

The bogie frame may be of cast high strength steel or may be a weldment manufactured from weather-resistant steel plate. It is also permissible to incorporate high strength castings into a weldment.

Machining datum points shall be provided on the bogie frame to allow frame distortion to be readily assessed after a derailment or collision.

Each bogie frame shall be stamped with a unique serial number, which shall be readily visible from the side of the vehicle.

4.6 WHEELS AND AXLES

Wheel sets shall generally conform to standard ISO 1005, EN 13103/13104. However, to minimize noise generated due to wheel squeal through curves, the Contractor shall incorporate features into the wheels that minimize wheel squeal. The noise attenuating feature shall require minimum maintenance. These wheels shall exhibit no significant settlement when a vehicle is not used for periods up to one month and the wheels shall not generate additional out-of-balance forces as a result of such.

The wheels of the trains shall be compatible and they should allow the trains to travel along the lines of the existing network.
The width of the wheel rim shall not be less than 135mm.

The preferred wheel tread profile is as per standard UIC 510-2; however, the Contractor shall propose alternative worn wheel profiles should a different profile be considered advantageous to AM. However, whichever profile is used, to ensure that the wheel profile is fully compatible with the rail head profile and that excessive wheel/rail wear will not ensue, the Contractor shall perform a wheel/rail head profile compatibility (wear) study, using proven methodology, and to present the results to ATTIKO METRO S.A. for approval.

The rail shunting resistance provided by a wheel set shall be measured and tested as per the requirements of EN 13260.

Wheels and gears shall be assembled to the axles by cold pressing to an interference fit. Full details of the axle, wheel and gear machining details shall be provided to ATTIKO METRO S.A., together with process details, including the specific type of lubricants used. The Contractor shall provide the pressing records of all wheel sets in the Car History Books.

After disconnection of the flexible drive couplings from the traction motors, both wheel set assemblies (comprising wheels, axles, axle boxes, gearboxes) shall be capable of being disconnected from the bogie and the bogie lifted from the wheel sets by four experienced maintenance staff within a period of 15 minutes.

4.6.1 Un-sprung elements

The mass of the un-sprung elements shall be kept to the minimum possible and their design shall be subject to ATTIKO METRO S.A's approval.

4.7 TERMINAL AXLE BOXES

Axle boxes must be of a robust fatigue-proof design that would ensure a problem-free service life of 30 years. The Contractor shall provide documented evidence of the ability to meet this requirement.

Axle box bearings shall be of the grease lubricated, taper or cylindrical roller type.

Bearings shall be sealed by labyrinth seals and if replenishment of lubricant is required between overhauls, this shall be possible without removing any other equipment.

Any design incorporating a wearing surface between the axle box and the bogie frame will not be accepted.

4.8 TRACTION MOTOR INSTALLATION

The design of the motor installation shall also be configured such that should the motor mounting hardware fail, the motor will not fall from the bogie and cause a derailment.

4.9 BOGIE-MOUNTED BRAKE EQUIPMENT

Details are given in Chapter 9.0 of this Performance Specification.

4.10 MISCELLANEOUS BOGIE-MOUNTED EQUIPMENT

4.10.1 General

The bogies shall be equipped with all pertinent equipment needed to meet the requirements of this Performance Specification, including, but not limited to, current collection equipment, ATC equipment, speed sensors, dump valves, lifting lugs, sanding equipment, piping, cabling, etc.

All resiliently mounted equipment on the bogie shall be designed to avoid resonance with all bogie suspension frequencies.

4.10.2 Wheel Flange and Tread Lubrication

Trains shall be supplied with proven equipment to dispense solid lubricant (Solid Stick Type) to the flanges of wheels. The number of wheels and axles so equipped and their arrangement, shall be carefully chosen based on experience and a survey performed by the Contractor of the wheel and rail head lubrication condition of Thessaloniki Metro system.

The solid lubricant shall be in stick form, mounted in spring-loaded cassettes. The lubricator arrangement shall ensure that adjacent areas of the under frame and the bogies are not fouled by excess lubricant. Should it be found necessary, the Contractor shall install easily removable and cleanable shields in affected areas.

In choosing the type of lubricant to be used, the Contractor's attention is drawn to the fact that track bed temperatures may reach 55^{o}C.
The type of the applied lubricant must be similar to or compatible with the lubricant applied in Series I trains.

4.10.3 Sanding Equipment

Equipment shall be provided to apply sand to the wheel/rail interface on the leading axle of the first and the last motor car as a minimum. The sand shall only be applied to the leading wheels with respect to the direction of travel. Sand shall be applied whenever wheel spin or wheel slide is detected and whenever the emergency brake command has been initiated. (Reference Chapter 9.0 of this Performance Specification).

The need for sand replenishment shall be announced at the Train Control System and at the Train Control Centre for the maintenance personnel to be advised accordingly.

The quantity of sand deposited shall be reduced to a minimum so that it will not interfere with track signaling circuits or the safe operation of any track equipment. The Contractor shall propose the feed rate and characteristics of the sand proposed. Also, the Contractor shall deliver the trains with the sand boxes full.

4.11 BOGIE-TO-CAR BODY CONNECTION

It is preferred that the car body be supported by the bogies directly on the air springs, with no other moving parts. The design shall allow for the bogies to be retained by the car body when the car body is lifted, and the bogie-to-car body connections must also retain the bogies in the event of a collision.

The design shall be approved by ATTIKO METRO S.A. and these mounting features shall be tested in accordance with an ATTIKO METRO S.A. approved procedure.

The Contractor shall provide the earthing design of the bogie/car body connection, in order to prevent the conducting of stray electrical current (other than through the grounding straps).

Bogie/car body connections shall be designed to reduce the transmission of noise and vibration to the absolute minimum.

It shall be physically impossible for connections to be mismatched.

4.12 BOGIE-TO-CAR BODY CLEARANCE

Under all loading conditions (EL E, EL S, EL 5 and EL 8) and under all conditions of movement between the bogies and the car body, including fully inflated and deflated air spring conditions, there shall exist a sufficiently minimum clearance between bogie-mounted and car body-mounted equipment. This shall include any end of the car having fully inflated air springs, with the opposite end having deflated air springs.

In addition, under the same aforementioned conditions, but with the wheels of any axle positioned on the rail sleepers (bogie rotated appropriately), neither the bogie frame nor any bogie-mounted equipment shall contact the underside of the car body, nor any car body-mounted equipment. The intent of this requirement is to limit damage in the case of a minor derailment.

4.13 STRUCTURAL REQUIREMENTS

Bogies and their equipment in terms of design, calculations and testing shall comply with the requirements of EN 13749 “Railway applications – Wheelsets and Bogies – Methods of specifying structural requirements of bogie frames, category B III” and with the requirements of this Specification.

A stress analysis, structural stress and fatigue strength, of the entire bogie structure shall be performed using a Finite Element Model. The model, its type and number of elements, and the criteria used for the acceptability of stress levels shall be subject to the review and approval of ATTIKO METRO S.A.. The results of the FEM analysis shall be presented to ATTIKO METRO S.A. for approval.

The Contractor shall perform the appropriate laboratory tests to ensure compliance with the following requirements and the requirements of the standard EN 13749, which shall include both static and fatigue testing.

During the static load testing, strain gauges shall be placed in all areas where the stress analysis has predicted stress levels greater than (100/1.05)=95% of the yield or 0.2% proof stress.

Additional static loads shall be applied to enable the stresses from the fatigue loads to be established and the fatigue damage calculated.

In addition, during the Simulated Revenue Service Testing program, the Contractor shall instrument the bogie with strain gauges at critical locations and shall perform a fatigue life assessment in order to confirm that the bogie frame life is in conformance with the design criteria. It is important that this instrumentation and testing is also extended to the axle box.

All test procedures shall be approved by ATTIKO METRO S.A..

4.13.1 Proof Load Cases

4.13.1.1 General

The bogie frame and attachments shall withstand the proof loads delineated herein. Proof loads shall, unless otherwise stated, be applied individually and shall be based on the EL 8 loading condition of ATTIKO METRO S.A..
The stress levels induced as a result of these loads shall not exceed the (100/1.05)=95% of material's yield stress or 0.2% proof stress, so as not to cause permanent deformation.

4.13.1.2 Loads

- Vertical Loads
- Lateral Loads
- Longitudinal Loads
- Curving
- Track Twist
- Friction Brake Equipment
- Traction Drive Equipment
- Equipment Inertia Loads
- Wheel set-Mounted Equipment
- Re-Railing Loads
- Car Lifting Loads.

4.13.2 Fatigue Load Cases

4.13.2.1 General

The bogie frame and attachments shall be designed for a probability of failure of less than 2.5% under the loads defined herein. Unless otherwise specified, EL 5 loading conditions shall be used. The phasing of the loads shall represent actual service conditions. The partial fatigue damage resulting from the individual load cases shall be calculated, and their sum shall not exceed unity.

- Vertical Loads
- Lateral Loads
- Curving and Steering Loads
- Track Twist
- Friction Brake Equipment
- Traction Drive Equipment

- Wheel set-Mounted Equipment
- Passenger Loading and Unloading
- Damper Connections
- Miscellaneous Appropriate loads arising from other equipment, such as torsion bars (if used) shall be applied.

The number of the load cycles (switching between maximum and minimum load) to be applied on the bogie frame shall be as follows:

CROSS-OVERS	500,000 cycles
STRAIGHT TRACK	1,000,000 cycles
CURVES	500,000 cycles
SERVICE LOADS	3,900000 cycles
INERTIA LOADS	4,100,000 cycles
VERTICAL LOADS	10,000,000 cycles
LONGITUDINAL LOADS	10,000,000 cycles

Table 4.13.2.1 Loading cycles

5.0 COUPLERS AND DRAFT GEAR

5.1 GENERAL

The two train ends shall be equipped with automatic couplers.

The couplers shall be compatible with the “FAIVELY PROPACT SD130” Type couplers on the existing fleet of Series I trains.

Couplers shall ensure mechanical, electrical connection and connection through Ethernet if required by the design, as well as pneumatic connection. The Technical Specification for the coupler of Series I trains in included in the Annex:

A5-1: Coupler Specifications AIASA – 16750 - 0GS1RS051G100C.

The height installation of the automatic coupler shall be 610mm from top of rail.

Train coupling and uncoupling can be automatic through the Train Control Centre without necessitating the presence of personnel in the vehicles or in the coupling area.

Coupling/uncoupling can also take place from the console of the non-damaged train. As soon as couplers are uncoupled, couplers shall be ready to operate automatically again.

The Series I and IIt rain coupling speed shall be approximately 2 Km/hr.

Train cars in case of non-articulated trainset shall be connected via semi-permanent couplers or articulations.

The couplers shall be capable of transmitting all loads (pulling or pushing condition) resulting from normal service conditions (semi-permanent) and emergency trailing conditions (automatic).

5.2 AUTOMATIC COUPLERS

Automatic couplers shall be service-proven.

Coupling shall be possible along the full length of the network. The couplers’ centering device (self-centering) shall ensure coupling in all cases of gathering of the train coupling axles encountered inside the network and the Depot. The automatic coupling, under all possible gathering conditions, horizontal and vertical level, curves, vertical tilting and horizontal twist between identical vehicles or existing vehicles or between vehicle and other towing equipment, e.g. Locomotive, Unimog, electric vehicle, shall be possible without damaging the equipment or the structure of the car body. The Contractor shall submit a diagram with the maximum permissible gathering range for successful coupling. In addition, he shall submit a coupling simulation for all critical areas of the network, e.g. smaller turning radius, etc.

Manual uncoupling by the personnel between the cars shall also be possible. To this end, automatic couplers shall incorporate a manual uncoupling device which shall function with ease under the most adverse conditions of coupler alignment.

There shall be a simple visual means of confirming that all securing devices on the coupler are safely engaged.

Coupling with one de-activated train shall be possible.

Coupling and uncoupling shall be performed within 10s.

The coupler head face shall be protected against corrosion.

Wearing parts (if any) shall incorporate either self-lubricating or non-lubricated bearings of an approved design.

5.2.1 Electric coupling

The electric coupling shall be compatible with Series I trains.

The coupler shall be equipped with one or two hardwired electric boxes with contact pins and shall also allow for Ethernet connection between vehicles.

Electric coupling can be manually isolated.

Electric contacts shall be manufactured for a life cycle of at least 35000 coupling/uncoupling cycles

The electric portions shall be watertight and shall contain a drain hole in the bottom. Contact pins shall be properly labelled to identify the pertinent electrical circuit.
Contact pins shall be readily replaceable from the front of the coupler. It shall be possible for one technician to exchange a contact block within 30 minutes.

The electric portion shall provide for 10% spare train lines.

The electrical contact blocks shall be designed in such a manner so that failure to transmit the electrical command after coupling be not more than 1 in 2,000 times.

A signal interruption (if any) in case of accidental separation of the vehicles or the Service Vehicle, shall result in the activation of the emergency brake.

5.3 SEMI-PERMANENT COUPLERS

The semi-permanent couplers will only be coupled or uncoupled in the Depot.

Pneumatic connections shall be made through the coupler head.

Electrical connections shall also be made through the coupler head.

Should this is not be feasible, electrical connections shall be made to terminal blocks in junction boxes via jumper cables, using quick disconnect couplings securely locked with wire Should this is not be feasible, electrical connections shall be made to terminal blocks in junction boxes via jumper cables, using quick disconnect couplings securely locked with wire.

The connectors for each cable, if of the same size, shall be keyed differently to prevent misconnection, and shall be color coded to enable connectors to be easily distinguished.

In all cases, the required technical measures shall be taken to ensure that strain relief is provided for all cables leaving the junction boxes, and that all cables are properly supported in suitable cleats, and that no chafing of the cabling takes place under all possible movements of the coupler.

5.4 DRAFT GEAR

Each coupler type shall utilize rubber, double acting draft gear capable of withstanding all of the service and emergency loads described in this Performance Specification, and which will not transmit undue vibrations into the car body.

The draft gear systems of the automatic coupler and of the semi-permanent coupler shall allow for coupling of a train with a standing Series II train as follows:

Coupling speeds up to approximately 5km/h shall not cause permanent deformation in the energy absorption device.
Coupling speeds up to approximately 10km/h shall not cause excess of the design proof load of the car body, i.e. without structural damage of the cars.

If couplers are part of the train crash draft gear they shall comply with Standard EN15227.

6.0 CAR INTERIOR

6.1 GENERAL

The interior of the cars shall be aesthetically pleasing and the arrangement and materials used shall reflect the most modern industry standards. All materials used shall be vandal resistant (impact, graffiti, etc.), non-glare, and shall have a proven record in rail transit service and shall meet the fire safety requirements of this Performance Specification.

The optimized layout of ergonomically shaped seats allowing ample legroom, the incorporation of well-designed stanchions, the wide gangways, the architecturally designed lighting fixtures providing uniform lighting and eliminating dark zones, the car windows dimensions and shape including the doors windows, the ventilation openings, the interior finish panels, the rubber flooring and the overall selection of colors shall all be integrated in a modern, functional design for the car interior.

The entire interior arrangement, including choice of hardware, shall be approved by ATTIKO METRO S.A.

The interior arrangement shall allow for easy maintenance. All surfaces shall be smooth, and no edges shall be created which will cause dust traps. Likewise, all edges shall be rounded to the extent possible to preclude passenger injury and to facilitate cleaning.

The Contractor shall provide a selection of three (3) colored artist's renderings for review by AM. Using these as a foundation, the Contractor will work with AM to supply a final set, which will be used as the basis for the color and configuration of the interior arrangements of each type of vehicle.

It is preferable, the doors of the electrical cabinets, containing the electrical boards, to be hermetically closed in order to prevent ingress of dust. They will be operated with a triangular key and secured with ¼ turn locks bearing a "locked" position indication.

The Contractor shall provide detailed cleaning instructions, including recommended cleaning agents, for all materials. In particular, the Contractor shall provide instructions for the removal of coffee, blood and ink stains, and for the removal of chewing gum and the removal of graffiti.

6.2 INSULATION

6.2.1 Thermal Insulation

The car body sidewalls roof and under floor shall be insulated with a suitable grade of fiberglass insulation, which shall have been treated to resist fungus and mildew. The fiberglass insulation shall be installed so as to prevent shakedown in service.

6.2.2 Acoustic Insulation

Where found necessary by the Contractor's noise analysis, viscoelastic sound damping material shall be installed in each vehicle to damp noise-generated vibrations.

6.3 INTERIOR FINISH PANELS

6.3.1 General

Interior finish panels shall be lightweight, of balanced construction to minimize warpage under differing temperature conditions. The texture and color of panels shall be unaffected by common liquids with which they may come into contact, such as coffee, cola, fruit juices, nail varnish, acetone, etc. Also, the panels shall be unaffected by aerosol paints and felt tip pens, and by the cleaning agents used to remove their effects and the effects from graffiti paint. The panels shall not fade nor discolor over time. The Contractor shall provide samples of the materials to be used for ATTIKO METRO S.A.'s approval. All interior panels shall be approved by ATTIKO METRO S.A.

Joints between panels shall be covered by aluminum extrusions, stainless steel strips, or other approved means. In certain areas, depending upon the panel edge configuration, it shall be permissible to simply butt adjacent panels. The edges of composite panels shall be covered with an ATTIKO METRO S.A.-approved stainless steel rolled channel section or similar aluminum extrusion. Interior components with a color finish, other than finish panels, shall be coated with an approved thermosetting powder coating, or other approved method.

The interior liners, under the windows in the passenger compartment, should preferably be independent (not integral) of the door posts for their easy replacement.

6.3.2 Flat Ceiling Panels

Flat ceiling panels shall have a minimum thickness meeting the strength and rigidity requirements. They shall be constructed of integrally colored "aluminum honeycomb sandwich" type, which means aluminum faced panels with an aluminum honeycomb core.
Other forms of construction will be considered, but require the approval of the Service.
Number of joints shall be minimized.

6.3.3 Heating, Ventilation, Air Conditioning Units Panels

If access to the heating, ventilation, air conditioning equipment is required, then the panels of heating, ventilation and air conditioning equipment installed in the ceiling shall be hinged and shall be equipped with jacketed safety chains and spring clips. The clips shall allow the panels to be opened by 50mm before the clips engage the frame of the access opening.

6.3.4 Curved or Profiled Ceiling Panels

Curved or profiled ceiling panels joining the sidewall linings to the flat ceiling panels shall meet the minimum thickness strength and rigidity requirements and shall be constructed of integrally colored "Nomex honeycomb sandwich" type, which means glass fiber/phenolic resin faced panels with a Nomex honeycomb core.

Other forms of construction and materials like aluminum extrusions, Fiberglass Reinforced Plastic (FRP), aluminum honeycomb panels, compliant with the fire safety requirements will be considered, but require the approval of the Service.

6.3.5 Side and End Wall Panels

Side and end wall panels shall have a minimum thickness consistent with the strength and stiffness requirements and shall be constructed of integrally colored glass fiber/phenolic resin faced panel. These panels shall be properly reinforced with Nomex honeycomb core with a minimum thickness consistent with the strength and stiffness requirements.

Other forms of construction and approved core materials necessary to achieve the required stiffness and strength will be considered, but require the approval of ATTIKO METRO S.A..
Window masks shall be integrated in the side wall lining and sloped to prevent dirt build-up.

6.4 FLOORING

The interior flooring shall be supported by the car body under frame structure. It shall be constructed to minimize floor deflection under full passenger loading. The flooring shall be designed and tested not to deflect more than 1/250 of the shortest span between supports, up to a maximum of 3mm, under EL 8 passenger loading, and without exceeding 50% of the yield strength of the flooring material.

The entire floor construction shall be required to pass a fire resistance test, as described in this Performance Specification, para. 18.6.2. The test procedure shall be approved by ATTIKO METRO S.A..

The interior flooring shall cover the entire passenger compartment area, and shall consist of plywood or plymetal sheets securely fastened to the car body under frame structure, covered with transit grade rubber sheeting.

Joints between the plywood or plymetal sheets shall be reinforced with stainless steel plates or equivalent method, in order to avoid cracks of the rubber sheeting.

To prevent noise due to car deflections, the plywood or plymetal sheets shall be insulated from the metallic structure by means of an approved material.

Between the sound damping material described above and the plywood or plymetal sheets, backing of proper material shall be placed to ensure the gluing capabilities.

Between the sound damping material described above and the rubber sheeting a web of proper material shall be placed to ensure the dimensional stability.

The rubber flooring will be required to continue up the sidewalls by approximately 200mm, to provide a transition. Should it not be feasible to utilize a single width of rubber flooring, three widths of flooring shall be utilized, with one of the lengths being installed in the center of the cars. Transverse joints are deprecated. The seams of all joints shall be welded. The plywood or plymetal flooring shall be levelled before the installation of the rubber flooring, and the levelling compound shall be approved by ATTIKO METRO S.A..

The rubber flooring shall be of type proven for mass transit applications and shall be compliant with the fire safety requirements. The Contractor shall provide all the relevant information for the approval of ATTIKO METRO S.A..

The rubber flooring shall be manufactured with synthetic rubber, mineral charges, vulcanizing agents and additives of high quality; it shall be free from natural rubber, recycled rubber, coarse fillers and Polyvinyl chloride (PVC). The density of final product shall be less than 1.65g/cm^3, in order to reduce the floor's weight.

The rubber floor covering shall be elastic and flexible. Also, it shall be non-staining, 100% non-oil extended and shall not discolor.

At a temperature of 20ºC, the rubber flooring shall bend around a mandrel 18mm in diameter without breaking, cracking, crazing or showing any change in color. In addition, the elongation at break shall be 100% at least and the tear resistance 20N/mm at least. The surface of the flooring shall be smooth and the product shall be fully homogeneous with small colored

speckles inserted in the whole thickness. The floor covering shall be also in compliance with the requirements of the EN 1817, with an abrasion resistance limited to 180mm^3 maximum.

The floor covering itself shall be tested to the gas-toxicity test specified by Annex B.2 of the BS 6853 and has an index of toxicity R $\leq$ 5. (Refer also to the Clause 18.6.3 of this Performance Specification).

The texture and color of the rubber flooring shall be unaffected by common liquids with which they may come into contact, such as coffee, cola, fruit juices, nail varnish, acetone, etc. Also, the flooring shall be unaffected by aerosol paints and felt tip pens and by the cleaning agents used to remove their effects. The Contractor shall provide a list of permitted cleaning agents.

The flooring shall require easy cleaning and maintenance. Therefore, maintenance through application of additional layers of special coating (dispersion of emulsion) shall not be required.

The flooring shall be slip resistant.

All floor penetrations (for piping, conduit, etc.) shall be suitably sealed and samples of such floor penetrations must be included in the fire barrier test piece of the aforementioned fire resistance test. Panels allowing access to under floor equipment are deprecated. Floor penetration methodology shall be approved by ATTIKO METRO S.A..

6.5 CEILING

The car ceiling shall present an aesthetically pleasing smooth surface and shall incorporate lighting fixtures, conditioned air outlet grilles, public address speakers, etc. The ceiling panels and fixtures shall not vibrate, rattle or squeak during normal service conditions.

6.6 PASSENGER SEATS

6.6.1 Seat Construction

The seat shells shall be manufactured from Glass Reinforced Polyester (GRP), a metal stamping, or other approved method.

The seat design shall take into account the anatomy of the human body.

The seat design shall eliminate gaps that will trap dirt or liquids. Also, the seat design shall incorporate upholstery, which shall be treated to repel dirt and liquids. The seats shall be durable to vandalism actions and shall have a stainless steel grid or other resistant material underneath the upholstery.

A particular attention should be made so that the structure of the seats and the seat fabric of the upholstery do not include any protruding elements, which will destroy the clothes of the passengers.

The Contractor shall supply documented evidence that the seats proposed have provided trouble-free service in a similar operating environment.

6.6.2 Seat Tests

The Contractor shall perform structural tests on the seats in accordance with industry standards. Testing procedures shall be approved by ATTIKO METRO S.A..

6.7 STANCHIONS AND HANDHOLDS

Suitable stanchions and handles of vertical and horizontal type, as well as handholds between seats, shall be provided, allowing standing passengers to comfortably remain at their position at all times in all areas of the cars, and seated passengers to firmly remain on their seats in conditions of acceleration/deceleration.

Vertical type shall be used for the stanchions and handles:

- located at each door post
- located in the center of the door vestibule areas with three (3), aesthetically designed, handles at 120^0 covering the middle 2/3 of the stanchion, if ATTIKO METRO S.A. is left with no other choice than the artistic proposal/presentation of the interior of the train by the Contractor.
- a vertical stanchion shall be provided, extending from the ceiling to the floor, at the sides of each pair of seats, so that each seated passenger has a vertical handhold on one of his/her side
- the gangway areas.

Horizontal type shall be used with two parallel rows through the whole length of the train, except the door vestibule areas.

Provision shall be made for handholds between seats. The seats shall be fitted with handhold on both their sides, which shall be common in case of tandem seats.

In addition, flexible handholds shall be installed to assist less tall passengers. At a minimum, every standee shall have a handhold within a reach of 60cm. The location of the flexible handholds on the horizontal stanchion shall be fixed.

Stanchions and hand rails shall be manufactured from either aluminum alloy, or stainless steel or carbon steel with a colored finish, at least 30mm in diameter. If manufactured from stainless steel, the stanchions and hand rails shall incorporate a circumferential finish to be approved by ATTIKO METRO S.A.. The material and finish to be used will be chosen by ATTIKO METRO S.A. at the time the interior finish scheme is developed using the interior mockup or on a real train at the factory.

Suitable hand rails shall also be supplied to assist detraining passengers in the event of an emergency. The hand rails shall be manufactured from a similar material to the stanchions and the remaining hand rails.

No less than 50mm of clearance shall be provided around stanchions and hand rails, but without allowing any limb to become trapped between the rail/stanchion and surrounding structure.

The stiffness and strength of the stanchions and the hand rails, and their connections shall be designed and tested to ensure that they will withstand the rigors of the environment. Specifically, vertical stanchions and hand handles shall be designed and tested to withstand, without permanent deformation, a load of 1.7kN applied in any direction in the most disadvantageous manner. Horizontal hand rails shall be designed and tested to withstand, without permanent deformation, a vertical load of 1.7kN per meter span applied in the most disadvantageous manner.

Interconnecting fittings shall be substantial and shall be manufactured from cast aluminum or cast stainless steel with a satin finish or a colored finish, as appropriate.

6.8 WINDOWS AND GLAZING

6.8.1 Windows

All side windows (including door windows) shall be made by toughened or laminated safety glass.

The side windows shall be fitted with dual glass panes. The use of a single-ply glass pane with acceptable characteristics related to safety and thermal properties is also acceptable.

The side windows shall have such dimensions, in order to maximize the view for the passengers.

The door windows shall provide the same appearance and maintaining the same height with the side windows.

The glass shall not exhibit any optical distortion when viewed from any location in the passenger compartment.

The upper portion of passenger compartment windows shall have a section that hinges inwards against a positive stop to introduce air in the event of failure of the Air Conditioning system.

The latch shall contain provisions to allow the window to be easily locked and unlocked by ATTIKO METRO S.A.'s personnel. Also, the latch mechanism shall be free from finger traps when closing and opening.

Windows shall be tinted, with approximately (40-50)% visible light transmissions. The tint color shall be chosen by ATTIKO METRO S.A. during the design process.

Window assemblies shall be retained using endless (vulcanized joint) neoprene glazing sections, and shall be removable in no more than 20 minutes from the exterior of the cars.

It is preferable, sealant not be used, in order to ensure a watertight seal.

Windows may also be bonded in place from the exterior of the vehicle provided they give a smooth, flush appearance and all other requirements are met.

Window assemblies shall be free from rattles and the window and mountings shall be capable of withstanding the pressure differentials associated with passing trains, prevailing winds, etc. The windows and mountings shall also be able to withstand the loads imposed by passengers leaning on them under crush loaded conditions.

The Contractor shall install in proper locations the required quantity of emergency hammers, which will be used by the passengers to break the windows in case of emergency.

All windows shall be designed, tested and certified as per ECE 43: Regulation No. 43 of the United Nations Economic Commission for Europe (UNECE).

6.8.2 Screens

Suitable screens shall be installed by the seats adjacent to the passenger side entrance doors to prevent drafts and to prevent boarding passengers from interfering with seated passengers.

Screens shall be of neutral tinted toughened safety glass and shall be designed, tested and certified as per the pertinent Standard ECE 43: Regulation No. 43 of the United Nations Economic Commission for Europe (UNECE).

6.8.3 Windshields

Windshields shall be of neutral tinted laminated safety glass, meeting current industry standards for impact resistance, and shall provide maximum vision for driving.

The windshields shall be designed, tested and certified as per UIC 651.

The windshields shall be installed in such a way that can be removed by the fire brigade personnel from the out side of the car using a special tool, in case of emergency. The Contractor shall provide full details of the removal process, as well as the proper quantity of the special tools for the whole fleet.

Each windshield shall be provided with external electric wiper/washer unit.

The windshields shall be equipped with an antifogging and defrosting system.

The windshields will be installed on the front face panels of the Driving Cars with rubber seals in order to facilitate their replacement when and if needed.

6.9 PASSENGER COMPARTMENT LIGHTING

The passenger compartment of each car shall be illuminated by two continuous rows of LED lighting fixtures, one on each side of the car. Also, at the end of the vehicles and in the gangway areas, LED lighting fixtures of appropriate type shall be installed.

LED lighting fixtures and fittings shall be covered by diffusers, which shall seal against dirt, dust, moisture and insect ingress. The design shall allow each individual LED assembly to be quickly replaced and shall protect against electric shock should the lights be lit. Diffusers shall be secured in position with vandal-resistant quick-release clips.

LED assemblies shall be standard and commercially available units.

All LED items throughout the train shall emit the same light color.

The lighting fixtures, except for the emergency units, shall be powered from two individually protected circuits fed from the low voltage power supply.

The lighting fixtures arrangement shall be configured to provide uniform lighting, to eliminate glare and to minimize the creation of shadows. The lighting intensity at passenger reading level shall be no less than 350 lux, and no less than 250 lux at floor level.

Emergency lighting will be provided by LED tubes in each door entrance area, which shall be powered from the battery. Under emergency conditions, the lighting at floor level shall be no less than 30 lux.

Full lighting shall be maintained for a minimum of 20 s in the event of interruption of third rail power and/or the auxiliary power supply, after which only the emergency lighting fixtures shall be illuminated.

The lighting system of the passenger area shall comply with Standard EN 13272.

6.10 SIGNS

6.10.1 General

The material of all signs shall be vandal and graffiti resistant, and shall be edge-sealed. The artwork shall be approved by ATTIKO METRO S.A. prior to manufacturing. The number and location of the signs and the materials used shall be approved by ATTIKO METRO S.A.

The following signs, as a minimum, shall be provided in both the Greek and English languages:

- No smoking decals
- Door warning and operational notices
- Emergency notices
- Car number (one at each end)
- Notices for Persons with Special Needs
- Notices that the passenger compartment area is monitored with CCTV
- Sign for camera surveillance for safety reasons
- Fire extinguishers operating instructions
- Notices for fines for improper use of alarm handles
- Sign for not throwing things outside of the windows.

Stainless steel or aluminum frames shall be provided for the mounting and display of advertisement cards, the quantity and size of which will be defined as the interior design progresses. The design shall prevent the card from sagging or migrating and shall cover all edges of the card. The design shall allow cards to be replaced by unskilled staff in no more than 5 seconds.

6.11 MISCELLANEOUS EQUIPMENT

6.11.1 Fire Extinguishers

Fire extinguishers of the 3kg dry powder type, or equivalent, shall be provided. Two fire extinguishers shall be fitted in each car. They shall be placed in recesses, behind a transparent cover, however they shall be readily accessible. The operation mechanism of these extinguishers shall be protected from accidental operation and inhibit vandalism.

6.11.2 Electrical Outlets

Twelve (12) 230Vac socket outlets incorporating ground fault protection to power laptop computers, test instrumentation, etc. shall be installed in ATTIKO METRO S.A.-approved locations in each car as follows:
One 230V ac electrical outlet should be installed in every car end (2 in each car).
On the Operator's Desks, two 230V ac electrical outlets shall be provided, one within electrical cubicle and one outside of the electrical cubicle. The electrical outlet line inside the

cubicle will be used for the battery charger of the three-color light while the socket will remain available.

6.11.3 Event Recorder

Each trainset shall be equipped with 2 event recorders, located above floor level in secure locations and inaccessible to unauthorized personnel. Each unit shall fit within a space envelope, which shall include all fixings, connections, cable harnesses and access space for installation and maintenance. It shall be possible to remove the crash protected memory and replace it with another in no more than 5 minutes. The exact locations of the event recorders shall be defined at the design stage.
Event recorders shall comply with EN 62625-1.

A dedicated, removable memory card shall retain one week of data history before write-over and all data channels shall be sampled at least every 100ms. A record shall be made whenever a defined event occurs, e.g. change of a digital signal. Storage entries shall be made sequentially in a rotating buffer and when a buffer is full, each new entry shall overwrite the current oldest entry. The data shall be retrievable by removing the memory card, by downloading to a notebook computer and by removing the crash protected memory. Data download by using a computer shall be possible password protected. The memory card shall be secured by a cover. For opening the cover a key shall be required. The Contractor shall supply the required hardware and software to analyze the data and to be able to present the data in a form readily understood by AM's personnel. The software shall be capable of displaying data in tabular and graphical form (including color), and it shall readily interface with Microsoft Access, Excel or Word.

At a minimum, the system shall be capable of providing the following facilities:

- A printout of the state of all inputs between specified dates and times.
- Sample graphs of specified inputs versus time, distance and speed.
- Printouts of input states before and after a specified trigger event.
- Printouts of all occurrences of a specified input changing state.
- Printouts showing all occurrences of a specified sequence of events.

The Contractor shall provide the means, e.g. independent and fail-safe hard disc, to store the contents of the event recorder storage device on another medium for archiving and later analysis.

The following minimum data shall be recorded. The final parameters shall be approved by ATTIKO METRO S.A..

- Brake Cylinder Pressure
- Bypass/Inhibition Switch Status (all)
- Distance Travelled Since Event
- Door Closure Status
- Operator's Desk Status (Active, Not Active)
- Operator's Vigilance System Status
- Electric Brake Application
- Friction Brake Application
- Line Voltage
- Time/Date
- Train Direction (Forward, Reverse)
- Train exceeds the speed limit in Manual Forward mode
- Train exceeds the speed limit in Manual Reverse mode

- Train Operating Mode (ATO, ATP, Manual, etc.)
- Train Speed
- Door release signal
- Car Number
- Smoke Detection System Status
- Emergency brake, etc.

The event recorder shall incorporate its own real time clock, generating year, month, day, hours, minutes and seconds. It shall be accurate within ± 3 seconds per month and shall continue to run for not less than 30 days should external power be removed. It shall correctly count leap years and insert February 29 when required.

Stored data shall be retained for a minimum of 1 year with no external power required and the data shall not be lost on the application of power.

The event recorder shall not influence the state of circuits being monitored, nor any other circuits, even under fault conditions. The Contractor shall provide evidence, including failure and reliability analyses, to demonstrate compliance with this requirement.

The event recorder shall be designed and installed in the cars to protect critical data in incidents such as derailments, collision, fire, etc., to be readily available to support an accident investigation. The data shall be protected according to the requirements of Standard EN 62625, whether by the design of the data storage units or insertion in a box. Dust and water immersion protection shall be IP67, according to EN60529.

The event recorder memory shall also be protected against magnetic fields according to EN 50121-3-2.

The method of protecting the event recorder shall be approved by ATTIKO METRO S.A..

The Contractor shall provide a Failure Modes and Effects Analysis so that:

- The Mean Time between Failures (MTBF) of the unit shall be greater than 50,000 hrs.
- It shall be possible to replace the unit and set it in operation in less that 1 hour
- Failures in data recording, i.e. recording a mistaken data other than the input one, shall be less than 10^{-5} per train operation hour.
- Failures in data recovery, i.e. recording a mistaken data other than the recorded one, shall be less than 10^{-5} per train operation hour.

The event recorder shall require the minimum of maintenance and shall be no more frequent than once every 5 years.

When the Operator's Desk is activated, the event recorders shall be switched on. The units shall then self-test its function during service, either at regular intervals or with another method. Self-test shall not prevent the recorder from logging events occurring during self-test procedure. Self-test shall include verification of the crash protected memory. Malfunctions shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

6.11.4 Smoke Detection System

The train shall be equipped with a smoke detection system, which shall consist of:

- Smoke detectors strategically installed on the air ducts and the passenger compartment
- Smoke detectors or heat sensitive cable underneath the vehicle floor
- A smoke detection control unit per car or a pair of control units per train where each unit shall cover the entire train, while 100% redundancy shall be ensured through a second unit.

The smoke detection system shall be able to distinguish between dusty tunnel environment and other smoke/fume sources from smoke being caused by tunnel fire, while it shall be able to detect smoke and/or temperature.

Smoke detection shall be recorded and reported to the Auxiliary Operator's Desk and the OCC by the Train Control and Management System through the smoke detection control units.

Also, faulty or dirty smoke detector shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The time delay between detection and announcement shall be the least possible.

6.12 INTERIOR MOCKUP

In order to evaluate the efficacy of the car interior and its layout, the Contractor shall develop the interior design using a full-scale mockup. This shall include the mockup of the Operator's Desk and of the underfloor equipment. As the design progresses, simulated hardware shall be replaced with production components.

In addition, it is ATTIKO METRO S.A.'s intent to possibly utilize the mockup for public relations purposes. Therefore, the exterior of the mockup shall also accurately represent that of the vehicle, and shall be painted to simulate actual materials used. Because the mockup will need to be transported from one venue to another, it will be need to be constructed on a substantial platform, to facilitate transportation and to prevent cracking and distortion of the hardware.

The mockup shall be delivered to Athens by the Contractor and shall become the property of ATTIKO METRO S.A., except otherwise approved by ATTIKO METRO S.A..

Alternatively, it shall be also acceptable to proceed with a detailed demonstration in the real vehicles at the manufacturing factory or to the demonstration of a similar vehicle in operation in another Metro system worldwide.

6.13 PROVISIONS OF PERSONS WITH SPECIAL NEEDS (PSN)

The trains shall provide full accessibility to persons with special needs, including the elderly, disabled, mobility impaired – including wheelchairs, hard-of-hearing and visually impaired passengers.

In addition to the requirements cited elsewhere herein for Persons with Special Needs, the area dedicated for Persons with Special Needs shall be equipped with suitable safety belts to prevent the wheelchairs and their occupants from moving under all normal train operating conditions.

Signs shall be installed on the relevant interior finish panel and on the floor to advise the riding public that preference must be given to mobility-impaired passengers.
The design of this area shall be approved by ATTIKO METRO S.A.

Also, vertical belts with red and yellow stripes shall be applied on the end sections of the car bodies, where gangways exist.

7.0 DOORS AND DOOR CONTROLS

7.1 CONSTRUCTION REQUIREMENTS

7.1.1 Design of doors

Doors shall be double sliding plug doors, electrically operated.

When closed, doors shall be flush with the train body.

An “over-centering” mechanism shall be utilized for the doors to be locked automatically and mechanically to the full door closed position.

The doors’ life-cycle shall be 30 years.

The foreseen door usage shall be 5000 cycles per opening / closing per door on an annual basis.

Each door shall be controlled by a separate Door Control Unit (DCU).

Doors shall open and close automatically via the ATC system in synchronization with the platform screen doors.

The average power required for one full cycle (open/close) shall not exceed 150 W.

In addition to the requirements referred to in this Performance Specification, the doors related design and tests shall be prepared and conducted in line with Standard EN 14752 Railway applications – Bodyside Entrance systems.

The Contractor shall provide a clause to clause compliance matrix with all requirements and tests per EN 14752.

7.1.2 Door Installation

The train doors shall be adjustable vertically and horizontally.

All door mounting hardware and door actuation hardware must be readily accessible for adjustment and removal through the aforementioned access panels.

Thresholds shall be manufactured from cast aluminum or aluminum extrusions and shall provide a non-slip surface with easy to clean grooves for foot grip.

Thresholds shall slope downwards and away from the door to allow water to readily drain away.

7.1.3 Door Performance

All train doors shall open and close simultaneously. Doors shall fully open in 3.0±0.5s and shall fully close within the same time period.

The time starts from the moment the Door Control Unit receives the door closed command until the Door Control Unit transmits the signal “door closed and locked”.

The possibility of adjustment shall be within a range of approximately 2.5-4.0 s.

The adjustment shall be done by ATTIKO METRO S.A. by updating the control software.

The door operator system shall include damping to smoothly arrest door leaf motion at the end of the open and close stroke.

7.1.4 Passenger Door Operators and Controls

Door operators and Door Control Units shall be service-proven in a similar environment to that of the Thessaloniki Metro system and shall be approved by ATTIKO METRO S.A.

The door operators shall be driven by a single electric motor to move, lock and unlock the door, powered by the train's low voltage power supply system.

Every Door Control Unit shall communicate directly on the train communication bus, so that operation, maintenance, troubleshooting, modification and enhancement of parameters at a central level be feasible, when needed.

Each fault shall be permanently recorded with their context.

Access to the recorded faults shall be possible with a laptop computer.

The maintenance port of the Door Control Unit shall be a USB type.

An opening/closing counter shall be incorporated on each Door Control Unit.

7.1.5 Door Waterproof Sealing

All joints shall be sealed against humidity and, on an as required basis, drainage holes shall be provided for at the lower part of the doors for condensation runoff purposes.

Gutters for rainwater runoff shall be provided for at the upper part of the doors.

The door guiding components shall be protected against water, dust and debris.

The door panel perimeter seals, which shall also provide a weather tight seal and be capable of withstanding the rigors of service, shall be located on the inner face of the door panels, in order to provide a flush surface appearance between the car body exterior surface and the door panels when the doors are fully closed and locked.

The design of the perimeter seals shall provide the required water tightness performance and shall be provisioned to evacuate water at the top end of the door.

When the doors are fully closed and locked, the seals may be slightly apparent in the gap between the door panel perimeter and the car body.

7.1.6 Door Painting

The inner surfaces of the doors shall be painted at a color to be agreed upon with ATTIKO METRO S.A., so that they be harmonized with the design of the bogies shell and the inner surfaces of vehicles.

7.2 ACCESS TO TRAINS

7.2.1 Fixed Step

Each door shall be equipped with a fixed step, in order to fill the gap between the door threshold edge and the platform edge.

The fixed step shall consist of two parts: a metallic part and an elastomeric part.

The metallic part shall be mounted on the carbody and the elastomeric part shall be mounted on the metallic part.

Each part shall be easily replaceable.

The fixed step shall be level with the door threshold.

The metallic part of the fixed step shall be provided with an anti-slip surface and shall be arranged to allow water to drain away. Water accumulation shall be prevented.

When the door opens, the door shall not move downwards, in order not to come in contact with the fixed step.

7.2.2 Steps providing Access to Track Level

Track level access requirements shall be in accordance with EN 14752, Clause 4.1.3.

A suitable number of emergency steps (ladders) shall be provided under each one of the two center passenger side entrance doors to allow passengers to exit the vehicles under emergency conditions.

Particular emphasis must be placed on configuring the steps and their location, together with the placement of hand rails on the interior of the trains, to allow passengers to readily exit the cars to a low tunnel walkway under emergency conditions.

These doors must be marked on their inner part.

7.2.3 Gaps between Trains and Platforms

A maximum horizontal gap between the deployed fixed step and the platform edge of 60^{+0}mm is required.

Maintaining this gap, a section of the fixed step shall be made of a suitable elastomer material.

A maximum vertical step between the floor level and the platform level of 40_{-5}mm is required.

The relevant attached drawings are as follows:
A7-1: (Gauge in Stations – 3 drawings) AIASA-15088 - 1S00CW225C304C
A7-2: Platform Interface Guideline AIASA-15106 - 0GS1RS0010035C
A7-3: VehiclePlatformInterfaceAIASA-15106 - 0GS1RS0010113C (01&02)

7.2.4 Handholds

Handhold requirements shall be in accordance with Clause 4.1.6 of EN 14752.

Hand rails shall be placed on both sides of the doorway at the door posts.

7.2.5 Door Windows

Door windows with double glazed safety glass shall be provided in the door entrance area as per the requirements of Chapter 6 of this Performance Specification.

7.3 DOOR MECHANICAL STRENGTH

7.3.1 Door Mechanical Strength

The passenger retention requirements shall be in accordance with Clause 4.2.1.1 of EN 14752.

The elastic deformation under the aforementioned load shall be within acceptable limits, not to infringe the rolling stock kinematic load gauge and not to cause mechanical unlocking of doors.

The door mechanical locking system shall withstand horizontal forces 1200 N.

Also, no significant permanent deformation (<1mm) is allowed at a perpendicular load of 3,500 kN distributed across the whole surface width of one leaf for at least 5 minutes. Test shall be done on a leaf alone.

7.3.2 Steps Mechanical Strength

The mechanical strength of the steps shall be in accordance with EN 14752, Clause 4.2.2.

The stiffness and strength of the emergency step and their connections shall be designed and tested to allow use by a person exerting a force of 1.3kN (load applied at a 45^{o} angle), without permanent deformation and with the maximum deflection limited to 1mm.

7.3.3 Vibration and Shock

Vibration and shock requirements shall be in accordance with EN 14752, Clause 4.2.1.5.

Furthermore, as regards vibration and shock requirements, doors shall be in accordance with EN 12663 (only for static loads) as regards the equipment appendages to the carbody shell.

7.4 LOCAL DOOR CONTROL DEVICES

7.4.1 Door Crew Switch for Accessing Purposes

Two doors on either side of trains shall be equipped with internal and external crew switches to operate using a special key (switch). The crew switch shall allow the Operator and cleaning & maintenance personnel to access the vehicles.

The crew switch shall be electronically activated and shall open both leafs of the doors electrically, on condition that the door is not insulated and the train is stopped.

It shall be a three-position switch, i.e.: I Open, 0 Neutral, III Close with spring return to the neutral position 0.

The crew switch shall activate or de-activate the interior lighting.

7.4.2 Emergency Egress Device

Adjacent to each doorway in the passenger compartment, an emergency egress device shall be installed, which may be used by passengers to open the pair of door leaves in the event of an emergency, after the train has stopped.

The Egress device shall be in line with the relevant paragraphs of Standard EN 14752. It shall be of robust manufacturing and could be used for at least 300 times per door per year without presenting any fault.

For avoiding their activation by mistake, the emergency egress devices shall be properly secured in recesses. Protection of the emergency egress devices shall be achieved through a sliding cover. Their use shall be confirmed through a seal affixed on them.

The emergency egress device shall be mounted on the door post at about 1.70m above the car floor level.

The complete device shall be colored in red according to RAL 3020.

The emergency egress device shall feature a 2-position lever 1, 2, towards the same direction. It shall be possible for the lever to be always pulled only up to position 1 (20^0).

Position 2 shall be blocked via an electromagnetic device to be controlled by the ATC; moving from position 1 to position 2 shall not be possible if not allowed so by the ATC, e.g. when the train is moving.

At position 1, no action is effected on the door, the train moves normally but the action is transferred to the Control Center for communication with the Passengers.

In case of emergency requiring door opening, and should the suitable conditions exist, e.g. train standstill, the ATC allows the lever to move from position 1 to position 2.

In this case, the door is mechanically unlocked and door leafs can open manually.

The operation of the subject devices shall be shown on the Display of the Operator's Desk Control Center, the Train Control Center as well as locally on the relevant door.

7.4.3 Emergency Access Device

Car body flush mounted emergency access device shall be provided to open one door on each side of each car accessible from the track side and the platform.

The emergency access device shall be mounted at the closest position to the door to be accessed.

The doors featuring emergency access device shall be in accordance with Standard EN 14752.

The operation of the subject devices shall be displayed on the Display Train Management and Control System of the Operator.

The use of the device:

- Shall transmits the “Emergency” sign to the DCU
- Through the wire rope, the door unlocking mechanism shall be released and the door shall open manually.

Restoration is effected via the manual closing/locking of the door.

7.4.4 Labels/Warning Signs on the Devices

The labels and warning signs shall be in accordance with EN 14752, Clause 4.4. Their content, type, number and material shall be approved by AM.

7.5 INTERFACES WITH THE TRAIN

7.5.1 Electric Power Supply

The electric and pneumatic equipment of the door shall be in accordance with EN 14752, Clause 4.5.1.

7.5.2 Mechanical interface with the Train

The mechanical interfaces with the train door shall be in accordance with EN 14752, Clause 4.5.2.

7.6 OTHER REQUIREMENTS

7.6.1 Fire Resistance

The fire resistance of the doors and the associated equipment shall be in accordance with Clause 18.6 of this Performance Specification.

7.6.2 Noise Insulation

All doors shall be appropriately insulated to meet the noise requirements of Clause 2.13.1.1 of this Performance Specification.

The acoustic transmission loss index (R_w) of the door shall be defined accordingly. This shall be verified by test in a laboratory, where a complete door system will be installed with the same sealing arrangement as the door to be installed on the train. The R_w measurement shall be in accordance with EN ISO 140-3.

The noise produced by the operation of all the passenger side entrance doors on one side of a car, with the panel above doors closed, excluding the audible warning tone, shall not exceed 75 dB(A) on the fast meter scale at all points 1m from the doors at 1m above the car floor.

7.6.3 Thermal Insulation

The thermal insulation of the doors shall be in accordance with EN 14752, Clause 4.6.2.2.

Measurements shall be performed in accordance with EN ISO 12567-1.

7.7 RELIABILITY, AVAILABILITY, MAINTAINABILITY SAFETY (RAMS)

The RAMS of the doors and the associated equipment shall be in accordance with Chapter 15 of this Performance Specification.

7.8 ENVIRONMENTAL CONDITIONS

7.8.1 Weather

The environmental conditions are defined in Clause 2.4 of this Performance Specification.

7.8.2 Water Tightness

The door water tightness shall be designed and tested in accordance with EN14572, Clause 4.10.2 and Annex B.

7.8.3 Air Pressure Tightness

The door air pressure tightness shall be designed and tested in accordance with EN14572, Clause 4.10.3 and Annex C.

7.9 OPERATIONAL REQUIREMENTS

7.9.1 Door Control

Door shall open and close, in ATC mode, by the Operator's Desk in manual driving mode.

Enabling of the doors for opening and closing shall not be possible if the power supply for the door system fails.

Propulsion power shall be inhibited until all doors have closed and are locked.

An unlocked (not closed and not unlocked) door shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The control system shall be designed in accordance with EN 14752, Clause 5.1.4.

The mechanical locking device shall be designed in accordance with EN 14752, Clause 5.1.5.1.

7.9.2 Door Opening

In automatic train operation mode, doors shall open via the ATC.

In manual operation mode (ATC BYPASS), the pushbuttons of the Operator's Desk give the relevant commands to the Door Control Unit, which opens/closes doors.

Doors can open if:

- They are not mechanically isolated,
- The train is standstill.

The sequence for the door opening is as follows:

1. Activation of an audio and visual sound
2. Release of the motor brake
3. Activation of the door motor
4. The door opens and the sign “Door Open” is transmitted by the Door Control Unit to the train control system.

In case a door opening command is given while the door is in the process of closing, then the door will interrupt the closing process and will open only when all preconditions for the door opening function are met.

Doors can also open locally via the Door Control Unit in case the Operator activates the pushbutton for door opening in the local Train Control Unit.

7.9.3 Closing Conditions

The aim of the door safety provisions, as regards door closing, shall be in accordance with EN 14752, Clause 5.2.1.1.

The audible warning requirements from inside and outside the train shall be in accordance with EN 14752, Clause 5.2.1.3.1.1.

The audible door closing alarm sequence requirements shall be in accordance with EN 14752, Clause 5.2.1.3.1.2.

The sound level shall be clearly audible from the platform level outside the train and inside within 2m distance from the doorway.

The sound level shall be in excess of 10 dB(A) the maximum ambient level in the range of one third of octave around the main frequency.

The sound level shall be adjustable and shall be adapted to suit the operating environment through a sound operated automatic level adjusting system.

The alarm shall be repeated when a door reopens after detecting an obstacle.

The audible alarm requirements to indicate that the door is enabled for passenger use shall be in accordance with EN 14752, Clause 5.2.1.3.1.3.

The visual alarm requirements from inside and outside the train shall be in accordance with EN 14752, Clause 5.2.1.3.2.

The visual door closing alarm sequence requirements shall be in accordance with EN 14752, Clause 5.2.1.3.2.1.

The requirements regarding the visual warning sing to the passengers that the door is activated for use shall be in accordnace with paragraph 5.2.1.3.2.2 of Standard EN 14752.

7.9.4 Door Isolation during Operation

Every time the door opens, the operation mechanism shall be able to be held in the isolated position from the internal of the vehicle, via a cut out device using a special switch.

Further to the requirements referred to in this Performance Specification, the cut out device shall be in accordance with paragraph 5.1.6 of Standard EN 14752.

The Operator shall have access to this switch-operated device without being necessary to remove any cover.

Isolation shall be possible with the door being either open or closed.

The door cut out device holds the door in the isolated position in case of electrical or mechanical failure.

- It isolates all door functions
- It isolates the power supply to the motor
- It isolates door from the loop “Door closed and locked”

The illuminated sign “Door out of service” shall be displayed automatically to the passengers within the train car.

The isolated door shall be recorded and reported from the Train Control and Management System – along with its location identification – to the Operator’s Desk and the Train Control Center for the respective platform door to be held in the isolated position too.

Respectively, having received the relevant command by the Train Control Center, any train door corresponding to an isolated platform door can be selectively held in the isolated position.

In case of a defective Door Control Unit, the sign “Door out of service” could be activated through the Train Control and Management System.

7.9.5 Electrical Isolation of Doors during Maintenance

A cut out device shall be fitted on each door to isolate the door feeding system for maintenance reasons.

The subject device shall feature two positions: OFF – NORMAL.

The device shall feature a Door Opening/Closing and Self-Test Pushbutton.

7.9.6 Door Obstacle Detection System

An automatic obstacle detection system shall be provided and controlled by the door control unit of each door. The subject system shall be able to identify an obstacle during door opening/closing.

The operation of the obstacle detection system shall be based on:

- Motor current monitoring system. When the motor current increases up to a certain level, in case of jamming an obstacle, the detection program shall intervene.
- Way/time monitoring system
- Sensitive edges. A “sensitive edges” system shall be provided featuring an electrical tape switch.

When an obstacle is detected, the door control unit shall trigger a re-opening of the door.

The door control unit shall permit a suitable re-opening of approximately 200mm or fully opening when obstacle has still been detected.

The opening length shall be selectably adjustable.

The cycles of closing and opening shall be one to ten.

The quantity of the cycles shall be selectable.

If the obstruction is still detected upon the final re-closure attempt, the door shall remain open until relevant instructions are reported by the Control Center or the Operator in manual driving.

If the obstruction is detected during door opening process, the status is transferred to the train Control Unit and the door awaits for the door closing command.

The position of door re-opening, time delay and obstacle detection value-force shall be adjustable by AM.

Propulsion power shall be inhibited, when the system is activated.

The sensitivity of the basic obstacle detection system shall be in accordance with EN 14752, Clause 5.2.1.4.1.

The sensitivity of the sensitive edge system shall be:

- Static conditions: 5mm X 30mm rubber 80 Shore A and rod diameter of 6mm
- Dynamic conditions: Leash 1mm X 8mm with pull force of 150N at an angle of 25º to the longitudinal direction of the door leaves, measured at 25ºC.

7.10 SAFETY REQUIREMENTS OF THE DOOR SYSTEM

Requirements pertaining to the door interlocking system shall be in accordance with EN 14752.

7.10.1 Door Loop

All doors shall be connected to the door loop. There shall be a bonding switch of the loop to the Operator's Desk.

When the loop is open, trains cannot depart.

The status of the loop (open/closed) is reported to the ATC, the Control Center and the Operator's Desk using the appropriate illuminated sign and indication on the Display.

Open loop can be by-passed by the Operator's Desk position.

7.10.2 Distinct of the stairs

The distinct edge of the stairs shall be in accordance with Paragraph 5.6.2.1 of EN 14752.

The lighting of the edges of the stairs shall be in accordance with Paragraph 5.6.2.2 of EN 14752.

7.10.3 Status Indication

In addition to the requirements referred on this Performance Specification the status indication requirements shall be carried out in accordance with EN 14752, Clause 5.6.3.

Each door that does not close on command shall be recorded and reported to the Operator's Display Unit and the Control Center by the Train Control and Management System. Signs shall be different as far as failures and obstacles are concerned.

7.11 FAULT DIAGNOSIS

Faults during door operation shall be stored in the local diagnostic Door Control Unit, in relation to time.

These faults can be read locally by the Unit through the Ethernet.

Furthermore, these faults are transmitted to the Faults Storage Unit of the train.

For operational reasons, the Door Control Unit transmits faults to the Train Control Unit and the Train Control Center per category, depending on their importance.

In case the DCU fails, this diagnostic sign shall be displayed on the Display Unit of the Operator.

7.12 TESTS

7.12.1 General

In addition to the requirements referred on this Performance Specification the door system shall be tested in accordance with EN 14752, Clause 6.1 and the present Annex B for the test plan.

7.12.2 Type Tests

In addition to the requirements referred on this Performance Specification the door system shall be type tested in accordance with EN 14752, Clause 6.2.

Doors shall be subject to an accelerated life cycle test, whereby the doors are installed in a simulated door frame and operated for a minimum of 1.5 million cycles.

This test shall be completed preferably before the first car is ready for assembly and must ensure that the specified reliability will be met.

7.12.3 Routine Tests

In addition to the requirements referred on this Performance Specification the door system shall be routine tested in accordance with EN 14752, Clause 6.3.

7.12.4 Functional Test on the fully Assembled Train

In addition to the requirements referred on this Performance Specification, the door system shall be functionally tested on all fully assembled trains in accordance with EN 14752, Clause 6.4.

7.12.5 Documentation

In addition to the requirements referred on this Performance Specification (e.g., Chapter 16.0) the documentation for the door system shall be provided in accordance with EN 14752, Clause 7.

8.0 AIR CONDITIONING, HEATING, VENTILATION

8.1 GENERAL

All cars shall be equipped with Heating, Ventilation and Air Conditioning, as per the requirements of EN 14750-1, *Air-Conditioning for Urban and Suburban rolling Stock,* unless otherwise provided for in this Performance Specification. The Contractor shall provide a list of compliance with the requirements of EN 14750-1 and EN 14750-2 on an article-by-article basis.

The classification of trains as to the subject Standard shall be category B, the passenger load shall be EL 5 (5 standing pass/m^2) and the Climate zone Winter Summer (I).

Heating, Ventilation and Air Conditioning shall be exclusively achieved through roof-top units. Each car shall feature at least one (1) HVAC unit on its roof.

Two compressor and two cooling circuits for each unit shall be necessary.

The units shall be interchangeable between cars.

The components and technologies to be used for the air conditioning shall be of a proven-in-service design.

The car body structure shall be designed and constructed to accept a roof-mounted unit equipment.

The removal and installation of the air conditioning unit shall be simple with the minimum number of connections and fasteners. All electrical connections are made via quick-release connectors meeting the requirements of this Performance Specification.

The Contractor shall provide two lifting devices, as part of the special tools supply for the removal and re-installation of the air conditioning unit on the car roof.

The air conditioning shall produce noise and vibration levels compatible with the requirements of Clause 2.13.1.

Each air conditioning unit shall contain as a minimum:

- Condenser fan assemblies,
- Condensers,
- Refrigerant circuits including fully hermetic horizontal compressors,
- An air conditioning control unit,
- An emergency inverter (if this will be part of the air conditioning unit),
- An evaporator,
- An electric heater,
- An evaporator blower assembly and
- Miscellaneous components.

During ten operational cycles of opening and closing doors on the one side, the air conditioning unit shall be capable of achieving the performance defined in this Chapter before the next cycle commences.

More specifically, the durations for opening and closing doors shall be as follows:

Status	Duration (s)
Doors closed	70
Doors open	20

Table 8.1.1 Durations for opening and closing Doors

8.2 HEATING SYSTEM

8.2.1 General

Cars shall be exclusively heated by the HVAC units through controlled system using overhead heater/blower units.

At the minimum exterior temperature of 1.2ºC,

- at the maximum train operational speed,
- without solar load,
- with EL 0 load and
- with the minimum fresh air supply12m^3/hr,

the mean interior temperature in the comfort envelope shall be 19ºC.

The unit shall be capable of operating at exterior temperatures down to -10ºC.

Above -10ºC and below 1.2ºC, the Contractor shall identify the conditions achieved within the train, optimizing the design of the air conditioning.

The temperature range shall be in accordance with or better than the requirements of EN14750-1 for Category B vehicles.

The system hysteresis on temperature shall be limited to maximum 1ºC.

The interior temperature shall be recorded by the Train Control and Management System.

The system shall provide automatic temperature control via the Train Control and Management System.

8.2.2 Overhead Heat

Overhead heaters shall be installed in the air conditioning units, downstream of the evaporator coils, to warm up the fresh air intake.

Heater elements shall be readily accessible and easily removable. Also, the heater elements shall have low thermal inertia.

Semi-conductor or mechanical contactors shall activate the overhead heaters and shall automatically control its heating capacity.

The control circuitry shall not allow the heaters to be powered unless the evaporator blowers are operating.

Heater element over temperature protection shall be provided.

Self-resetting thermostats shall be installed adjacent to the heaters to deactivate the heaters, through the contactors, when excessive temperatures are detected.

8.2.3 Heating Stand by Operation System

The cars shall be equipped with an automatically controlled stand by operation system to operate the heaters to maintain a mean interior temperature of 7ºC.

This system shall be enabled five minutes after:

- the air conditioning switch in the Operator's Desk is switched on,
- the train has been deactivated by the ATC (Sleeping Mode)

8.3 VENTILATION SYSTEM

8.3.1 General

Car ventilation shall be provided by the evaporator blowers supplied as part of the air conditioning.

Fresh air inlets (one per side) shall be integrated into the air conditioning unit using suitable filters.

Fresh air shall pass through the filters into a mixing air chamber adjacent to the evaporator unit.

The design shall prevent blown rain or snow from entering the plenum and leaking into the car interior.

A minimum of $12m^3/h$ per passenger per car of fresh air shall be provided – status EL5. For the dimensioning of the heating/cooling, provision can be made for a $8m^3/h$ supply of fresh air per passenger.

Re-circulated air shall be drawn through grilles in the ceiling and mixed with the fresh air. This mixed air shall then pass through another filter into the evaporator/overhead heater/blower compartment, where-from the blowers shall force the air through the evaporator coils into the main air ducts.

The air velocity in the duct shall not exceed 6m/s.

The ventilation system shall be balanced to provide positive car pressurization, with all doors and windows closed, of (25-30) Pa. Overpressure shall not affect the operation of the vehicle doors.

The aforementioned conditions shall be maintained under all operating conditions, including vehicle speed, acceleration, deceleration, in tunnels, etc.

8.3.2 Emergency Ventilation

The emergency ventilation shall be provided as per the following modes:

- Ventilation
- Emergency
- Smoke

8.3.3 Failure Mode: Ventilation

In the event of failure of an air conditioning unit to provide heating and/or cooling, ventilation shall be available.

The failure shall be recorded and reported to Operator's Desk by the Train Control and Management System.

8.3.4 Emergency Mode

In the event of failure of third rail power or third rail power is available and power from all the auxiliary converters is not available, emergency ventilation shall be provided and powered from the batteries. (Refer to Clause 12.3.1).

A re-circulated air damper shall be fitted in the re-circulated air grill. It shall be closed by the air conditioning control unit when the emergency mode is activated. Then 100% fresh air shall be delivered into the passenger compartments without any recirculation. (Cooling is inhibited).

When the power from the Auxiliary Power Supply Equipment is available again, then the air conditioning shall return to its normal operation.

A minimum of 12m^3/h of fresh air in case of emergency per passenger per car under passenger load status EL5 shall be provided.

The emergency mode operation shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

8.3.5 Smoke Mode

In the event of smoke being detected entering the passenger compartment, HVAC shall not operate.

8.3.6 Air Distribution Duct

The main air distribution duct shall be manufactured from stainless steel or anodized aluminum and shall be constructed to ensure that the exiting air velocity is constant throughout its length. Ceiling panels may act as the lower side of the duct.

Other types of ducts, such as thin aluminum foils, are not acceptable.

The duct shall be thermally and acoustically insulated.

The thermal insulation value shall be sufficient to prevent condensation.

The acoustic insulation value shall be sufficient to meet the noise levels indicated in Clause 2.13.1 of this Performance Specification.

The design of the air distribution duct shall enable air distributionthroughout the length of the car.

If this is not feasible, then secondary air distribution ducts shall be connected to the main air distribution duct.

8.3.7 Air Diffusers

The air distribution/diffusion system shall comply with EN 14750.

Exiting speed of the air from inlets shall not exceed 2.5m/s, and shall not cause discomfort to seated or standing passengers.

Air speed throughout the car interior shall not exceed 0.75m/s at 1.7 m above floor level and 0.5m/s at 1.1 m above floor level.

Once the HVAC system closes, the fresh air intake diaphragm shall also close.

This operation shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

8.3.8 Air Filters

All air filters shall be of the cardboard-framed, disposable type, and shall be sufficiently supported to prevent passing air from dislodging them should the filters become saturated. Alternative filter layouts with fixed (e.g. metallic) frame and consumable filter surface are also acceptable. Washable filters are not permitted.

The filters shall be of standard size, commercially available, and non-combustible. They shall seal well at all edges.

The filters shall be easily replaced without the use of tools, and shall be sized as not to require replacement at intervals less than 30,000km of operation.

The filters shall be preferably replaceable from inside the passenger compartment area (not accessible to the passengers).

Access to the filters will be through grilles that can be opened and secured with a ¼ turn locks, which are operated using a triangular key on one side. The locks shall bear a "locked" indication. Safety and retention devices shall be provided on the other side.

Filter performance shall meet the requirements of EN 779. The filter grade shall be greater than or equal to grade G3.

8.4 COOLING SYSTEM

8.4.1 General

The automatically controlled air conditioning shall be capable of cooling and dehumidification and shall automatically maintain the following conditions:

- At the maximum ambient temperature of 35ºC Dry Bulb with relative humidity of 45%,
- with a stationary train,
- with lighting load
- with EL 5 load and
- with the minimum fresh air supply being $8m^3$/hr per passenger,

the average interior temperature shall be 26ºC with relative humidity of 65% for a supply of up to $8m^3$/s and up to 29^0C for a full supply of $12m^3$/s.

Under extreme conditions in tunnels and stations, the maximum ambient temperature and the relative humidity may reach 40ºC Dry Bulb and 40% respectively.

Above 35ºC and below 40ºC, the Contractor shall identify the conditions achieved within the train, optimizing the design of the air conditioning system.

Above 40ºC, the interior temperature shall be as the system may provide.

The air conditioning shall be capable of operating at ambient temperatures up to 48ºC.

The system hysteresis on temperature shall be limited to maximum 1ºC.

The real interior temperature shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The air-conditioning system shall provide automatic temperature control via the Train Control and Management System.

8.4.2 Refrigerant Circuitry

Each air conditioning unit shall have one or two independent refrigerant circuits, each one with a compressor.

The refrigerant to be used shall be R407C or R134a. The refrigerant shall be totally contained within a sealed system.

The air conditioning shall include all required components, such as:

- check valves,
- filter dryers,
- liquid line solenoid valves,
- modulating solenoid valves,
- capillary tubes or thermal expansion valves,
- pressure cut-off switches (high and low pressure switches),
- accumulators,
- suction filters (if required), etc.

In addition, appropriate gauge ports for troubleshooting shall be provided.

The refrigerant piping shall be made of seamless copper and all connections shall be brazed, eliminating screw threads.

8.4.3 Evaporator Section

Air flow over the evaporator coils shall be sufficiently low to prevent any moisture in the air from entering the main air supply duct. Evaporator coils shall be made of copper and shall have copper fins or aluminum fins suitably protected against corrosion.

A condensate drain pan shall be provided beneath the evaporator coil. The pan shall be made of stainless steel. Baffling shall be provided in the pan to prevent spillage under all operating conditions. If required by the design, the condensate drain lines shall be insulated to prevent condensation.

The evaporator blowers shall be direct-driven by a motor that shall be of double shafted, totally enclosed, non-ventilated construction.

The evaporator blower assembly shall be designed and manufactured so that it can be removed from the air conditioning unit as a complete assembly. All components, including the motor, the two blowers, the blower housings and the inlet rings shall be mounted to a base plate, which can be maintained and balanced at bench level.

The blower fins, two per blower assembly, shall be of a forward curved, double inlet design. Each blower fin shall be secured to the motor shaft using a key and nut on each side of the shaft.

8.4.4 Compressor Section

Each air-conditioning unit shall consist of one or two fully hermetic scroll or screw compressors of proven service operation, providing a multistage capacity control.

Compressor unloading device shall be provided, in order to deal with partial loading, as well as the high refrigerant pressure due to the extreme conditions in tunnels and stations referred to Clause 2.3 of this Performance Specification.

In the event that all conditions return to normal, the unloading device shall be reset and the air conditioning shall be automatically set to normal operation.

Sequential starting of compressors on a train shall be provided.

8.4.5 Condenser Section

Condenser coils shall be made of copper and shall have copper fins or aluminum fins suitably protected against corrosion. Fin spacing shall be 2.5mm, as a minimum, to prevent dirt built-up.

The condenser fan assembly shall be mounted on the air conditioning unit. The condenser fan assembly shall be designed and manufactured so that it can be removed from the air conditioning unit as a complete assembly. This assembly shall consist in a motor with a multi-bladed axial fan.

The fan shall be attached to the motor shaft using a key and nut. The assembly shall be bolted to the air conditioning unit.

8.5 CONTROLS

8.5.1 General

Each air conditioning unit shall be equipped with an Air Conditioning Control Unit.

The Air Conditioning Control Unit shall provide as a minimum the following controls:

- Temperature control and
- Equipment control.

8.5.2 Temperature Control

The function of the Air Conditioning Control Unit shall be the automatic control of the air conditioning operation, in order to maintain the interior temperature at the specified conditions by using the data provided by the temperature sensors.

In addition, the Air Conditioning Control Unit shall automatically control all modes of the emergency ventilation, as well as the stand by heating system.

Moreover, it shall be feasible for the Air Conditioning Control Unit to make a self-test, as well as a test through a maintenance laptop.

Temperature sensors shall be suitably located so as to ensure that they are not unduly affected by local sources of heat, such as motors or resistors, and that they are readily accessible for maintenance and replacement reasons.

The Air Conditioning Control Unit shall incorporate an operation and display panel through LED diodes, indicating the status of the temperature control functions.

The unit shall also indicate the fresh air temperature and the re-circulated air temperature.

Indicators shall also be provided to verify circuit normal conditions.

The operation and display panel shall be accessible from the passenger compartment, by opening the re-circulated air grille.

The equipment shall also include a fault indication and diagnostic system, which shall be fully integrated into the Train Control and Management System.

The Air Conditioning Control Unit shall monitor the status of the air conditioning, it shall determine the faults and transmit the fault data to the Train Control and Management System.

The Air Conditioning Control Unit shall communicate with the maintenance laptop via a USB port.

The interior temperature shall be set in three ways, namely:

- by the Train Control and Management System,
- locally, by the operation and display panel of the Air Conditioning Control Unit,
- by the maintenance laptop.

The operation compressor shall be stopped for protection purposes, if the temperature of the fresh air is less than 15ºC or if the re-circulated air temperature is less than 22ºC.

8.5.3 Equipment Control

Moreover, the Air Conditioning Control Unit shall control as a minimum:

- Compressors
- Condenser Fans
- Overhead Heater
- Evaporator Blower Motor
- Fresh air and re-circulated air dampers
- Emergency inverter (if this is part of the air conditioning unit).

8.6 TESTING REQUIREMENTS

The air conditioning shall be tested in accordance with the requirements of EN 14750-2, Test Level 2 (TL2), covering the following:

- Preliminary verifications
- Comfort tests
- Climatic tests
- Tests at extreme exterior operating conditions
- Complementary tests.

9.0 BRAKING SYSTEM

9.1 GENERAL

The trains shall have both equipment and functions as described in this Specification, such that a complete, fully integrated and fully functioning friction and electro-dynamic brake system be provided.

All equipment shall be supplied by an experienced brake equipment manufacturer having documented previous satisfactory experience with similar equipment to that specified herein.

Braking actions shall be controlled by the Automatic Train Control (ATC) System and the Operator's Desk, and the service and emergency rates shall be achieved using the same equipment.

The brake cylinder pressure shall be regulated by the Brake Control Unit based on signals received from the Central Control Unit of the train. The Brake Control Unit shall provide a braking signal based on the train weight measurement.

The brake system shall comply with the requirements of the Standards EN 13452-1 and EN 13452-2.

The braking equipment shall be tested to demonstrate compliance with the requirements of this Performance Specification.

9.2 SERVICE BRAKING

The primary service braking shall be electro-dynamic and shall be applied on all motored axles.

The electro-dynamic braking shall take priority over the friction braking and its capacity shall be fully utilized in order to achieve the specified braking rates.

Load weighing shall be provided on a per-car basis, for all car weighing up to EL 8.

9.3 EMERGENCY BRAKING

Emergency brake shall include Hydraulic (or pneumatic) brake and electro-dynamic brake, in line with EN 13452-1 Paragraph 7.2.2. (Emergency 3) and shall apply rotation control and load weighing.

9.4 SECURITY BRAKE

The security brake, in line with EN 13452-1 Paragraph 7.2.2, shall be fail-safe (SIL4) and when activated shall cause irretrievable brake application.
It shall be possible to activate the security braking from the train Operator's Desk using the security braking mushroom pushbutton.
Security braking shall be mechanical only, protected by the wheel slide protection system, but shall not be jerk limited.
Traction power shall be inhibited when the security braking has been commanded.

9.5 HOLDING BRAKING

Holding braking shall be ensured through the mechanical braking equipment. It shall be applied automatically and shall protect the car from moving when the train is in standstill.

During train starting, immobilization braking shall be released if the traction force has been developed at a degree which prevents the train from rolling back.

9.6 PARKING BRAKING

Parking braking is mechanically applied and is activated only when the train is in standstill. Braking may be applied and released by the ATC but also by the Operator's Desks at both train ends.
The parking braking status shall be reported to the Train Control Centre and to the panel of the Operator's Desk providing detailed information on the location where parking braking has been applied. Parking braking as a whole shall be indicated via a light signal on the "parking braking" button at the Operator's Desk.

9.7 FRICTION MECHANICAL BRAKING

9.7.1 General

Mechanical braking shall be pneumatic or hydraulic.
Each axle shall be equipped as a minimum, with a split-type vented brake disc, and braking torque shall be applied to the disc by the brake pads. Wheel mounted brake discs are also acceptable.
Mechanical braking shall be fully capable of performing all braking commands, without the assistance of the electro-dynamic braking. If there are cases under specific loading conditions and speeds, where this cannot be achieved, then the Contractor shall provide an automatic speed limitation system, with the relevant messages in the Operator's Desk and the Control Center.

9.7.2 Brake Actuators

Brake actuators with integral automatic slack adjusters shall be mounted to the bogie frame.
One actuator per disc shall be used.
The upper area of the brake actuator, where access is cumbersome, must be equipped with metallic extensions of the grease fittings, so that the appropriate level be achieved for the maintenance personnel to reach them.

9.7.3 Brake Pads

The brake pads shall be retained by the brake callipers and shall be of composite or organic type and, in any case, they shall meet the set performance.

The pads shall not contain any asbestos or other cancer inducing materials, and the Contractor shall provide ATTIKO METRO S.A. with full details of the material composition to allow assessment of health hazards.

The brake pad material shall be carefully chosen so as not to generate brake squeal, while still satisfying the remaining performance characteristics required by this Performance Specification.

The Contractor shall also provide ATTIKO METRO S.A. with the braking characteristics of the pad material, along with information demonstrating the successful use of the pads in similar service.

The Contractor shall demonstrate the adequacy of the brake pads by:

- simulation and testing at all revenue service and downgraded operation conditions
- simulation and testing of the towing of failed trains at the Depot. Simulation shall include all loading cases and failures of electro-dynamic and mechanical braking of the failed train, as well as transportation to the Depot from any point of the network.

- simulation and testing of a train passing though the network lines towards the Depot. The train shall be empty, under ELE condition, it shall be manually operated (ATC BYPASS), running at a speed of 20KM/h and it shall not stop at stations while mechanical braking shall only be used.

- qualification tests of the braking system, testing the heat capacity of the disc and the pads in three stops under emergency conditions and load condition EL 8.

These tests shall be utilized by the Contractor during the assessment of the life cycle of the brake pad under normal operation conditions.

9.7.4 Friction Brake Release

9.7.4.1 Automatic Friction Brake Release

A remote friction brake release system shall be provided per bogie (by the Operator's Desk).

Should it not be possible to release the brake cylinders on a car, then:

- the location of the brake system failure shall be recorded and reported to the Display Unit of the Operator's Desk by the Train Control and Management System, and

- the Operator shall release these brakes from the Operator's Desk by pressing the pushbutton "Remote Friction Brake Release".

The remote release action pertaining to the mechanical brake shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

9.7.4.2 Manual Friction Brake Release

A manual friction brake release system shall be provided per bogie.

Should it not be possible to remotely release the brake cylinders on a car, then:

the location of the brake system failure shall be recorded and reported to the Operator's Desk by the Train Control and Management System and
the Operator shall release these brakes manually.

The manual release action pertaining to the mechanical brake shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

9.7.5 Parking Brake Release

9.7.5.1 Automatic Parking Brake Release/Application

An automatic parking brake release/application system shall be provided per bogie.

Should sufficient liquid/air pressure not be available to release the parking brake cylinders on a car, then:

- the location of the failure shall be recorded and reported to the Operator's Desk by the Train Control and Management System and
- the Technician shall have the option to release these brakes by pressing the pushbutton "Parking Brake Release".

All parking brakes on the train shall be released within 30 seconds.

9.7.5.2 Manual Parking Brake Release

A manual parking brake release system shall be provided per bogie.

Should sufficient liquid/air pressure not be available to release the parking brake cylinders on a bogie, then:

- the location of the failure shall be also recorded to the Operator's Desk display unit by the Train Control and Management System and
- the Technician shall have the option to release electrically (through the central system(s) or mechanically (locally or in groups by means of tools or pumps) these brakes.

The system shall be automatically re-activate upon pressure resetting.

9.8 ELECTRO-DYNAMIC BRAKE

The electro-dynamic brake shall have the capability to produce all service braking effort.

Electro-dynamic brake shall be preferably fully effective for deceleration down to less than or equal to 0.5 km/h, facilitating a smooth and non-jerky operation.

Regenerative braking shall be capable of recovering, at a minimum, 75% of the theoretically available kinetic energy of the moving train, less conversion losses, when the DC power system:

- is 100% receptive,
- line voltage is within the allowable range,
- with the train in the EL 5 loading condition and
- the entry speed being 80km/h.

9.9 BRAKE BLENDING

Upon giving a braking command, electro-dynamic brake shall be actuated.

Only in case the capacity of the electro-dynamic brake is not sufficient, the friction braking shall apply additionally.

The transition from 100% electro-dynamic brake to mechanical brake shall take place preferably at a speed less than or equal to 0.5 km/h.

Response times during brake blending shall be minimized, in order to facilitate a smooth and non-jerky operation.

Braking on non-motored axles shall be closely coordinated with that on motored axles to achieve optimal braking distribution.

The brake blending scheme shall be approved by ATTIKO METRO S.A.

9.10 WHEEL SPIN/SLIDE CONTROL SYSTEM

Trains shall be equipped with wheel spin/slide protection systems to maximize the utilization of available wheel/rail adhesion under low adhesion conditions, to eliminate damage and unnecessary wear to wheel treads.

Spin/slide shall be detected on a per axle basis.

The sanding system shall be activated whenever wheel spin or wheel slide is detected and shall remain active until the condition no longer exists.

The wheel spin/slide protection systems shall be separated in two independent systems:

- a wheel spin protection system for the traction system and
- a wheel slide protection system for the mechanical braking.

The wheel slide protection system shall be UIC approved.

The independent hardware and software systems shall reliably detect all wheel spin or wheel slide conditions that may occur on any axle and shall initiate actions that minimize or terminate these conditions, whenever they occur.

In both motoring and braking modes, each system shall produce a signal proportional to the greatest axle speed differential between any two of the four axles on any car. Each system shall automatically compensate for wheel size differences.
During the commissioning phase of the first train, the wheel spin/slide protection systems shall be optimized to its best performance.

Each system shall incorporate monitoring features to detect both failure of sensor inputs, and system performance indicative of failure of that function. During detection of sensor or system malfunction the system shall be disabled so as to guarantee traction or braking. All faults shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

In addition, a permanently locked axle shall be recorded and reported to the Operator's Desk by the Train Control and Management System. In this case the train shall be braked through the security braking into standstill. Then, the train shall not be able to move, (traction shall not be available), until the activation of the mechanical brake release.

The systems shall be designed and manufactured to be interchangeable between cars without the need for calibration or adjustment.

The wheel spin and wheel slide protection control systems shall be approved by ATTIKO METRO S.A..

9.11 UNDESIRABLE BACK ROLLING OF TRAIN

Speed sensors shall also emit an additional signal that will identify the direction of the speed.
This information shall be utilized by the ATC or, in case of manual operation, by an active cabin (setting the direction).
If the distance covered by the back rolling of the train is greater than 0.4m, then a brake command shall be given.

9.12 CONTROL OF SANDING EQUIPMENT

The number and the location of the sanding equipment shall ensure the performance of the train preventing wheel sliding and rotation so as ensure safe braking and train headways. The relevant design shall be submitted by the Contractor.
Sand blasting parameters shall be determined during the testing phase in the Network.

10.0 PNEUMATIC EQUIPMENT

10.1 GENERAL

The design of the pneumatic system, including the number of the compressors and the air reservoirs, shall take into consideration whether the braking system is hydraulic or pneumatic.

In case of a pneumatic braking system, two (2) air compressors and two (2) air reservoirs shall be foreseen, otherwise, if the braking system is hydraulic, one (1) air compressor and one (1) air reservoir unit is acceptable.

If two (2) air compressors are available, each air compressor shall be able to satisfy all air related requirements of the train in case one of the air compressors fails.

All vented air, except the air from dump valves and cut-out cocks shall be silenced using silencers.

Compressed air shall be produced by the air compressor assembly described here below. Before entering the compressor, air first passes through a filtration system. After being compressed, the air shall pass through a cooler and a dryer unit before entering the main supply reservoir. The reservoir feeds the main supply line between cars. The compressed air equipment is fed from the main supply line, via pressure reducing valves and auxiliary reservoirs, as appropriate. All supplies from the main supply line shall be protected by check valves, to prevent the rapid loss of air should a rupture in the line occur.

When air compressors are switched on, they shall not operate for less than 30 seconds (excluding power supply cut-off). The time for the compressor(s) to bring up the entire pneumatic system pressure from zero to maximum shall not exceed 15 minutes. The operation of any system in a train shall not cause a sudden drop in main line pressure of more than 0.5 bar.

Compressor control logic shall be such that if the main line pressure is less than the minimum at any compressor governor, then all compressors shall be switched on. When all compressor governors have detected maximum main line pressure, then all compressors will be switched off. Other control logic may be proposed, if necessary, to ensure the required duty cycle of compressors.

All reservoirs of the pneumatic system that are used for storing air shall be manufactured and tested in accordance with the requirements of EN 286 part 1, part 2, part 3 and part 4and the Council Directive 2014/68//EU.

All equipment, other than consumables, shall be designed to require maintenance at intervals of not less than six years.

10.2 AIR COMPRESSOR

The air compressor unit shall be directly driven by an electric motor. The air compressor shall incorporate a dust level indicator in the air filter assembly and an oil level indicator. The assembly shall be installed under the vehicle via resilient mounts and care shall be taken to minimize noise and vibration emitted into the car body structure and wayside.

The air compressor motor shall be powered from the 400Vac, 50Hz auxiliary power supply system.

Each air compressor shall have an air dryer mounted next to it.

The air compressor unit shall produce noise and vibration levels in conformity with the requirements of Clause 2.13.1 of this Performance Specification.

The air compressor duty cycle shall be within the range of 20% to 45% during normal service conditions, where the duty cycle is defined as the quotient of the air compressor “on time” and the cycle duration. It should be noted that a train may be in service for up to 19 hours per day, but may be stabled (out of service) for up to seven days. While stabled, the duty cycle may fall to as low as 1%. The air compressor shall be capable of running continuously for a period of up to eight hours at a pressure of 11 bar under fault control conditions.

The air compressor shall incorporate a safety valve, installed between the output and the main line, which shall operate at a maximum pressure of 1 bar over the maximum pressure limit of the air system.

The air compressor shall be equipped with an intake air filter to remove all dirt particles greater than 25 microns in size from the air stream. (The filter shall operate satisfactorily for a period of 1000 operating hours or 12 months before replacement).

If a fan is required for cooling purposes, it shall be driven from the air compressor unit without using belts or any other detached drive system.

The air compressor shall be designed to achieve a minimum of 3,000 hours between successive overhauls. Routine maintenance shall not be required at a frequency of more than once per year and shall not require removal of the compressor from the car.

In cases the replacement of the air compressor and the air dryer are deemed necessary, provisions must be made so that the venting of the downstream pneumatic circuit be not necessary.

The air compressor shall not be removed from the vehicle for overhaul purposes prior to a six-year period.

The oil filler, oil sight glass, oil filter and air filter shall be readily visible and accessible.

The air compressor design shall enable the following activities to be carried out in the maximum times delineated:

Activity	Time
Check compressor oil level.	1 minute
Top up oil level.	5 minutes
Change air filter.	10 minutes
Change oil and oil filter.	10 minutes
Change air compressor delivery hose.	10 minutes
Remove air compressor unit.	30 minutes
Install air compressor unit.	45 minutes
Overhaul air compressor.	8 hours
Overhaul motor.	4 hours

Table 10.2.1 Air Compressor Activities and Time

10.3 PNEUMATIC SYSTEM DETAILS

Stainless steel or copper piping shall be used for all car-body airlines. Stainless steel piping shall be used on the bogies. The grade and configuration of the pipe shall be approved by ATTIKO METRO S.A.. Joints shall be made using ATTIKO METRO S.A.-approved

compression fittings. Joints shall not be made to connect straight runs of pipe work, unless approved by ATTIKO METRO S.A.. Inaccessible runs of pipe work shall not utilize joints, too. All piping shall be installed to keep fittings to an absolute minimum.

All piping shall be installed with elastomeric tape between the pipe and the clamp, or by means of clamps with integral, moulded vibration-damping inserts, to prevent any rattling in service. Clamps shall not be welded to the pipe. Where piping passes through holes in the floor, structural members, etc., it shall be rigidly clamped immediately adjacent to the hole to prevent contact with the edge of the hole. Piping shall be routed as far away as possible from electrical apparatus, to preclude fuelling in the case of a fire.

All piping shall be de-burred and blown out after cutting, and the ends of pipes shall be capped while in storage. After all piping has been installed on the vehicle, the entire air system shall be thoroughly cleaned.

The flexible hoses, from the compressor to the dryer and from the dryer to the circuit (if applicable), shall be equipped at their ends with “quick connectors”, in order to facilitate their disassembly during equipment replacement.

All brake piping, on each bogie, shall incorporate test fittings with “quick connectors”, in order to enable measurements during the tests.

All cut-out cocks shall be of the locking type and their handles shall be installed so that in the open position they are parallel to the air flow, and in the closed position they are perpendicular to the air flow. The handles shall be locked in their normal operating position. Cut-out cock handles shall be readily accessible for use in an emergency. All cut-out cocks shall be of the vented type, unless the function prohibits their use. The function of all cut-out cocks shall be clearly identified by means of ATTIKO METRO S.A.-approved engraved stainless steel plates riveted to structure adjacent to the valve, the lettering on which shall be filled with black epoxy paint.

Separate systems within the pneumatic system shall be supplied via a vented cut-out cock and a strainer, and shall be provided with separate air reservoirs, supplied through a check valve to protect against loss of air pressure. If the braking system operates with compressed air, the air brake reservoir shall be sized to provide three (3) security brake operations under EL 5 loading conditions. Reservoirs shall be tilted so as to enable moisture concentration. A color changing silica shall be provided to indicate the moisture levels in the main air compressor system. The method used to provide corrosion protection in the interior of air reservoirs shall be approved by ATTIKO METRO S.A..

The main air reservoir shall have sufficient capacity for the simultaneous operation of all pneumatic devices. Calculations for the capacity of all air reservoirs shall be submitted to ATTIKO METRO S.A. for approval.

All flexible hoses shall be date stamped, and at the time of delivery to ATTIKO METRO S.A., their life cycle shall be less than 6 months.

10.4 DEVICE REFERENCE DESIGNATORS

All pneumatic and/or hydraulic system devices shall be clearly identified through stainless engraved plates, approved by ATTIKO METRO S.A., placed on the body of the devices through rivets. The text on the plates shall be filled in using black epoxy paint. Their alphanumeric designation shall correspond to that used on the relevant schematic diagram. The methodology shall be submitted to ATTIKO METRO S.A. for approval.

11.0 PROPULSION SYSTEM

11.1 GENERAL

A modern three-phase alternating current propulsion system shall be provided.

The service life of the equipment shall not be less than 30 years under normal service conditions.

The propulsion system shall be provided by a single manufacturer who has had a minimum of 10 years of demonstrable experience in manufacturing service-proven, reliable 3-phase AC propulsion equipment in networks similar to that in the city of Thessaloniki.

Each individual propulsion system shall have the following characteristics:

1. One or two independent DC to AC inverter packages (Power Conversion Equipment).
2. A Train Control System.
3. Four AC squirrel cage traction motors, each driving a gear unit.

The propulsion system design shall automatically compensate for wheel diameter variations up to 1% between wheels on the same inverter. There shall be no restriction on wheel diameters between bogies powered by a different inverter. Therefore, the traction motor shall be properly dimensioned to satisfy this requirement.

Each part of the traction system shall undergo type tests or it shall be proven through the appropriate Certificate that the system has been tested in the past.

11.1.1 Combined System Test

The Contractor shall perform a combined system test in accordance with EN 61377-1. Part 1: Combined testing of inverter-fed alternating current motors and their control system. The Contractor shall provide a list of compliance with the requirements of EN 61377-1, on an article by article basis.

The testing shall be performed in a Workshop at minimum, nominal and maximum line voltages.

Full type tests and diagnostic tests (including optional tests to be agreed with ATTIKO METRO S.A.) shall be performed.

The test on the maximum permissible difference of wheel diameter (Article 7.2.4, EN 61377-1) shall be included.

In relation to the aforementioned requirement and based on the design of the Contractor, an additional temperature-rise test of the motors shall be performed or an additional torque characteristic shall be obtained by a test (article 7.3, EN 61377-1).

The characteristics shall be drawn for the ¼, ½, ¾ of the maximum torque reference over the entire speed range in motoring and braking (article 7.5.1..1, EN 61377-1).

11.2 POWER CONVERSION EQUIPMENT

The power conversion equipment shall consist of all necessary equipment to convert the power supply from ATTIKO METRO S.A.'s third rail system into a fully useable power supply, to drive the traction motors under fully controlled conditions, in order to meet the requirements of the Performance Specification with respect to speed, acceleration, rheostatic braking, if foreseen, and regenerative braking.

The Contractor shall demonstrate by calculation and by test that the thermal stress upon the equipment will result in a service life of not less than 30 years under normal service conditions.

The propulsion equipment shall have a proven track record of high reliability and low maintenance in a similar operating environment to the Thessaloniki Metro.

Power conversion equipment design and testing shall be carried out in accordance with EN 50207*Railwayapplications: Electronic power converters for rolling stock*.
The Contractor shall provide a list of compliance with the requirements of EN 50207, on an article by article basis.

The traction inverters shall be able to support the operation of the traction motors under full load condition.

Propulsion equipment shall include the following, indicatively but not limited to:
- Inverter equipment
- Inverter Control Unit
- Inverter protection equipment (except the main circuit breaker)
- Input filter
- Braking resistors, if foreseen, based on calculations.

It shall be possible to replace the entire inverter unit as a module.

The inverters shall utilize Insulated Gate Bipolar Transistors (IGBT) power semi-conductors (or a later service-proven technology, as approved by ATTIKO METRO S.A.) and shall utilize pulse width modulation control.

All power semi-conductors shall operate at no more than 70% of their nominal design value and shall be designed and applied to provide a 40-year design life under the required operating conditions.

The power semi-conductors shall be preferably arranged into integral phase modules, each mounted on its own heatsink or heat transfer surface and shall be readily replaceable using standard hand tools.Arrangements mounted on aheatsink are also acceptable.

The inverter equipment shall be convection cooled, without the need for forced ventilation and the inverter enclosure shall be integrated with the car design to ensure that the motion of the vehicle produces sufficient air flow across the cooling fins to produce the required heat transfer.

The inverter power semi-conductors shall be housed in watertight, dustproof enclosures according to IEC 60529, class IP54 as minimum requirements and shall be convection cooled.

The traction inverter shall not be protected by fuses.

The input of the propulsion inverters shall incorporate ground fault protection. Upon detection of a ground fault, the affected inverter shall be shut down. A ground fault shall be recorded and reported to the Operator’s Desk by the Train Control and Management System.

The inverters shall be provided with over-temperature protection, which shall initiate a reduced level of performance from the affected unit. Once temperature reverts to normal, the inverters shall be automatically reset. The inverter over-temperature indication shall be recorded and reported to the Operator’s Desk by the Train Control and Management System.

Full type, routine and investigation tests (including optional to be agreed with ATTIKO METRO S.A.) shall be performed.

11.3 BRAKING RESISTOR

Braking resistor's design and testing shall be carried out in accordance with IEC 60322Railway applications: Electric equipment for rolling stock. Rules for power resistors of open construction. The Contractor shall provide a list of compliance with the requirements of IEC 60322, on an article by article basis.

Braking resistor shall be convection cooled.

Adequate shielding shall be provided to protect surrounding equipment, including cables and pipes, from heat dissipation.

Screens shall be provided to minimize the possibility of paper, plastic bags and other debris from contacting the resistor elements.

Moreover, care shall be taken to ensure adequate air flow around the elements and to prevent dirt build-up on the enclosure and the resistor elements.

All resistor frames, heat shields, screens and hardware shall be made of stainless steel.

The braking resistor elements shall be arranged into appropriate frames for modular replacement.

Care shall be taken to ensure that cable locations are located so as not to be overheated due to normal resistor heat dissipation.

The braking resistor design shall minimize EMI coupling into the track circuits.

Braking resistor shall provide over-temperature protection and the maximum operating temperature of the resistor shall not exceed 600^{o}C. The temperature of any grid shall not exceed 90^{o}C.If the temperature exceeds 600^{0}C, electrodynamic brake shall be interrupted and friction brake shall take over. The fault shall be announced and recorded to the Train Control and Management Unit and to the OCC.

The Contractor shall perform testing in accordance with an ATTIKO METRO S.A.-approved procedure to demonstrate the adequacy of the application.

11.4 TRACTION MOTOR

Traction motors have a proven service history of at least 3 years on railway networks.
Traction motors shall be AC squirrel cage, self-ventilated, induction machines.

During electric braking, motors shall act as generators while regenered braking energy shall be conferred to the DC circuit feeding the 3rd rail.

Traction motor design and testing shall be carried out in accordance with IEC 60349-2*Rotating electrical machines for rail and road vehicles*. Through simulation and testing,it shall be demonstrated that the motor winding temperatures remain within those allowed for by IEC 60349-2 Class F insulation, while winding insulation shall be Class 200.The Contractor shall provide a list of compliance with the requirements of IEC 60349-2, on an article by article basis.

TheContractorshallprovidethemotorefficiencycurveinrelationtotheratioN [kW]/N1 [kW], where:

N is the power given in the motor axle and N1 is the nominal power.

The following points shall be identified in the curve:

(η, N/N1 = 1,00),
(η, N/N1 = 0,75),
(η, N/N1 = 0,50),
(η, N/N1 = 0,25)

The motor efficiency shall be greater than or equal to 0.93 at the point N/N1 = 1,00.

The traction motor shall be rigidly mounted or with rubber bushings on the bogie frame, driving the gearbox via a flexible coupling.

The motors shall incorporate over-temperature protection, whose scheme shall be approved by ATTIKO METRO S.A..

Traction motor technical characteristics shall be described by the Contractor / manufacturer in table form.

In addition, dimensioning of the traction motor shall be in compliance with the following requirements:

- Running condition and performance of trains (ch. 2),
- Electro-dynamic brake preferably fully effective down to less than 0.5 km/h
- Transition from 100% electro-dynamic brake to mechanical braking, preferably ata speed less than 0.5 km/h
- Maximum permissible difference in wheel diameter
- The ratio of the total of the nominal power of the motors to the tare weight of the train must be greater than 11.

Alternatively, the transition from 100% electro-dynamic brake to mechanical braking shall initiate at least at a speed less than 10.0 km/h, on condition that parking accuracy of the train next to the platform and jerk free operation can be ensured.

The traction motor rotor cage shall be made of copper alloy bars short-circuited at their ends with brazed or welded rings.

However, transit-proven motors with a successful service history of having used cast aluminum rotors will also be allowed.

Bearings shall be electrically isolated for preventing currents to pass through them.

The Contractor shall identify the proposed motor protection scheme according to IEC 60529, and shall identify the motor duty cycle according to IEC 60034-1.

The design of the motor installation shall permit the motor to be removed from/reinstalled to the bogie from above (using a crane, with the car body removed) without the need to remove or relocate any other bogie-mounted equipment.

The replacement of one traction motor (disconnection of cables, removal of motor, installing of another motor, and reconnection of cables) shall be carried out by two experienced technicians within one hour. These are critical requirements, and the Contractor must demonstrate that these requirements will be met during the Conceptual Design.

In order to ensure that the traction motor leads have been correctly connected into the traction motor quick-disconnect box, power shall be fed to each motor bogie before its installation under the car so as to confirm that axle rotation is correct.

The traction motor cables are connected to the traction motor, with the quick disconnect to be located at the opposite end.

The name plate of the motor shall be placedin such a manner so as to be readable from the maintenance pit level. It shall include the following information as a minimum: manufacturer name, Type, Serial No, rated Power, rated Voltage, rated Current, No. of phases, rated RPM, etc.

Full type tests and diagnostic tests (including optional teststo be agreed upon with ATTIKO METRO S.A.) shall be performed.

It shall be demonstrated that the motor winding temperatures remain within the levels permitted by IEC 60349-2 Class F insulation, while using IEC 60349-2 Class 200 winding insulation.

The characteristics shall indicate the performance of the motor at minimum, nominal and maximum line voltages.

The environmental conditions to be taken into account are specified in Clause 2.3 of this Performance Specification.

The noise and vibration levels induced by the traction motor shall conform with the requirements of Clause 2.13 of this Performance Specification.

11.5 GEARBOX AND COUPLING

Each traction motor shall drive its axle via a parallel drive, shall be equipped with a single or double reduction gearbox and flexible coupling arrangement. The above shall be based on a proven rapid transit design experience.

Shims, special tools and precision measuring devices shall not be required to mount the gearbox onto the bogie.

Gearbox movement shall be restrained by a torque reaction link between the gearbox and the bogie frame.

A safety device shall be integrated to restrain gearbox rotation should the link fails in service.

The performance of the gearbox shall be fully compatible with the remaining propulsion equipment.

Bearings shall have a minimum L_{10} life that corresponds to 1,200,000km.

The gears shall be helical or preferably double helical and shall not require service at intervals less than 1,200,000km, while their fatigue life shall be not less than 2,000,000km.

The gears shall be oil lubricated and it will be possible to check the oil level during maintenance in the gear case.

The gearbox shall incorporate sufficient baffles, oil passageways, etc., to ensure adequate lubrication under all service conditions.

In addition, a magnet plug shall be fitted to eliminate any metallic particles from the gearbox oil.

The Contractor shall carry out testing under load to visually and functionally confirm the efficiency of the lubrication system at all speed range of the trains.

It shall be necessary neither to check the oil level at intervals less than 30,000km, nor to add oil at intervals less than 60,000km.

Moreover, changing oil shall not be conducted at intervals less than 240,000km.

The gearbox shall utilize labyrinth seals between rotating components.

The labyrinth seals shall not require replacement between major overhauls.

Adequate bolted (preferably gasketed) inspection openings shall be provided to enable inspection of all gears while the car body is on the bogie.

The noise and vibration levels induced by the gearbox shall conform with the requirements of Clause 2.13.1 of this Performance Specification.

Two gearboxes, selected at random by ATTIKO METRO S.A. shall be subject to a 100-hour test. This test shall be based on the actual duty cycle, but shall be performed using the worst case service conditions, with the torque and speed conditions increased by 20%. Testing shall start with the gearboxes at a temperature of at least 30°C and the gearbox oil temperature shall be continuously monitored to ensure that it does not exceed the manufacturer's recommendations, being consistent with the life-cycle between oil changes. The gears rotation direction shall be reversed every eight hours as a minimum.

Upon completion of the test, the gearboxes shall be disassembled and all parts shall be carefully examined. Gear tooth meshing and tooth wear pattern shall be checked, recorded and compared with the pre-test conditions. Should the gear teeth exhibit any wear an investigation will be conducted by the Contractor and any repairing activities shall be agreed upon with ATTIKO METRO S.A.

11.6 MAINTENANCE REQUIREMENTS

The equipment to be supplied shall require the minimum possible maintenance, while the regular inspection required for various features shall be conducted at intervals not less than 30,000km.

The Power Conversion and the Central Control Unit Equipment shall require maintenance at intervals not less than 120,000km.

No component in the Power Conversion Equipment and the Central Control Unit shall require removal or replacement before 240,000km of service operation.

Any fault in the Power Conversion Equipment and the Central Control Unit shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

Means shall be provided to automatically discharge capacitors whose voltage might present a hazard to a maintenance technician who opens any enclosure containing capacitors.

11.7 ELECTRICAL POWER DISTRIBUTION

11.7.1 Third Rail Current Collection

The 750 Vdc power will be collected from the lower part of the third rail using electro-pneumatically operated current collectors, actuated/de-actuated from the Operator's Desk or from the OCC.

It shall be also possible to lift and lower the collector shoes manually.

Their number and location per driving motor shall be compatible with the construction of the trackwork in the Thessaloniki Metro Lines, the train requirements and the requirements of the 3rd rail power supply system (no bridging of the protective gaps and protective sections of the 3rd rail through interconnection of the train collector shoes).

The design of the 3rd rail interface shall be compatible with the existing condition:
A11-1: 3rd Rail Interface Clarification – 0GS1RS0010046B
A11-2: Three (3) Drawings AIASA – 0GS1RS0010047B AIASA-6582.

The current collector shall include as a minimum:

- a collector shoe
- a collector shoe gear
- a fuse box with associated power cables.

The fuse shall include an indicator to show fuse-fault. Fuse fault and the positioning of this fuse shall be recorded and reported to the Operator's Desk, the Train Control and Management System and to the OCC.

A suitable arc shield shall be provided around the current collector shoe gear to protect adjacent equipment.

The collector shoe shall incorporate a readily identifiable system to indicate the need for imminent replacement.

Should any current collector on a car fails (e.g., damaged collector shoe gear or fuse-fault), the remaining collectors shall be capable of continuously performing all electrical duties for that car.

For a short time period, to be agreed with ATTIKO METRO S.A., one current collector must be capable of powering the loads connected on it, so as there is a non-problematic crossing of the 3rd rail gaps.

The control scheme shall prevent the application of voltage through the current collectors immediately prior to the action of raising.

The design of the current collector shall not permit current to pass through the collector hinge or bearings.

In order to minimize movements of the collector shoe and allow the complete and effective collection of electrical power, the current collector will be connected to the axle boxes. All movements of the collector shoe shall have as a point of reference the axle boxes.

The current collector shall be able to perform all necessary movements, taking into account the third rail installation tolerances, bogie manufacturing and wear tolerances, the third rails

gaps etc., to allow the complete and effective collection of electrical power in the network lines.

The height of the current collector shall be adjustable to account for wheel and shoe wear.

The Contractor shall deliver two devices, as part of the special tools scope of the project for measuring the height of the current collector shoe from the running rail.

The current collector shall utilize a flexible connection to conduct current from the collector shoe to an intermediate terminal, where the connection to the car body power cable shall be made.

Shoes shall be easily replaceable without the need to replace any electrical connection.

The Contractor shall install a CCTV system on a train to verify that the current collectors operate successfully at all speeds over ATTIKO METRO S.A. entire system.

11.7.2 Stinger Connection

For the description of the stinger connections on the bogies, as well as on the auxiliary converters, refer to the Clause 12.2.9 of this Performance Specification.

11.7.3 Collector Shoe Safety Covers

The Contractor shall supply one hundred current collector shoe safety covers, which shall fit over the current collector assembly and the stinger connection on the cars.

The covers shall provide protection for maintenance technicians, who are likely to come to contact with the collector shoes or stinger connections when carrying out their duties. As such, the covers shall fit securely over the current collector assemblies, shall not easily be dislodged accidentally and shall provide the required degree of electrical protection against 750Vdc power.

The covers shall be monoblock, cast, made of Fiberglass Reinforced Polyester, or made of an approved equivalent material, of robust manufacturing, capable of withstanding the rigors of use in a railway workshop environment.

The covers shall be yellow and shall have an ATTIKO METRO S.A.-approved “Danger - High Voltage” decal placed on the front vertical surface. The decal shall be edge-sealed.

The cover material shall meet the fire safety requirements of Chapter 18.6 of this Performance Specification.

11.7.4 Power Input Protection

In order to sense any fault that might damage cables or equipment, the power supply shall be protected by a heavy duty, transit-proven, ultra High-Speed Circuit Breaker (HSCB), which shall be capable of handling the short circuit capacity of the Power Conversion Equipment.

The High Speed Circuit Breaker shall have a breaking time (the breaking time is the opening time plus the arcing time), which shall be agreed with ATTIKO METRO S.A and shall be installed in a dedicated explosion-proof enclosure.

The device must not be damaged when battery voltage drops to zero.

To the extent possible, the HSCB's auxiliary contacts shall be used for its control circuits, in order to minimize the number of additional relays used.

Tripping of the HSCB shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The HSCB shall be re-settable from within the Operator's Desk.

11.7.5 Return Current

The negative return current from 750Vdc circuits shall run to an ATTIKO METRO S.A - approved insulated common point located under the car. The insulated common point shall be connected to the axle ground brushes through removable jumper cables.

A return current system shall be provided in order to prevent damage to axle box bearings.

The axle bearing housing of each motored axle shall incorporate insulated ground brush assemblies to direct the 750Vdc return current and car safety grounds to the axles around the axle bearings, and gearbox and traction motor bearings.

The brushes shall contact a ring pressed onto the axle.

The ground brush shall have the shape of a rectangular prism and will bear a wear indication.

Circular disc brushes are not allowed.

The ground brush shall be designed in such a way as to prevent its wear dust to enter the area of the axle bearings and contaminate their lubricant.

The brush shall have a service life of not less than 120,000km and the ring not less than 1,200,000km.

At least one identical ground brush per axle shall be installed on the non-motorized bogies in order to ground the low voltage circuit and fault currents.

In case of articulated train-sets, at least one identical earthing brush per axis shall be installed in every bogie to ensure earthing of the fault currents.

The ground brush housing shall allow ready access to the brushes and electrical contacts by maintenance technicians.

Dirt built-up shall not affect the insulation.

Each ground brush and its cable and connections shall be sized so that any two ground brushes on a car be capable of continuously carrying the total return current, without damage.

Additionally, the car body safety-ground brushes and connections shall be sized so that each brush circuit be capable of carrying the maximum fault current without damage, while limiting the potential difference between the car body and the running rail to 50V.

Other return current systems may be offered by the Contractor but they will require approval by ATTIKO METRO.S.A.

The Contractor shall perform testing to confirm that, within practicable limits, the current returning through each ground brush is as equal as possible.

11.7.6 Short Circuiting Device

Two different kinds of short circuiting devices shall be provided: remote and manual.

An appropriate number of remote short circuiting devices in each motor car shall be provided, which, when activated by the Operator's Desk, shall cause the current collector equipment to be connected directly to the car body ground bus.

A manual short circuiting device shall also be provided in an area close to the Operator's Desk, which may be used by the Technician to directly short the third rail to the running rail.

Each device of both types shall be dimensioned for safely withstanding the reapplication of third rail power after power supply cut off.

Especially for the remote short circuiting devices, provision shall be made in order to avoid their energisation when the corresponding third rail section or sections are under voltage.

The Contractor shall test both devices to ensure that they meet these requirements.

12.0 AUXILIARY ELECTRICAL SUPPLY SYSTEM

12.1 GENERAL

All electrical equipment on the trains, other than the Power Conversion Equipment and the supply to the Auxiliary Power Supply Equipment, shall operate using the following nominal voltages:

- 400Vac, 3-phase, 50Hz
- 230Vac, 1-phase, 50Hz
- 110Vdc
- 24Vdc
- 12Vdc
- or other as required.

Trains shall be equipped with two (2) auxiliary electrical supply systems.

The design shall achieve an efficiency of at least 80% for all combinations and conditions of load and supply, except when the load is less than 20% of full load.

Auxiliary electrical supply systems shall consist of:

- one auxiliary converter (Auxiliary Power Supply Equipment or APSE) and
- one storage battery.

The auxiliary electrical supply system shall be independent from the propulsion system.

12.2 AUXILIARY CONVERTER

12.2.1 General

The auxiliary converter shall provide:

- an alternating current (AC) three phase output for supplying the 3-phase, 1-phase AC circuit and
- a direct current (DC) output for supplying the DC circuit and charging the battery.

The auxiliary converter design and testing shall be carried out in accordance with EN 50207. The Contractor shall provide a list of compliance with the requirements of EN 50207, on an article by article basis.

Full type and routine tests shall be performed.

When designing the auxiliary converter, particular care must be taken to prevent simultaneous starting of large auxiliary loads (e.g. air conditioning compressors).

The auxiliary converter shall produce noise and vibration levels compatible with the requirements of chapter 2.

The auxiliary converter shall contain as a minimum the following:

- Input voltage monitoring and control
- Output voltage monitoring and control
- Loss of phase monitoring and control
- Line Filter
- Over voltage protection

- Dead Battery Starter
- Pulse Width Modulation Inverter using Insulated Gate Bipolar Transistors (IGBTs)
- Battery Charger
- Transformer
- AC Filter
- Auxiliary Converter Control Unit.

Preferably, in order to increase the efficiency of the inverter, capacitors' discharge resistors shall be installed and come into circuit right after the inverter is switched off.

The auxiliary converter output shall be galvanically isolated via a transformer and the secondary windings shall incorporate a ground fault protection system.

Upon detection of a ground fault, a fault message shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The auxiliary converter shall incorporate reverse polarity protection and shall allow the equipment to operate normally when the reverse polarity is removed, without the need for further action.

The auxiliary converter shall inhibit its output under the following fault conditions:

- The output voltage is out of tolerance.
- The output frequency is out of tolerance.
- Any other fault condition that may cause malfunction or failure of the auxiliary converter and its load.

Faults shall be categorized as either major or minor. Minor faults are self-rectifying.

A manual reset facility of the APSE shall be provided in the Operator's Desk.

12.2.2 Characteristics

12.2.2.1 Input Characteristics

The auxiliary inverter shall be supplied by 750 Vdc through:

- a circuit breaker, or
- through an arrangement of disconnect switch and high speed fuse

The status of the automatic breaker or of the disconnect switch and of the high speed fuse shall be supervised and recorded by the TCMS and shall be transmitted to the Control Centre and to the Operator's Desk.

The auxiliary converter shall be capable of operating in the full voltage range from 500 Vdc to 900 Vdc of the dc supply system under full output load, and still maintain the outputs as specified.

12.2.2.2 Output Characteristics

The auxiliary converter shall supply the following voltages with the following characteristics:

AC output voltage:

- voltage and tolerance: 400, 230Vac, ±5% (preferably ±3%)
- frequency and tolerance: 50Hz, ±2%

DC output voltage:

- voltage and tolerances (charging mode): To be determined as functions of the type of battery, the number of cells and the operating conditions, ± 1% below 50% load and ± 3% above 50% load.

Equipment connected to the dc output voltage shall operate at 110Vdc, or at 24V, -30%, +25%, depending on the converter output.

12.2.3 Cooling System

The auxiliary power equipment shall be convection cooled and the power semiconductors shall be mounted to grounded heat sinks.

Under all normal and emergency operating conditions, the temperatures of all semiconductors shall not exceed 90% of their specified peak junction temperature ratings.

The maximum temperature within the equipment enclosure shall not exceed 65^{o}C under normal operating conditions.

12.2.4 Load Shed Operation

In the event of failure of an auxiliary converter in the train, the system shall be designed to minimize restrictions during passenger service.

The AC output of the auxiliary converter in operation shall be such that it shall not cause the loss of more than:

- the 50% of the passenger compartment air conditioning in each car if the HVAC system has been designed for being powered by the APSE.
- The 50% of the air compressors.

The DC output of the auxiliary converter in operation shall be arranged to ensure the normal operation of all DC loads of the entire train, excluding the battery charging of the failed auxiliary converter.

Therefore, the DC circuit shall be fully train lined at all times.

The load management shall be performed by the Train Control and Management System.

The failure of an auxiliary converter shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

In addition, the requisite DC power shall be train lined to enable rescue operation during emergency conditions.

12.2.5 Diagnostic Logic and Fault Logging

The auxiliary converter shall use a control scheme that contains extensive self-diagnostic logic and fault logging means, which shall be fully integrated into the Train Control and Management System.

As a minimum, the diagnostics system shall identify a range of credible faults, identify whether a Line Replaceable Unit (LRU) is responsible for the fault and whether the LRUs (or non-LRUs) must be replaced or whether the system has just to be reset.

The diagnostics system memory shall be retained when the train is powered down.

12.2.6 Dead Battery Starter

Each auxiliary converter must incorporate a dead battery starter feature.

When batteries are discharged below a certain voltage and the auxiliary converter cannot start after the restoration of 750Vdc, the dead battery starter will be supplied by 750Vdc and will convert it to 110Vdc or 24Vdc, depending on the converter output, in order to restore the operation of the auxiliary converter.

Main features shall be:

- Supplied with 750Vdc only when battery is discharged.
- Switch on command is given automatically
- Switch off command is given automatically when 110Vdc or 24Vdc is established and DC battery charger output contactor closes.
- Fault signal will be provided
- Dead Battery starter operation shall be recorded and reported to the Operator's Desk and the OCC by the Train Control and Management System.

The converter/charger/dead battery starter system shall be capable of charging all chargers of the train, when fully discharged.

12.2.7 Battery Charger

The battery charger shall operate at all times when train is energized.

The battery charger shall contain as a minimum the following:

- Input voltage monitoring and control
- Output voltage monitoring and control
- Output current monitoring and control

In case the design sets the battery charger automatically off, when the train is de-energized, then the Automatic Battery Charge feature function will be effected as follows:

- third rail power available,
- train de-energized (shut down),
- auxiliary converter switch on.

Upon battery voltage dropping to 90Vdc or approximately 20V, depending on the charger output, the battery charger shall be activated to bring the battery to full charge.

The battery charger shall be able to charge a fully discharged battery to 50% of its rated capacity within three hours and to 90% within 20 hours.

The failure of the battery charger shall be recorded and reported to the Operator's Desk and the OCC by the Train Control and Management System.

12.2.8 Bonding and Safety Grounding

The negative return current from each subsystem on each car shall run individually to ATTIKO METRO S.A.-approved insulated common points located in enclosures under the car.

The enclosures shall be grounded to the car body structure through a grounding point and a removable jumper cable and shall provide easy access from the side of the car.

12.2.9 Stinger Connection

Trains shall incorporate means to allow movement in ATTIKO METRO S.A.'s maintenance facilities where third rail power is not available, by utilizing ATTIKO METRO S.A.'s 750 Vdc existing power system of the "stinger" type.

The cars shall be equipped with stinger connections, which shall be compatible with the stinger system in use in ATTIKO METRO S.A.'s maintenance facilities.

Each motor car shall be equipped with two stingers, on diagonal positions, suitable for the vehicle maintenance activities, as well as for its movement from the area without the existence of a third rail towards the third rail tracks and vice versa.

As regards the stinger connections, the option shall be provided so that only the auxiliary converters and the auxiliary loads be independently powered, by means of a motorized switch, similar to that of the existing trains, which will selectively isolate the other stinger connections and current collector shoes. The motorized switch shall be capable of feeding at least two traction converters and all auxiliary power converters and auxiliary loads by isolating the collector shoes.
The subject switch shall also be able to ground the inputs.

The number of stinger connections, as well as the number of the motorized switches shall be such so as all traction converter, all auxiliary power converters and auxiliary loads be voltage-powered, without feeding the collector shoes. The Contactor may propose alternative power supply configurations different than the stinger connections which must be accompanied by the relevant documentation. These configurations shall be approved by ATTIKO METRO S.A. on condition that the relevant maintenance requirements are met. The push buttons that are going to be used for the control of the motorized switch shall be IP 65, if situated outside the train.

These stinger connections shall be protected inside a lockable watertight enclosure.

The position the motorized switch is turned to shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

12.2.10 AC Electrical Outlets

Twelve (12)230Vac electrical outlets shall be installed – two (2)on each car, and two (2) in each Operator's Desk.

12.2.11 110Vdc/24Vdc Converters

The Contractor shall identify the quantity and the arrangement of the 110Vdc/24Vdc converters, in order to power the required equipment.

12.2.12 110Vdc/24Vdc/12Vdc Converters

The Contractor shall identify the quantity and the arrangement of the 110Vdc/24Vdc/12Vdc converters, in order to power the required equipment.

12.3 BATTERY

The batteries of the trains shall be used to supply DC control voltage and the electrical consumers like all controllers, electronic units, head-tail lights, indication lights, door motors and other items as required.

Each auxiliary power supply system shall be equipped with nickel-cadmium storage cells contained in a stainless steel battery box.

All cells shall be standard size, vented and the battery cases shall be made of a material having good thermal stability and suitable chemical resistance.

The battery case material shall also meet the requirements of Clause 18.6 of this Performance Specification.

Cells shall be individually renewable.

The battery shall be designed to withstand the shock and vibration conditions associated with a rugged railcar environment.

The battery dimensioning and testing shall be carried out in accordance with EN 60623, while the appropriate reduction coefficients shall be taken into consideration.

Full type and routine tests shall be performed.

The Contractor shall provide a list of compliance with the requirements of EN 60623, on an article by article basis.

When the train is de-energized, the red tail lights at the train ends shall automatically be powered from the batteries.

Batteries shall be designed for a life cycle of at least 15 years.

12.3.1 Emergency Load Operation

The battery shall provide standby DC power.

In the event of power failure due to the loss of third rail power or auxiliary power supply, the batteries shall be capable of supplying the following emergency loads for period of one hour as a minimum:

- Emergency interior lighting
- Communications and radio-communications system
- Head lights at the front of the end cars
- Doors system – opening / closing
- Brake control system
- Propulsion control system
- ATC equipment
- Train Control and Management System (TCMS)
- Train number plate
- Event recorder
- Horn
- Other systems, as required for for safe and emergency operation (to be determined during the design).

In addition, the operation of the emergency ventilation in all air conditioning units is required for a period of 30 minutes.

The emergency load management shall be performed by the Train Control and Management System.

12.3.2 Battery Box

The battery box shall be electrically isolated from the car body structure.

The cell groups shall be assembled with flexible jumpers and shall be contained in a tray installed on heavy duty stainless steel rollers, to allow the battery to be rolled out for inspection and maintenance.

A warning sign shall be provided, in order to prevent the rolling out of the battery, if the cables have not been disconnected.

The battery box shall be designed in such a way that the cells be prevented from bouncing in the box during normal operation.

The battery box shall be designed to drain away any battery liquids inside the box.

The emission of battery gases shall be negligible and the battery box shall be suitably vented.

The Contractor shall provide means in the battery box cover, in order to prevent any dangerous metallic part flinging in ATTIKO METRO S.A.'s Depots and Workshops, in case of battery explosion.

12.3.3 Battery Protection and Isolation

The output of the battery shall be suitably fused.

A readily-accessible switch shall be provided on the side of the battery box to allow the battery output to be isolated.

The switch shall be red and shall be suitably labelled.

The ON or OFF position of the switch shall be easily distinguished from a distance and shall be recorded and reported to the Operator's Desk by the Train Control and Management System. The switch shall be ON or OFF without requiring to be under voltage.

The battery shall incorporate a temperature sensor to disconnect the battery from the battery charger when the battery temperature exceeds the limit imposed by the battery Manufacturer.

Overcharging of the battery shall be prevented by means of an isolating contactor, which shall operate at a voltage specified by the battery supplier.

Activation of these features shall be recorded and reported to the Operator's Desk by the Train Control and Management System and failure of the batteries to be charged shall be also recorded and reported to the Operator's Desk by the Train Control and Management System.

12.4 BATTERY CHARGER AND DISCHARGER

Two programmable battery charger and discharger units shall be provided.

The units shall be suitable to charge and discharge the battery, in accordance with EN 60623, and the directions of the battery manufacturer on battery regeneration. The charge/discharge and rest cycles of the battery, as described in Standard EN 60623 and in the directions of the battery manufacturer on battery regeneration, shall be fully automated and shall not require resetting by the controller during the steps of the battery charge/discharge and rest cycles.

Chargers shall generate detailed reports at the end of each step of the battery charge/discharge cycles indicating the start and end time of each step together with the voltage and current values, so as to verify that each step of the charge/discharge cycles has been properly completed, providing thus a conclusion on the battery status.

The units shall be installed in ATTIKO METRO S.A.'s Depot and they will be used to verify the good condition of the battery cells during periodic maintenance.

The Contractor shall deliver, install and commission the units.

Moreover, the following documentation must be provided as a minimum:

- drawings,
- circuit diagrams,
- logic diagrams,
- equipment list with brief description including all electrical and electronic components,
- maintenance and troubleshooting manuals,
- technical data sheets,
- operation manual including details of the programmable settings
- security manuals.

12.5 CIRCUIT BREAKER PANELS

The DC, AC power supply output shall be controlled by ATTIKO METRO S.A.-approved miniature circuit breakers.

The final quantity and location shall be agreed upon in the design phase.

13.0 COMMUNICATIONS, PASSENGER INFORMATION AND SECURITY SYSTEMS

13.1 GENERAL

The communications system of the trains shall be compatible with the Communications System in operation within the Network. Further details are given below, namely:

A13-01: TELECOMMUNICATIONS – VEHICLE HEALTH DATA PROTOCOL SPECIFICATIONS
AIASA-17259 – 0G00LV100G108
A13-02: ON BOARD SYSTEM - TECHNICAL SPECIFICATION (DFD)
AIASA-15079 –1G00LV644G162
A13-03: On Board System Software Requirements and Specification
AIASA-13867 – 1G00LV644C301

Each train shall be provided with communications equipment to provide the following functions:

- One-way audio communication from any Operator's Desk of the train to the passengers (Public Address System).
- One-way audio communication between the Operation Control Center and the passengers via the Public Address System.
- Two-way audio (full duplex) communication between the Operator's Desk of the train and passengers (Passenger Emergency Intercom).
- Two-way audio (half duplex) communication between Operator's Desks (Intercommunication System).
- Two-way audio (full duplex) communication between the Operator's Desk and the Operation Control Center (Train Radio System).
- Two-way audio (full duplex) communication between passengers (Passenger Emergency Intercom) and the Operation Control Center (Train Radio System).

The equipment shall be controllable from any Operator's Desk, and must be fully functional over a length of two trainsets. The train's communication system shall be compatible with the design of the existing couplers, so as to ensure communication, via LAN, between two coupled train sets.

The communications equipment shall be supplied by individual circuit breakers from the DC power supply, backed up by the battery.

Special attention shall be given to the shielding of all communications equipment wiring.

Moreover, the train shall be provided with the following passenger information equipment:

- Electronic system route maps with digital LED screens
- Interior Electronic Information Displays (destination and information)
- Exterior Electronic Destination Display.

Furthermore, the train shall be provided with the following security equipment:

- Closed Circuit Television System for the surveillance of the passenger area.
- Closed Circuit Television System for the surveillance of the surrounding area. The external cameras shall survey both couplers and tracks.

The video images of the CCTV system shall be transmitted to the OCC via DCS (Digital Communication System).

13.2 COMMUNICATIONS SYSTEM

13.2.1 Public Address System

The Public Address system shall allow:

- the Operator from a special position independent from the Operator's Desk at the two ends of the train, and
- the authorized Operator in the Operation Control Center.

to make automatic announcements to the passengers in all cars of the train or of the two coupled trains, via loudspeakers ,which are located in the ceilings of cars or in other locations to be agreed by ATTIKO METRO S.A..

The announcements from the Operation Control Center shall be performed through a Train Radio System.

The Public Address system shall also be capable of delivering automatic announcements, including, but not limited to:

- Door Opening,
- Door Closing,
- Station Arrival,
- Station Departure,
- Next Stop,
- Terminal Station.

In addition, the Public Address system shall be capable of delivering automatic triggered pre-recorded announcements and non-automatic triggered pre-recorded announcements (pre-stored in the train) from the Control Centre.

Non-automatic announcements shall override automatic announcements. The table of priorities shall be approved by ATTIKO METRO S.A.

Furthermore, the Public Address system shall include:

- passenger emergency intercommunication system (Refer to the Clause 13.2.2 of this Performance Specification) and
- intercommunication system between the two control positions (Refer to the Clause 13.2.3 of this Performance Specification).

The Public Address system shall include the following as a minimum:

Per Operator's Desk:

- A Digital Automatic Voice Announcement Unit including the Door Closing Audible Alarm
- An Operating Panel with loudspeaker and microphone
- A Public Address Unit with digital Public Address Amplifier
- An Automatic Coupler Interface Unit
- An Interface Unit interfacing with the following as a minimum:
    - The internal electronic information display units
    - The external electronic information display units
    - The electronic system route maps
    - The Train Control and Management System
    - The Train Radio System

Per car:

- Public Address amplifier(s)
- Loudspeakers
- Passenger emergency intercommunication levers and passenger emergency intercommunication microphones. (Refer to the Clause 13.2.2 of this Performance Specification).

A sufficient number of high quality, strategically placed loudspeakers shall be provided to ensure that all messages are clearly heard by passengers under all operating conditions.

Loudspeaker sound level shall be adjustable by ATTIKO METRO S.A. technicians.

In addition, the loudspeaker sound level shall be adapted to suit the operating environment through a automatic sound level adjusting system.

The Public Address system shall perform a self-test in the start-up sequence.

Moreover, each amplifier and loudspeaker shall be provided with equipment to check the proper operation.

If an announcement cannot be broadcasted to the passenger compartment area, then an alarm status indication shall be provided.

The results of the self-test, as well as the alarm status indications shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

The system shall have sufficient memory to allow for the inclusion of additional 50 station announcements and/or other relevant messages.

The automatic announcements will continue with the correct order, having the train completed the auto reversing at the terminal stations.

The messages either automatic or non-automatic shall be bilingual (Greek and English), audio and video (refer to the Clause 13.3 of this Performance Specification), and there will be a choice to select either language or both.

The noise generated by the Public Address system in the standby condition with the equipment energized at its nominal level shall not exceed 40dB(A) at 0.3m away from any loudspeaker.

The Contractor shall provide a fully equipped maintenance workstation (route database and speech editor) with all the required hardware (including digital recording equipment) and software and with the following capabilities as a minimum:

- It must allow route database, station definitions and announcements (automatically and non-automatically triggered) to be readily created, added/deleted, modified and recorded in Greek and English. The option shall be given for composite messages using pre-recorded phrases or parts of sentences.

- Once the route database and announcements have been finalized, the result shall be previewed and played for confirmation.

- Downloading/uploading of data oe new configurations shall take place in a maintenance laptop though a Universal Serial Bus (USB) port, through Ethernet and wireless through WiFi to the train (see article 23.10).

The Contractor shall also provide a portable test equipment (maintenance laptop), to customize the Digital Automatic Voice Announcement Unit, the Public Address Amplifier (e.g., the volume settings, the sound operated automatic level adjusting system settings, etc.) and to manage the stored announcements.

The aforementioned maintenance workstation and laptop shall have both audio and video processing capabilities, for serving the passenger information system too.

The Contractor shall also provide all messages required for the Metro operation at this phase of the Project (Base Project and Extensions), in Greek and in English, to be integrated into the Public Address system of the train, according to ATTIKO METRO S.A.'s instructions. The messages shall be installed in the train systems and shall be delivered to ATTIKO METRO S.A. in all forms.

13.2.2 Passenger Emergency Intercommunication System

One passenger emergency intercommunication system device (located diagonally every two adjacent doors) shall be provided in each area in the vehicle with facing doors, to allow passengers to communicate with the Operator or the Control Centre and vice versa, under emergency circumstances.

The alarm shall consist of a recessed lever, normally retained in the horizontal position by means of a lead seal, which is pulled downwards by any passenger in case of an emergency.

When the lever is depressed, an adjoining microphone/loudspeaker unit is energized, an alarm sounds at the active Operator's Desk (if activated) and a two-way (half duplex) communication between the passenger and the Operator/Driver or the Control Centre is established, should the Driver or the OCC Operator accepts the call.

The identification of the activation of the lever shall be displayed in the Main Operating Panel, and shall be recorded and reported to the Operator's Desk by the Train Control and Management System.

Push buttons are also acceptable instead of a lever. The intercommunication system shall be similar to the one already in operation in Series I Trains (for uniformity reasons).

The system can be used by Persons with Special Needs.

Especially, for the dedicated area for Persons with Special Needs in the driving car, the passenger emergency intercom system shall be located at an appropriate height.

13.2.3 Intercommunication System between Operator's Desks

Each Operator's Desk shall have an audio intercommunication system to permit communications among all Operator's Desks in a train or in two coupled trains.

The intercommunication system shall be initiated by the Operator on either drive area through the Operating Panel.

Both panels shall indicate the activation of the intercommunication system.

13.2.4 Train Radio Communication

The Train Radio Communication equipment shall be provided by the Contractor. The pertinent equipment shall be in compliance and in absolute compatibility with the specifications of the radio communication system of the Base Project and the Extension to Kalamaria and shall operate unobstructedly in these sections.

As regards the Base Project, the description and characteristics of this system is included in the information data (Annex A15-1), while Annex A15-2 contains the specifications document of the Radio Communication System for the Extension to Kalamaria, for which there is an ongoing tender.

The operational requirements of the radio communication system on-board the trains are as follows:

- The Contractor shall provide and install at least two (2) portable radio communication devices per new train.

- The portable radio communication devices shall be equipped with a radio digital transceiver compatible with ETS EN TETRA, for operation frequencies ranging from 410 – 430MHz, and shall be used for transmitting and receiving voice and data. Only one device shall be activated each time, while the other one shall be at a standby mode.

- The portable radio communication devices shall be interconnected both with the train communication system and the train communication management system.

- The portable radio communication devices shall support the following voice and data functions:

    - Voice communication between the OCC and the train driver (in case of non-automated operation).
    - Voice communication between train passengers (via the devices for communication in emergencies) and the OCC.
    - Playback of announcement (PA-recorded at real time), deriving from the OCC, on-board the train.
    - Transmission of data from / to the Integrated Communications and Control System (ICCS) in the OCC for the playback of a pre-recorded announcement (PA) on-board the train.
    - Transmission of data from / to the Integrated Communications and Control System (ICCS) in the OCC for the playback of visual announcements (PIS) – recorded at real time - on-board the train.
    - Transmission of data from / to the Integrated Communications and Control System (ICCS) in the OCC related the train equipment status of operation (Vehicle Health Data) and transmission of control data related to the communications system on-board the train.

- The portable radio communication devices shall not be used for:

    - Transmitting CCTV data and video.
    - Downloading CCTV archives in the Depot.
    - Transmitting signalling or vital data to /from the signalling system or the ATS.

- The Contractor shall be responsible for fully integrating the radio communication devices on-board the trains into the radio communications system of the Thessaloniki Metro and the Integrated Communications and Control System (ICCS) and for making all modifications, additions, reconfigurations, etc. that may be required.

The train portable devices shall be equipped with: a console integrated into the driver's control, a loudspeaker, a suitable microphone in each train control panel.

- The train portable devices shall be equipped with a control and an interconnection unit with the remaining train systems. The control unit, along with the central unit of the portable radio shall be placed within a metal enclosure, suitable for installation and easy maintenance purposes within the train.

- The radio communication portable devices shall use the suitable antenna system for the transmission and emission / receiving of RF signals.

- The radio communication portable devices on trains shall be fed by the DC power feeding system on-board the train.

- The radio communication portable devices on trains and their accompanying equipment shall be certified per EN 50155, they shall be of temperature class T1 and compatible with standard EN 50121-3-2.

13.3 PASSENGER INFORMATION SYSTEM

13.3.1 General

The Passenger Information System shall comprise of the following subsystems:

- Electronic System Route Map
- Interior Electronic Information Displays
- Exterior Electronic Destination Display.

The Passenger Information System shall be able to detect, at any time of its operation, any hardware and software fault. The faults shall be monitored by the Train Control and Management System and shall be announced to the Integrated Communication and Control System (ICCS) at the Operation Control Centre (OCC).

The Passenger Information System shall be able to carry out a Light Emitting Diode (LED) test, when the LED test command is received from the Train Control and Management System.

The LED test shall be conducted where applicable on the aforementioned subsystems separately.

All screens shall be service-proven and appropriate for Metro railway vehicles.

13.3.2 Electronic System Route Map

One service-proven electronic system route map LED or Liquid Crystal Display (LCD) unit shall be installed on each coving panel of the door to display the electronic route map of the system. Display units shall be colored, high resolution, and shall be equipped with an automatic brightness adjustment system.

The dimensions of the unit shall be the maximum possible, taking into account the full available area of the door coving panel.

The information displayed to the passengers shall be continuously flashing on a real time basis.

This information shall include, as a minimum, the following, namely:

- the line where the train is running,
- the final destination,
- the terminal station,
- the next station,
- the current station,
- the interchange station and the corresponding line for interchange,
- the passenger doors' opening side.

The maps' functioning and appearance shall be agreed with ATTIKO METRO S.A..

The unit shall be programmable and shall be of such capacity, in order to accommodate any future extensions.

13.3.3 Interior Information Display

One service-proven interior electronic information display system shall be provided. This system shall consist of the following items, namely:

- An interior electronic destination information LED display unit to be installed at each end of the interior of each car to display destination information(minimum three colors) and
- In the middle of each car interior, a twin view internal coloured Liquid Crystal Display (LCD) unit shall be installed; it shall be visible on either side of the vehicle and shall display the messages of the Passenger Information System and any eventual advertising messages (if a server exclusively used for the management of advertisements is installed in the future).

The final destination displayed shall be synchronized by the external destination display indicators at the Operator's Desk to display the next station stop and the terminal station.

When advertising messages are not being displayed, then the train final destination or any other appropriate information shall be displayed.

In case of emergency, the Control Centre (or the Emergency Control Room) shall have the ability to display pre-stored messages on-board to passengers, as well as free text messages, which shall take precedence over all other messages.

13.3.4 External Electronic Destination Display

A service-proven, full matrix large external electronic destination LED or Liquid Crystal Display (LCD) display unit shall be installed above the windshield in each driving car.

The unit shall display:

- Final destinations,
- PTI number,
- Line number,
- Special messages e.g., the train is not in service.

The displayed message shall be legible at a minimum distance of 30 m ahead of the train and at an angle of up to 45^0, by a person with normal eyesight standing on the platform.

The unit shall display the final destinations in both Greek and English.

The minimum height of the Greek fonts shall be 120mm, while the minimum height of the English fonts shall be about half.

A hinged panel shall be installed in the vehicle to provide direct access to the destination display unit.

The destination displayed on the driving car display unit shall be the identical to the destination displayed at the other end car.

The destination display unit shall be fully programmable by ATTIKO METRO S.A.'s personnel to display messages.

13.4 SECURITY SYSTEM

The security system shall include the Closed Circuit Television (CCTV) system for the surveillance of the train interior and the CCTV system for the surveillance of the area outside the train.

The OCC Operators will have the option to access the on-board CCTV system to display video images in real time via the Wireless Data On-Board Communication System.

At the end of the Metro revenue service, images and videos recorded on the trains during their operation shall be automatically transmitted to the Integrated Recording and Central Storage System.

13.4.1 Closed Circuit Television System for the Surveillance of the Passenger Area

Every car shall be equipped with Closed Circuit Television surveillance cameras to record pictures from the entire train interior.

The Closed Circuit Television system shall meet the local regulations for picture quality, storage time, level of encryption, sequence of evidence (law / police requirements) and personal data protection act (GDPR).

The subject system shall be compatible with the equivalent system installed in the stations and with the central Integrated Communications Control System (ICCS) at the OCC.

The cameras shall be located in such a manner that they cannot be subject to vandalism.

The cameras shall cover the entire interior passenger area and there shall be overlapping.

Two (2) cameras shall be installed per wagon; however, at the first and at the last car, a 3rd camera shall be also installed, which shall cover the area of the Emergency Driving Position and the front passenger seats. The exact location of cameras shall be agreed with ATTIKO METRO S.A..

The system shall be activated automatically when the power is supplied.

The system shall perform a self-test in the start-up sequence.

The system shall be able to record pictures at 25 frames per sec on a 24h basis, as a minimum.

When the specified recording time is reached, the system shall start to write over the oldest stored images.

Images shall be recorded together with information about date, time, camera identification, camera location, train number and train location.

Time and train location synchronization data shall be received from another system.

All images shall be stored in one location, on a common on-board storage media on-board the train.

The recording media shall be physically removable, with a special key, from the train to be viewed later in another location.

All cameras shall be color type, of high definition and of an at least 2 Mpixel resolution.

All visible faces of cameras shall be black painted.

All finished parts must facilitate the removal of graffiti and not easily degrade as a result of the removal process.

Surface coating methods used must allow local retouching following repairing activities.

As a minimum, the quality of the picture recorded under normal lighting conditions in the cameras shall be - at least - category E according to EN 50132-7.

This quality shall be measured by playing the records on a playback station.

The Closed Circuit Television system shall be modular and expandable for reasons of greater functionality, without the need for replacing the existing features, or with the need for replacing only a limited number thereof.

All CCTV cameras shall have the ‘detection’ feature, while cameras near doors shall also have the ‘recognition’ feature.

The Closed Circuit Television system devices shall be connected to the Train Control and Management System and to the Integrated Communication and Control System (ICCS) at the Operation Control Center (OCC) and the Emergency Control Room (ECR).

By connecting a laptop or a dedicated monitor to a service port, it shall be possible to view live images from any onboard camera, as well as the already recorded images onboard from any connected recorder in the train.

The on-train playback time shall be limited to the last 5 minutes of recording and access to this function shall be protected with the use of a security procedure.
A playback station shall be provided to decode and display the data recorded on the removable recording media of the trains.

A playback station shall allow playing video and the operation interface shall include the following features:

- Playing forward and backward in normal speed.
- Playing forward and backward in high speed.
- Freeze pictures, pause the playing.
- Step frame by frame forward and backward.
- Search by time and date.
- Different viewing modes, single camera selection, quad view with synchronized pictures, etc.
- Swap between cameras at a certain point in time without performing a new time search.
- Zoom function.
- Search on the basis of train location.

It shall be possible to export single images or selected sequences into a standard file format (e.g. JPEG, AVI, MPEG) for digital storage.

The playback software shall be accessible for use via a security procedure, e.g. user identification and password.

13.4.2 Closed Circuit Television System for the Surveillance of the Train External Area

Every car shall be equipped with exterior Closed Circuit Television surveillance cameras, to transmit images to the Control Center from both train sides and both ends (direction to the tunnel). To serve the automatic coupling of trains (without the presence of operators/technicians) there shall be a surveillance/control camera for the coupling related procedure.

The minimum frames rate per second shall be 25.

As a minimum, the quality of the picture displayed under all normal lighting conditions shall be at least category E, according to EN 50132-7.

This quality shall be measured by playing back the files using a playback station.

All images shall be colored with exception of low light conditions; in this case, it shall be allowed to switching over to black and white.

The cameras must be equipped with a quick auto iris – or similar – function.

The system shall be activated automatically as soon as it is powered.
The system shall perform a self-test in the start-up sequence.

Monitors shall be blank until the start-up sequence is completed.

The field of view must be sufficient to view a person at the nearest door (e.g., at least the head of a child 1.2 m tall).

Digital system shall have an indicator that ensures that the viewed images are in real time and the picture is not frozen.

The external cameras directed towards the tunnel can also be installed inside the train.

The complete camera assembly shall fit in the rolling stock kinematic envelope.

The brackets shall be adjustable to all directions to achieve the right angle for optimized coverage; however it shall be possible to lock all settings.

14.0 AUTOMATIC TRAIN OPERATION

14.1 GENERAL

The train operation principle is that the trains shall be automatic, driverless trains. All functions (acceleration, braking, door opening / closure, towing, etc.) shall be managed and supervised by the ATC equipment. In case of degraded operation mode, it shall be possible for a train to be driven by an Operator, via the Operator's Desk located at the front and rear ends of the train.

The signaling system of the trains shall be supplied by an independent contractor with whom this Contractor shall cooperate, as required in view of ensuring the absolute technical and functional coordination of the rolling stock and the signaling system.

The train shall be both, physically and operationally, compatible with the existing signaling system, as this is described in the following documents, namely:

A14-01: ATS System Specifications for the Extension to Kalamaria.
A14-02: Specifications of the Signaling System for the Extension to Kalamaria.
A14-03: Technical Description of Functions – Train Series I Interface with Signaling AIASA-17399 Vehicle General Functional Description
A14-04: ATC (Automatic Train Control) - On Board SMC TOD Interface Specification AIASA-14339 (rev.B) – 0G00LV640R930B
A14-05: ATC (Automatic Train Control) – OnBoard CC – PSIS Interface Specification AIASA-17677 0G00LV640R933
A14-06: ATC (Automatic Train Control) – On-board CC-TAR Interface Specifications AIASA-17677 0G00LV640R932
A14-07: ATC (Automatic Train Control) – On-Board CBTC - PV Parameters AIASA-17677 0G00LV640G132
A14-08: ATC (Automatic Train Control) – On-board CC-TCMS Interface Specification AIASA-17677 0G00LV640R931
A14-09: ATC (Automatic Train Control) - Vehicle Functional Interface AIASA-17677-0G00LV640G138
A14-10: ATC (Automatic Train Control) – PV – On board CBTC Train Installation and Interface Specification AIASA-17677 - 0G00LV640G140
A14-11: Implementation of Remote Reset and Isolation of EDOD, PEI and PEH Functionalities AIASA-12332 – 1G00GE410C150 B
A14-12: DCS -Technical Specification AIASA-16267 – 1G00LV260G202
A14-13: DCS - Vehicle - Schematic Drawing AIASA-15870– 1G00LV260C101
A14-14: Washing Plant procedures AIASA-14337
System operating plan (Operational Scenarios) DN1 Passage through the Washing Plant without Washing 1G00GE450C831
System operating plan (Operational Scenarios) DN2 Normal Exterior Cleaning (with Underframe Cleaning - Fixed Mode Option) 1G00GE450C832
System operating plan (Operational Scenarios) DN3 Intensive Exterior Cleaning (with underframe cleaning - fixed mode option) 1G00GE450C833
System operating plan (Operational Scenarios) DN4 Underframe Cleaning 1G00GE450C834
A14-15: In / out Stinger – AIASA-16619 System operating plan (Operational Scenarios) DN6 Train Movement Into and Out of the Workshop Area 1G00GE450C836
A14-16: System operating plan (Operational Scenarios) DN10 Train Movement Onto and From the Wheel Set Diagnostic Track AIASA-14123 - 1G00GE450C840A
A14-17: System operating plan (Operational Scenarios) ME2 Activation of an On-Board Emergency Stop Handle AIASA-12726 1G00GE450C820A

A14-18: System operating plan (Operational Scenarios) ME3 Activation of On- Board Emergency Door Open Handle AIASA-12726 1G00GE450C821A
A14-19: System operating plan (Operational Scenarios) ME1 Carborne Controller FailureAIASA-13616 1G00GE450C819B
A14-20: System operating plan (Operational Scenarios) MF4 Radio (TETRA) Failure AIASA-14322 1G00GE450C815A
A14-21: EMI/EMC ACTIVITIES PLAN AIASA 4261 1G00GE221R705D

14.2 OPERATOR's DESK

14.2.1 General

One Emergency Driving Position shall be provided at one end of each extreme vehicle, providing the possibility for manual train driving.

The Emergency Driving Position shall be integrated into the interior design of the vehicle and shall not be directly visible to the passengers when inactive.

The overall design of the Emergency Driving Position shall be approved by ATTIKO METRO S.A..

14.2.2 Controls at the Emergency Driving Position

All controls at the Emergency Driving Position shall be integrated into a special desk at the bearing structure of the end of the extreme vehicle.

The desk shall be retracted to a safe position, or shall be safely covered when inactive. It shall remain closed via mechanical means and its operation by the Operation Company shall require the use of a special key.

Moreover and if feasible, a seat shall be developed for the Operator. The design of the seat shall be approved by the Service. The front seats of the passengers can also be utilized by the driver in cases of maintenance or in emergencies, should this be ergonomically acceptable.

Special care must be taken in the ergonomic design of the Emergency Driving Position desk and its associated controls, so as to achieve optimum efficiency. All controls shall be easily accessible by the seated or standing Operator, and logically arranged for optimum use. Accepted anthropometrics shall be adopted, so as to ensure that the Emergency Driving Position and its controls can be easily used by member of the Operators population falling between 5% of the female operators and 95% of the male operators.

Any abnormal control functions (unfortunate or erroneous selection of the position of a switch, etc.), as well as the activation of the security brake shall be recorded in the Fault Indication and Diagnosis System, as well as in the Event Recorder.

14.2.3 Controls on the Control Desk

The Operator's Desk shall incorporate all necessary equipment and instruments to safely drive the train to the Depot in case of failure.

The Contractor shall propose an ergonomically designed combination of controls on the vehicle, which shall be reviewed and approved by ATTIKO METRO S.A.. The overall arrangement of the control desk shall be commented upon/approved by ATTIKO METRO S.A., based on the acceptance of the mock-up Emergency Driving Position or on a "real" train, at its manufacturing phase.

The controls desk at the Emergency Driving Position shall feature at least the following items:

- All necessary illuminated indications and selector switches / contact buttons.
- Main Controls Panel.
- Automatic train control Panel.
- Wireless (Radio) communication console.
- Display Unit (TCMS)

Moreover, the Contractor shall supply any other control equipment required for the effective train operation and control.

14.2.4 Illuminated Indications and Selector Switches / Contact Buttons

The illuminated indications and selector switches / contact buttons shall be placed on a panel and shall incorporate at least the following information:

1. **Illuminated indications**
   - Low Battery Voltage
   - Line Voltage
   - Smoke Detection
   - Correct Coupling
   - Minor fault. These faults shall be specified by the Contractor and shall be agreed upon with ATTIKO METRO S.A.
   - Major fault. These faults shall be specified by the Contractor and shall be agreed upon with ATTIKO METRO S.A.
   - Passenger Emergency Signal
   - Door open.

2. **Selector Switches / Contact Buttons**
   - Lamp test
   - Horn
   - Door Open Right Side
   - Door Open Left Side
   - Door Closed
   - ATC Override
   - High Speed Circuit Breaker
   - Coupling
   - Uncoupling
   - Override buttons for: safety loops, emergence escape doors, vigilance, inhibition of traction
   - Mushroom type Emergency Brake Button
   - Contact Button - Hydraulic Brake Release
   - Contact Button – Collector Shoes Up/Down
   - Contact Button – Exterior lights
   - Contact Button – Interior lights
   - Windshield Washer/Wiper Control Assembly
   - Parking Brake
   - HVAC operation

14.2.5 Master Control Panel

The Master Control Panel shall include at least the following controls:

1. **Rotary Selector Switch for Automatic Train Control system (ATC)**

   This Rotary switch shall provide the required functions to cover, as a minimum, the following modes:

Automatic Operation with ATC "ON".

- Fully automatic operation under ATC, including automatic reversal.
- Washing Plant mode for train washing at maximum speed of 5 km/h and automatic movement through the Plant.
- Train coupled with another train.

Operator Driving Mode with ATC "ON".

- Manual operation mode supervised by the ATP, with continuous speed monitoring.

Operator Driving Mode with ATC "OFF".

- Manual driving with speed control; driven by the propulsion system at maximum speed of 15 Km/h across the network.

- The operation of the driving mode selector shall be announced to the train event recorder and to the Control Center.

2. Drive / Brake Master Controllers

The functions of traction, coasting, braking and emergency braking, and Vigilance Control shall be provided by the drive / brake master controller. The Vigilance control must be activated/de-activated at regular and pre-determined intervals, so as to avoid the application of the emergency brake.

3. Rotary Selector Switch "ON"/"OFF".

This Rotary Selector Switch shall have a main key and shall activate the Emergency Driving Position.

4. Odometer

Displays the distance travelled by the train in Km.

5. Speed and Time Indicators

14.2.6 Automatic Train Control Panel (ATC)

The automatic train control panel (ATC) shall display the required functions on the display unit and shall be equipped with a digital tachometer.

14.2.7 Wireless Communication Console

The wireless communication console shall be fitted with the necessary equipment.

14.2.8 Display Unit

The display unit -as detailed in Chapter 13 TCMS- shall be capable of incorporating any of the functions and indications mentioned above. The Contractor shall submit his proposal for review and approval by ATTIKO METRO S.A..

14.2.9 Miscellaneous Items of Equipment at the Emergency Driving Position

The Emergency Driving Position area shall be fitted with a cabinet for storing emergency equipment (hand-held short circuiting device, current collector shoe actuator, axle, first aid kit, flashlight, three-color lamp, human body bags, stretcher for the transport of persons, etc.). The three-color lamp will have its battery charger, in order to maintain its nominal voltage. All emergency equipment shall be provided by the Contractor and the ATTIKO METRO S.A.logo

shall be indelibly marked on it. Moreover, the position shall also provide a battery charger base for charging ATTIKO METRO S.A.'s portable wireless communication device.
A USB port must be provided at the Emergency Driving Position to ensure connection with the control systems of the train.

14.2.10 Model of the Emergency Driving Position

In view of assessing the effectiveness of the Emergency Driving Position and its layout, the Contractor shall produce the Emergency Driving Position design using a full scale mock-up. The Emergency Driving Position mock-up is part of the model for the vehicle's interior specified in paragraph 6. As the design progresses, the modelled material shall be replaced with the actually produced material.

15.0 RELIABILITY, AVAILABILITY, MAINTAINABILITY, SAFETY REQUIREMENTS

15.1 RELIABILITY PROGRAM REQUIREMENTS

15.1.1 General

In order to demonstrate that the Reliability, Availability, Maintainability and Safety (RAMS) requirements are met, the Contractor shall submit, during the design phase, a RAMS demonstration plan to be approved by ATTIKO METRO S.A., in accordance with EN 50126 or other equivalent Standard.

The objective of the reliability analysis is to increase the reliability and availability of the cars. To this end, all of the Contractor's Suppliers shall provide reliability data for their equipment, unless the equipment is determined to be non-critical. Non-critical items are not subject to such an analysis. However, this requirement will not be waived without the approval of ATTIKO METRO S.A..

The Contractor shall provide reliability data in the form to be agreed upon with ATTIKO METRO S.A..

The data shall be based on actual operating information of the equipment. If the equipment in question has no previous operating experience, operational data from a similar piece of equipment shall be used. In this case, the reliability data shall be taken from equipment having approximately the same electrical and mechanical characteristics (including, but not limited to, voltage and current rating, power rating, size and weight) and operating under similar conditions. Under these circumstances, the use of this data must be approved by ATTIKO METRO S.A..

The analysis shall be carried out and provided in accordance with IEC 62278 "Railway Applications – Specifications and demonstration of Reliability Availability, Maintainability & Safety".

15.1.2 Chargeable failure

Chargeable failure is the failure of an item resulting into a temporary or permanent loss of its operation, requiring to be repaired by the maintenance personnel, i.e.:

- Failure of the item during operation, which occurs within the boundaries of the specified design and environmental operational frameworks.
- Item failure caused by improper operation, maintenance or test of the item, as a result of the documentation provided by the Contractor.
- Periodic failures during operation - No Failure Found (NFF) requiring replacement of any sub-system or component.
- Item failure identified during the recommended preventive maintenance period, causing loss of operation or near loss of operation of the specific item (consumables not included).
- Consumables requiring replacement for reasons beyond normal wear/ageing of the fleet.

Approved consumable components are excluded from chargeable failures, unless they fail to complete their designed service life. Moreover, excluded are failures on systems readily attributable to an earlier failure , as well as failures due to is insufficient maintenance on the

part of the Operation Company, failures due to vandalisms or inappropriate use and damage due to operation conditions, or extremely severe weather conditions.

15.2 RELIABILITY REQUIREMENTS

15.2.1 First Reliability Target: Mean Distance Between Failures

The Mean Distance Between Failures (MDBF) shall be:

$MDBF_1 \geq$ 100,000 km. (train out of service)
$MDBF_2 \geq$ 20,000 car km. (train in service but in degraded mode)

The aforementioned distances $MDBF_1$ and $MDBF_2$ shall be calculated based on the following formulas:

$MDBF_1 = D/F_1$
$MDBF_2 = D/F_2$
whereas
D is the total travelled distance of the train fleet, cumulatively, during the measurement period,
F1 is the total number of chargeable failures putting the train out of service, and F2 is the total number of chargeable failures leading to degraded operation mode.

F_1 failure placing the train out of service is defined as follows:

- Failure placing a train out of service on the Metro network and requiring towing by another train
- Failure resulting in immediate withdrawal to the Depot, without passengers
- Failure resulting in non-scheduled commencement of train operation

A non-exhaustive list of F_1 failures is presented as follows, resulting in the withdrawal of the train car:

I. Loss of traction resulting in train withdrawal
II. Complete failure of the battery charging system
III. Complete failure of the TCMS function
IV. Door closing failure
V. etc.

Apart from the above, bidders shall also take into account any other failure placing the train out of revenue service.

F_2 failure resulting in degraded operation mode:

A non-exhaustive list of F_2 failures is presented as follows, resulting in degraded operation mode, which shall be taken into account during the Tender phase:

- Failure causing a delay of 4 min or more in the train revenue service at the end of the route, or to its departure from the Depot.
- HVAC failure causing train performance loss equal to or higher than 50%
- Failure requiring isolation of more than two doors on the same side of the train.

The MTBF shall be calculated based on the following formula:

$$\text{MDBF} = \frac{\sum_{i=1}^{n} km_i}{\sum_{j=1}^{n} F_j}$$

Km = the total number of km of each train

i = train number

F = failure caused during the subject verification period

j = failure number

Bidders shall specify in their Technical Offer the Reliability values $MDBF_1$ and $MDBF_2$ of the fleet, as described above, based on the anticipated annual covered milage of 120.000 km/train.
The values provided by the Bidder shall be binding and considered as an integral part of the Performance Specification. The values to be provided with the Offer shall be verified against the actual reliability, measured during the RAMS demonstration period.

15.2.2 Second Reliability Target: Mean Distance Between Component Failures

The Mean Distance Between Component Failures (MDBFCF) is the ratio of the total mileage cumulated by the total number of identical components, to the total number of the respective chargeable failures that occurred within the group of these identical components.

The Mean Distance Between Component Failures (MDBCF) of the major systems and components of the train shall be no less than the values shown in the following table:

System	MDBCF (km)
Complete Train	2,600
Car Body	175,000
Gangway	100,000
Bogie	50,000
Automatic Coupler	200,000
Door System and Control equipment (including interlocks and signals)	15,000
HVAC - Passenger Compartment Air Conditioning System	30,000
Mechanical Brake Equipment	17,500
Traction System	24,000
Auxiliary Power Supply System	30,000
Communications and Passenger Information System (except Radio System) and Safety System	26,000
Train Control and Management System	25,000
NOTE: The figures above are valid per train.	

Table 15.1.2.2.1 MDBCF of Major Systems and Components

The Bidder shall complete the above Table with his reliability target values for the remaining systems and components, maintaining at the same time all values mentioned above.

15.3 AVAILABILITY REQUIREMENTS

Availability shall be calculated based on the following formula:

$$As = \frac{\sum_{i=1}^{n} \frac{F_{Fi} - F_i}{F_{Fi}}}{n}$$

As = Availability at the specific time.

n = Monittoring period, number of days

F_{Fi}= Totalnumberoftrainsminusthose trains scheduledformaintainance, or trains that cannot be checked due to accident, vandalism or failure not attributed to the Contractor.

Fi= Numberoftrainsnotavailableforcontrolatthespecifictime period due to the Contractor's liability.

Each day, during service hours, a random measurement shall be taken. For the purposes of this measurement, the service hours shall be from 06.00 to 22.00.

The random time shall be selected using an acknowledged and approved selector system and a selection point at any 30min interval.
In their Technical Offer, Bidders shall specify the fleet availability. The value provided by the bidders shall be binding and shall be considered as integral part of the Performance specification. The value quoted in the offer shall be confirmed against the actual availability, measured during the RAMS demonstration period.

15.3.1 Availability Target

On the basis of the aforesaid definition, the minimum average monthly train availability shall be 92%.

15.4 MAINTAINABILITY REQUIREMENTS

The design criteria for optimizing maintainability shall include: equipment organization through modularity, accessibility, built-in-tests, standardization, interchangeability and installation simplicity.

The Contractor shall submit a Maintenance Plan. In addition, he shall include the Preventive Maintenance stages time periods.

The Contractor shall provide a maintainability analysis for ATTIKO METRO S.A.'s review and approval. The objective of the maintainability analysis is to minimize the time and effort involved in performing both scheduled and unscheduled maintenance. To this end, all of the Contractor's Suppliers shall provide information regarding the recommended maintenance procedures for their equipment, which shall be in compliance with this Performance Specification. Non-critical items are not subject to such an analysis. However, this requirement will not be waived without approval by ATTIKO METRO S.A..

The Contractor shall provide a Maintainability Design Checklist. The content and format of this checklist shall be as agreed upon with ATTIKO METRO S.A.. In addition, the Contractor shall provide information regarding Mean Time To Repair (MTTR) of the equipment, in man-hours. This should include the time required to remove and replace the item, as well as the actual repair time.

The Contractor shall submit a complete Analysis of the Life-Cycle Cost (LCC) for the vehicle, in accordance with EN 50126.

The Contractor shall provide a listing of the lowest level replaceable units (LLRU) in the equipment supplied. For all LLRU units, diagnostic tools shall be provided, along with the respective software.

15.4.1 Maintainability Target

The MTTR is the time required for repairing the failure of any system or sub-system, so that the vehicle becomes operational.

The MTTR for a car shall not exceed 1.8 hours, which shall be based on the weighted average of the MTTR of the major car systems, which shall not exceed those listed as follows:

System	MTTR (man-hours)
Bogie	1.57
Automatic Coupler	1.50
Door System and Controls (including interlocks and signals)	0.84
HVAC – Passenger Compartment Air Conditioning System	2.12
Friction Brake Equipment	2.03
Propulsion System	1.75
Auxiliary Power Supply System	1.50
Communications and Passenger Information System (except Radio System) and Safety System	1.04
Lighting System	0.50

Table 15.4.1.1 MTTR of Major Systems

The following formula shall apply to calculate the system MTTR.

$MTTR_{system} = T/F$

where T = The total number of corrective maintenance time within a period

F = The total number of failures within the same period

Moreover, the following shall be also submitted, namely:
MTRR, Mean Time to Remove and Replace
MTBM, Mean Time between Maintenance.

In cases, the repair method involves replacement of a system by another, which has been repaired, then the minimum quantity of the spare parts shall be calculated so that availability be not affected.

In addition, the Mean Time Maintenance Man-hours (for preventive and corrective maintenance) per Year per Vehicle (MMMH) shall be calculated.

15.5 SAFETY REQUIREMENTS

The Contractor shall provide the following for review and approval of ATTIKO METRO S.A.:

- A Rolling Stock Safety Management Plan,
- A Rolling Stock Safety Analysis
- A List of Rolling Stock items, including interface hazards, which should take into account the classification of the risk as an impact and the frequency of occurrence in tabulated form. Then, risk shall be classified as follows:
  - Negligible (no action required)
  - Acceptable (accepted based on ATTIKO METRO S.A.'s concurrent opinion)

- Undesirable (accepted based on ATTIKO METRO S.A.'s concurrent opinion)
- Unacceptable (to be eliminated).

The safety of the train crew, maintenance personnel, passengers and bystanders must all be taken into account.

In addition, the Contractor shall provide his Rolling Stock System Safety Target for review and approval by ATTIKO METRO S.A.. To this end, all of the Rolling Stock's sub-contractors must be able to demonstrate the inherent safety of all their equipment.

The safety requirements shall be described according to the terminology defined in IEC 60050-191 Amendment 1: International Electro-technical Vocabulary.

Furthermore, the Contractor shall provide:

- The quantification of the inherent hazards of the Rolling Stock equipment and
- The Rolling Stock System Safety Case.

Additionally the Contractor shall develop a Rolling Stock Quantitative Risk Analysis Assessment during the Design.

The Failure Mode Effects and Criticality Analysis shall be performed and provided in accordance with IEC60812 and EN 50126.

All Rolling Stock System Hazard Analyses, and Rolling Stock Sub-System Hazard Analyses, shall be performed in accordance with the requirements set forth herein.

The Contractor shall also take positive steps to minimize the consequences of these hazards. This shall be effected through design (interlocks, fail-safe design, redundant design, safety overrides, protective devices, etc.), preventive maintenance procedures, operator training, warnings, or a combination of the above. The Hazard Severity rating of any given hazard shall take into account any mitigating factors in the design.

It is hereby clarified that the Rolling Stock safety cases both, the generic and the application safety cases, shall cover:

- The entire train
- All trainborne control systems including their interfaces with train operation.

The Contractor shall propose for approval to ATTIKO METRO S.A. a "Notified Body", who shall make the safety assessment of SIL 3 and SIL 4 level systems including the safety related interfaces. The "Notified Body" shall be independent from the Contractor.

At least the following train operations shall be certified at SIL levels:

- Door opening in emergencies: at least SIL 3
- Safe detection of the state "Doors closed and locked" SIL 4
- Traction suspension and emergency brake in case "Doors Closed and locked" is not detected SIL 4
- Doors are kept properly locked and closed to prevent door opening without detecting the zero speed signal: at least SIL 3
- Traction suspension in case of emergency braking: SIL 4.

The same or another "Notified Body" accepted by ATTIKO METRO S.A. shall evaluate the Rolling Stock safety from the design to the testing level, as well as the interfaces with the remaining systems and with the existing rolling stock and shall issue a Certificate for the safe

operation and the suitability for commercial operation (with passengers) of Series II Trains in the Thessaloniki Metro Network.

The results of the evaluation shall be incorporated into the general Project safety case.

15.6 RELIABILITY, AVAILABILITY, MAINTAINABILITY AND SAFETY (RAMS) DEMONSTRATION PROGRAM

Setting each vehicle in operation shall be agreed upon and co-signed by the Contractor and ATTIKO METRO S.A..
The maintainability demonstration program shall start six (6) months (burn-in period) after the commissioning of the last train and shall last at least 12 months.

At the end of RAMS demonstration period, the Contractor shall prove that the fleet has achieved all RAMS-related targets, as set in his Technical Offer, and the subject program shall be successfully completed.

If even one of the RAMS targets is not achieved, then the period will be extended so as to simultaneously and successfully achieve all RAMS targets during a period of 12 successive months. The guarantee shall be extended until all RAMS targets are achieved.

In order to apply the RAMS demonstration plan, the Contractor shall install a computer integrating a software application, operating on a network environment such that ATTIKO METRO S.A./Operation Company will have the necessary access to the data therein. The system will be operative throughout the warranty period. The variables and general data utilized by the software and recorded in the computer, as well as the mathematical formulae utilised for the calculation of statistical quantities, including the calculated statistical figures themselves shall be submitted to ATTIKO METRO S.A. for approval. At the end of the warranty period, the electronic system (hardware and software) will become property of the Operation Company.

Regardless of the aforementioned 12-month program, the Contractor shall run the fault monitoring system in relation to the equipment's RAMS, from the moment the first train is put into revenue service until the end of the vehicle warranty period. Inputs to this system shall be agreed upon on a monthly basis between ATTIKO METRO S.A./Operation Company and the Contractor.

15.6.1 Failure Analysis

In the event of any chargeable failure as the term is defined in paragraph 15.1 herein, during the contractual testing period or the guarantee period, the Failure Monitoring System shall be updated. Subsequently, the Contractor shall submit the following within a 30-day period:

- A Failure Analysis Report, which will clearly identify the root causes of the failure,
- Corrective actions, along with
- The relevant time schedule for failure rectification.

In case corrective actions are necessary, the Contractor shall make the pertinent recommendations to ATTIKO METRO S.A. for approval.

The Failure Analysis Reports shall be submitted to ATTIKO METRO S.A./Operation Company for approval.

15.6.2 Systematic Failures – Defective Equipment

In case 10% of the entire hardware or software suffers failures not related to one another, these shall be considered as defect of the fleet or systematic failure and the specific item shall be characterized as defective.

It shall be examined whether the above is a construction defect or a design flaw. On this basis, the Contractor shall develop and implement a plan encompassing:

- Fault analysis
- Checking of the remaining train fleet
- Corrective actions to rectify the failure
- Time Schedule for Repairs.

The corrective actions plan shall be approved by ATTIKO METRO S.A.. Correcting a design flaw or a series construction defect requires fleet refurbishment. In such cases, a 3-year guarantee period shall commence for the refurbished equipment, along with a 12-month period of RAMS measurements for both the system in which the subject failure occurred and for the entire train. The guarantee and RAMS commencement period shall start upon completion of the train fleet repair and its acceptance by ATTIKO METRO S.A..

15.6.3 Applicable International Standards

The System Analysis shall be carried out in accordance with the Standards quoted below, while not revoked is the requirement for compliance with any other Standard to which reference is made elsewhere in this Specification.

- EN50126, Railway applications – The specification and demonstration of dependability, availability, maintainability and safety (RAMS),
- EN50129, Railway applications – Safety related electronic systems for signalling,
- IEC 61508, Functional safety of electronic/programmable electronic safety-related systems,
- EN50128: Railway applications – Software for railway control and protection systems.

15.6.4 Main Interfaces

This section identifies the minimum interface issues that should be considered in order to achieve safe operation of the train vehicles.

- Compatibility between the trains and Electrification Systems (i.e. System Voltage, Line Current, Harmonics, System Performance, Current Collector Performance, etc).
- Electromagnetic Compatibility between Infrastructure and trains.
- Compatibility of the trains with network infrastructure (e.g., tracks, alignment, point machines etc.)
- Compatibility of train with Control and Communication Systems
- Compatibility of trains with Signalling System
- Compatibility of train with Other vehicles of the Operation Company (Locomotives, series I)
- Compatibility of trains with the station platforms and environmental conditions, in general.
- Compatibility of train with the special needs of Passengers (e.g. pace-makers)
- Compatibility of trains with Emergency Procedures (e.g., fire, detrainment, crashworthiness/structural strength, emergency equipment, emergency access, etc.)
- Train Compatibility with PSDs.

15.6.5 Documents deliverable to ATTIKO METRO S.A. to demonstrate system assurance

System assurance shall be demonstrated through the submission of the documents listed in the table below, at the Contractor's exclusive responsibility. Approval by ATTIKO METRO S.A. of all the documents presented below constitutes a precondition in order to demonstrate system assurance.

TITLE	DELIVERY DATE	EXPLANATION
System Assurance Plan	Within one month as of Contract signing	It shall contain the Contractor's proposals for undertaking the System assurance activities throughout service life of the project
Preliminary Hazard Analysis	At the end of Design Stage, Equipment Configuration and selection stage	
Fault Tree Analysis(FTA)	At the end of design stage	
Failure Mode Effect and Criticality Analysis (FMECA)	At the end of design stage	
Interface Hazard Analysis, **System Hazard Analysis**, **andOperating Hazard Analysis**	At the end of design stage, Equipment Configuration and selection stage. Updated during the following stages: Manufacturing, Construction and Installation Stage Testing and Commissioning Before the end of the warranty period.	
RAM Modelling Allocation and Prediction	At the end of Design Stage, Equipment Configuration and selection stage and updated during the following stages: Manufacturing, Construction and Installation Stage Testing and Commissioning End of the warranty period	RAM Testing will be carried out during the following stages: Design, Equipment Configuration and selection Manufacturing, Construction and Installation Stage Testing and Commissioning RAM demonstration period.
Safety Case Document	At the end of Test and Commissioning period.	
RAM Performance Demonstration Report	at the end of RAM demonstration period.	

System Assurance Report	Deliverables at the end of the following stages: Design, Equipment Configuration and selection Manufacturing, Construction and Installation Stage Testing and Commissioning End of the RAM demonstration period.	It shall enclose the current status of the above deliverables and shall summarise any findings.

16.0 GENERAL DOCUMENTATION REQUIREMENTS

The Contractor shall provide listings on a monthly basis that record the status of all documentation provided to ATTIKO METRO S.A..

Additional details (such as document numbering, drawing guidelines, etc.) regarding the production of drawings and documents are given in ATTIKO METRO S.A. GS 0100 Drawing Office Manual. For the production of documents and drawings, the Contractor shall take into consideration the general guidelines given in ATTIKO METRO S.A. Drawing Office Manual and he shall then submit a document describing the codification, numbering and symbols for the entire electromechanical equipment, as well as the notation and symbol system and guidelines used by him in the production of drawings and other technical documents, including all electrical, connection and wiring diagrams. Once approved by ATTIKO METRO S.A., this numbering, coding and notation / symbols shall apply to all drawings, diagrams, technical documents, lists of equipment, spare parts, etc. Regarding drawing and document numbers, the Contractor is allowed to propose a modified codification for the main system categories, other than the codification proposed in the Drawing Office Manual without however allowing for any modifications to the document numbering system. Adherence to international standards shall be required, as also mentioned in paragraph 16.1.4.

The International System of Units (SI) shall be utilized for all drawings and documentation.

16.1 DRAWINGS, GENERAL

All drawings furnished by the Contractor shall be in accordance with the following guidelines:

1. All drawings shall be supplied in printed and electronic format. The electronic format shall require the approval of ATTIKO METRO S.A., and shall be accompanied by the required number of prints.

2. The drawings submitted shall be of a quality capable of being clearly reproduced.

3. The drawing number and its revision level shall be clearly marked on the drawing.

4. When revisions are made on the drawings resulting in resubmittal, these drawings shall be accompanied by a cover letter detailing the changes made.

16.1.1 Drawing Submittals

16.1.1.1 Drawings to be Submitted for Acceptance

The drawings to be provided by the Contractor for approval by ATTIKO METRO S.A. shall include, but not be limited to, information detailed in the following paragraphs. ATTIKO METRO S.A. reserves the right to request additional drawings, as required, to clarify and amplify the intent of the drawings submitted, and reserves the right to approve such drawings. All drawings shall be production drawings. The Contractor shall also submit a Drawing Tree, delineating all major categories of drawings involving the construction of vehicles, and indicating construction and system logic.

16.1.1.2 System Requirements

- Exterior elevations
- Exterior elevations of each car type
- Electrical schematic diagram (750Vdc equipment)
- Electrical schematic diagram (110Vdc, 24Vdc, 12Vdc equipment)
- Electrical schematic diagram (3-phase, 400V AC equipment)
- Electrical schematic diagram (1-phase, 230V AC equipment)
- Electrical equipment (split in separate functional system groups)

- Grounding scheme
- Pneumatic schematic diagram
- Pneumatic schematic (air brake equipment)
- Hydraulic diagram
- Interface control drawings
- Clearance drawings
- Vehicle interrelationships during curving.

16.1.1.3 Vehicle Body

- Car body framing assembly and major subassemblies (under frame, bolster, anti-climbers, side frames, roof frames, end frames, coupler attachments, etc.)
- Roof equipment layout
- Under floor equipment layout
- Conduit, wire duct and cable layouts and details
- Transverse sections to show all variations in cross section (through doorways, windows, etc.)
- Bogie assemblies
- Bogie frame assemblies
- Suspension details
- Wheel details
- Axle assemblies and details
- Axle Box bearing details
- Grounding brush installation

16.1.1.4 Couplers and Draft gear

- Automatic coupler assembly and installation
- Automatic coupler electrical connector details
- Semi-permanent coupler assembly and installation
- Pneumatic connection details
- Electrical connection details
- Collision Energy Absorption Mechanism

16.1.1.5 Car Interior

- Floor arrangements
- Ceiling arrangements
- Longitudinal section of both sides of all vehicles
- View of ends of all vehicles
- Lighting fixture assembly and installation
- Air diffuser assembly and installation
- Public Address speaker assembly and installation
- Passenger seat assembly and installation
- Stanchion and grab rail assembly and installation
- Handhold assembly and installation
- PSN area details, including wheelchair securement
- Interior lining arrangement and details
- Flooring installation and details
- Vehicle views with Operator’s Desk
- Operator’s Desk’ equipment layout
- Operator’s Desk’ desk layout
- Assembly and installation of master controller and mode switch

16.1.1.6 Doors and Door Controls

- Door system electrical schematic
- Door operator assembly and installation
- Door assembly, details and installation (overall)
- Door threshold assembly and installation (overall)

16.1.1.7 Air Conditioning

- Air Conditioning unit assembly, details and installation
- Air Conditioning system electrical and piping schematic diagrams
- Air Conditioning unit electrical and piping connections
- Refrigerant compressor assembly
- Evaporator and condenser coil assemblies

16.1.1.8 Braking System

- Disc brake assembly and installation
- Brake actuator caliper assembly and installation
- Brake pad details
- Pneumatic or hydraulic control units assembly and installation
- Electronic control unit assembly and installation

16.1.1.9 Pneumatic Equipment

- Piping layout and installation
- Air reservoir assembly and installation
- Hardware details and installation
- Air compressor assembly and installation

16.1.1.10 Propulsion System

- Propulsion system electrical schematic diagram
- Power conversion equipment assembly and installation
- Propulsion inverter control unit assembly and installation
- Traction control unit assembly and installation
- Traction motor assembly and installation
- Gearbox and coupling assembly and installation
- Braking resistor assembly and installation
- Speed sensor details
- High speed circuit breaker assembly and installation
- Grounding brush assembly and details

16.1.1.11 Auxiliary Electrical Supply System

- Auxiliary power supply system electrical schematic diagram
- Auxiliary power supply equipment assembly and installation
- Battery assembly and installation
- Battery box assembly and installation
- Miniature circuit breakers details and installation

16.1.1.12 Communications System

- Communications system electrical schematic diagram
- Public Address module assembly and installation
- Radio communication equipment assembly and installation
- Passenger Information system electrical schematic diagram
- Passenger Information system assembly and installation
- Closed Circuit Television schematic diagram

- Closed Circuit Television assembly and installation

16.1.1.13 Automatic Train Control System - Rolling Stock Interface

- ATC system – Rolling Stock interface schematic
- ATC equipment – Rolling Stock interface: Assembly and installation
- Metro equipment interface (PSD, etc.)
- List with all interface signals between ATC and Rolling Stock which shall show the unique signal code , brief description, type of signal, e.g. digital etc. the source (device, terminal code), destination (device, terminal code), as well as description of the anticipated effect of the signal on the equipment.

16.1.2 General Format

1. All drawings shall be produced on standard sheet sizes.
2. All drawings shall contain a title block in the lower right hand corner of each sheet, containing the following minimum information:
   - Supplier company name.
   - Drawing title (which should not be ambiguous).
   - Revision level of drawing, and date of revision (which must be updated for any change and resubmitted for ATTIKO METRO S.A. acceptance).
   - Scale, where appropriate.
   - Number of sheets as "x" of "y".
   - Date drawing released.

3. A table of revisions shall be provided for each drawing, which shall show each revision level, the date and the revision made. It is acceptable for the Contractor to either briefly describe the change in the revision table and to fully describe the nature of the work in a separate revision history document, or to refer to the engineering change notice number.

4. Either a list of parts and required quantities shall be provided on each drawing, or a separate bill of material shall be submitted.

5. The drawing shall comply with accepted drawing standards. The Contractor shall define which standard shall be used. The drawing system shall be in accordance with the European system.

6. A clear area shall be made available in the lower, right hand side corner of the drawing for ATTIKO METRO S.A.'s title block. As a minimum, the title block shall include space for ATTIKO METRO S.A. Project Manager and Responsible Engineer approval, and the ATTIKO METRO S.A. approval status.

16.1.3 Drawing Requirements

Drawings submitted shall conform to the following **minimum** requirements in relation to scope, content and format. These requirements are not intended to restrict the presentation of information and should apply as appropriate to the equipment concerned.

All pneumatic diagrams and graphical information shall comply with the requirements of ISO 1219-1.

All electrical drawings (circuit diagrams, functional analysis, circuit diagrams explanation, arrangement drawings, connection diagrams, cable diagrams, cable lists, terminal connection tables etc) shall be produced in A3 format in accordance with Standard IEC 61082-1/2/3. Graphical symbols on electrical drawings shall comply with Standard IEC 60617-1/10, while designation of each item shall be in accordance with IEC 60750.

All electrical and electronic equipment shall be documented in accordance with IEC 60571-1/2/3.

Mechanical drawings shall be delivered in Autocad format.
Electrical drawings shall be delivered in a format such that all drawings be linked. The electrical design software package shall be capable of automatically producing cable lists and terminal connection tables. Any change in or modification to any item of equipment on the circuit diagrams shall update every related drawing and/or cable list and/or terminal connection table (e.g. the use of a free contact of an existing relay will be automatically reflected in the relevant drawing sheet as well as in the cable list and the terminal connection table).

16.1.3.1 Top Level Assembly/Outline Drawing

These drawings shall show equipment, as supplied, in sufficient detail to determine compliance with this Performance Specification. Drawing content shall be as follows:

Important dimensions:

- Mounting arrangements and their tolerances. In addition, wherever needed, the applicable tightening torques.
- Panel, enclosure, frame, etc. construction, material, and finish.
- Direction of rotation (where applicable), speed or frequency.
- Location of center of gravity, mass (in full working order), and mass corresponding to each mounting point.
- Location and size of grounding straps or grounding facility.
- Location of maintenance features and clearance requirements for removal of all normal maintenance items.
- Labelling and location of notices and signs.
- Special mounting instructions.
- Equipment arrangement, including fastening items of equipment.
- List of parts, which must include the type number of devices as documented by the original manufacturer.

The following electrical information shall be provided on drawings:

- Operating voltage, power consumption, power factor, and tolerances thereof.
- Type of windings (for transformers and machinery) and type of insulation.
- Resistance and tolerances.
- Contact ratings.
- Operating parameters relevant to type of device.
- Type and size of cables and wires used.
- Wire codes, and marking methods of wires and devices.
- Indication of color-coding of wire insulation (if used).

16.1.3.2 Circuit Diagrams

Circuit diagrams shall show in diagrammatic form how the train automation functions.

Circuit diagrams shall fully integrate all systems and subsystems. It shall not be acceptable for a single document to integrate independently-produced subcontractor drawings. Circuit diagrams shall be in book form, no larger than A3 format.

Circuit diagrams must present the following:

- Grid reference 1,2,3,4,5,6 horizontally and A,B,C,D vertically,
- Brief functional description related to grid reference (Train activated, Dead man, etc.),
- Equipment designation codes on the left hand side of the items,

- Location designation codes on the left hand side of the items, if the location differs from the location indicated at the bottom right corner,
- Functional systems codes on the left hand side of the items,
- Cross reference from one circuit element to another on the left hand side of the items (e.g.=71/39.5D). Cross reference shall be effected automatically by defining equipment and components,
- Terminal connections on the drawings lines,
- Connection numbers on the right hand side of the terminal connection symbol,
- Brief description on control lines crossing the train as bus lines (door close command, emergency brake, 3Km/h, shoes down, 750 V, etc.)
- Contacts aligned below their equipment and terminals aligned vertically or horizontally with their terminal block designations (-X2 : 18 :19 :20)
- Wire identification code numbers,
- Car builder/Supplier interface terminal code numbers and connector pin numbers,
- Trip/rupture current values of all protective devices,
- Settings of all pressure, temperature, limit switches, time delay relays, etc., with tolerances,
- Values and tolerances of passive components,
- Load power consumptions,
- Circuit voltages (nominal).

16.1.3.3 Functional analysis

A Functional Analysis Manual, based on the train circuits and the automation system for each system and for the entire train-set shall be submitted.

16.1.3.4 Circuit diagrams explanation

The circuit diagram explanations shall present in all details the circuit diagrams by providing specific references to all involved equipment, components and control elements. The explanation will be made system by system. The explanations will be provided to ATTIKO METRO S.A. in A4 paper size format.

16.1.3.5 Arrangement drawings

In Electrical cabinets, electrical boxes, and any other electrical enclosure, all electrical - electronic equipment including all relays, switches, buttons, circuit breakers, terminal block strips, cable trays, instruments, etc., shall be shown in arrangement drawings.

16.1.3.6 Connection diagrams

Connection diagrams must show and list the connections of an installation and equipment. They shall also provide the above mentioned information for the connections within the constructional units.

16.1.3.7 Cable diagrams

Cable diagrams shall show and identify cable routing, cable trays, conduits, connections, etc.

16.1.3.8 Cable lists

Cable lists shall identify all cables and cores. For each separate section of cable, at a minimum the following information shall be provided:

- Cable and core codes
- Origin (FROM device/terminal)
- Destination (TO device/terminal)
- Wire size
- Voltage rating
- Length.

16.1.3.9 Terminal connection tables

Terminal connection tables shall provide information concerning internal and external connections to the terminals, showing core and cable codes.

16.2 ENGINEERING DOCUMENTATION SUBMITTAL REQUIREMENTS

The Contractor shall furnish one copy in electronic format and all required prints of the latest revision of all necessary contract drawings and documents, including as-built drawings. The electronic format shall be as approved by ATTIKO METRO S.A., but must allow the latter to clearly document future changes. The Contractor shall control all subsequent revisions to these documents and shall submit one copy in electronic format and all required prints of all revisions of these controlled documents to ATTIKO METRO S.A. for approval. Where drawings are not available in electronic format, the Contractor shall submit scanned images (at 300 dpi) of full-size original drawings on “Mylar” or clean original paper sheets, which shall be provided as image data files in “TIFF”, “PCX”, or an approved alternative format, plus all required prints.

All documents shall be written in the English and Greek languages.

All drawings and documents submitted for approval shall be grouped into separate, logical packages by subject (e.g., car body structure, bogies, seating installation, lighting).

16.3 MAINTENANCE MANUALS

16.3.1 General

Fully integrated, modern maintenance manuals shall be submitted, to provide step-by-step instructions on the manner to repair and replace all components on the vehicles, down to the Lowest Level Replaceable Unit. It shall be assumed that the technicians performing this work are familiar with rail vehicles, but not a detailed working knowledge.
The LLRU shall be defined as any component within an assembly that is identified in the Original Equipment Manufacturer’s illustrated parts list and/or is offered for sale by the OEM. Any changes to the documentation needed as a result of service experience during the warranty period, shall be incorporated at no cost to ATTIKO METRO S.A..

The maintenance manuals shall provide all necessary detail to perform the work required, and shall include the use of diagrams, drawings, photographs, illustrations, etc., as appropriate for the task at hand. Detailed maintenance and troubleshooting procedures and test and repair procedures shall be provided for all electronic assemblies and circuit boards. As regards the door systems, the Auxiliary Power Supply Inverter, the Braking system and the Train Control and Management system, the Contractor shall submit the Boolyn logic diagrams gates (AND OR etc.) specifying the operation of the respective equipment items. Description and explanation of the diagrams describing the equipment operation and failures shall be provided. Manuals shall identify all tools (special and standard tools) needed to perform the work. This listing of tools shall be provided in the section describing the distinct task being performed. The Contractor shall provide an appropriate number of all special tools for ATTIKO METRO S.A.’s use. Special tools shall include diagnostic test equipment for all electronic assemblies and printed circuit boards, and the equipment needed to test all train lined systems. Suitable manuals shall be provided for pertinent special tools (diagnostic equipment, etc.)

All manuals shall be submitted in electronic format to be approved by ATTIKO METRO S.A. (which must allow ATTIKO METRO S.A. to clearly document future changes), and in the required number of properly bound oil and dirt resistant hard copies (“Tyvek” or equivalent). The material for the hard copies shall be approved by AM.

All manuals shall be approved by ATTIKO METRO S.A..

The maintenance manuals shall be divided into three parts: Running Maintenance, Scheduled Maintenance, and Overhaul.

16.3.2 Running Maintenance Manuals

The Running Maintenance Manuals shall describe all work and inspections to be performed on the trains on a daily or routine basis, including servicing, lubrication, adjustments, problem diagnosis, etc. Cleaning procedures shall be recommended, including necessary cleaning solutions. A substantial troubleshooting guide shall be included to streamline the process of finding the root cause of problems and providing resolution.

16.3.3 Scheduled Maintenance Manuals

The Scheduled Maintenance Manuals shall describe all work and inspections to be performed on the trains according to pre-set time periods or distance travelled. They will contain all the Work Instructions per maintenance period, such as Nominal Maintenance Examination, Limited Inspection, etc. An appropriate troubleshooting guide shall be provided.

16.3.4 Overhaul Manuals

The Overhaul Manuals shall describe all disassembly works and inspections to be performed on the trains at designated overhaul periods. An appropriate troubleshooting guide shall be provided. The Contractor must submit the Test Manuals applicable after each Partial and Main Overhaul.

16.4 ILLUSTRATED PARTS CATALOGUES

The Illustrated Parts Catalogues (IPC) shall enumerate and describe all assemblies and constituent components down to the LLRU. The IPCs shall be ordered in a logical fashion, by system, and shall identify the Contractor's part number and the OEM part number. The Contractor shall also include ATTIKO METRO S.A.'s stock number. Where possible, the commercial or military equivalent for all pertinent parts shall also be provided. For standard commercial spare parts, i.e., screws, nuts, washers, their type, dimensions and applicable standard must be mentioned. Additionally where possible, the Contractor shall provide the pertinent information on at least two different alternative suppliers for all components. Any changes to the documentation needed as a result of service experience during the warranty period, shall be incorporated at no cost to ATTIKO METRO S.A..

At the front pages of the IPC there shall be a list cross-referencing the part number, the page number and the serial number of the part.

Common spare parts among different assemblies shall bear the same Contractor's part number. The assembly of all parts next level shall be clearly identified.

The essential use of individual, isometric drawings and drawings in full development, photographs, illustrations, etc., shall aim at clearly identifying all components down to the LLRU.

The IPCs shall be submitted in electronic format to be approved by ATTIKO METRO S.A. (which must allow ATTIKO METRO S.A.to clearly document future changes), and in the required number of properly bound oil and dirt resistant hard copies ("Tyvek" or equivalent). The material for the hard copies shall be approved by ATTIKO METRO S.A..

The Contractor shall provide one fully equipped workstation whereby the documentation shall be modified, including all required hardware and software. The software license shall be purchased in the name of ATTIKO METRO S.A.. Moreover, the Contractor shall be required

to provide the required training for two persons on the part of ATTIKO METRO S.A. staff, who will be able to adequately utilize the workstation. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

The Illustrated Parts Catalogues shall be approved by ATTIKO METRO S.A..

16.5 OPERATOR'S MANUALS

The Contractor shall provide ATTIKO METRO S.A. with the required number of properly bound A5-size Operator's Manuals, which shall contain all information required for the proper operation of the vehicles. This shall include general car familiarization material and its location, function and operation of all controls, switches, indicators, gauges, etc. Any changes in the documentation needed as a result of service experience during the warranty period, shall be incorporated, at no cost to ATTIKO METRO S.A..

The Operator's Manuals shall also be submitted in electronic format, to be approved by ATTIKO METRO S.A., which must allow ATTIKO METRO S.A.to clearly document future changes.

The Contractor shall provide one fully equipped workstation whereby the documentation shall be modified, including all required hardware and software. The software license shall be purchased in the name of ATTIKO METRO S.A.. Moreover, the Contractor shall be required to provide the required training for two persons on the part of ATTIKO METRO S.A. staff, who will be able to adequately utilize the workstation. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

The Operator's Manuals shall be approved by ATTIKO METRO S.A.. This manual shall be placed in Operator's Desk area.

16.6 TRAINING MANUALS

The Contractor shall provide ATTIKO METRO S.A. with the required number of properly bound Training Manuals, which will be used to train ATTIKO METRO S.A.'s personnel to operate and maintain the vehicles.

The Training Manuals shall also be submitted in electronic format, to be approved by ATTIKO METRO S.A., which must allow ATTIKO METRO S.A. to clearly document future changes.

The Contractor shall provide one fully equipped workstation whereby the documentation shall be modified, including all required hardware and software. The software license shall be purchased in the name of ATTIKO METRO S.A.. Moreover, the Contractor shall be required to provide the required training for two persons on the part of ATTIKO METRO S.A. staff, who will be able to adequately utilize the workstation. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

The Training Manuals and the entire training program shall be approved by ATTIKO METRO S.A.

16.7 CAR HISTORY BOOKS

The Contractor shall provide ATTIKO METRO S.A. with a Car History Book for each car at the time of delivery. Each Car History Book shall contain the following car-specific information:

- Certified weight (car and axle loads), including scale tickets.
- Results of all tests performed on the complete car and its systems and subsystems.
- Description of all modifications, including incorporation date.
- List of defects noted and disposition.

- List of serial-numbered equipment.
- Axle assembly (wheels, bearings, gears) mounting records, including pressing charts.
- Provision for ATTIKO METRO S.A. to record inspection, servicing, overhaul and repair activities.
- Shipping documents.

The Car History Books shall also be submitted in electronic format, to be approved by ATTIKO METRO S.A., which must allow ATTIKO METRO S.A.to clearly document future changes.

The Contractor shall provide one fully equipped workstation whereby the documentation shall be modified, including all required hardware and software. The software license shall be purchased in the name of ATTIKO METRO S.A.. Moreover, the Contractor shall be required to provide the required training for two persons on the part of ATTIKO METRO S.A. staff, who will be able to adequately utilize the workstation. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

The Car History Book format shall be approved by ATTIKO METRO S.A..

16.8 PHOTOGRAPHS

The Contractor shall supply three sets of professional-quality A4 size photographs which clearly depict the method of manufacture and assembly of all major elements entering into the construction of the vehicles, including the final assembly of each vehicle type. The photographs shall be in color, except when ATTIKO METRO S.A. has specifically requested monochrome photographs. The Contractor shall also supply the negatives, and the copyright of the photographs shall be vested in ATTIKO METRO S.A..

These photographs can be substituted with photo file, which will be provided in electronic form (the print outs included).

All prints shall be marked on the reverse side with the date of exposure (dd/mm/yy), the name and address of the photographer, the identification number, and a clear, but brief, description of the picture.

17.0 TESTING REQUIREMENTS

17.1 TESTING

The vehicles shall be tested according to the International Standard IEC 61133 *Testing of Rolling Stock on completion of construction and before entry to service,* and the additional tests listed in the chapters of this Performance Specification.

The Contractor must initially submit to ATTIKO METRO S.A. a Test & Inspection Plan and a matrix of compliance with Standard IEC 61133, and compliance to the additional requirements of this Specification document, listing all the test procedures, tests and test and inspection reports that will be required. The plan shall briefly describe the scope of each test and shall incorporate a detailed time schedule for the tests.

The test list shall include as a minimum the tests described in Annex B of this Specification.
The Contractor must submit the Test Plan for approval six (6) months before the commencement of the tests.

Upon approval of the Test Plan, the Contractor must submit a Test Status Plan, updated on a monthly basis to reflect the actual status of the executed tests and the tests to be executed in the future, as well as their time schedule.

The Contractor must submit to ATTIKO METRO S.A. for approval the test procedures at least two (2) months before test commencement.
A two (2)-week notification is required before the commencement of the tests. ATTIKO METRO S.A. reserves its right to witness all the qualification tests.

After each test, the Contractor shall prepare a report documenting the test conditions and results, and shall submit the report to ATTIKO METRO S.A. for approval.

ATTIKO METRO S.A. reserves the right to witness all tests and any other associated procedure, including necessary tests at the suppliers' and sub-contractors' premises.

For any unit previously qualified, or with a railroad proven service history, the Contractor may request a waiver from performing the qualification test. The request for a waiver must be accompanied by a test report for approval, in order to satisfy qualification requirements. The waiver request must include justification of the claim that the equipment and test(s) are substantially identical to those in the current qualification requirements. For variations in design parameters between the previous tests and the Specification, extrapolated calculations must accompany the test report.

Only with the written consent of ATTIKO METRO S.A. will Test or Certification requirements be waived.

All tests shall have been completed successfully upon the system's trial run.

17.2 DESIGN QUALIFICATION TESTS (TYPE TESTS)

The Contractor shall prepare and conduct design qualification tests (type tests) on individual components of the train equipment or on train parts, e.g. car body, bogies, etc., as per the requirements of the applicable Standards and the Performance Specification. These tests shall be conducted in laboratories or in the premises of the Contractor or his Sub-contractors.
Type tests shall be conducted at the manufacturer's plant on the first (1) train as a complete unit after completion of the construction to test the functioning and cooperation of the individual systems as well as the adherence to the performance requirements and functional characteristics of the entire train.

Type tests on the first (1) train shall be conducted in the Metro network too, as regards performance, safety and interface with the other systems.

These tests shall be carried out as per the suitability tests' procedures compiled by the Contractor and approved by ATTIKO METRO S.A..

After testing, the Contractor shall write a report documenting the test conditions and results, and shall submit the subject report to ATTIKO METRO S.A. for approval. Any design changes, adjustments, etc., that are required to meet the performance requirements, shall be fully re-tested and documented. Equipment design changes shall be subject to prior approval by ATTIKO METRO S.A.

17.3 ROUTINE TESTS

The Contractor shall conduct at the Manufacturing Plant acceptance tests (production conformance tests or routine tests) on each piece of equipment to be furnished to ensure that the equipment is functioning correctly.

Routine Tests shall be also conducted on complete train units, after the approval of the 1st train.

These tests shall be performed in accordance with Acceptance Test Procedure prepared by the Contractor and approved by ATTIKO METRO S.A.

17.4 TESTING OF ROLLING STOCK ON THE METRO NETWORK BEFORE COMMISSIONING

Before commissioned, trains shall be tested and certified as per Standard IEC 61133.

The following tests shall be performed:

- preliminary adjustment tests
- shakedown tests
- simulated Revenue Service
- acceptance tests
- type tests in the Network
- routine tests in the Network
- investigation tests.

17.4.1 Preliminary Adjustment Tests

The Contractor shall prepare under ATTIKO METRO S.A's supervision the vehicles after their arrival at the Depot for the type and routine tests, as well as the qualification tests for commissioning.

17.4.2 Shakedown Testing Requirements

For all vehicle systems and components to be adapted to the new environment, before being commissioned, each train shall be subject to a Shakedown test.

The trains shall be in the tare condition and shall be run from one end of the line to the other in accordance with the operational timetable.

All systems shall be operational.

The trains shall be required to make station stops, and the passenger side entrance doors shall open and close at each stop.

Each train shall undergo this testing for twenty four hours.

Should any train exhibit a failure during the last eight hours of testing, the eight hours of testing shall be repeated until the train has completed eight hours of testing without any failure, before it will be accepted by ATTIKO METRO S.A..

The test procedure shall be approved by ATTIKO METRO S.A..

17.4.3 Simulated Revenue Service Testing

In order to confirm the overall performance of the system, one train shall be subject to a Simulated Revenue Service test for a minimum mileage of 10,000km.

The train shall be loaded to the EL 5 loading condition and shall move from one end of the line to the other in accordance with the operational timetable.

All systems shall be operational.

The train shall be required to make station stops, and the passenger side entrance doors shall open and close at each stop.

This testing may also be utilized to train ATTIKO METRO S.A.'s staff.

17.4.4 Investigation Tests

Investigation tests shall be performed, including all downgraded operation modes.

17.5 TESTS TO VERIFY THE VEHICLE COMPATIBILITY WITH MAINTENANCE AND EMERGENCY EQUIPMENT

Type tests to ensure compatibility of the trains with the following existing equipment and vehicles of Operation Company:

- Lifting jacks
- Washing plant for train exterior washing
- Washing plant for bogies
- Underfloor wheel lathe
- Sanding system
- Coupling with Series I trains
- Coupling of the vehicles with the existing Unimog of the Operation Company.

Additional type tests are foreseen to ensure compatibility of the vehicles with the following items:

- Network alignment
- Platform end
- Turnouts
- Traction power supply
- Trackside equipment

- EMC.

The Contractor shall ensure the compatibility of the Vehicles with the Emergency Procedures, such as:

- Fire
- Derailment
- Collision/Structural strength
- Emergency equipment etc.

17.6 TEST DOCUMENTATION

All procedures, reports and certifications shall be provided with a document bearing a unique document number. The following minimum guidelines shall be followed for producing test documentation:

17.6.1 Test Plan

The Contractor shall submit once a month a Test Control Plan listing all the test procedures, tests and test reports that will be required to satisfy the requirements of this Performance Specification. The Contractor shall not begin any test program until the Test Plan has been reviewed and approved by ATTIKO METRO S.A..

The Test Plan shall identify each item by its document number and revision level, and will indicate the scheduled date of submission to ATTIKO METRO S.A. for approval.

In addition to the above, the Test Plan shall include the details listed in Clause 4.3 of IEC 61133.

The Test Plan shall be updated on a monthly basis to reflect the actual submittal status of all test documentation.

Test Plan and Procedure changes shall be submitted to ATTIKO METRO S.A. for approval.

17.6.2 Test Procedures

The test procedure must state the purpose of the test, and make reference to the relevant portion of the Performance Specification or Standard with which the procedure has to comply.

The test procedure shall clearly specify the condition of the equipment and the test set-up (test conditions), and any tests that the equipment must have previously been subject to. The test procedure must describe in detail the equipment needed to perform the test.

The test procedure must provide detailed, step-by-step instructions as to how the test is to be carried out. This includes results expected and actions to be taken, should the expected result be not achieved.

The test procedure shall define the data to be recorded.

17.6.3 Test Reports

The test report shall identify the test procedure in accordance with which the test was performed, and the reason for performing the test.

The test report shall describe the specific test conditions, highlighting differences, if any, among those required by the test procedure.

The test report shall provide a detailed description as to how the test was performed, clearly stating if any steps were different than specified, and describing the differences. The test report must provide a rational explanation for any deviations from the procedure.

The test report shall clearly detail the results obtained, and shall compare the subject results with the anticipated ones.

The test report must provide a conclusion as to whether the test passed or failed.

18.0 MATERIALS AND WORKMANSHIP

18.1 GENERAL

All material to be utilized for manufacturing these items of equipment shall be new, of first-class quality, consistent with materials commonly used in railcar manufacture. All structures shall be of high quality and shall conform with the best manufacturing practices in all respects.

All materials, special items, equipment component parts, and accessories shall be manufactured in accordance with, and shall comply with, the European Standards or in their absence with the National or International Standards. In special cases the Standards or specifications of the appropriate national technical or professional society or trade association or Government or other railway networks can be used.

All materials shall be marked or stored to be readily identified and shall be adequately protected during handling and storage.

All materials shall be suitably protected against corrosion, including protection of different metal items. The specific means chosen shall be approved by ATTIKO METRO S.A..

To the extent possible, all materials to be utilized in vehicles shall be recyclable. The Contractor shall provide a matrix of all materials used, which shall identify and describe the processes to be used to successfully recycle each of the separate materials in the piece of equipment.

It is prohibited for the following materials to be used in vehicles:

- Asbestos
- Carcinogenic materials
- Polyvinyl Chloride (PVC)
- Polychlorinated biphenyl (PCB)
- Materials containing Beryllium Oxide.

Moreover, the Contractor shall make all possible efforts to comply with the requirements of Directive 2002/95/EC of the European Commission about the Restriction of Hazardous Substances (RoHS).

18.2 FASTENERS

All exposed fasteners shall have a surface providing protection against rust or shall be made of stainless steel. All structural and/or load carrying bolts shall have a minimum property class of “8.8” according to ISO 898 Part 1. Stainless steel fasteners shall have the classification “A2-70” or better according to ISO 3506. All fasteners not made out of stainless steel shall be plated with zinc or another effective corrosion protection. The zinc plating specification shall be compliant to DIN 50960/50961 or equivalent Standard.

Self-tapping screws shall not be used to secure items that may need to be removed during maintenance operations.

Bolts used with nuts shall provide at least two full threads through the nut.

All bolts and cap screws shall have the head marked to indicate grade. All nuts shall be marked to indicate grade.

All bolts, nuts, cap screws and machine screws of undoable connections shall be locked to prevent loosening in service. The locking method shall preferably include lock washers or washers and self-locking nuts, not locking plates with bendable tabs and shall be subject to

ATTIKO METRO S.A.'s review and approval. All fasteners shall be “torque striped” after torquing using an approved method.

The threads of stainless steel fasteners shall be suitably treated to prevent damage during installation.

18.3 FITTINGS

Components, plates, protective shields, or other parts which may be removed for repair or maintenance, shall be interchangeable.

Components not requiring maintenance shall be designed for a useful life of 30 years. If, during the warranty period, it is demonstrated that the extrapolated life of any component is less than 30 years, then the subject component must be re-designed and replaced on every vehicle.

All fittings shall be free from sharp edges and burrs that might injure persons or damage clothing.

18.4 ELECTRICAL EQUIPMENT

All wires and cables shall be halogen free and flame retardant.

All cables, including multi-core cables, shall be marked as applicable, e.g. manufacturer’s name, number of cores, cross-section, cable designation code, etc.

All cable tests shall be declared and test certificates shall be provided.

18.4.1 Terminals

Conductors shall be attached to terminals by certified equipment. Terminals shall be of ring type or stud type or cage-clamp type, except for terminals for electronic equipment and bus circuit connections. Soldered terminations shall only be used with the approval of ATTIKO METRO S.A., unless on printed circuit boards.

Solderless terminals shall be identical to those provided by Amp, Hollingsworth, Co. Weidmueller, Co. WAGO, or Thomas and Betts.

All other types of terminals that might be proposed by the Contractor are subject to ATTIKO METRO S.A.’s approval.

Lugs for power cables shall be compressed by hexagonal crimping tools.
The inspection hole of cable position for external cables, shall be sealed.
For all power cables a thermally shrinkable sleeve shall cover and protect a part of the cable insulation and a part of the cable lug.

18.4.2 Wire Insulation

Unless otherwise specified, wire insulation shall be one of the following types:

For general car body wiring, insulation shall be flame retardant and flexible. The operating temperature rating for high voltage cables (DC) shall be up to 110^{o}C, while for medium and low voltage cables a temperature rating of up to 90^{0}C shall be acceptable. The insulation shall be rated at 2000V for all wires carrying a nominal voltage greater than 450V, rated at 600V for wires carrying a nominal voltage between 110V and 450V and rated at 300V for wires carrying less or equal than 110V. All wiring that will be relatively inaccessible during maintenance activities shall be rated at 2000V.

Where wiring is connected to heat generating equipment where the ambient temperature can exceed 125°C, insulation shall be abrasion resistant having a temperature rating of 260°C and meeting the requirements of relevant standards. The insulation shall be rated at 1000V for all wires carrying a nominal voltage greater than 110V, and rated at 600V for wires carrying less or equal.

The insulation on wiring within replaceable modular units, to electronic equipment such as printed circuit boards, etc., shall have a continuous temperature rating of 150°C.

All wire insulation shall be subject to ATTIKO METRO S.A.'s approval.

18.4.3 Wire Ampacity

The selection of wire sizes and insulation shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature and flexibility requirements, in accordance with applicable - contractual standards. Cable type and installation shall comply with Standards EN 45545 and EN 50343. Cable size shall be such that the voltage drop in any circuit due to cable and terminal resistance shall not exceed 5% of the circuit supply voltage.

Maximum wire ampacities shall conform to applicable ATTIKO METRO S.A.-approved standards. Where more than three (3) conductors are routed in a raceway or cable, the ampacities shall be suitably derated.

Unless otherwise specified, conductors in all electrical wires and cables, including wires and cables in apparatus furnished by sub-contractors, shall be of soft, annealed tinned copper in accordance with the appropriate standards approved by ATTIKO METRO S.A..

All wiring shall be supplied to a consistent standard.

18.4.4 Wire Stranding

Wires stranding and conductor construction shall be appropriate for their application, taking into account wire size, flexing requirements, etc., and shall comply with the appropriate standards approved by ATTIKO METRO S.A.

18.4.5 Wiring

Pinch screw terminals and solid conductors are strictly forbidden.

18.4.6 Creepage and Clearance

Electrical creepage and clearance shall be adequate for the voltage levels and environment and shall comply with EN 50124-1.

18.4.7 Insulation Resistance

The integrity of all wire insulation shall be tested in accordance with IEC 61133 and an ATTIKO METRO S.A.-approved Insulation Resistance Test and High Potential Test procedures.

18.4.7.1 Insulation Resistance Tests

Insulation resistance testing shall be conducted on all wire and cable on the vehicles following the successful completion of continuity testing. Insulation testing shall also be conducted between the input and output circuits of high voltage switches and circuit breakers, as part of the regular component tests by the respective Manufacturer. The testing shall prove the integrity of wire and cable within equipment enclosures and between wire and cable of different voltage classes. Double-insulated equipment shall be tested over each set of insulators. High voltage shall not be applied across battery terminals.

Prior to being installed on the car, preferably during the manufacturing stage, all equipment shall be subject to the following voltage levels, and the insulation resistance shall be as determined and not less. The test voltage shall be applied for one minute between the cable circuit and ground.

Nominal Circuit Voltage	Applied Test Voltage	Minimum Resistance
110Vdc/24Vdc/12Vdc	500Vdc	5MΩ
230Vac	500Vdc	10MΩ
400Vac	500Vdc	10MΩ
750Vdc	500Vdc	10MΩ

After having been connected to the equipment boxes, the car body wires and cables shall be subject to the following voltage levels, and the insulation resistance shall be as determined and not less. The test voltage shall be applied for one minute between the cable circuit and earth.

Nominal Circuit Voltage	Applied Test Voltage	Minimum Resistance
110Vdc/24Vdc/12Vdc	500Vdc	5MΩ
230Vac	500Vdc	10MΩ
400Vac	1,000Vdc	10MΩ
750Vdc	1,000Vdc	10MΩ

18.4.7.2 High Potential Tests

Following the successful completion of the insulation resistance tests, high potential tests shall be conducted on all wires and cables on the vehicles in accordance with IEC Standard 60077. High voltage shall not be applied across battery terminals and lighting inverter ballasts. Electronic equipment shall be tested in accordance with the requirements of EN 50155.

Prior to being installed on the car, preferably at the manufacturing stage, the insulation of all equipment wires and cables shall be tested. There shall be no disruptive discharge, as evidenced by a sudden drop in applied test voltage, or by excessive leakage current. The value of the maximum acceptable leakage current shall be established based on the past experience of the manufacturer of the equipment. The test set leakage current circuit breaker trip point shall then be set at a value slightly higher than this value. If the circuit breaker does not trip, the test shall be considered acceptable. Repeated tests shall be carried out at a voltage level of 85% of the previous test voltage level.

After having been connected to the equipment boxes, the insulation of all car body wires and cables shall be tested. There shall be no disruptive discharge, as evidenced by a sudden drop in applied test voltage, or by excessive leakage current. The value of the maximum acceptable leakage current shall be established by using the high average leakage current value (clarification) measured on the first few cars with proven acceptable wire and cable installations. The test set leakage current circuit breaker trip point shall then be set at a value slightly higher than this value. If the circuit breaker does not trip, the test shall be considered acceptable. Repeated tests shall be carried out at a voltage level of 85% of the previous test voltage level.

18.4.8 Voltage Segregation

Wires shall be segregated into separate bundles/harnesses and connectors according to the voltage ratings in the following classes:

Class A: High voltage AC/DC wiring

Class A1: Line wiring, power supply and return wiring
Class A2: Other high voltage AC/DC wiring, e.g. 400Vac wiring

Class B: Low voltage AC/DC wiring, e.g., 110Vdc battery wiring

Class C: Signal wiring, e.g., data bus, radio, intercom, Public Address, etc.

If an equipment Supplier has stronger requirements regarding voltage segregation than the above, then the stronger requirements shall prevail for cabling assigned to that equipment.

18.4.9 Devices and Hardware

18.4.9.1 General

All electrical devices, such as circuit breakers, miniature circuit breakers, relays, contactors, switches, motors, etc., shall be suitable for use in a rugged mass transit vehicle environment, shall be readily available on the open market, and shall be supplied by well-known manufacturers having extensive rail transportation experience. All electrical devices and hardware are subject to the review and approval of ATTIKO METRO S.A..

The designation codes of the circuit breakers, relays, contactors, switches, fuses, etc. must be on them and below them, in the installation frame.

18.4.9.2 Circuit Breakers

Circuit breakers shall have ON and OFF positions, which shall be permanently marked on the handle or the case of the device. Auxiliary switch, which shall indicate the circuit breaker has tripped (either electrically or manually), shall be fitted to the left hand side of the circuit breakers. Each circuit breaker pole shall be equipped with a trip mechanism and shall have adequate means of arc extinction to prevent flashover.

The trip elements shall be thermal-magnetic or magnetic, as appropriate for the application.

Electrically operated circuit breakers shall be powered from the low voltage DC supply.

Circuit breaker rating shall be clearly and permanently marked, and shall be visible after installation.

High Voltage DC Circuit Breakers

Where there is a direct mechanical linkage between two or more circuit breakers, such that they operate in unison, it may be assumed that the switching duty is shared between them. The required current breaking capacity shall therefore apply to the operation of the devices in series, and not to each device individually.

It is not acceptable to reduce the specified duty of circuit breakers based on the assumption that two ground faults would be required for a short circuit to occur, nor that the fault currents are limited by resistors.

18.4.9.3 Relays and Contactors

18.4.9.3.1 General

All relays and contactors shall be designed, constructed and utilized such that in the event of a failure, neither the passengers and the Operator nor equipment will be subject to any hazard. All relays and contactors shall be installed such that they are fully accessible for inspection (from the front), repair in situ, or removal and replacement. All relays and contactors shall provide a clear visual indication of the state of the device.

Where plug-in relays suited for railway applications are applied, they shall be secured in their sockets by a mechanical restraining device.

There shall be a maximum of two wire terminations on any one terminal of a device, unless otherwise approved by ATTIKO METRO S.A..

Contactor ends shall be ON/OFF via a rolling and wiping action.

Contactors shall be installed such that the arc is directed by an arc chute away from ground and any other adjacent electrical devices.

18.4.9.3.2 Control Relays and Contactors

Relays and contactors supplied from the low voltage DC system or using AC voltage supplied by the Auxiliary Power Supply Equipment shall utilize operating coils that are continuously rated over the full application supply range. In order to limit voltage transients when power is cut-off, coil suppression shall be furnished, and it is preferred that suppression be of theR-C or varistor type. Coil suppression shall not adversely affect the response times of the device.

Unless otherwise specified, all time delay relays shall use R-C type delays for safety-related applications, and solid state electronic type delays for general applications.

Relays and contactors shall be rated to achieve a minimum life expectancy of 20 years before replacement of wearing parts, adjustment or testing. The contact rating shall account for the anticipated number of operations over 20 years, system voltage, power factor or time constant of the load, switching current, nature of load suppression, any use of contacts in series, mounting orientation and other.

18.4.9.3.3 High Voltage DC Contactors

Where there is a direct mechanical linkage between two or more contactors, such that they operate in unison, it may be assumed that the switching duty is shared between them. The required current breaking capacity shall therefore apply to the operation of the devices in series, and not to each device individually.

It is not acceptable to reduce the specified duty of contactors based on the assumption that two ground faults would be required for a short circuit to occur. However, a reduction of the specified duty of contactors may be considered on the basis that fault currents are limited by resistors or other equipment, provided it can be proven that under all reasonable electrical and mechanical failures, a full short circuit would not occur. In this case, the rated contactor current shall be the maximum load or fault current applicable to the contactor circuit.

The rated breaking capacity of contactors shall be the full load current of the circuit fed by the contactor. However, no hazard shall be caused if the contactor opens on higher fault currents.

18.4.9.4 Switches

All switches shall be keyed to prevent rotation of the switch body after installation. Contacts and connection points shall be suitably plated, as approved by ATTIKO METRO S.A.. The maximum in-circuit contact resistance shall be 0.1Ω. There shall be a maximum of two wire terminations on any one terminal of a device, unless otherwise approved by ATTIKO METRO S.A..

18.4.9.5 Fuses

The rating of all fuses shall be clearly and permanently marked on the fuse itself and adjacent to the fuse holder. The fuse holder shall incorporate a fuse retention device at each end. A suitable means to prevent the use of over-rated fuses shall be utilized.

All fuses shall be readily accessible, and a spare of each type of fuse shall be mounted adjacent to the active fuse and shall be identifiable by rating.

18.4.9.6 Bus Bars

Bus bars shall be manufactured from oxygen-free electronic copper and shall be tin coated. In general, bus bars shall be manufactured according to the standards DIN 40500 and DIN 46433. The current density shall be calculated according to the standard DIN 43671. The current density in connections shall be according to the standard DIN 46206. Also, bus bars shall be CU/SN8 coated according to the standards DIN 50965.

18.4.9.7 Transformers and Inductors

Transformers shall be supplied in accordance with IEC 60310. Transformers rated over 100W and all inductors and reactors in electrical circuits shall be fabricated with copper or aluminum coils using an IEC 60085 Class 200 or service proven insulation system.

All equipment, connections and connecting cables shall be totally enclosed and protected against all weather conditions and flying ballast.

18.4.9.8 Electric Motors

A motor of each type shall be tested at maximum load and maximum ambient temperature conditions to ensure that the motor temperature is within the manufacturer's recommended limits for a 30-year life cycle.

Motor rotation direction shall be indicated by an arrow stamped/cast on the motor casing, and shall be clearly visible upon installation of the motor.

Any motor weighing more than 10kg shall incorporate suitable provisions for lifting.

Full motor data shall be provided to ATTIKO METRO S.A. for review and approval.

Motors shall be tested in accordance with IEC 60349.

Motor labelling must contain appropriate technical data and must be clearly visible.

18.4.9.9 Printed Circuit Boards

All electronic printed circuit boards (PCBs) shall be of the plug-in type unless specifically approved by ATTIKO METRO S.A.. The type of connector and contact material shall be identified by the Contractor. Components shall not be installed using sockets unless specifically approved by ATTIKO METRO S.A.. Use of surface mount devices must be approved by ATTIKO METRO S.A.. Semiconductor operating temperature rating shall meet or exceed -25^{o}C to +85^{o}C.

PCBs shall be mechanically retained to prevent loosening in service. Circuit boards shall not be hard-wired to the equipment, and shall be mechanically keyed to prevent insertion into the wrong rack location.

All PCBs shall be labelled with a part number, serial number and part description. All components shall be labelled on the board with component drawing references and such other information that may be required to troubleshoot the board. Capacitor and diode polarity, and transistor and thyristor orientation shall be clearly delineated.

18.4.9.10 Wire and Cable Installation

Electrical wires and cables shall be run in cleats, conduit, ducts or trays, as the application permits, but they shall all be protected against damage, such as chafing, ballast impact, etc.

Wire runs shall be continuous and unbroken between connection points, and the wiring support points shall be spaced at 600mm, as a maximum. At each support point, the wiring shall be protected against mechanical crushing and abrasion. Care shall be taken not to

overfill conduit, ducts and wire trays, and the fill ratio shall be in accordance with the appropriate industry standard. (However, under no circumstances shall the fill ratio exceed 75% for three or more conductors. Where a length of conduit of less than 600mm is run between enclosures, with total bends of less than 15°, a maximum fill ratio of 75% will be permitted).
During the design and manufacturing stages, the Contractor shall include 10% additionally spare wires and cables, to enable the replacement of damaged wires and cables.

It shall be ensured that water is not allowed to enter apparatus or equipment via cables or wires. Any wiring run through the floor shall be in ducts or conduits. No wires or cables shall pass through or over the battery box, or over heat generating equipment, even if in ducts or conduit. Wires shall not be draped over the edge of wire ways, with or without wire way edge protection.

Sufficient extra margin- length-wise - shall be provided in wiring, to allow as follows, where technically reasonable and necessary:

- Wire cross-section up to 6mm^2: Three re-terminations.
- Wire cross-section over 6mm^2: Two re-terminations.

All wire ties to be used shall be of the weather-resistant (black) variety, and shall be snugly fitted using the manufacturer's approved tensioning tool and neatly trimmed, without causing indentation or cold flow damage to the insulation. The use of adhesive-type wire tie bases is not acceptable.

The Contractor's attention is drawn to the requirements of Clause 18.4.8 regarding voltage segregation. In addition, as regards cables' fire safety and their insulations, they shall satisfy the requirements of clause 18.6.

All wire and cable installation is subject to the approval of ATTIKO METRO S.A..

18.5 PAINTS, COATING AND PROTECTION

18.5.1 General

All metal surfaces, except stainless steel, plated carbon steel, anodized aluminum, copper alloys and other alloys having inherent corrosion resistance properties, shall be prepared and painted as described herein, unless otherwise approved by ATTIKO METRO S.A.. Fiberglass Reinforced Polyester shall also be painted as described herein, and the paint system shall be compatible with the material.

Any equipment which would be damaged or suffer impaired operation from painting shall not be painted, but shall be corrosion resistant and suitable for operation in this specific environment. The following equipment items shall not be painted:

- Wires and cables
- Hoses
- Power resistors
- Heat transfer surfaces
- Wearing surfaces
- Linkages
- Fastener threads.

All preparation and painting shall be carried out in a properly ventilated, enclosed area. From the start of preparation to the completion of drying of the paint system, the metal shall not be exposed to weather conditions.

A detailed inspection schedule of the paint condition shall be foreseen as part of the Quality Assurance System. This schedule shall take into consideration the operating conditions, regular cleaning and special cleaning (graffiti removal) and will cover all sensitive areas such as:

- Side cladding joints on the frame through continuous welding seams
- Side cladding joints on windows
- Car ends' cladding
- Door perimeters
- Headlights – rearlights areas
- Areas potentially influenced by hot air outflow from underframe equipment.

18.5.2 Paint

All painting materials shall form a high quality finishing system resistant to corrosion, chipping and fading, and shall retain the gloss level. Only water based paints respecting the ecological criteria set by EU Directive 1999/13/EC shall be used in all paints, varnishes etc. All applicable EN standards shall be provided to ATTIKO METRO S.A.. The characteristics and specifications of the painting products to be used and the painting processes used shall be submitted to ATTIKO METRO S.A. for approval. A sample of the final external surface appearance will also be submitted.
Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. Paints and coatings for these areas shall be of a type especially resistant to the impact from ballast gravel, stones etc.

All paints shall be supplied in sealed containers of the manufacturer, which shall be clearly labelled with the following information:

1. Name of manufacturer
2. Brand name and specification type
3. Interior or exterior use
4. Color
5. Batch number, expiration date and date of manufacture
6. Category of Hazard.

Paint shall be stored in sealed containers not exposed to high temperatures. The storage temperature shall be such that the paint is not damaged in any way. Any special storage conditions recommended by the manufacturer shall be observed.

Paint not used within the "shelf life" period specified on the containers, or within 12 months of the date of manufacture, whichever is the lesser, shall be replaced.

The Contractor shall identify and provide the paint standards to be used. All components and materials to be used in the painting process shall be approved by the Contractor's Quality Assurance / Quality Control department.

18.5.3 Surface Preparation

Surfaces shall be thoroughly cleaned to remove all dirt, grease, etc., and all loose materials of organic composition shall be removed.

Blast cleaning shall be carried out in accordance with an approved standard. Non-metallic abrasive shall only be used with the approval of ATTIKO METRO S.A.. The abrasive shall be free of contamination. The maximum amplitude (peak to trough) of the blast cleaned surface shall not exceed 0.1mm locally. Surfaces shall be protected after having been blast cleaned. (Latest after 6 hours).

Mechanical cleaning shall be carried out by power driven tools, such as abrasive grinding discs, chipping hammers and needle guns, followed by steel-wire brushing to remove all loose material. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall be avoided. Surfaces shall be protected after having been mechanically cleaned (at the latest after 6 hours). Small surface defects shall be treated by successive filler application and sanding as applicable.

18.5.4 Priming

Surfaces shall be primed within four hours of having been cleaned. All surfaces shall be thoroughly degreased and be free from dust and dirt prior to the application of an approved primer. If the cleaned surface deteriorates below the specified standard, then the affected areas shall be cleaned again.

The dry film thickness shall be 50 microns, in general.

Damaged surfaces shall be prepared anew, except small areas that may be touched up by brush applied paint should ATTIKO METRO S.A. approve it.

18.5.5 Application of Paint

Paint shall be applied in accordance with the manufacturer's instructions. The paint, when applied, shall be completely uniform in texture and free from particles so that the dried film will be smooth and even colored.

All painting shall be carried out by skilled painters under competent supervision.

Painting shall be carried out only in such weather conditions in which water is not likely to condense on the surface to be painted.

All surfaces to be painted shall be completely free from moisture at the time of applying the paint. Any paintwork which is adversely affected by weather conditions following application shall be repaired by the Contractor.

Unless otherwise agreed by ATTIKO METRO S.A., each coat of paint shall be applied to produce a continuous film of paint of uniform and even thickness.

The first undercoat shall be applied on a clean, dry, sound, primed surface and each coat shall be thoroughly dry before application of the subsequent coat.

Finishing coats shall be carefully applied such that, upon completion of works, the surface is free from runs, sags, brush marks, etc.

In all cases, any coat that has become damaged or defective in any way shall be repaired before application of the subsequent coat.

The total dry paint film thickness of the paint system on bare steel surfaces shall be not less than 130 microns. The dry paint film thickness shall be measured using instruments approved by ATTIKO METRO S.A..

In order to obtain the dry film thickness specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be attained.

Wet film thickness gauges may be used for checking the membrane, but shall not be permitted to be used as a means of predicting the dry film thickness.

18.5.6 Repairs to Damaged Surfaces

Painted surfaces which have been damaged shall be cleaned to the bare material and the edges of the undamaged paint shall be levelled with an abrasive.

The fully specified painting systems shall be then re-applied and the new paint shall overlap the existing paint by at least 50mm all around the affected part.

18.5.7 Testing and Inspection

The Contractor shall conduct dry film thickness measurements and inspection of the painted surfaces using electrical means and shall re-paint and repair as necessary to comply with the requirements stated herein.

After repaired and re-painted areas have dried sufficiently, the Contractor shall test the integrity of the full paint system using a methodology approved by ATTIKO METRO S.A.. Painting thickness which is specified in microns shall be measured with a certified magnetic type dry film thickness gauge. Discontinuities and voids in the paint system shall be determined with an approved low voltage detector of the wet sponge type. Any painted surface not in compliance with the requirements shall be re-painted, repaired, and re-inspected until all the requirements of the Performance Specification are met.

18.5.8 Graffiti cleaning

Graffiti cleaning shall not modify the colour or shine or other characteristics of the paintwork. The Contractor (in cooperation with the paints manufacturer) shall propose and make practical demonstrations and carry out related factory tests of the most suitable graffiti cleaning products, compatible with the paints used. The above products must be non-toxic, shall meet the related EN standards, and their characteristics and specifications shall be submitted to ATTIKO METRO S.A..

18.6 FIRE SAFETY

18.6.1 General

The Contractor shall ensure that all materials used in the construction of the equipment supplied have properties that are not conducive to the propagation of fire, nor to the generation of smoke and toxic gases, consistent with the properties required to perform the intended service.
As a minimum, materials shall comply with the requirements of Standard EN45545, or with a substantially equivalent fire safety standard for train manufacturing (to be approved by ATTIKO METRO S.A.), for example NFPA 130, and with the requirements stated herein, unless specific materials are exempted by ATTIKO METRO S.A..

The Contractor shall provide data pertaining to all relevant tests having been performed on the materials proposed to be used.

It is acknowledged that the performance requirements of certain electrical and electronic components (for example, the charge/discharge characteristics of a capacitor) may demand the use of materials that cannot comply with the requirements of this Clause. Such materials may be allowed, provided they are housed in suitably sealed cases. However, the use of such materials requires the explicit approval of ATTIKO METRO S.A.. In any case, the use of non-compliant materials shall be restricted to 500g per car, allocated in the entire car.

The Contractor shall produce and maintain a Fire Loading Matrix, which will list all materials not complying with the requirements of this section, the reason for non-compliance, the effects of non-compliance, the location used, and the weight of the material used in the

particular application. The matrix must be approved by ATTIKO METRO S.A. and must be updated and submitted to ATTIKO METRO S.A. for approval when changes are made.

The Contractor shall submit the following:

- Fire Safety Study of the train
- Vehicle Fire Load calculation of all non-metal materials complying or not with the selected Specifications. The calculation shall separately include materials over and under the train floor.
- Simulation study of the heat released, as a function of time: Heat Release Rate (HRR). Indicatively, it is stated that the peak value of the HRR for Thessaloniki Series I trains is of the order of 25 MW. The subject study shall also specify the worst fire scenario within and outside the train (roof or underfloor equipment) as well as the location of the fire.

In the framework of the Fire Safety Study, the Contractor shall calculate the train evacuation times in a station or at the worst point of the tunnel and shall compare them with the most adverse HRR diagram.

18.6.2 Floor Assembly Fire Resistance Test

The Contractor shall test a floor assembly in accordance with a standard to be approved by ATTIKO METRO S.A., to demonstrate a 30-minute endurance rating in an independent test laboratory.

The test specimen shall be a full width vehicle section, including the solebars, crossbeams, etc., and shall have a minimum length of 3.5m. At least two typical penetrations shall be included, together with typical floor splice configurations. At least three typical transverse supports shall be included.

The test specimen shall include the floor covering, floorboards, floor structure, thermal and acoustical insulation, and floor pans.

The test specimen shall be loaded to EL 8 passenger loading conditions and concentrated loads shall be used to simulate underfloor equipment.

18.6.3 Toxicity

Materials and products generally recognized to have highly toxic products of combustion shall not be used. All materials used in the construction of the vehicles, except for those used in such a small quantity that would not contribute significantly to the propagation of fire or to the generation of smoke or toxic gases, as agreed with ATTIKO METRO S.A., shall be tested for toxicity using an ATTIKO METRO S.A. approved standard.

18.7 EQUIPMENT ENCLOSURES

All equipment enclosures installed at locations exposed to weather conditions shall be designed and manufactured to prevent the ingress of foreign substances, such as liquids (including water, spilled drinks, car wash over spray, and wheel splash), snow, dust and dirt, oil, debris, or vermin. In designing the enclosures, it should also be assumed that liquids will enter the enclosure, and the design shall ensure that liquids will not cause damage to equipment and shall be drained away.

In addition, equipment installed in areas normally occupied by passengers, operators, or maintenance staff shall be designed and manufactured to prevent ingress of foreign substances, such as spilled drinks and cleaning materials. However, in designing the equipment, it should also be assumed that liquids may ingress the equipment, and the design

shall ensure the liquids will not adversely affect operation of the equipment nor cause damage to it, and shall be drained away.

Enclosures containing equipment which may produce gases (such as battery boxes and switchgear) shall be designed and manufactured to ensure that the gases are safely exhausted outside the enclosure.

Equipment installed in enclosures shall not be attached directly to the enclosure by fasteners through the enclosure walls or top and bottom sheets, but to standoffs welded to the enclosure. All hardware, including hinges used to secure access covers or plates to the enclosure, shall be of stainless steel. All access covers shall be provided with quick-release, spring-loaded, stainless steel latches. The latches shall not infringe upon the car dynamic clearance envelope when not engaged. The latches shall be adjustable to compensate for seal relaxation, including hard contact between the cover and the enclosure. Prior to water tightness testing, the latches shall be adjusted to compress the cover seals by no more than 50%. Only one type of hollow section, closed-cell foam tube, or similar, shall be used for all cover seals. Flat foam strips are not permitted.

The covers of all equipment enclosures shall be sufficiently light and configured as to be easily removed or re-fitted by one maintenance technician in no more than 20s, without the use of any tool. Spring-loaded secondary restraining devices shall be fitted to ensure that covers remain within the car clearance envelope should the latches fail. Covers shall also incorporate a “hold open” feature.

The covers for enclosures of capacitors, batteries or of any other device that can cause an explosion shall be specially designed. This design shall prevent any dangerous metallic parts flinging in ATTIKO METRO S.A.’s Depots and Workshops in case of explosion.

The names of all equipment enclosures shall be clearly labelled by means of an ATTIKO METRO S.A.-approved substantial engraved stainless steel plate riveted to the cover of the enclosure. The engraved letters shall be block capitals, at least 10mm high and with a thickness of 2mm, and configured in accordance with an approved international Standard. Engraving depth shall be at least 0.5mm, and the engraved lettering shall be filled with black epoxy paint. The label shall also identify the weight of the enclosure (including all equipment).

Preferably a demonstration for the removal of all the equipment boxes from the vehicle will take place during the training period.

18.8 PLYWOOD

Plywood shall be formed from one piece (not spliced), and all edges and cut-outs shall be sealed with aluminum paint or other appropriate means of sealing. Plywood shall meet the fire safety requirements of this Performance Specification. The plywood shall be waterproof and resistant to rot and mildew.

All wood shall be certified by Forestry services. Any other internationally accepted certification shall be also accepted.

18.9 HONEYCOMB PANELS

The bond strength of honeycomb panels shall develop the full strength of the honeycomb material.

18.9.1 Strength Requirements

Certification shall be provided verifying that the material in the finished product complies with the following or similar requirements:

Property	ASTM Test	Minimum Requirements
Tensile Strength	D 638	238MPa
Tensile Modulus	D 638	22GPa
Flexural Strength	D 790	298MPa
Flexural Modulus	D 790	15GPa
Compression Strength	D 695	297MPa
Compression Modulus	D 695	22GPa
Flatwise Tensile Strength	D 297	261MPa
Flatwise Compression Strength	D 365	229MPa
Bending Load at Max.	D 1781	1KN
Bending Displacement	D 1781	7.47mm
Drum Peel Strength	D 5420	100MPa

Testing according to other applicable standards, e.g. European standards proving similar performance, is also acceptable.

18.10 MELAMINE-FACED ALUMINUM

Melamine on aluminum panels shall be constructed by laminating melamine to aluminum sheets, by moulding the melamine-impregnated papers directly to the aluminum under heat and high temperature conditions. The use of contact adhesive is not allowed. The bond between the melamine and the aluminum sheets shall meet the following minimum requirements, or similar:

Property	ASTM Test	Minimum Requirements
Internal Bond	D 952	18MPa
Flexural Strength With grain: Cross grain:	D 790	 183MPa 175MPa
Modulus of Elasticity With grain: Cross grain:	D 790	 20GPa 22GPa
Tensile Strength With grain: Cross grain:	D 638	 154MPa 140MPa

Testing according to other applicable standards, e.g. European standards proving similar performance, is also acceptable.

18.11 THERMOPLASTIC SHEET

18.11.1 General

Thermoplastic sheet used in the construction of the vehicles shall not contain any Polyvinyl Chloride (PVC) derivatives and shall be fully capable of withstanding all of the physical and functional requirements described herein, including being resistant to cleaning solutions. The sheet shall be homogeneous and shall be extruded from non-used stock. Only UV stabilized pigments shall be used to create the specified color. The finish of the material shall be approved by ATTIKO METRO S.A. prior to the production run of components. Imperfections larger than 0.25mm and with a density over one defect in 0.37mm^2 shall be a cause for rejection.

18.11.2 Strength Requirements

Certification shall be provided verifying that the material in the finished product complies with the following or similar requirements:

Property	ASTM Test	Minimum Requirements
Specific Gravity	D 792	1.20 to 1.45
Tensile Strength	D 638	38MPa
Elongation	D 638	50%
Flexural Strength	D 790	55MPa
Flexural Modulus	D 790	2.28GPa
Rockwell Hardness (R Scale)	D 785	90 to 110
Heat Shrinkage at 177^{o}C for 15 minutes		10%
Heat Deflection (annealed) at 1.82MPa	D 648	74^{o}C
Fabricated Component Gardener Dart Drop Test (13mm diameter ball, 23^{o}C)	D 3029	36.2Nm
Fabricated Component Gardener Dart Drop Test (13mm diameter ball, - 29^{o}C)	D 3029	9Nm

Testing according to other applicable standards, e.g. European standards proving similar performance, is also acceptable.

18.12 ELASTOMERS

Unless otherwise approved by ATTIKO METRO S.A, all elastomers shall be manufactured from neoprene. Unless otherwise approved by ATTIKO METRO S.A., all resilient mounts and bogie bumpers shall be manufactured from natural rubber. All elastomers shall be resistant to ozone, ultra violet, oxidation, heat, oil, grease, acids and cleaning compounds.

18.13 GLASS-REINFORCED POLYESTER (GRP)

18.13.1 General

GRP shall be manufactured by an open moulding or matched die moulding process, and production techniques shall ensure that the glass fiber reinforcement is uniformly distributed throughout the final product in such a manner so as to achieve the required strength properties. The Contractor shall provide an analysis to confirm that the selected construction method is suitable for the intended purpose and meets the required strength standards.

The finished gel coated or painted surfaces shall have a minimum gloss value consistent with the interior styling concept, and shall exhibit no print due to reinforcements or have any noticeable orange peel.

The attachment points shall have a greater thickness, and exposed edges shall not be allowed.

18.13.2 Resin

The resin shall be a good commercial grade, selected to meet the physical and fire resistance requirements of this Performance Specification, while being compatible with the moulding process requirements.

18.13.3 Fiberglass Reinforcement

The fiberglass reinforcement shall be mat, fabric woven roving, continuous roving, chopped spun roving, or swirl mat, as required to meet the physical properties cited herein and to be compatible with the moulding process requirements. The glass content shall be a minimum of 20% by weight.

18.13.4 Gel Coat and Painting

The gel coat shall be resistant to scuffing, fire, weather conditions, water absorption, cleaning agents, etc. The gel coat shall have a minimum thickness of 0.4mm. If the surface of the GRP component is to be painted, a primer shall be used and the component shall be painted in accordance with the requirements of this Performance Specification.

18.13.5 Additives

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants and smoke inhibitors shall be added to the resin mixes to obtain finished products with the physical characteristics and fire resistance specified herein. Antimony Trioxide shall not be used.

18.13.6 Physical Strength Requirements

The Contractor shall provide independent certification verifying that each of the production batches meets the following standards, or similar. The test specimens shall be maintained in accordance with ASTM D 618, or similar.

Mechanical Property	**ASTM Test**	**Minimum Requirements**	
		Open Mouldings	**Matched Die Mouldings**
Tensile Strength	D 638	70MN/m^2	85MN/m^2
Compressive Strength	D 695	125MN/m^2	155MN/m^2
Flexural Strength	D 790	105MN/m^2	155MN/m^2
Impact Strength	D 256	8Nm per 25mm of notch	11Nm per 25mm of notch
Hardness		45 Barcol	45 Barcol

18.14 SEAT UPHOLSTERY

Fabrics used for the passenger seat upholstery shall be made of woven, transportation grade fabrics of a 90% wool and 10% nylon blend. Fabric shrinkage shall be 2% in either the warp or fill directions. Fabrics fire resistance shall be maximized through the use of fire retarding materials or coatings.

The Contractor shall provide certification verifying that the fabric has been tested to meet the following requirements, or similar:

Property	**ASTM Test**	**Minimum Requirements**
Fabric Weight	D 3776	16.5oz/sq. yd.
Fabric Count	D 3775	Warp (ends) – 16 Fill (picks) 23
Breaking Strength and Elongation	D 5034	Warp – 672N Fill – 896N
Tear Strength (Tongue)	D 2261	Warp – 311N Fill – 311N
Seam Strength	D 1683	8 to 10 stitches per 25mm.

		Warp – 444N Fill – 444N
Color Fastness	D 3597	Water – Class 4 Solvent – Class 4 Crocking – Class 4 Light – Class 4
Taber Abrasion Test	D 3884	700 cycles, no breaks
Wyzenbeck Abrasion Test	D 3597	1500 double rubs, no breaks
Martindale Abrasion Test	D 4966	25,000 cycles, no breaks

Note: Only one of the abrasion tests need be performed.

18.15 SEAT CUSHION MATERIAL

Passenger seat cushion fill material shall be low-smoke flexible foam constructed of fire retardant materials. The material shall have a polymerized or thermal – bonded, homogeneous, cellular structure, free from foreign material, with a porous surface and open cells. The cells shall be interconnecting and uniform in size. Cellular material may be moulded in one piece or constructed from laminated parts securely bonded together. The cushion material shall be properly cured to prevent odor.

The seat cushion material shall have the following physical characteristics, or similar:

Property	**ASTM Test**	**Minimum Requirements**
Tensile Strength	D 3574 Test E	35kPa
Elongation	D 3574 Test E	70% minimum
Compression Set at 50%	D 1055	15% maximum
Flex Fatigue	D 1055	5% maximum thickness loss
Tear Strength	D 3574	14kPa

19.0 PROJECT MANAGEMENT REQUIREMENTS

19.1 GENERAL

Within 30 days of contract award, the Contractor shall submit a Project Management Plan for ATTIKO METRO S.A.'s review and acceptance. This plan shall define the Contractor's project organization, including the names of key personnel offering their services in the framework of this project, and shall describe the responsibilities of each separate organization and their contribution to this project.

Prior to commencing work, the Contractor shall submit for ATTIKO METRO S.A.'s approval the names, qualifications and experience of all the aforementioned key personnel in the organization. Any changes or additions, either to the organization or to key personnel, shall be subject to the prior approval of ATTIKO METRO S.A..

The plan will also describe the means by which the Contractor will adequately control all major suppliers and sub-suppliers, including ensuring their adherence to the requirements of this Performance Specification. Based on this, ATTIKO METRO S.A. reserves the right to approve all the Contactor's sub-suppliers.

Moreover, the subject Plan shall include the organization of personnel and the method based on which the Contractor -during the design - shall deal with synergies and train interfaces with the existing system.

The Contractor shall be required to provide a responsive written reply to all ATTIKO METRO S.A. letters within 14 calendar days of receipt of ATTIKO METRO S.A.'s letter. It shall not be acceptable for the Contractor to merely confirm receipt of ATTIKO METRO S.A. correspondence, or not to provide a thorough and considered response.

19.1.1 Project Manager

The Contractor shall assign a Project Manager, who shall be fluent in English and shall be based in the factory where the trains are manufactured. The Contractor shall also have staff in the Contractor's local office in Thessaloniki, capable of performing a liaison engineering function, who shall likewise be fluent in English. The Project Manager shall have extensive prior experience in the management of rail passenger vehicle procurements, and shall be familiar with rail vehicle design, the procurement of equipment from Sub-contractors, and with the rail vehicle construction, testing and inspection.

The Project Manager shall be granted full authority to make both technical and commercial decisions on behalf of the Contractor with respect to this procurement. The Project Manager shall serve as the Contractor's representative in all meetings with ATTIKO METRO S.A.. No substitution of the Project Manager shall take place without ATTIKO METRO S.A.'s prior approval.

19.1.2 Progress Review Meetings

The Project Manager shall conduct progress review meetings with ATTIKO METRO S.A., initially on a weekly basis. As trains related design and development progresses, ATTIKO METRO S.A. may elect to decrease this frequency. Depending on the matter to be covered, ATTIKO METRO S.A. may opt to conduct these meetings at the Contractor's manufacturing facilities or at the facilities of the Contractor's Sub-contractors. The Contractor shall ensure that qualified personnel shall attend all such meetings.

The Contractor shall publish an agenda at least three days prior to each meeting, and ensure that all attendees receive a copy. As a minimum, the following topics shall be discussed at each meeting:

- Introduce new attendees and their field of responsibility.

- Review Minutes of previous meetings, make appropriate changes, and concur.
- Review the master schedule and corrective actions being taken to maintain schedule.
- Review work completed since previous meetings (design status, manufacturing status, delivery issues, problems that occur due to changes, etc.).
- Discuss the status of design, construction, testing, procurement, quality control, etc.
- Discuss the work taking place over the next six weeks.
- Preparation and distribution of “Minutes of Meeting”.
- Review changes on the data base of the “Management of Requirements”.

19.2 SUBMISSION, REVIEW AND TIME SCHEDULES OF THE DESIGNS

19.2.1 General

The Contractor shall submit to ATTIKO METRO S.A. for approval the trains related designs. The manufacturing of trains shall adhere to the approval of the respective designs. It shall be the responsibility of the Contractor to promptly advise ATTIKO METRO S.A. on any anticipated delays in the submission of drawings or documentation, stating also the reasons for such delays, so that the related impact can be assessed and the appropriate measures be implemented.

The Contractor shall review the designs prior to their submission so as to ensure the suitability of all designs and to confirm compliance with the requirements of this Performance Specification.

The submissions shall cover, as a minimum, the following systems:

- Car Body
- Bogies
- Wheel sets
- Gearbox and Coupling
- Suspensions
- Gangway between cars
- Propulsion system – train motor
- Traction inverter control unit – Traction control unit
- Auxiliary power supply and distribution equipment – Power conversion equipment – Batteries
- Brake System and its subsystems
- Automatic Train Operation/Protection Equipment Interfaces
- Braking Equipment, including Air Compressor
- Car Interior Arrangement
- Car Roof Layout
- Car Underfloor Layout
- Couplers and Collision energy Absorption Mechanism
- Door system - Door Actuation and Control Equipment
- Operator’s Desk and Operator’s Desk’ area Layout
- Ventilation and Air Conditioning System (HVAC)
- Lighting System
- Power Collection Equipment
- Radio Communication Equipment
- Passenger Information Equipment
- Train Management and Control system
- Security Equipment
- Seats
- Windows, glazing and windshields.

The purpose of the design review process is to achieve the following goals:

- To ensure that, under normal operating conditions, the product's performance meets the requirements of this Performance Specification.
- To evaluate the possibility of various failure modes due to abnormal, worst-case operating conditions, and to ensure that such failure modes do not affect passenger or personnel safety.
- To optimize product reliability.
- To ensure adequate maintainability.
- To identify the quality assurance techniques to be utilized, and any improvement potentials.

At each design submission and respective review, the Contractor shall provide a Compliance Matrix, which shall reference all pertinent sections of the Performance Specification and Contract, and shall clearly delineate how the proposed design meets these requirements. This Compliance Matrix shall be updated on an as needed basis at each stage of the design review process and shall be part of the design documents, which will be submitted for ATTIKO METRO S.A.'s review and approval.

In view of understanding the function and interaction of each system, the Contractor will be required to produce a System Description for all systems, which will clearly describe the nature of the system, the components involved, the function of the system, and how the system interfaces with any other system.

19.2.2 Design Review

The purpose of the design review is initially:

- To establish an agreement on the Contractor's approach to the design of the train and its systems.
- To finalize the requirements of the systems and sub-systems.
- To perform a conformance review with the Performance Specifications and the Technical Offer.
- To provide the required additional detail necessary to fully describe the design approach and to eliminate ambiguities, if any.
- To define the requirements for the selection of system sub-suppliers

Further on, the following information shall be submitted, namely:

- Technical descriptions and operation related information of all systems and sub-systems of the trains. This may be an elaboration, confirmation, or clarification of information submitted along with the Technical Offer.

These submissions shall also include:

  - Technical Descriptions of the systems' performance
  - Technical Descriptions of the systems' operation
  - Technical Descriptions of the systems' interfaces,

And the following shall be attached thereto:

  - Table of compliance with the specifications
  - The comments of ATTIKO METRO S.A. and the Contractor's responses, if any
  - The manufacturing (factory) type of the equipment
  - The manufacturer of the specific equipment and the country of origin

- Dimensions of trains and of their main components
- Structural Analysis, fatigue and collision analysis for the car body

- Car body and bogies drawings
- Technical characteristics and dimensions of equipment per system
- Equipment drawings
- Assembly and installation drawings
- Electrical drawings
- Schematic diagrams
- Flow charts
- Logic diagrams
- Control systems architecture
- Data sheets concerning materials and individual items of equipment
- Performance calculations for each system/sub-system, as required
- List of line replaceable units (LRUs)
- Mass and center of gravity of equipment and cars
-
- Fire safety data
- Electric loads analysis and power requirements
- Noise control plan and calculations
- EMC technical information, electro-magnetic interference envelope
- Access for equipment control
- Access for equipment maintenance
- Coordination with all systems of the Line and the OCC/ECR
- Ensuring the compatibility of the new trains with the line, the depot equipment and the 18 initial train sets (Series I).

The mockups shall be reviewed and any changes/modifications shall be implemented in the finalization of the trains' and the equipment designs.

The designs review and submission process shall be completed according to the approved Time Schedule of the Project.

19.3 SYSTEMS INTEGRATION

Prior to the commencement of design work, the Contractor shall submit a Systems Integration and Interface Plan to ATTIKO METRO S.A. for review and approval. This plan shall describe in detail the means by which the Contractor will ensure that all systems and sub-systems of the trains are compatible with each other and with the existing systems of the line (trackwork, signaling, traction, telecommunications, etc.) to satisfy the requirements of this Performance Specification.

The plan must present the methods used to guarantee that the correct interface information is provided to pertinent groups within the Contractor's organization and to suppliers and sub-suppliers, including both physical and functional compatibility.

19.4 DESIGN APPROVAL PROCESS

The Contractor shall submit the documentation required by Chapter 16.0, following the design submission and review process outlined in Section 19.2 of this Performance Specification. Should standard hardware be proposed for any application, it will be acceptable, with the prior approval of ATTIKO METRO S.A., to submit design drawings for approval. Similarly, should existing designs be proposed, it may be acceptable, with the prior approval of ATTIKO METRO S.A., to submit the subject drawings for approval.

Upon approval of the manufacturing drawings and documentation, the Contractor can begin manufacturing. Any manufacturing activity performed prior to this approval will be entirely at the Contractor's own risk.

The Contractor's manufacturing schedule shall allow for a period of 30 calendar days as of the date of submittals acceptance by ATTIKO METRO S.A. for the relevant comments to be issued or for approval. Five (5) copies of drawings/documents shall be submitted to ATTIKO METRO S.A. for approval. After review by ATTIKO METRO S.A., the Contractor will be informed on the category into which each such drawing/document is classified, according to the following:

a) Category 1 – APPROVED. Works may proceed.
b) Category 2 – REVISE AND RESUBMIT. Works should not proceed.
c) Category 3 – REVIEW NOT REQUIRED. Works may proceed.

Category 1 shall mean that the Contractor may proceed to manufacture in accordance with the accepted design.

Category 2 shall mean that the Contractor must revise the drawing/document and resubmit it to ATTIKO METRO S.A. to reach Category 1. The Contractor should not proceed to manufacture.

Category 3 shall mean that ATTIKO METRO S.A. has taken cognizance of the information on the drawing/document and that these details do not call for classification into Category 1. The Contractor may proceed to manufacture.

Drawings/documents in Category 2 shall be revised and re-submitted to ATTIKO METRO S.A. for approval within 30 calendar days, calculated from the date of receipt by the Contractor of the comments of ATTIKO METRO S.A.. All revisions to drawings/documents by the Contractor shall be plainly marked on the drawings/documents, together with the dates when changes are made.

19.5 FIRST ARTICLE CONFIGURATION INSPECTION (FAI, FACI)

Prior to serial production, the Contractor shall conduct a First Article Configuration Inspection, both of the individual equipment, e.g. motor, bogie, doors, carbody etc. (FACI First Article Component Inspection), and of the entire trainset (FAI First Article Inspection), in accordance with a procedure approved by ATTIKO METRO S.A..

During this procedure, the first component produced will undergo a strict process to confirm that the hardware fully complies with the Contractor's design and manufacturing process requirements.

Hardware inspections may take place prior to this point, initiated either by the Contractor or ATTIKO METRO S.A., but they shall be considered as Hardware Reviews, and not FACIs.

During the FACI, the Contractor shall make available all pertinent design and manufacturing process documentation, test records, material certifications, etc. Should the requirements of the FACI be not met, then the inspection shall be considered a Hardware Review.

Upon acceptance of the FACI by ATTIKO METRO S.A., the Contractor may proceed to the manufacturing of all pertinent hardware. The hardware must meet or exceed the quality standards set by the FACI, while the Contractor must incorporate any comments made by ATTIKO METRO S.A.in the FACI.

The Contractor is reminded, however, that the installation of components or equipment items in the vehicle will likewise be subject to the FACI process. In addition, approval by ATTIKO METRO S.A. of any component or installation does not relieve the Contractor from meeting the requirements of this Performance Specification.

All hardware related to the construction of the vehicles shall be subject to the FACI process. As a minimum, the following equipment shall undergo the FACI process:

- Air Compressor
- Automatic Train Operation/Protection Equipment
- Auxiliary Power Supply Equipment
- Battery and Battery Box
- Bogies
- Braking Equipment
- Carbody Structure
- Car Interior Lining
- Car Interior without Lining
- Car Roof
- Car Underfloor
- Circuit Breaker Panels
- Couplers
- Diagnostic Test Equipment
- Doors
- Door Actuation and Control Equipment
- Operator's Desk
- Gearbox and Coupling
- Air Conditioning Equipment
- Lighting Equipment
- Power Collection Equipment
- Power Conversion Equipment
- Propulsion Inverter Control Unit
- Traction Control Unit
- Radio Communication Equipment
- Passenger Information Equipment
- Security Equipment
- Seats
- Signage
- Traction Motor
- Wheelsets
- Windows and Glazing.

The Contractor is reminded that permission to proceed does not relieve the Contractor from his responsibilities imposed by the Contract, neither does it constitute acceptance of the adequacy and accuracy of the design.

20.0 QUALITY ASSURANCE REQUIREMENTS

20.1 GENERAL

The Contractor shall implement a Quality Management System (QMS) and Project Quality Plan (PQP) to assure that the delivery of vehicles, equipment and provision of services meets the requirements of this Specification.

A complete Quality Management and Project Quality Plan, in accordance with ISO 9000 and IRIS or equivalent, in compliance with the design, manufacture, delivery, testing and commissioning of the Rolling Stock shall be delivered within 60 days of contract signing.

Within the framework of submission of the aforementioned documents, the Contractor shall submit to ATTIKO METRO S.A. for approval the curriculum vitae of the executive who will fill in the position of the person in Charge of the Quality Management.

ATTIKO METRO S.A. shall return to the Contractor the QMS and the PQP with any comments that may arise, which the Contractor shall incorporate in the revised versions of the QMS and the PQP. These shall be submitted to ATTIKO METRO S.A. for review and approval.

In case the Contractor responsible for the construction is a Consortium, the Quality Management System (QMS) and the Project Quality Plan (PQP) shall be universal application documents and shall determine all quality procedures and objectives undertaken by the Contracting Consortium.

The Consortium shall be represented by a mutually accepted Person In Charge of the Quality Management, as specified in the Conditions of Contract (CC). The individual Companies participating in the Contracting Consortium may appoint Quality Management Assistant Engineers to be instructed by the Person in Charge of the Quality Management of the Consortium.

In case the Contractor awards a part of the construction works to a Sub-Contractor or Sub-Supplier, the Sub-Contractor/Sub-Supplier is obligated to meet the approved Quality Management System of the Contractor.

Any modifications to QMS and PQP related documents proposed by ATTIKO METRO S.A. must be implemented. Any acceptance of the QMS by ATTIKO METRO S.A. does not release the Contractor from any modifications proposed at a later stage, arising due to adaptation to the applicable law or due to the necessity for revision recorded through Quality Inspections. Every provision of the final QMS and PQP versions must be in full compliance with the Contract.

All works shall be in accordance with the requirements of ISO 9001, IRIS.

20.2 QUALITY MANAGEMENT SYSTEM AND PROJECT QUALITY PLAN

The finally approved Quality Management System (QMS) should include the following:

- Defined Quality Policy and Objectives, explicitly specifying the Contractor's commitment to have the construction works completed on a Quality Management basis of the aforementioned Standards.
- Quality Manual describing the QMS overall structure and clarifying, inter alia, the QMS adequacy in monitoring and controlling all critical construction activities. In this framework, the Quality Manual shall constitute an element of the Project's deliverables.

- Organization Chart and Job Description Sheets. The Organization Chart should be the finally approved one by ATTIKO METRO S.A..
- Analytical Operational Procedures provided for by Standard 9001 or IRIS, as developed in paragraph 18.2.1 of this document. In addition, Work Instructions may be also included where required.
- The supporting documents ensuring the effective operation of all QMS procedures and proving its substantial control through systematic recordings.

20.2.1 Structure of the Quality Management System and Project Quality Plan

The structure of the QMS and the Operational Procedures shall cover through appropriate documentation at least the following subjects:

- Quality Management Procedures with reference to the QMS Review by the Management, the Development of QMS Documents, in-house Inspections, Corrective and Preventive Actions, Personnel Training, in-house communication, personnel hiring and evaluation and the in-house Non-Conformance Reports.
- Procedures related to the Project Management with reference to the Contract Management, the Installation and Organization, the Organization of the Project Files, the Project Planning, the Design Control and Monitoring and the Construction Methods. Particular emphasis will be placed on the used Account and Protocol Forms. In order to facilitate the preparation of the Project Deliverables, the traceability files shall be based on the code of Planning Manual for the distinct part of final deliverable (system – subsystem). All critical documents concerning the control of the final deliverable will bear the above code at a readily visible location and will be filed accordingly. In view of safely satisfying the requirements of ATTIKO METRO A.E., the Operational Procedure related to the development and revision of the QMS documents should provide for the automatic acceptance of ATTIKO METRO S.A.'s suggestions for the revisions of documents and forms related to the monitoring of the Rolling Stock manufacturing.
- Quality Control Procedures with reference to the Control and Testing Schedule, the Management of the Control and Testing Equipment, the Maintenance and Calibration of the Instruments and the operation of the Quality Control Laboratories.
- Procedures related to the Management of Health and Safety issues.
- Procedures pertaining to the control of Suppliers – Subcontractors and Associated Third Parties, with reference to the Evaluation of the Suppliers and Associated Third Parties in Construction Works, the Accomplishment and Checking of the Supplies and their Rendered Services, the Relation and Control of Subcontractors.

The Project Quality Plan form a part of the QMS and applies to all activities of the specific Project, aiming at ensuring fulfilment of the Contractual requirements.

The structure of the Project Quality Plan includes the following:

- Brief Description of the Project, Quality Policy Statement, Quality Objectives and Action Plans.
- Executed Checkings and Tests with reference to the Frequency of execution, the applicable Greek and International Standards, the Acceptance Criteria and the Independent Associated Laboratories. Special emphasis shall be placed on the reliability of the welding works. The Contractor is obliged to provide fully documented welding procedures, based on international/European or special railway standards, as well as organization of the quality control in the framework of the required non-destructive tests.

The above documentation shall include certified welding methods and personnel, design for the determination of critical weldings, quality control methodology using non-destructive tests etc.

The Contractor's ability shall be demonstrated by a certified Welding Quality Management system, prepared by an Independent Accredited Agency. Alternatively, the above requirement can be met by means of certifying the quality of welding on a sampling basis carried out by Independent Accredited Agencies possessing proven experience in the control of Rolling Stock material.

The proposed agency must be submitted to and approved by ATTIKO METRO S.A..

All independent laboratories for the execution of Non Destructive tests to be utilized by any involved party must be accredited per ISO 17025.

- Time Schedule of Works responding to the contract, including all Action Plans.
- Human Resources with the respective Organization Chart, the positions of Executives and the required qualifications in order to cover the positions.
- Approved Suppliers and Sub-contractors, as well as the selected Associated Third Parties with reference to the evaluation procedure, their Control and Inspection methods, as well as the methods of Acceptance of the delivered Goods and Services.
- Main Mechanical Equipment required for the implementation of the Project within the limits of the Time Schedule and Measuring Equipment for the needs of the Quality Control and other Controls.
- Document Management Methods with corresponding Lists, as well as methods for their filing in order to ensure the easy search for information and Project Deliverables.
- Non - Conformance / Corrective and Preventive Actions. It defines the method of management of non-conformances that may be identified during the execution of the Project and the preventive actions to prevent their re-occurrence. It also defines the procedure related to the verification of the effectiveness of the measures for non-compliance rectification.
- Quality Inspections. The PQP defines the implementation method, its frequency and connection with the work phases.
- Action Plans. For every Construction/ Manufacture of Main Equipment (e.g.: car body, bogies, motors, brakes, doors, HVAC, gangway / couplers, inverter, etc.) Manufacturing Phase, they describe the individual actions required for its completion, the Person(s) in charge, the Check Points of every action, which are classified in ATTIKO METRO S.A. Approval Hold Points and in Attendance Points, the applicable Specifications, Regulations and Standards, the Recording Forms and the cooperating Control Agencies.
- Approval Hold Points concerning the main equipment's construction / manufacturing works are the points where the presence of ATTIKO METRO S.A. aiming at the issuance of a Permit for the Continuation of the Work is deemed necessary. Similarly, Attendance Points are defined the points where the presence of ATTIKO METRO S.A. is not necessary; however, they constitute important self-control points of the Contractor, aiming at the optimum technical performance of the construction work and ensuring the acceptable preparation of the Approval Hold Points.

20.2.2 Requirements concerning the Suppliers of Materials and Services

The management of the Construction Materials and Services accepted and incorporated into the Project should be clearly defined in detail in the Contractor's Quality Management System. This management includes the evaluation of the Suppliers by the Contractor, the

submission and approval by ATTIKO METRO S.A., the handling of material/equipment purchases and contracts with the suppliers and their inspection before and after the delivery.
Under the responsibility of the Person In Charge of the Quality Management of the Contractor, a record shall be kept including all acceptable suppliers with data related to the supplying/co-operation capability, as well as data of any previous co-operation. Based on this specific record, a "List of Acceptable Suppliers" is formed and updated at regular intervals. The evaluation of the Acceptable Suppliers by the Contractor is performed based on specific criteria, which include, *inter alia*, the following:

- Certification according to the ISO 9000 series of standards or IRIS standard
- Existence of Quality Control System
- Long-standing co-operation background
- Recommendations and scale of the supplier
- Visit for the evaluation of the supplier
- Previous co-operation results.

The selection of each supplier of construction/manufacturing of main equipment or system incorporated in the Project shall be subject to final approval by ATTIKO METRO S.A., following a respective submission of data concerning the Material/Equipment/System and the Supplier. The minimum required criteria for the approval of incorporated Materials/Equipment/System are as follows:

- Provision of the Material/Equipment/System in the Project designs and the contractual documents.
- Certificate in accordance with the series of standards ISO 9000 or IRIS standard.
- Quality Control Certificates of the product (Material/Equipment/System) issued either by the -approved by ATTIKO METRO S.A.- Quality Control system of the Supplier and/or an independent acknowledged testing or certification agency, according to the requirements of the contractual documents and the EU standardization legislation.
- Results of a previous Inspection of the Supplier's facilities by ATTIKO METRO S.A.
- The Contractor shall ensure that the purchases are made in a way excluding non-conformance of purchases due to erroneous data and specifications during the communication with the suppliers. For this reason, all purchases should be made based on a specific procedure and using a standardized QMS document. The same are applicable and valid for long-term purchase agreements or agreements for the Provision of Services; in this case, special contracts are signed including all the aforementioned data.
- Concurrently, where necessary, controls and inspections shall be performed by the Contractor in order to ensure that the purchased goods meet the requirements agreed upon. A record of these controls and inspections is kept by the Person In Charge of the Quality Management of the Contractor.
- Within the framework of the Quality Inspections performed by ATTIKO METRO S.A., Inspections of the Supplier's installations may be also included either before and/or after their approval. Any non-conformance identified during the above Inspections is also recorded as Internal Non Conformance of the Contractor's System and is monitored through the method provided for by the QMS.

20.2.3 Inspections on the application of the QMS and PQP

According to ISO 9001, the implementation of the QMS is also checked, inter alia, by means of In-house Quality Inspections. The inspections should be performed in an appropriate way, in order to ensure the objectivity and impartiality, which are achieved through the proper selection of Supervisors who should not check the field of their own responsibility.
As a minimum requirement, the Contractor shall issue an In-house Inspections Program for every semester, which shall include all sections and procedures provided for in the QMS. The trends of the identified Non-Conformances should constitute a basic input in the QMS Reviews by the Management.
AM reserves the right to inspect the Contractor's Quality Management Control systems and the application of the PQP.
These controls include, as a minimum requirement, the following:

- **Initial QMS Review**, which aims mainly at the identification of any omissions related to the covering of all requirements of ISO 9001, IRIS standard and the contractual documents.
- **QMS Implementation Inspections,** during which a checking is performed at regular intervals with regard to the implementation of the initially approved QMS of the Contractor through scheduled quality inspections based on the following methodology:
  1. Issuance of an annual program
  2. Preparation of a List of Inspection Points
  3. Preparation of an Inspection Report
  4. Issuance of Non Conformance Reports (if required)
  5. Scheduling of Re-Inspection in order to check the progress of the corrective actions agreed upon
  6. Report concerning the completion of corrective actions/ Non Conformance Reports.
- **Inspections related to main equipment Construction/Manufacture Works** using a methodology equivalent to the one developed above. These Inspections are oriented towards the implementation verification of the Check Points Lists, focusing on the method of implementation of the Approval Hold Points by ATTIKO METRO S.A..
- **Quality Control Adequacy Inspections**, during which the checking is focused on the following points:
  - Checking of the adequacy of the associated laboratories in relation to the installations, the personnel, the equipment and the recording data. During this checking, the verification and calibration certificates of the equipment are concurrently checked.
  - Ensuring reliable results of accredited laboratory tests by inspecting the method of execution of tests.
  - Checking of the raw materials, incorporated materials and E/M equipment through Inspections carried out at the batch plants, where necessary, or through the quality certificates of the Supplier and Manufacturer, in combination with the quality control test certificates.
  - Checking of implementation of the standards, specifications, regulations etc. provided for on a case-by-case basis during the conduct of the quality control of the construction.

In the framework of the above verifications / inspections, ATTIKO METRO S.A. reserves the right to ask the Contractor to offer his support to ATTIKO METRO S.A. personnel in terms of hardware (indicatively, desk, P/C, internet connection, telephones, printers, etc.) throughout the verification / inspection period. The cost of the above actions shall be borne exclusively by the Contractor.

20.3 CONFIGURATION CONTROL

20.3.1 Design Changes

In order to control the vehicle configuration, the following requirements shall be adhered to for all changes to all equipment following First Article Configuration Inspection (FACI).
The Contractor shall submit to ATTIKO METRO S.A. for review design details of the proposed changes. In all cases, a written justification will be required for final acceptance.
The written justification shall be submitted in the form of an Engineering Change Notice (ECN), which shall contain the following information:

- Description of scope.
- Reason for change.
- List of related documents.
- Part numbers, serial numbers, quantities and location of affected parts or assemblies, as these are defined by ATTIKO METRO S.A. &the Contractor.
- The parts required to make the change.
- The effect of the change on interchangeability.
- Special tool requirements.
- Material disposition (reprocessed, scrap, etc.).
- A detailed procedure for making the change.
- Test equipment required.
- Test procedure.

For software changes, the Contractor shall demonstrate via a rigorous analysis and by tests that the change achieves the desired result.
No changes shall be made to equipment until the ECN has been approved by ATTIKO METRO S.A..
For changes required to be made to equipment having been already delivered, the ECN shall also be accompanied by a Field Modification Instruction (FMI). The FMI shall describe how the change shall be made in the field, in non-factory conditions. The FMI shall be approved by the ATTIKO METRO S.A.
The format and content of the ECN and FMI is the responsibility of the Contractor to determine, based on the Contractor's normal method of operation.
Only with the written approval of ATTIKO METRO S.A. will the above procedure be waived.
The Contractor shall submit to ATTIKO METRO S.A. for review a monthly listing of all active design change requests and their implementation status.

21.0 SPARE PARTS AND TOOLS

21.1 WARRANTY PERIOD SPARE PARTS

The Contractor shall provide all Rolling Stock spare parts, including consumable spare parts, required to support normal operation of the trains throughout the three-year warranty period.

A consumable is defined as any part that wears or becomes contaminated through normal usage, and, as a result, requires replacement at scheduled intervals. A consumable is also defined as any part that is not normally repaired, or is more expensive to repair than purchasing a new part. Examples of such are: oil, grease, air conditioning refrigerant, air dryer desiccant, brake pads, fuses, means of infiltration, light bulbs, etc. Should they be prohibitively expensive to repair, printed circuit boards shall be regarded as consumable items. Fuel and cleaning agents shall not be regarded as consumable items. The Contractor shall not be responsible for damage to the vehicles caused by ATTIKO METRO S.A.'s misuse or by vandalism.

Within 180 days of contract award, the Contractor shall provide a preliminary listing of all such parts to be supplied and within 360 days of contract award, the Contractor shall provide a complete listing of all such parts to be supplied, including the following information:

- Part description
- Contractor's part number
- Part number of the Manufacturer's Original Equipment
- Quantity of each type
- Quantity per train
- Unit price, Cost Including Freight (CIF) at ATTIKO METRO S.A.'s Depot
- Total price per item
- Maximum guaranteed delivery time from placement of order.

21.2 CAPITAL SPARE PARTS

The Contractor shall supply the Rolling Stock capital spare parts listed in the table shown on paragraph 21.3, to ATTIKO METRO S.A.'s designated warehouse in Thessaloniki. Parts requiring any change in configuration as a result of experience during the warranty period shall be upgraded by the Contractor at no cost to ATTIKO METRO S.A..

With respect to quantities, the following definitions shall apply:

Train set	The total quantity of the specified item used on one train, including any special hardware required to complete the installation, or associated hardware that normally suffers significant wear during the removal of the item.

Where only a number is used in the quantity column, the required number of complete units/assemblies shall be supplied, including any special hardware required to complete the installation, or associated hardware that is normally destroyed during the removal of the item.

Where the quantity is identified by a unit of time, the quantity of the hardware expected to be consumed in that time by all trains shall be supplied.

If, on the basis of the design, the proposed quantity of the spare parts to be procured is greater than the specified quantity, this will be indicated in a second additional column and shall be submitted to ATTIKO METRO S.A.

21.3 MAIN SPARE PARTS LIST

Part Description	Quantity Required
Vehicle Body	
Glass Reinforced Polyester (GRP) front end. (If used).	2
Gangway assembly, complete.	2 train sets
Windshield assembly, including seals.	6
Windshield cleaning assembly, complete.	12
Windshield wipers	20
Headlight assembly, complete, ready to install on car.	20 per type
Taillight assembly, complete, ready to install on car.	20 per type
Pneumatic horn.	12
Electric horn.	12
Exterior signs.	2 train sets
Bogies	
Motor bogie assembly, complete, ready for installation under car and immediate operation.	4
Trailer bogie assembly, complete, ready for installation under car and immediate operation.	2
Motor bogie axle with wheel set with gear.	8
Trailer bogie axle with wheel set.	4
Axle box.	8
Primary spring assembly, complete, ready for installation on car.	32
Secondary spring assembly, complete, ready to install on car.	6
Levelling valve assembly, complete with linkage.	10
Primary damper. (If used).	4 car sets
Secondary vertical damper. (If used).	4 car sets
Secondary lateral damper.	4 car sets
Set of bogie elastomeric components.	10 bogie sets
Couplers and Draft gear	
Automatic coupler assembly.	2 per type
Semi-permanent coupler assembly (if foreseen).	4 per type
Draft gear assembly.	6 per type
Car Interior	
Passenger seat assembly.	1 train set
Passenger seat insert set. (If used).	2 train sets

Vertical stanchion assembly, complete with all installation hardware.	1 car set
Interior grab rail assembly, complete with all installation hardware.	1 car set
Passenger handhold.	1 train set
Interior cladding panels, trim strips and mounting equipment.	1 train set
Rubber floor covering.	1 train set
Lighting fixture assembly.	2 train sets
Spare plaques for lighting fixtures, integrating LEDs, their entire guiding circuit, ready to install, as well as their connection cables.	3 train sets
Operator's console pushbuttons and switches.	40 per type
Driving / Braking Master controller assembly.	6
Set of Driving / Braking master controller switches.	6 per type
Passenger compartment window assembly, complete, including seals and frames.	1 train set
Interior signs.	2 train sets
Operator's Desk	1
Doors and Door Controls	
Passenger side entrance door assembly (2 leaves, left and right hand-side), complete, including weather stripping and glazing, ready to install on car.	8 left hand-side and 8 right hand-side sets
Passenger side entrance door operator and controls assembly (Door Control Unit, door glazing, threshold, etc.) complete, ready to install on car.	3 car sets
Emergency door handle assembly	2 car sets
Door control units.	30
Door motor units.	40
Door cables.	30 per type
Door sealing rubbers.	30 per type
Door indicator light assembly.	30 per type
Key Locks of staff doors	12
Fixed step	2 train sets
Air Conditioning Equipment	
Roof-mounted air conditioning unit, complete, ready for installation on the car and immediate operation.	1 train set
Set of air conditioning controls, complete.	6
Set of air conditioning system printed circuit boards.	6
Air conditioning system refrigerant compressor assembly, including electric motor.	2
Air conditioning system evaporator blower assembly, complete with electric motor.	6

Air conditioning system condenser coil assembly.	6

Air conditioning system evaporator coil assembly.	6
Heat resistors	6
Air filters	2 train sets
Contactors	2 train sets
Micro-automatic switches	2 train sets
Terminal blocks	2 train sets
Capacitors, coils and resistances	2 train sets
Electrical connectors, along with their cables, connected to one another (connectors with their cables connecting the electrical / electronic boxes, as well as connectors with their cables connecting equipment within the boxes shall be provided)	10 per type
Braking System	
Brake Control Unit (BCU) assembly.	8
Set of BCU printed circuit boards.	6
Electronic brake control equipment.	6
Brake disc assembly.	6
Brake actuator assembly, complete.	6
Brake pad.	480 MB + 160 TB
Brake actuator flexible hose.	12
Wheel flange solid lubricant stick	4000
Speed sensors	3 train sets
Pneumatic Equipment	
Air reservoirs.	2 per type
Set of air control equipment (valves, cut-out cocks, strainers, test points, pressure switches, etc.)	1 train set
Air compressor assembly, complete with motor, ready to install on car.	10
Air filters	2 train sets
Oil filters	2 train sets
Propulsion System	
Power conversion equipment assembly, complete, ready to install in car.	2
Set (assembly) of propulsion inverter power electronics modules.	6
IGBT items.	10
Starting units.	10
Diodes.	10 per type

Power sensors (transducers).	20 per type
Voltage sensors (transducers).	20 per type
Resistances (charging, discharging, etc.).	10 per type
Traction control unit, complete, equipped with all electronic cards, ready to install in car.	2
Set of traction control unit printed circuit boards.	10 per type
Power conversion equipment power conditioning equipment, complete. (E.g., filter reactors, filter capacitors, etc.).	2 train sets
Capacitors (not those of the major line filters).	10 per type
Coils (not those of the major line filters).	10 per type
Varistors, resistances.	10 per type
Contacts (charging, power, line, auxiliary, etc.).	3 train sets
Fixed and movable contact kits.	20 per type
Contact coils.	10 per type
Electrical connectors, along with their cables, connected to one another (connectors with their cables connecting the electrical / electronic boxes, as well as connectors with their cables connecting equipment within the boxes shall be provided, e.g. from the starting or control unit up to IGBTs).	10 per type
Power feeding units.	10
Temperature sensors.	3 train sets
Traction motor.	10
Set of speed sensors.	3 train sets
Fuses.	20 per type
Braking resistor.	2
750V dc high speed circuit breaker, complete.	5
Set for overhaul of the 750V dc high speed circuit breaker.	10
Current collector assembly, complete, ready to install on car.	2 train sets
Current collector shoe.	2 train sets
Manual short circuiting device.	4
Auxiliary Electrical Supply System	
Auxiliary power supply equipment assembly, complete.	3
Set of auxiliary power supply equipment printed circuit boards.	10
Set of auxiliary power supply equipment power electronics modules.	10
IGBT items.	10
Starting units.	10
Diodes.	10 per type

Power sensors (transducers).	20 per type
Voltage sensors (transducers).	20 per type
Resistances (charging, discharging, etc.).	10 per type
Capacitors (not those of the major line filters).	10 per type
Coils (not those of the major line filters).	10 per type
Varistors, resistances.	10 per type
Contacts (charging, power, line, auxiliary, etc.).	3 train sets
Fixed and movable contact kits.	20 per type
Contact coils.	10 per type
Electrical connectors, along with their cables, connected to one another (connectors with their cables connecting the electrical / electronic boxes, as well as connectors with their cables connecting equipment within the boxes shall be provided, e.g. from the starting or control unit up to IGBTs).	10 per type
Fuses	20 per type
Battery Control Assembly	2 train sets
Temperature sensor	3 train sets
Auxiliary power supply equipment power conditioning equipment, complete (E.g., filter reactors, filter capacitors, etc).	2 train sets
Battery box, complete, less batteries.	2
Battery cells.	2 train sets
Telecommunications System	
Public Address equipment, complete.	2 train sets
Train radio equipment, complete.	2 train sets
Passenger Information System	
Passenger Information System equipment, complete.	3 train sets
Electronic System route map.	5
Internal electronic information display.	5
External electronic destination display.	5
Device for the communication between Driver/OCC and passengers	2 train sets
Emergency Device	2 train sets
Security System (CCTV)	
Security System equipment, complete.	3 train sets

Miscellaneous Equipment	
Set of Train Control and Management System equipment (including displays, control units, I/O units, any ETHERNET switches, gateways, electrical connectors, network switches, etc.) and radio communication system with on-ground working stations.	3 train sets
Event recorder.	3
Set of Train Control and Management System printed circuit boards.	6 train sets
Relays, along with their auxiliary contacts and bases.	60 per type
Automatic Circuit breakers.	30 per type
Timers.	30 per type
Special mechanical fasteners.	9 per type
Oil.	3 years of progressing supply, on the basis of expiry date
Grease.	3 years of progressing supply, on the basis of expiry date
Sealants.	3 train sets
Pushbuttons.	40 per type
Switches.	40 per type
Electrical connectors of all types with glands.	10 per type
Electrical connectors assembly from one car to another, along with their cables fully connected.	4 per type
DC-DC inverters and power feeding devices (except for those referred to in the traction system).	10 per type
Terminal blocks of all types.	4 train sets
Cables of all types, i.e., power, high – medium – low voltage, network, telecommunications, etc.	50 meters per type
Glands.	40 per type

21.4 INFORMATION AND PRICING FOR THE ILLUSTRATED PARTS CATALOGUES (IPCs)

Concurrent with the delivery of the final Illustrated Parts Catalogues, the Contractor shall also provide the information required in Clause 21.1 of this Performance Specification for all items listed in the Illustrated Parts Catalogues, down to the lowest level replaceable unit.

The Contractor shall provide pricing for all components listed in the Illustrated Parts Catalogues.

21.5 SPARE PARTS AVAILABILITY

The Contractor shall guarantee that all required Rolling Stock spare parts shall be available to ATTIKO METRO S.A. for a period of 15 years following the end of the warranty period.

With respect to computer hardware and software, the Contractor shall guarantee that hardware and software -both physically and functionally compatible-shall be available during this time period.

21.6 SPECIAL TOOLS

The Contractor shall provide a complete list-table of all special tools required to perform maintenance and overhaul activities on the trains, by discrete activity, stating as well the quantities to be provided.

The Contractor shall provide a sufficient number of all special tools required to enable ATTIKO METRO S.A. to properly maintain and overhaul the trains. The number of tools shall be approved by ATTIKO METRO S.A. based on an operational analysis to be provided by the Contractor.

All special tools or special structures used by the Contractor in the area of the Depot for the arrival and the testing of the new trains shall remain at the Depot under ATTIKO METRO S.A.'s ownership.

A refrigerant filling device including the necessary piping shall specifically be supplied for the HVAC system.

21.7 DIAGNOSTIC TEST EQUIPMENT

The Contractor shall provide diagnostic control and test equipment to ascertain the functionality and safe operation of all discrete pieces of specialized equipment. It shall be possible to check all repairable or replaceable equipment as to its safe operation using the provided Diagnostic Equipment.

This equipment shall consist of portable test equipment and shop test equipment.

The portable test equipment shall also include a suitable number of pre-programmed laptops, as well as a sufficient number of standard cable connectors.

The application programs used shall be in English and shall run in MS Windows, the version to be agreed with ATTIKO METRO S.A.. Also, the application programs shall be compatible with the Greek regional settings. The display languages shall be in Greek and English. Therefore, two separate software versions in Greek and English shall be provided.

In addition, the application programs used in the pre-programmed laptops shall be able to be installed and used on any of ATTIKO METRO S.A.'s existing laptops.

Four (4) laptops shall be provided, as a minimum. They shall be of heavy duty-industrial type and state-of –the-art technology at the time they are delivered; they shall be suitable for the workshop environment and will be approved by ATTIKO METRO. The laptops shall be capable of being connected to the equipment to be tested, allowing faults to be quickly and easily diagnosed. Connection points shall be provided both on the cars' interior and exterior, as appropriate, to quickly diagnose faults with associated systems; the locations of these points shall be approved by ATTIKO METRO S.A..

Additionally to the portable laptops, the Contractor shall provide three (3) chart recorders, which will allow recording of at least the 3rd rail voltage, motor current, speed, the status (on

or off) of various contactors, or other analogue or digital signals etc. when running under normal or test conditions.

For this purpose, the equipment of all train sub-systems shall support this function by providing suitable outputs of digital or analogue signals, either integrated in the equipment, or by using additional cards which the Contractor shall supply.

The chart recorders shall of the heavy duty-industrial type suitable for the workshop environment and shall be approved by ATTIKO METRO S.A..

The shop test equipment shall consist of at least one set of test benches for each car system, whereby the equipment to be tested is removed from the car and loaded onto the test bench. The shop test equipment shall allow all faults to be easily and quickly diagnosed. Each test unit shall be completely wired and shall use 230Vac, 50Hz single-phase power and compressed air, as appropriate.

The Contractor shall also supply one set of power conversion equipment suitable for installation in ATTIKO METRO S.A.'s workshop to allow repaired and overhauled motors to be tested by being powered in a dynamometer. Similarly, equipment shall be supplied to enable overhauled Auxiliary Power Supply Equipment to be fully tested.

The Contractor shall also supply diagnostic test equipment for the HVAC systems which shall include a portable digital thermometer/humidity meter, a refrigerant pressure manometer and a leak detector unit, in addition to all other diagnostic equipment proposed by the Contractor. The above, including any special tools for the HVAC system shall be provided in a metal trolley tool box.

In addition to the above, the Contractor shall provide a sufficient number of pieces of diagnostic test equipment to allow ATTIKO METRO S.A. to properly maintain the trains. The number shall be approved by ATTIKO METRO S.A. based on an operational analysis to be performed by the Contractor.

As part of the diagnostic test equipment, the Contractor shall provide the following:

- Complete schematics and maintenance and calibration instructions for the equipment, including printed circuit boards and micro-processors.
- Complete schematics and maintenance and calibration instructions for the car-borne system and its printed circuit boards directly associated with the diagnostic test equipment.
- Spare parts.
- Five sets of replacement cable and connector assemblies for each piece of test equipment.

The Contractor shall maintain the equipment software throughout the warranty period.

22.0 PERSONNEL TRAINING REQUIREMENTS

22.1 GENERAL

The Contractor shall train, the nominated ATTIKO METRO S.A. personnel on the Operation and Full Maintenance of the Rolling Stock and its components. These trainees shall be ATTIKO METRO S.A.'s Training Instructors (Instructors for Operators and Instructors for maintenance staff), who will require training in technical matters according to their intended function and in instructional techniques.

22.2 TRAINING OBJECTIVES

The content, timing and duration of the training program shall be such that personnel trained by the Contractor will be able to operate and maintain the rolling stock in the designed manner with maximum reliability and economy. Training objectives in terms of minimum standards to be achieved by each trainee shall be clearly defined by the Contractor for each trainee post.

In any case, the trained Personnel shall be able to safely and successfully implement all procedures foreseen in the Maintenance and Operation Manuals.

22.3 TRAINING METHODS

The training shall be planned and carried out in a manner suitable for the intended occupation, and shall consist of:

1. Formal off-the-job theory and practice.
2. Practical on-the-job follow-up experience.

The Contractor shall demonstrate that ATTIKO METRO S.A.'s trained staff has achieved the minimum objectives established for each trainee post, as defined under Clause 22.2 of this Performance Specification.

The Contractor shall submit for the approval of ATTIKO METRO S.A., not later than 18 months upon the Award of the Contract, the training programs and the syllabus/documentation of training and the systems for monitoring the progress of both the training programs and individual trainees. The programs shall clearly show commencement and completion dates and the number of trainees for each training course and whether in an off-the-job or on-the-job mode. The training programs for the ATTIKO METRO S.A. personnel shall be in accordance with recognized European standards.

The syllabus shall clearly indicate:

1. Course title and objectives.
2. Course content and objectives.
3. Location of training course.
4. Methods of training.

The methods for monitoring progress shall relate to:

1. Theoretical tests and systems of assessment.
2. Practical test pieces and objective systems of assessment.
3. Progress reports.
4. Training schedules.

Training courses shall be held preferably in English but shall be translated without exception into Greek. Therefore, appropriate translators shall be used, who shall be subject to ATTIKO METRO S.A.'s approval.

Also, all training documentation shall be without exception in Greek and English.

Records of each trainee's progress shall be kept up-to-date and made available to ATTIKO METRO S.A. or to his representative for examination when required.

Copies of individual trainees' records, showing all test results and reports of progress, shall be sent to ATTIKO METRO S.A. on completion of each training course.

22.4 CONTRACTOR'S TRAINING STAFF

For all off-the-job formal training, in both theory and practice, the Contractor shall provide qualified staff as instructors to ATTIKO METRO S.A.'s trainees.

Where ATTIKO METRO S.A. trainees are assigned to the Contractor (or his Subcontractors) for the purposes of gaining job experience, all such trainees shall be properly supervised and monitored by a qualified training supervisor to ensure that each trainee has the best opportunity to benefit from the theoretical and practical experience.

ATTIKO METRO S.A. reserves the right to request additional training in cases where the training has been considered as inadequate or incomplete, or where training problems have been identified.

22.5 PERSONNEL TO BE TRAINED - OBJECTIVES

Training aims at fully familiarizing ATTIKO METRO S.A.'s Operation and Maintenance Personnel with the maintenance works of the entire Rolling Stock equipment.

Upon completion of the training, ATTIKO METRO S.A.'s personnel shall be:

- Capable of inspecting, maintaining and repairing all Rolling Stock equipment components, as well as using safely and effectively special tools.
- Sufficiently trained to provide future training, examine and to certify present and future employees.

22.5.1 Personnel to be trained

22.5.1.1 Operation Personnel

Having completed the training program, the Operation personnel shall be in a position to:

1. Understand all characteristics, functions and structures of the Rolling Stock.
2. Understand the safety precautions during the Rolling Stock or equipment operation.
3. Understand the operation of the Rolling Stock and its equipment under normal circumstances.
4. Understand the operation of the Rolling Stock and its equipment in degraded circumstances.
5. Understand interfaces with other sub-systems.
6. Use the material provided by the Contractor during the training courses.

22.5.1.2 Maintenance Technical Staff

Upon completion of the training on Rolling Stock systems, the trained maintenance staff shall be in a position to:

1. Understand all characteristics of the system, the functions and configuration of the sub-systems, the materials and the software structure.
2. Understand the safety precautions when working with sub-systems during the maintenance works.
3. Understand and implement the maintenance methods as regards preventive, corrective repairs as well as overhaul.

4. Understand and implement the troubleshooting techniques.
5. Replace Lowest Level Replaceable Units (LRU).
6. Perform preventive and corrective maintenance of the hardware and software (if required).
7. Use special tools and equipment (if any) for maintenance purposes.
8. Perform equipment tests, repairs, calibration, correction and certification.
9. Re-install software (if required).
10. Use the material provided by the Contractor during the training courses.

22.5.1.3 Rolling Stock Engineers

Upon completion of the training on Rolling Stock systems, the trained Rolling Stock engineers shall be in a position to:

1. Understand the overall system architecture and design concept.
2. Understand all key characteristics of the system, materials, functions and settings of the sub-systems and the software structure.
3. Understand the safety precautions when handling, operating and maintaining the Rolling Stock, as well as the equipment and tools provided by the Contractor.
4. Understand and implement the maintenance methods as regards preventive and corrective repairs and overhaul, as well as the option to schedule maintenance works using the specialized software.
5. Understand and implement the troubleshooting techniques.
6 Use the material provided by the Contractor during training courses.

22.5.2 Certification and Training Manager

For each trainee who has successfully completed training and passed the examination, the Contractor shall issue certificates describing:

- The attended course
- The result of the exams
- Trainee's proficiency in the subject of the course.

The Contractor shall appoint a Training Manager, who shall supervise the coordination of the overall training.
The certificates shall be signed by the Instructor and the Training Manager.

22.6 TRAINING LOCATIONS

The training of selected ATTIKO METRO S.A. staff shall be carried out at such locations where the greatest benefit for trainees may be gained. This may be in Greece, at locations of equipment manufacturing, assembly or testing, or at any other locations as deemed necessary. All places of training shall be approved by ATTIKO METRO S.A..

22.7 TRAINING EQUIPMENT

In general, the Contractor shall use equipment specifically dedicated for training purposes. However, he may use, as may be agreed upon, equipment being assembled, tested or commissioned for the training of ATTIKO METRO S.A.'s staff, if no such equipment is available. The Contractor shall not use spare parts from assemblies for this purpose.

The Contractor shall provide, at no cost to AM, such written or printed matter, samples, models, sections of equipment, slides, videos and other instructional material, as deemed necessary for training purposes. Such materials shall be retained by ATTIKO METRO S.A. at the end of the training program(s).

The supply of equipment and materials shall be sufficient both for the persons trained by the Contractor and for those to be subsequently ATTIKO METRO S.A.'s Instructors.

23.0 TRAIN CONTROL AND MANAGEMENT SYSTEM

23.1 GENERAL

All trains shall be equipped with a modern extensive Train Control and Management System, which shall provide train automation and enhanced co-operation between the systems, as well as centralized control and diagnostics of the connected sub-systems.

These sub-systems shall include, without being limited to:

- Propulsion system
- Auxiliary power supply system
- Brake control system
- Door system
- Air conditioning system
- Operator's Desk display unit
- Public address system
- Passenger information system
- CCTV security system
- Event recorder system
- Smoke detection system
- Failure management system
- Automatic Train Operation system (cooperation with ATC)
- Manual Operation System.

In addition, all cars shall be networked one to the other to enable centralized control.

The Train Control and Management System shall be managed by a Central Control Unit.

The Train Control and Management System shall be implemented in Ethernet network (Ethercat, TCP/IP, Profinet etc.).

Other network solutions shall be acceptable such as Controller Area Network (CAN), Attached Resource Computer NETwork (ARCnet), etc.

23.2 TRAIN COMMUNICATION NETWORK BUS SIGNALS

The Train Communication Network shall encompass, as a minimum, the following parts:

- Network, which interconnects devices within a car unit. It shall be bus optimized for fast response.
- Network, which allows data communication within a train. It shall be bus optimized for fast response.
- Network for PA/PIS and CCTV systems.

In addition, an Ethernet bus shall be provided for the connection of the system through a WLAN (Wireless Local Area Network) in the Depot and at various points along the network.

23.3 SYSTEM REQUIREMENTS

23.3.1 Hardware

All equipment used shall comply with the requirements of the Standard IEC 60571, EN 50155 and EN 50121. The Contractor shall also take into consideration other Standards referred to in other Clauses of this Performance Specification.

The components shall preferably not require air blast cooling.

Standard automation using relays shall be avoided and, to the extent feasible, digital solutions with the use of software shall be implemented.
If dual cables are used to monitor a signal, then both cables shall be monitored, so that failure of one cable can be announced to the Train Control and Management System.

The computer software shall be saved on an interchangeable storage medium or on non-easily rewritable storage medium, via an easily accessible communication port.

The safety-related software shall be stored only in storage mediums which do not need buffer batteries memory for data conservation.

If buffer batteries or other energy storage medium are used in vehicle/train control systems, in order to retain specific functions, while supply voltages being switched off, those voltage and/or energy content shall be permanently controlled. If voltage is drops under permissible limit values, the subject failure shall be indicated. Limit values are to be monitored and/or selected in such a way that a safe functionality is ensured for a sufficient time interval. The replacement cycle shall not be less than 5 years.

The type of the energy storage media to be utilized (batteries) shall be available in the market.

Short circuit proof Input/Output modules and interfaces shall be used.

23.3.2 Software

The planning and programming shall be in accordance with the Industrial Standard EN 61131-3 with the commonly used languages, such as Instrument List (IL), Function Block Diagram (FBD), Ladder Diagram (LD), Sequential Function Chart (SFC), Structure Text (ST) and shall ensure universal applicable software tools for control systems, subsystems, communication and diagnostics. In addition, it shall be possible to write new program sections in the high level language C. (American National Standards Institute (ANSI)-C).

Therefore, the Contractor shall provide a relevant software tool, for which the following requirements shall be satisfied:

- The Train Control and Management System shall be programmed in a graphical environment language. Logic diagrams of the used algorithm shall be provided, as well as the program screen printouts, referring to the algorithm logic diagrams. Therefore, executable operation software with graphic view function shall be provided.
- Interface software where all variables can be modified easily within their appropriate range shall be provided.
- ATTIKO METRO S.A. shall be able to parameterize the system components at any time. This shall permit ATTIKO METRO S.A. to have an effective programming adjustment and changing tool, simple maintenance and also a comprehensible documentation of changes to be possible. Any setting or change or any parameterization shall not modify the basic functions of the vehicles.

- Software programs needed for signal inputs, correcting and data selections and also special software tools for evaluation of stored data in fault-memory and also for upload and download of all data files are to be provided by the Contractor.
- Connection to system interfaces shall be applicable by using Windows based PCs or Laptops including the necessary application software.
- The software shall be documented in an appropriate way and shall be provided to ATTIKO METRO S.A. in the framework of the train documentation both in electronic format and in print-outs.
- All delivered software shall be handed over to ATTIKO METRO S.A. (in DVD format) with commissioning the first train and shall be stored at a protected area easily accessible by both parties.
- The Contractor will keep record of all future updates/revisions of the software during commissioning, testing and warranty period and shall make them available to ATTIKO METRO S.A..

For computer-controlled control systems the software shall be subdivided asa minimum into:

a) - Selection of all diagnostics memories
   - Selection of operating data and diagnostics data
   - Braking distance measurement

b) - Diagnostic opportunity of the data and signal transmission inside the control system and at system interfaces
   - Simulation of conditions of the Input/Output modules (e.g. for indication lamps, Light Emitting Diodes, etc.)
   - Display of conditions and test simulation of the Input/Output modules (supported by graphic language)

c) - Change of parameters (e.g. central change of all door parameters such as closing cycles, closing times and blockage of selected car doors)

d) - The application software shall be structured hierarchically and allowed having individual function packages, function groups and detailed function blocks.

In addition, the Contractor shall provide a maintenance software tool, in accordance with the requirements of Clause 23.9 of this document. It is stressed that the aforesaid maintenance software tool shall satisfy the requirements of the planning and programming software tool described above, if applicable.

23.4 TRAIN NETWORK STRUCTURE

The Contractor shall provide the Train Control and Management System diagram for ATTIKO METRO S.A.'s review and approval.

High safety functions shall be realized by train lines as a redundant network to the Train Control and Management System.

Therefore, the Train Control and Management System shall have a backup level. If, for example, both Ethernet Buses fail, a hardwired back-up level shall ensure the operation of the train at a reduced speed, for the train to be driven to the next station, for the passengers to disembark and the train to return to the depot.

The communication either way, (i.e. Ethernet bus and hardwire) shall be supervised and any failure to one communication method shall be announced and recorded to the Train Control and Management System and to the Event Recorder.

In addition, other train lines shall be also provided, e.g., for train's preparation, information about train status, door control, public address, etc.

The Contractor shall provide the Train Control and Management System Back-up Level diagram for ATTIKO METRO S.A.'s review and approval.

The Train Communication Network shall incorporate provisions for future extension of the network with new subsystems, which will have been already wired to the Train Communication Network. The new subsystems shall be easily identifiable and integrated into the Train Control and Management System.

The communication between the maintenance personnel and the Train Communication Network (for uploading/downloading of data and new versions of software, testing and any other purpose) shall be effected by connecting the appropriate portable computer to the Central Control Unit with Universal Serial Bus (USB) and serial connection, as well as to the Ethernet bus. Connection to TCMS shall be feasible from every car through Ethernet ports. Ethernet ports will be provided at each car end, two per car.

23.5 DATA COMMUNICATION

All signals related to operation, faults, commencement of self-tests and equipment status feedback shall be grouped per system or operation and shall bear a unique identification code, which shall remain the same during all design stages, tests (procedures, reports) and in manuals.

23.5.1 Train Control and Management System Network

Signal transmission between individual components shall be based on the Train Control and Management System. In addition, in order to have a proper bus interface connection without any difficulties for each component, the interface connections shall fulfil the requirements of the design, aiming at the homogenous integrated communication for all systems on-board the trains.

The network cable shall be shielded and shall have physical redundancy (routing from the other train side).

The Train Communication Network with real-time capability shall comprise of at least two redundantly wired bus systems.

The redundantly wired busses shall be placed on each side of the car unit and each bus cable shall run on different car side.

Whenever the train composition or the devices have been changed, the bus shall determine the proper position, orientation and characteristics of the individual components.

23.5.2 Vehicle Functions Network

The Vehicle Functions Network shall be designed to connect electronic components and control systems inside the train.

The Vehicle Functions Network shall control and coordinate data exchanged between the subsystems and shall function as a link between train control level and vehicle control level. Components of different manufacturers shall be applicable to the Vehicle Functions Network without restrictions.

The Vehicle Functions Network shall have a fixed configuration and shall not require any implementation phase to be commissioned.

23.5.3 Central Controlled and Monitored Components

The Vehicle Functions Network shall coordinate data transfer between the master Central Control Unit and subsystems and shall control all vehicle bus connected subsystems.

The Train Control and Management System shall cooperate, as a minimum, with the required quantity of separate controllers:

- Central Control Units
- Propulsion Inverter Control Units
- Auxiliary Converter Control Units
- Brake Control Units
- Door Control Units
- Air conditioning Control Units
- Operator's Display Units
- Public Address system
- Passenger information system
- Security system
- Event recorder system
- Automatic Train Operation system
- Input/Output Modules
- Vehicle Functions Network Maintenance Service Interfaces.

23.5.4 Central Control Unit

The Central Control Unit shall provide propulsion control functions, central control functions, as well as central diagnostics functions.

A transparent, redundant train bus communication between several vehicle controller units shall ensure a very fast and secure data transmission inside the system.

There shall be a direct connection of the Central Control Unit to the Vehicle Functions Network.

Two Central Control Units shall be used in each train. Upon activation of the train, one Central Control Unit shall be automatically specified as the master Control Unit, while the other Central Control Unit shall be automatically specified as the slave Central Control Unit.

If the master Central Control Unit fails, the train shall not brake automatically up to standstill. In this case, the system shall automatically switch over from the master Central Control Unit to the slave Central Control Unit and the train shall be available without any restrictions.

If all Central Control Units fail, the Train Control and Management System Back-up Level described in Clause 23.4 of the present document shall be set in operation.

The Central Control Unit shall perform the following functions, as a minimum:

- Communicate with the Automatic Train Control equipment (ATC mode)
- Perform load weight calculations.
- Detect the presence of third rail gaps.

- Compute required tractive or braking effort.
- Detect the onset of wheel spin and/or wheel slide and regulate the propulsion inverters via the Propulsion Inverter Control Units to control the event.
- Control regenerative braking.
- Limit jerk.
- Provide the electro-dynamic brake feedback signal to the friction braking system to ensure smooth brake blending.
- Provide a wheel slide detection signal to the mechanical braking system for fast slide correction.
- Communicate with, and provide the supervision of, the Propulsion Inverter Control Unit and the Brake Control Unit.

23.5.5 Propulsion Inverter Control Unit

The Propulsion Inverter Control Unit shall perform as a minimum the following functions:

- Control and protect the associated propulsion inverter equipment.
- Control and protect the associated brake chopper equipment.
- Regulate the associated propulsion inverter to control wheel spin and/or wheel slide.

23.5.6 Input/Output Modules

The digital and analogue inputs/outputs shall be used for the connection of sensors, actuators and devices enabling communication with the Vehicle Functions Network. These Input/Output modules shall be short circuit proof and shall permit a decentralized installation. The number of gateways for automation and limit controllers shall be as high as possible. It shall be possible to supply all the various vehicle controller units directly by the DC power supply system.

Failures of (sub)systems or partial failures have to be recognized in real time, stored by the Input/Output modules and announced to the Central Control Unit diagnostic systems. The Central Control Unit shall evaluate the degree of failure and shall indicate it accordingly on the Operator's Desk Display Unit.

A reserve of minimum 20% of free inputs/outputs at the Input/Output modules shall be provided.

23.6 VEHICLE SELF-TEST FUNCTION

When activating (start-up) the train by key or automatically through the ATC system, then a self-test has to be initiated automatically, so that the option be given for automatic detection of the train status.

This self-tests hall provide the option for train control, so that:

- The ability of the train to safely travel with passengers be assured;
- The Operator and/or the maintenance personnel be capable for checking the vehicle's operability.

Evaluation shall be realized automatically. The result shall be shown on the Operator's Desk Display Unit and shall be saved in the diagnostics memory of the Central Control Unit.

The train self-test shall be completed within the lowest possible time. If required, a later parameterization of additional test functions shall be realized.

The self-test procedure may contain the following tests, as a minimum:

- Power supply, external/internal
- Electronic systems' self-test

- Propulsion inverter self-test
- Lighting, signal lamps, etc.
- Door loop, state of doors, coupling
- Train stop function
- Brake system control /Brake system of bogies
- Compressed air system / pneumatic equipment
- Alarm devices
- HVAC system

23.7 CENTRAL DIAGNOSTIC SYSTEM

23.7.1 General

Diagnostics process shall contain collection, display, evaluation and saving of status and fault/event related messages.

The diagnostics system shall work in such a way that:

- The degree of the train's operating ability be indicated to the Operator's Desk and the Control Centre at any time,
- Disturbances be promptly signalled via the appropriate signals.

This shall enable an easier elimination of errors in service work, simplify maintenance and minimize the required time related to the above.

Inside the Central Control Unit there shall be a diagnostics unit with a back-up battery memory and integrated real-time clock. The diagnostics results of bus controlled subordinated control devices shall be saved and documented in chronological order in the diagnostics memory of both Central Control Units.

Only substantial status and error messages from the train diagnostics system, the fault classification A to C, shall be indicated on the Operator's display.

Disturbances, remedies and other information concerning the train status shall be indicated to the Operator's Desk through a multi-function (LCD) - (TFT) display or better. Messages on the Operator's display unit, as well as diagnostics content and texts, shall be subject to ATTIKO METRO S.A.'s review and approval.

Components used at the Vehicle Functions Network shall be equipped with systems being able to perform a self-diagnostics, to register errors and to make these data available for a later evaluation with time stamp.

The train diagnostics shall document the various software status implemented on the train automatically and shall control them concerning release status. Version number and/or version date of the installed software shall be visible with simple means or functions in the system.

Definition of the necessary diagnostics range in the subcomponents, which is to be selected by the Vehicle Bus, shall be subject to ATTIKO METRO S.A.'s review and approval.

It shall be possible that diagnostics memory, e.g. the Central Control Unit, Door Control Unit, Brake Control Unit etc., of a complete train can be selected by each central diagnostics system interface connector.

In order to be able to rapidly identify errors and to eliminate disturbance, all registered diagnostics data and associated Personal Computer analysis programs for different components shall be made available to the maintenance personnel. Therefore peripheral devices shall be equipped with well-accessible interfaces for commercially available and already used laptops by ATTIKO METRO S.A. for checking, uploading and changing operational parameters.

Registered disturbance data shall be stored in a non-volatile memory in the Central Control Unit. In this memory, all data shall remain stored in case of a failure of the electrical on-board supply system for half a year. If an error occurs, the error memory shall record the status values in real-time. A temporarily limited history of the error shall also be part of the relevant recordings.

It shall be indicated that an error memory is fully written.

It shall be possible to flexibly adjust provided diagnostics data to changed or extended train functions, components which were added or to changed diagnostics requirements. The necessary tools to this end shall be made available to ATTIKO METRO S.A..

For trains, the following diagnostics interfaces shall be provided as a minimum:

- Vehicle Functions Network interface for diagnostics of car unit as well as subcomponents
- Propulsion Inverter
- Auxiliary Converter
- Passenger compartment air conditioning
- Brake Control Unit
- Door Control Unit
- Communications system
- Passenger Information System
- Security system
- Automatic Train Control system

Simple error detection systems, e.g. description of an error code through a signal light, Light Emitting Diode signal or LCD – TFT display of the Operator's Desk shall be provided for electronic installation components, cards and devices wherever this is possible.

23.7.2 Fault Classification System

A fault classification system shall be provided, in order to inform the Operator, on the operational status of the train. It will have the following categories:

- Class A: Train is not able to provide service any longer
- Class B: Train may move only with specific restrictions
- Class C: Train requires maintenance attention, proceeding in revenue service is possible

The category A shall include faults or combination of faults that require immediate withdrawal after complete evacuation of the train.

The category B shall include faults or combination of faults that allow the train to finish its journey safely before withdrawal.

The category C shall include faults or combination of faults that allow the train to continue its scheduled journey safely.

The system shall have the ability not to display Class Con the Operator's Screen and the Control Centre, after the specific parameter change of the software by the authorized maintenance personnel, in order not to disturb the Operator with faults or combination of faults, which do not affect the revenue service. The authorized maintenance personnel will have the possibility to check all the relevant faults of the train after finishing its revenue service, using a special change of parameters of the software.

The display of the Fault Classification shall have priority over other information.

23.8 OPERATOR'S DESK DISPLAY UNIT

An Operator's Display Unit shall be installed in each end of the train. It has to indicate to the Operator or the Maintenance personnel all operation and fault statuses, as well as information about the route in a very clear and organized manner.

The Operator's Display Unit shall provide four primary screens for interface with the Operator and maintenance technicians. More specifically:

- Operation screen
- Control screen
- Fault screen
- Maintenance screen

The default setting shall display the operation screen.

The detailed screen layouts shall be subject to ATTIKO METRO S.A.'s review and approval.

The following are the minimum requirements:

- The Operator's Display Unit shall be located such that it is suitable for continual reference and actuation, without causing any discomfort or fatigue.
- The Operator's Display Unit shall be clearly visible to the Operator in both the seating and standing positions, from bright sunshine to darkness, without developing a brightness level that interferes with the Operator's view. Should brightness level adjustment need to be made to achieve this, it shall be performed automatically without Operator intervention. However, it shall be possible to adjust the screen brightness manually as well.
- The Operator's Display Unit shall be a high contrast or similar modern technology, color touch screen LCD - Thin Film Transistor (TFT) display with associated microprocessors and logic and shall be suitable for use in a rugged railcar environment.
- The Operator's Display Unit shall support both text and graphic presentation of information.
- Each screen, except the Operation screen, shall employ one or more levels of subsidiary screens, which present more extensive information and control choices. Subsidiary screens shall be arranged hierarchically, with a consistent interface to facilitate moving up and down the hierarchy.
- Where the same information is provided on several different screens, it shall be presented identically (text, graphics, color) and in the same location. Activation of a touch area shall be acknowledged by highlighting of the area, such as by reverse video.
- The Operator's Display Unit shall be able to indicate automatically the two classes of faults according to the Fault Classification system.

- Information shall be divided among screens and presented in a logical and orderly manner. Information must be displayed textually and/or graphically, depending on the clearest and most efficient method. No information shall be displayed that is not immediately understandable. Abbreviations, reference designators, etc, shall be subject to ATTIKO METRO S.A.'s review and approval.
- All screens shall display the time (24-hour system) and date (dd/mm/yy), the train configuration (including car unit's numbers) and the activated Operator's Desk.
- The usually display language shall be in Greek and on demand shall return in English, too.

23.8.1 Operation Screen

The operation screen shall present real time information and control functions useful to the Operator when the train is in operation. The information shall be arranged according to relevance and to operation of the train. Items of a higher priority level shall be the largest and most centrally located. Items of less importance shall be given a smaller or more peripheral display. Items of urgency (e.g. faults, disturbances) shall flash to bring attention to the Operator. Flashing shall be cancelled by use of a fault acknowledge control.

23.8.2 Control Screen

Control Screens shall present information and control functions relevant to set-up, configuration or preparation of the train for service, but which are not required sufficiently often to warrant inclusion in the operation screen. Start-up functions shall be limited to monitoring internal diagnostics, pictograms and important displays.

Prior to the commencement of operation there shall be a special control screen (Departure Check Screen), which will inform the Operator of the readiness of the train. If there is a sub-system on the train which has a fault, critical for operating its intended service, this will be announced in this screen to inform the Operator of the status of the train. In addition, all by-pass switches shall be controlled by the acknowledge function, if activated.

23.8.3 Faults Screen

The purpose of the faults screen is to provide pertinent information regarding conditions which directly affect the operation of a train. The displayed information shall be a subset of information collected by the Central Control Unit diagnostics memory module (including information of connected subsystems and analogue sensors). The display of this data shall have priority over other information.

As a minimum, the faults screen shall display the following information:

- Passenger Emergency Intercommunication System Device: location
- Door not locked: failure location
- Brake failure: location – car, bogie, side
- Insufficient propulsion: failure location
- Circuit breaker tripped: location, circuit breaker identification
- Power supply system fault
- Auxiliary power supply system fault
- Air supply fault
- Air compressor fault
- Network fault
- Any other faults or events described in the Performance Specification

"Location" information shall be graphical to show which part inside a train is faulty supplemented by text (including car number, e.g. door number) and sufficient additional information to isolate the fault to the subsystem or component. If corrective action must be taken immediately, this must be so identified accordingly. The Operator shall get text information on the actions that must be undertaken.

23.8.4 Maintenance Screen

There shall be a selection of different levels of maintenance screens, as approved by ATTIKO METRO S.A., arranged to provide access to all Central Control Unit functions and capabilities. Access to such functions shall be protected physically by a key or password.

Status screens shall display real time status information from all sources. The status must include active faults.

Fault logging screens shall display the major failures of each car unit subsystem.

- The fault data in real text mode shall include the failure time, car unit number or position, the fault category, the disturbed system or subsystem and a brief description of the fault.
- Fault recording screens shall display all train faults (either active, or not) in chronological order. It shall be possible to display faults (at least) per system, per fault category (A, B, C), per fault status (active, or not) or per combination of the above.
- The format of the individual subsystem fault logs shall be consistent, regardless of the source of the fault data.
- The maintenance screens shall allow scrolling through all logged faults by subsystem hierarchical organized.
- The highest level faults in each system shall be highlighted, whether or not they are microprocessor-controlled.
- The technicians shall be able to scroll through the content of individual subsystem fault logs resident in the subsystems. All fault logs shall be available to the maintenance personnel for review on the screen or to be downloaded to portable test equipment or storage media.
- A "Fault Log Full" message shall indicate whenever faults began to overwrite elder faults in any fault log. Provision shall be made to conserve fault log memory by incrementing a counter for repetitive faults, rather than making a new entry.
- The maintenance screens shall allow access to the fault logs of every subsystem of every car in a train, without the need to move from one Operator's Desk to the other.
- One of the maintenance screen levels shall allow a technician to select customized subsets of historical or status data, such as timeframe of interest or specific data from different subsystems, for display on the same screen.
- One of the maintenance screen levels shall allow the technician to initiate self-tests of all microprocessor-based subsystems and to view the results without changing the screens. Such testing shall be blocked while trains are running.
- A maintenance screen level shall allow access to the Central Control Unit internal fault logs.

Alternatively, all the aforementioned requirements as regards the maintenance screen can be adhered to through the use of an external portable unit – laptop equipped with the suitable software, which (laptop) shall be connected to one of the USBs on the train-set. In this case, the Contractor shall provide three laptop units, of industrial – heavy duty type, state-of-the-art-technology at the time they are handed over by him; these laptops shall be equipped with the suitable software to support diagnostics and maintenance activities, while – if deemed necessary – it might be required by the Contractor to integrate the aforesaid software in two existing laptop units, as well.

23.9 MAINTENANCE REQUIREMENTS

Trouble self-diagnostics systems with microprocessors shall be used and all relevant kinds of data shall be collected by a laptop through the Central Control Unit.

The technical characteristics of selected subsystems and devices shall fulfil the requirements for an effective maintenance. All relevant required signals, device status information, malfunctions, etc., shall be presented and shall be accessible. The sampling frequency for failure information acquisition shall be as high as possible to draw the failure curve without distortion.

The kind and precision of data shall meet the maintenance requirements of the train. The hardware information and documentation to be submitted shall enable ATTIKO METRO S.A. to identify the failure to individual devices, plug boards, etc.

Normally, all stored information shall remain more than half a year after loss of power supply.

The diagnostics data shall contain information on any subsystem malfunction.

Given time and a large enough fleet, the maintenance system shall be able to predict the possible occurrence of future malfunction. Based on this information ATTIKO METRO S.A. shall perform preventive and effective maintenance.

Therefore, the Contractor shall provide a relevant maintenance software tool.

The diagnostic data obtained through a laptop shall be evaluated and archived for further investigation.

The maintenance software tool shall provide as a minimum the following:

- Representation of diagnostic data shall be in an easy comprehensible form, structured in charts or graphs.
- For documentation purposes, remarks shall be added to every fault. As a consequence, the tool shall provide references, in case of similar malfunctions occurred in the past.
- Fault data shall be used to create failure statistics with respect to individual components.
- Data shall be archived.
- There shall be selection criteria, in order to provide data for various application levels. Thus, for example, data shall be selected according to the train number and for a given time period.
- Evaluation of the diagnostic data shall be made by means of searching, sorting and creating statistical functions.
- Charts and graphical diagrams shall be printed and selected diagnostic data shall be exported to an external database for other software applications.
- There shall be selection criteria, in order to provide data for various user levels. Fault statistics shall be generated corresponding to each system / sub-system. In addition, the data shall be selected according to the train number and for a given time period.

- A set of graphs and fault search routines shall be provided as part of the maintenance software tool. The tool shall give the opportunity to ATTIKO METRO S.A. to implement individual functions and graphs.

23.10 WIRELESS DATA TRANSMISSION

The train shall wirelessly transmit at regular intervals data such as its history log, fault log, status data or other operational information to the Depot, via Wi-Fi.

This function shall be achieved through the use of αhardware and software system, to be installed by the Contractor on-board the train, as well as on a special work-station and a respective antenna in suitable areas of the train stabling shed at the Depot. An indication shall appear on screen that the trains are running through an area with a Wi-Fi coverage.

Attention shall be paid on the safety of the information exchanged between the trains and each Workstation. Trains shall have the appropriate hardware and software to prevent any malicious act or intervention to data transmitted wirelessly between the train and the trackside equipment.

During train stabling in the Depot, all train data shall be automatically “downloaded” and train software versions shall be checked. In case it is found that a newer release for a certain sub-system is available, then this shall be displayed on the screen and in the OCC. The successful completion of the software updating process shall be announced and recorded to the Train Control and Management System and in the workstation.

If the automatic software update fails, this shall be announced on the screen of the Train Control and Management System to the Operator’s Desk, as well as to the Workstation; the technician shall be able to make the transmission manually.

The Operator shall also be able to transmit part of the entire volume of information (history log, fault log, etc.) of the train, which is available at certain point of time, (after being emptied from the last time of downloading), as well as the type of data of the equipment selected by this person (a selection will be done among all the entire equipment and subsystems which are monitored by the TCMS). There will also be a selection for transmitting the whole volume of information of all the equipment on the train. By default, the system shall not allow the transmission of already transmitted data, to avoid double entries. The aforementioned function shall be carried out by the Operator only in case the automatic transmittal of train data is not possible.

The automatic transmission will be announced in the TCMS display at the Operator’s Desk such that the Operator shall be aware of this function. Moreover, after the completion of data transmission, there will be a message informing the Operator/Maintenance Person that this function has been completed successfully. A successful transmission means that the receiving system will verify the integrity of the data, as well as the validity of the source of information. All uploading of information shall be stored in an uploading history log in the Workstation.

The software of the Workstation will also include a user-friendly graphical interface for fast and easy navigation, which will give the opportunity to the maintenance personnel to upload new versions of software for the subsystems of the train as well as making changes in their parameters (e.g. change the number of retries for door re-close attempts or change the temperature of the cooling air in the passengers’ compartment).

24.0 LIST OF ANNEXES

ANNEX A: EQUIPMENT TO BE SUPPLIED

ANNEX B: TESTS

ANNEX C: SUPPLIERS/MANUFACTURERS AND PLACES OF MANUFACTURE, INSPECTION AND TESTING

ANNEX D: TABLE OF STANDARDS

ANNEX E: PASSENGER CAPACITY TABLE

ANNEX A: EQUIPMENT TO BE SUPPLIED

At the designs' phase, the Contractor shall confirm in the following Table, the minimum quantities of the equipment to be supplied under this Performance Specification and, subsequently, he shall provide the pertinent equipment.

Item No.	Description	Quantity Required	
1	Covers for the gangway openings (Clause 3.9)	8	
2	Current collector shoe safety covers (Clause 11.7)	50	
3	Battery Charger/Discharger (Clause 12.4)	2	

ANNEX B: TESTS

The Contractor shall have to perform the following tests as a minimum, under this Performance Specification. Where required by the designs to be compiled and submitted, the Contractor shall add the required additional tests required and shall add their remarks, if any.

Table B1: Type Tests

Test Description	Confirmed	Remarks
Systems		
Clearances		
- Gangway		
- Bogie to Car body		
-Intercar		
-Gauge		
-System Gauge		
Car Roll Angle		
-Static		
-Dynamic		
Electromagnetic Compatibility		
-Train Emissions		
-Wayside Compatibility		
Train Control and Management System Performance		
Simulated Revenue Service		
Train Mixed Consist Compatibility		
Train Performance (see note at the end of this table)		
Train Noise		
Safety of Running		
Ride Quality		
Weight and Weight Distribution		
Car Body		
Car body Structure		
-Compressive Loading		
-Corner Post Loading		
-Vertical Loading		
-Car body Camber		
-Floor Stiffness		
-Passenger Seat Loading		
Headlight Performance		
Taillight Performance		
Horn Performance		
Bogies		
Bogie Structure		
-Fatigue		

-Static		
Bogie Suspension		
-Static Deflection		
-Damping Characteristics		
-Yaw Stiffness		
Bogie Rotational Resistance		
Bogie Wheel Unloading		
Wheel Truing Machine Compatibility		
Couplers and Draft gear		
Coupler Performance		
-Compressive Load		
-Tensile Load		
-Emergency Release		
-Mechanical Coupling/Uncoupling		
-Electrical Coupling/Uncoupling and Isolation		
-Pneumatic Coupling		
-Gathering Range		
Car Interior		
Floor Fire Resistance		
Floor Stiffness		
Lighting Intensity		
Passenger Seat		
Window Impact		
Window Removal		
Windshield Impact		
Doors and Door Controls		
Door System Performance		
-Accelerated Life Cycle		
-Structure		
-Performance under Loaded Car Conditions		
Air Conditioning system		
Air Conditioning System Performance		
Car body Heat Transfer Coefficient		
Braking System		
Braking System Performance		
-Brake Disc Thermal Capacity		
-Brake Pad Characteristics		
-Brake Pad Noise		
-Electric Brakes		
-Friction (Mechanical) Brakes		
-Brake Shoe Force		
-System Response Time		
-Wheel Slip/Slide Control System		
- Braking distance measurements in degraded modes of brake operation		

Propulsion System		
Propulsion System Performance		
-Combined Performance		
-Gearbox and Coupling		
-Power Conversion Equipment		
-Traction Motor		
Auxiliary Power Supply Equipment		
Auxiliary Power Supply System Performance		
Balanced Current Return		
APSE Performance		
Battery Function		
Current Collector Performance		
Communications System		
Communication System Performance		
-Intercommunication		
-Public Address		
-Passenger Emergency Intercom		
-Train Radio		
Passenger Information System		
Passenger Information System Performance		
Security System (CCTV)		
Security System Performance		
Automatic Train Control System		
ATC System Interfaces		
Materials and Workmanship		
Electric Motors		
Material Flammability, Smoke Emissions, Toxicity, Floor Fire Resistance		
Melamine-Faced Aluminum Physical Properties		
Glass Reinforced Polyester Properties		
Seat Upholstery Material Properties		
Seat Cushion Material Properties		
Type Tests according to IEC 61133		
Braking distance measurements in degraded modes of brake operation.		

Table B2: Routine Tests

Test Description	Confirmed	Remarks
Systems		
Car body Levelling		
Train Control and Management System Function		
Reliability Demonstration		
Shakedown		
Train line Connections		
Weighing and Wheel Loads		
Wiring		
- Continuity		
- High Potential		
- Resistance to Ground		
Car Body		
Car body and Equipment Water tightness		
Headlight Aiming		
Taillight Aiming		
Horn Performance		
Car Interior		
Lighting System Function		
Doors and Door Controls		
Door System Function		
Air Conditioning System		
A/C Function		
Braking System		
Braking System Function		
- Electric Brakes		
- Friction Brakes		
Wheel Slip/Slide Control System		
Pneumatic and Hydraulic Equipment		
Pneumatic System Leakage		
Hydraulic System Leakage		
Propulsion System		
Propulsion System Function		
- Acceleration		
- Jerk		
- Top Speed		
- Wheel slip Protection		
Traction Motor Connections		

Test Description	Confirmed	Remarks
Auxiliary Power Supply Equipment		
Auxiliary Power Supply Function		
Communications System		
Communication System Function		
- Intercommunication		
- Public Address		
- Passenger Emergency Intercom		
- Train Radio		
Passenger Information System		
Passenger Information System Function		
Security System (CCTV)		
Security System Function		
Automatic Train Control System		
ATC System Function		
Materials and Workmanship		
Insulation Resistance		
Equipment Enclosure Water tightness		
Routine Tests according to IEC 61133		

NOTE: Under the Column “Confirmed”, the indication “Yes” shall be noted.

ANNEX C: SUPPLIERS/MANUFACTURERS AND PLACES OF MANUFACTURE, INSPECTION AND TESTING

The Contractor shall provide a list of all the Suppliers/Manufacturers and places of manufacture, inspections and testing of the equipment of this Performance Specification, as per the sample that follows on the next page, by updating – should it be required - and properly documenting – his Technical Offer.

ATTIKO METRO S.A. reserves the right to justifiably reject potential Suppliers/Manufacturers and the Contractor is entitled to replace them so that they are acceptable.

It shall be emphasized that Suppliers/Manufacturers without QA/QC certification per ISO 9001 shall not be accepted.

There follows Annex C, Sample List, whose columns shall be completed by the Contractor, along with the relevant documentation requested in the table.

Item No.	Description	Name of Supplier/ Manufacturer	Place of Manufacture	Place of Inspection and Testing	References of Previous Customers for the same Product	Greek Agent	Family of Standards Used	QA/QC Certification	Commercial Financial
1	Air Conditioning Equipment								
2	Auxiliary Power Supply Equipment								
3	Battery								
4	Bogies								
5	Brake System								
6	Car body Complete								
7	Car Interior Panel								
8	Communications System								
9	Couplers								
10	Doors								
11	Gangway								
12	Gearbox and Coupling								
13	Passenger Information System								
14	Power Collection Equipment								
15	Power Conversion Equipment								
16	Radio Communication Equipment								
17	Seats								
18	Security System								
19	Suspension Primary								
20	Suspension Secondary								
21	Traction Motor								
22	Train Control and Management System								
23	Wheel sets								

ANNEX D. LIST OF STANDARDS

The Contractor shall submit a list-table with the Standards used in the proposed trains.

Item No.	Standard Ref.	Standard Description	Range of Application/Comments
1			
2			
3			
4			
5			

ANNEX E. PASSENGER CAPACITY TABLE

The Contractor shall provide the data concerning the passenger capacity for the offered trains as per the following table.

	VEHICLE A		**…B, C, D**	**TRAIN**	
	S/N	WEIGHT		S/N	WEIGHT
EL E					
Weight under EL E					
EL 5					
Floor surface for standees					
Number of seated passengers					
Standees at 5 passengers / m^2					
Total number / Weight of standees and seated passengers					
Comfort factor (Number of seated passengers / total number of standees and seated passengers)					
Weight under EL 5					
EL 8					
Standees at 8 passengers / m^2					
Weight under EL 8					

ADDENDUM – INFORMATION DOCUMENTS

The information referred to in various sections herein related to the longitudinal alignment and the longitudinal profile of the project and Kalamaria Extension, geometrical information for stations and tunnels, gauges, track-related systems, equipment of the depot, information deriving from the existing trains, etc. is all provided through this document. In particular, the subject information concerns the following:

A2-01-AIASA_16766_SERIES-I_TRAIN_GENERAL_LAYOUT
A2-02-AIASA_16151_STATIONS_PLATFORM_LENGTH
A2-03-AIASA_16151_PLATFORM_TRAIN SECTION PLAN VIEW
A2-04-AIASA_15757_DIMENSIONS_PLATFORM_SCREEN_DOORS
A2-05-AIASA_13669_GAUGE IN TUNNEL & STATIONS
A2-06-AIASA_06583_GAUGE_FOR_BALLASTED_TRACKS
A2-06-AIASA_06583_HIGH_SPEED_TRAIN_GAUGE
A2-07-AIASA_11299-UNDERFLOOR_WHEEL_ LATHE
A2-08-AIASA_14195_BOGIE_CLEANING_PLANT
A2-09-AIASA_13 3 25_DEPOT_PAINTING_FACI LITIES
A2-10-AIASA_16060_WASHING_PLANT
A2-11-AIASA_10591_LIFTING_JACK_SET
A2-12-AIASA_16558_RERAILING_EQUIPMENT
A2-13-AIASA_16811_BATTERY ELECTRIC VEHICLE BOGIE
A2-14-AIASA_15752_BOGIE_DEFLECTIION TEST RIG
A2-15-AIASA_14176_BOGIE_FRAME_SQUARING_TEST_PLATFORM
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