



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

# **Performance Specifications**

## Table of Contents

<p><b>1. Introduction and Purpose</b></p> <ul style="list-style-type: none"><li>1.1 Introduction</li><li>1.2 Reason of the procurement</li><li>1.3 Scope of supply</li><li>1.4 Name of series, name of type</li><li>1.5 Numbering of vehicles</li><li>1.6 Procedure of vehicles dispatch at stops</li><li>1.7 Special systems and operating conditions</li><li>1.8 Gauge definitions</li><li>1.9 Load definitions</li></ul> <p><b>2. Design principles and concept of vehicles</b></p> <ul style="list-style-type: none"><li>2.1 General Principles</li><li>2.2 Design Requirements</li><li>2.3 Standards and Regulations</li><li>2.4 Vehicle Type</li><li>2.5 Arrangement of the important equipment</li><li>2.6 Driving concept</li><li>2.7 Wheel Profile</li><li>2.8 Undercarriage design – bogie design</li><li>2.9 Tramway configuration</li><li>2.10 Maximum number of vehicles in case of emergency</li><li>2.11 Vehicle life</li><li>2.12 Accessibility to Elderly and Persons with Special Needs</li></ul> <p><b>3 Operational requirements</b></p> <ul style="list-style-type: none"><li>3.1 Passengers on-board the tramway vehicles</li><li>3.2 Headways and operational speed</li><li>3.3 Acceleration performance</li><li>3.4 Braking performance</li><li>3.5 Body suspension</li></ul>	
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3.6 Vehicle weight and wheel load	
3.7 Protection against derailment	
3.8 Vehicle envelopes	
3.9 Platform Interface	
3.10 Noise and vibration levels	
3.11 Environmental Conditions	
3.12 Energy Measurement	
3.13 Track curves' and cants' limits	
<b>4 Maintenance</b>	
4.1 Maintenance requirements	
4.2 Life cycle cost	
4.3 Existing maintenance facilities	
4.4 Wheel skids	
4.5 Accommodation bogies	
4.6 Adaptor for the service vehicle	
4.7 Special Tools and Equipment	
4.8 Cleaning fluids	
4.9 Battery electric vehicle, auxiliary tractor	
4.10 Existing maintenance infrastructure	
<b>5 Car Body Structure</b>	
5.1 General design criteria	
5.2 Underframe	
5.3 Side panels	
5.4 Front design	
5.5 Roof	
5.6 Articulation	
5.7 Corrosion Protection	
5.8 Thermal and acoustic insulation	
5.9 Crash protection	
<b>6. Car Interior</b>	
6.1 Passenger compartment	

<p>6.2 Driver's cab</p> <p>6.3 Signs</p> <p>6.4 Provisions for the installation and operation of Automatic Fare Collection System</p> <p><b>7. Car Exterior</b></p> <p>7.1 Design and Color</p> <p>7.2 Lights</p> <p>7.3 Passenger doors</p> <p>7.4 Coupler</p> <p>7.5 Movements through the wheel lathe</p> <p>7.6 External viewing</p> <p>7.7 Wheel flange lubricator</p> <p>7.8 Miscellaneous</p> <p><b>8. Electrical and Auxiliary Equipment</b></p> <p>8.1 Auxiliary Power Supply Equipment (APSE) – Static Inverter</p> <p>8.2 Battery</p> <p>8.3 Bell / Horn</p> <p>8.4 Sanding Equipment</p> <p>8.5 Safety and Security devices</p> <p>8.6 Mounting of electrical cables</p> <p><b>9. Traction System</b></p> <p>9.1 Pantograph</p> <p>9.2 High Speed Circuit Breaker</p> <p>9.3 Traction Control and Inverter</p> <p>9.4 Traction Motors</p> <p>9.5 Braking Resistors</p> <p>9.6 Earthing Devices</p> <p><b>10. Train Control and Monitoring System (TCMS)</b></p> <p>10.1 Driver's Display Unit</p> <p>10.2 Fault announcement system</p> <p>10.3 Event Recorder</p>	
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- 10.4 Subsystems Control Units
- 10.5 Wireless communication between the vehicle and the network in the depot
- 10.6 Maintenance requirements

## **11. Heating, ventilation, air conditioning (HVAC)**

- 11.1 General
- 11.2 Passenger compartment
- 11.3 Driver's cab
- 11.4 Cooling-Heating System Performance
- 11.5 Maintenance and troubleshooting

## **12. Brake System**

- 12.1 General
- 12.2 Braking modes
- 12.3 Slip-slide protection
- 12.4 Priority arrangement
- 12.5 Braking mode table

## **13. Integrated on Board Information System**

- 13.1 General
- 13.2 On Board Computer
- 13.3 Public Address System
- 13.4 Traffic Control System
- 13.5 Video passenger information system
- 13.6 Communication with OCC
- 13.7 Special Panel for PSN
- 13.8 Passenger Counting System
- 13.9 Closed Television System (CCTV)
- 13.10 Diagnostic functions
- 13.11 Support Equipment
- 13.12 Provision for installation and operation of Automatic Fare Collection System

## **14. System Assurance**

- 14.1 Reliability, Availability, Maintainability and Safety (RAMS) Requirements
- 14.2 RAMS Demonstration Plan
- 14.3 Failure Analysis
- 14.4 Systematic Failures – Defects
- 14.5 Applicable International Standards
- 14.6 Main Interface Issues
- 14.7 Documents deliverable to AM to demonstrate system assurance
- 14.8 Electromagnetic compatibility

## **15. Test, Commissioning, Delivery and Acceptance**

- 15.1 Testing
- 15.2 Delivery and Acceptance Arrangements

## **16. Documentation and Training**

- 16.1 Drawings - General
- 16.2 Engineering Documentation Submittal Requirements
- 16.3 As-Built Vehicle Specifications
- 16.4 Maintenance Manuals
- 16.5 Illustrated Parts Catalogue (IPC)
- 16.6 Operator's Manuals
- 16.7 Training Manuals
- 16.8 Car History Books
- 16.9 Copies of Manuals and Documentation
- 16.10 Photographs
- 16.11 Training

## **17. Project Management Requirements**

- 17.1 General
- 17.2 Engineering Schedule and reviews

**18. Quality Management Requirements**

18.1 General

18.2 Quality Management Systems and Project Quality Plan

18.3 Configuration Control

**19. Spare Parts and Tools**

19.1 Warranty period

19.2 Delivery time

19.3 Capital spare parts

19.4 Special tools and diagnostic equipment

**20. Appendix 1: Vehicle Interfaces with the existing systems, vehicle envelopes and the Depot**

20.1 Depot and Workshop

20.2 Traction Power System (TPS)

20.3 Envelopes of Vehicles

20.4 Gauge Enlargement due to Horizontal Curves (throw)

20.5 Trackwork

20.6 Alignment

20.7 List of Drawings

**21. Appendix 2: Tramway Network Alignment – Profile and Characteristics**

List of Abbreviations

A	Availability
A/C	Air Condition
AC	Alternate Current
APSE	Auxiliary Power Supply Equipment
ATP	Automatic Train Protection
BCU	Brake Control Unit
BOStrab	German Federal Regulations on Construction and Operation of Tramway Systems
DC	Direct Current
DIN	German Industrial Standard
DKE	Dynamic/kinetic envelope
E&M	Electrical and Mechanical (in this context)
EMV	Electro-mechanical influence of vehicle
GFD	General Final Design
HVAC	Heating, Ventilation, Air Conditioning
IBIS	Integrated on Board Information System
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
ISO	International Standard Organization
LCC	Life Cycle Costs
MDBF	Mean Distance Between Failures
MKBF	Mean Kilometres Between Failures
MTBF	Mean Time Between Failures
MTTR	Mean Time To Restoration
OBC	On-board Computer
OCC	Operations Control Centre
OHLE	Overhead Line Equipment
PA	Public Address
RAM	Reliability, Availability, Maintainability
RAMS	Reliability, Availability, Maintainability, Safety
ROW	Right of Way





**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

RS	Rolling Stock
RSIS	Rolling Stock Interface Specification
TCMS	Train Control and Management System
TCU	Traction Control Unit
TOR	Top of Rail
TPS	Traction Power System
UIC	International Union of Railways
VCU	Vehicle Control Unit
VDE	Federation of German Electrical Engineers
EN	European Standards

# 1 Introduction and purpose

## 1.1 Introduction

This Specification sets out the requirements for the tramway vehicles as well as for the related services, spare parts, tools and equipment, which ATTIKO METRO S.A. intends to purchase and operate on the existing tramway system network (lines and depot), as well as on the foreseen extensions, as these are described in paragraph 1.2 of the present document.

## 1.2 Reason of the procurement

The existing lines of the network are:

- Line S1 (length: 5.92 km): Paleo Faliro – Neo Faliro – SEF
- Line S2 (length: 8.36 km): Syntagma – Fix – Neos Kosmos – Paleo Faliro.
- Line S3 (length: 10.18 km): Paleo Faliro – Agios Kosmas – Glifada - Voula.
- Line S3.8 (length: 2.4 km): Connecting line between depot and line S3.

The network extensions foreseen are as follows:

- Line S1 (length: 5.4 km – single track) : Neo Faliro - Piraeus– SEF
- Line S3 (length: 1.1 km): Tram Depot – Argyroupoli METRO Station

In order to cover the increased operational needs, in the existing network and in its foreseen extensions, Attiko Metro SA in cooperation with the Operation Company has decided to procure additional vehicles.

All the specifications and requirements defined in this document are applicable both for the existing network and the future extensions.

## 1.3 Scope of supply

This specification covers the supply of goods and related services, as summarized below that will meet the requirements of this specification and all appendices. The details are given in the relevant chapters of this specification, as well as in the appendices attached hereto. The scope of the supply shall include the following:

1. Supply (design, manufacturing/installation of equipment, factory tests, delivery at Depot, performance testing and commissioning) of twenty-five (25) tramway vehicles. All vehicles to be supplied shall be of the same type and they should not present any variation or differentiation in their technical or other characteristics. The vehicles shall be fully compliant with the infrastructure and, more specifically, with the alignment and longitudinal profile of the Tramway network, its extensions, the depot, as well as the control and operational systems of the Operation Company.
2. Supply of equipment for moving the tramway vehicles in cases of breakdown and maintenance. Specifically:



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- Two (2) sets of wheel skids;
  - One (1) set of accommodations bogies;
  - Two (2) adaptors (sets), for the service vehicle (Unimog) in order to push and pull the vehicles
  - Battery Electric Vehicle, auxiliary tractor
  - One (1) set of specific lifting tackle for the phases of loading/unloading/transport of the tramway vehicles.
3. Supply of the necessary special tools, which are necessary to maintain and overhaul the vehicles, as well as the diagnostic equipment (hardware and/or software) to test, troubleshoot and rectify damage, verify the functionality of the vehicles and all the specialized items of equipment.
  4. Supply of the Spare Parts, as these are defined in type and quantity in this Performance Specification. The Contractor shall deliver all spare parts at a warehouse facility of the Operation Company depot.
  5. Supply of all consumable materials and parts which are necessary for the preventive maintenance of the vehicles, during the warranty period.
  6. Preparation of the complete vehicle design, along with the calculations, drawings, as well as the final “As Built” drawings.
  7. Supply of all manuals, technical documents and illustrated parts catalogues necessary for the training of technical staff and drivers, operation, maintenance, overhaul, troubleshooting and rectification of damage, repair of vehicles, as well as the Vehicle History Book of each vehicle.
  8. Provision of services for the execution of performance and commissioning tests in the Operation Company network and in the depot; during the aforementioned tests, the Contractor shall prove the equipment capacity to meet the specifications, as well as the compatibility of the equipment to be supplied with the existing vehicles and facilities.
  9. Supply of the warranty service, namely the required and qualified personnel, sufficient tools, test equipment, spare parts, etc., which will be necessary to repair or replace all faulty hardware and software and to ensure that all vehicles are fully available for revenue service during the warranty period.
  10. Supply of training to all pertinent staff of the Operation Company to ensure full familiarity with the design, operation, maintenance, overhaul, troubleshoot and rectification of damage and repair of the vehicles.

The entire equipment referred to the Contract shall be new. Any items of equipment either repaired or refurbished shall not be acceptable.



#### **1.4 Name of series, name of type**

The series of Rolling Stock to be procured by AM is "TRAM Athens Series II" henceforth referred to as TA2.

#### **1.5 Numbering of vehicles**

The vehicles shall be numbered according to the production series from 36 to 60.

As to the name of series, the numbering of the vehicles shall be as follows:

TA20036

TA20037

Up to:

TA20060

The above numbering shall be maintained and referred to in the corresponding "Vehicle History Book" as well.

In view of clearly detecting the vehicles at the line, only the three last numbers are to be fixed at the two fronts, sides and the roof of the vehicle. Details, exact position and sizes will be agreed upon with Attiko Metro SA.

#### **1.6 Procedure of vehicles dispatch at stops**

The vehicles drivers will execute "self-dispatch" of the vehicles with the aid of onboard camera monitors.

The vehicles will only be allowed to proceed if all doors are closed.

Vehicles dispatching is supported by the onboard vehicle computer, which is also responsible for the schedule control and monitoring. In certain instances the driver may require additional instructions from the OCC to proceed.

It is not necessary to stop at a station if nobody wants to enter or to disembark the vehicles.

#### **1.7 Special systems and operating conditions**

The implementation of the tramway network along the entire length is undertaken using both double tracks in opposing directions and single tracks. The standard track width is used (1.435 mm).

The vehicles will be driven by "line of sight".

The vehicles shall be fed through a 750VDC (+ 20%, - 30%) overhead power supply system. Full traction capacity shall be ensured for line voltages from 650VDC to 950VDC, while the traction capacity shall linearly drop in line voltages ranging from 500VDC to 650VDC.

Full capacity of the electric-dynamic braking shall be ensured in voltages from 750V to 900V.

The traffic light pre-emption system will give priority to the vehicles.

The right of way (ROW) conditions are used or shall be used in future extensions in the vehicle operation are listed below:

#### **1.7.1 Shared Right of Way (Category E)**

A mixed traffic conditions with the vehicles, road vehicles and pedestrians all using the same ROW. So as not to interrupt the flow of traffic, the tramway vehicles travels on rails that are embedded into the road surface.

#### **1.7.2 Segregated Right of Way (Category D)**

The tramway vehicles are segregated from the rest of the traffic. The segregation can be achieved by means of road markings or low barriers. The tramway vehicles are therefore segregated from the rest of the traffic, except at the at-grade road intersections. At these intersections priority through the signals is at most occasions given to the vehicles.

#### **1.7.3 Exclusive Right of Way (Category C)**

The existing roadway is used exclusively for the tramway vehicle, and the rest of the corridor is pedestrianized. Grooved rails embedded into the pavement are used and the sidewalks are separated from the tramway vehicle by means of highway markings.

#### **1.7.4 Exclusive-Protected Right of Way (Category B)**

The tramway vehicle line is totally segregated from the rest of the traffic. The segregation is by means of physical barriers (trees, plants, walls, etc.). Pedestrian crossings are provided at intervals along the route.

### **1.8 Gauge definitions**

#### **1.8.1 Static Load gauge**

The static load gauge is the outline of the maximum permitted dimensions of the vehicle's cross section (including its maximum manufacturing tolerances) when it is dwelling centered on a tangent flat track. The cameras shall not be included in the static gauge of the vehicle, provided in Appendix 1; however, the Contractor shall include the subject cameras in the static gauge of his vehicle. The static load gauge is not affected by external to the vehicle factors (e.g. track gauge or rail wear).

#### **1.8.2 Kinematic load gauge**

The vehicle kinematic load gauge is the static load gauge widened in a way that it allows maximum possible movement of the vehicle as to the track when stationary or when the vehicle moves (e.g. free play between wheel flange distance and track gauge), taking into consideration the maximum permissible wear/ maintenance tolerances and the suspension characteristics.

#### **1.8.3 Dynamic gauge**

The vehicle dynamic gauge is the kinematic gauge widened, in order to take into account the direct impact of the maximum allowable tolerances of the track gauge and the transversal elevation difference of the track, including the impact caused by

the track wear, except the impact due to cant and throw at curved sections. The dynamic gauge should take into account the most unfavorable positions for the wheels running on the track, the manufacturing tolerances, the elastic track deformations, wind forces, etc.. Thus, the dynamic gauge includes the overall cross-section of the vehicles and, as applicable, their loads under all operation and maintenance conditions of vehicles and tracks.

#### **1.8.4 Structural gauge**

The structural gauge is the outline that relates to the standard coordinate axes of the track; it shall not be violated by any part of any fixed structure or fixed items of equipment. There are special provisions permitting the platform edge and the overhead traction power conductor to infringe the structure gauge. In case of non-ballasted track, the perimeter of the aforementioned gauge is at distance of 100 mm from the dynamic gauge. In case of ballasted track, this distance is 150mm.

#### **1.8.5 Application of gauge at curved tracks**

Each gauge (dynamic or structure gauge) shall be enlarged at curved tracks, taking into account the central or side throws (also see paragraph 3.8 and Appendix 1).

### **1.9 Load definitions**

Vehicle capacity shall be specified according to the following definitions of the load conditions and specified main characteristics:

- AW0: empty load.
- AW1: "Comfort" load: based on 2 standing passengers per square meter, all fixed seats and folding seats (if any) being occupied.
- AW2: "Normal" load: based on 4 standing passengers per square meter, all fixed seats and folding seats (if any) being occupied.
- AW3: "Overload" load: based on 6 standing passengers per square meter, all fixed seats and folding seats (if any) being occupied.
- AW4: "Exceptional" load of 5000N/sq.m. (resulting from standing passengers and all fixed seats and folding seats -if any- being occupied), specified only for design calculation purpose.

For each of the above load cases the train crew will be on the train. The train crew will consist of one driver and one assistant.

The weight of one person shall be considered as 75 Kg.

## 2 Design principles and concept of the vehicles

### 2.1 General principles

The vehicles shall meet the requirements of this Specification and all the Appendices.

The vehicles shall be designed to operate as efficiently and safely as possible in the existing Tramway Network system and the foreseen Tramway Network extensions.

Economical operation and maintenance is of a high priority in the design of the vehicle and its components. For that reason, the vehicles and their components shall be of a state-of-the art proven technology, in terms of manufacturing and operation, requiring low maintenance and guaranteeing a cost effective service.

The vehicle shape and style shall express an image of rapid, efficient and reliable travel. In their technical offer, the bidders shall submit an artistic “rendering” of the external view of the vehicle in order to prove compliance of the vehicles proposed design principles with the criteria mentioned above.

All European Union regulations with regard to fire protection, environmental protection and accident prevention must be fully satisfied.

To the extent possible, all materials to be used in the vehicles shall be recyclable. The Contractor shall supply a list containing all used materials, which shall identify and describe the procedure to be utilized for the successful recycling of each individual material of each item of equipment.

It is forbidden for the following substances to be used in vehicles, namely:

- Asbestos
- Carcinogenic substances
- Chloride Polyvinyl
- Polychlorinated Biphenyl
- Materials containing beryllium oxide

In addition, the Contractor shall make all possible effort to fully comply with the requirements set forth in Directive 2002/95/EC of the European Council regarding the restrictions on the use of dangerous substances.

All parts and equipment used for in the construction of vehicles must be interchangeable, and should be supplied at the same level of technical quality.

In the bidders’ proposals, all components and systems required for the vehicles shall be described in detail. Any components necessary for the safe and reliable operation of the vehicle not mentioned in this Specification shall be included in the offer.

### 2.2 Design requirements

In general, the vehicles offered shall be to be suitable for their intended use.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The Contractor shall design and prove through the performance of the appropriate tests, that the vehicles will operate in the whole network, extension lines, the depot, stabling facilities and workshops and the depot access tracks, under all loading conditions. Moreover, vehicles shall be compatible with the communication and information systems of the existing network.

No equipment is permitted to operate by central compressed air supply with the exception of the flange lubricating and sanding equipment for which the utilization of a central compressed air system is optional.

The design of the vehicle shall fulfil the following basic requirements:

1. Safe Operation
2. Provision for the safe use by disabled and people with special needs, aged persons and passengers travelling with children
3. Low operating and maintenance costs (i.e. easy access and replacement of modules, components and equipment)
4. Energy-efficient
5. High ride quality (x,- y,- and z-direction) and passenger comfort
6. Minimum noise and vibration during operation and running
7. The vehicles are to be provided with high level of protection against vandalism (selection of materials, painting, seats, etc.)
8. Easy recognition of worn components and failed systems
9. Interchange ability of all modules, components and equipment between vehicles
10. Environment-friendly; with no thermal or electromagnetic influence of components (EMC) on other systems operating adjacent to the vehicle
11. Suitability for its intended operation, with favourable ergonomic maintenance and operating conditions
12. The passenger compartment and the driver's cab shall have the required thermal and sound insulation
13. The vehicles should have a modern exterior and interior design of high aesthetics
14. Vehicle compatibility with the existing network as regards the following systems:
  - TETRA
  - IBIS (Integrated on Board Information System)
  - Traffic Control System, which includes:
    - a) Traffic priority
    - b) Point switch mechanism control.



### 2.3 Standards and Regulations

The Standards and Regulations to which the vehicles shall conform shall be the prevailing and most recent European or International standards. The Contractor shall detail the standards he is using.

Unless otherwise explicitly specified, the vehicle will be designed, manufactured and tested in accordance with the following International Standards and Regulations:

1. European Standards EN incorporated into the National Legislation
2. EN
3. IEC/ISO
4. UIC

Where no European or International standards exist, the tramway vehicles shall be designed, manufactured and tested in accordance with National Standards. These will be the following or equivalent accepted standard:

1. BOSTrab
2. DIN
3. DIN VDE
4. VDV
5. NF

The tramway vehicles shall be also in full compliance with the relevant European Regulations.

The Contractor may propose alternative Standards to the extent that he proves their equivalency with the specified ones. The standards used will be recommended by the Contractor and shall be approved by ATTIKO METRO S.A.

### 2.4 Vehicle Type

The vehicle to be supplied shall be of a Low Floor type over the whole passenger compartment. No interior steps are allowed, although the floor may have a small inclination. Low non-inclined floor vehicles shall receive a higher score. The vehicle shall be articulated and capable of bi-directional drive.

The vehicle shall include a fully equipped driver-cab in both directions, in order to ensure full operation, control and performance of the vehicle.

The vehicle shall be 2.40m wide between the outer side panels. The vehicles shall be less than 36m long.

### 2.5 Arrangement of the important equipment

The components to be used shall be of a proven-in-service design. In their offer, the bidders shall detail the arrangement of the driving and trailing bogies/wheel sets. The bidders shall include in their technical offer, drawings of the bodywork, showing the layout of the principal equipment which is to be installed on the roof or under-floor of

the vehicle. In addition, in their offer, the bidders shall describe the layout of the driving and trailing bogies / wheels.

The bidders shall describe the level of operation with a combination of traction motors isolated. Consideration shall be given from full operation to all traction motors inoperative.

The design shall ensure the minimum wear of the wheel-rail system and low maintenance and operations costs.

## **2.6 Driving concept**

The traction system shall convert the 750V DC line voltage from the overhead supply system into 3-phase electrical power and shall drive the traction motors. IGBT technology shall be employed for the traction motor inverter and AC traction motors shall be installed in the vehicle. The electronic controls shall be equipped with 32-bit or better microprocessors.

A regenerated energy scheme shall be employed in the braking concept. The traction system shall, during braking, regenerate electrical power to feed the overhead line, provided that the overhead line is receptive; e.g. another vehicle is requiring power at the same time. Should the line not be receptive, energy will be dissipated at the on-board braking resistors.

## **2.7 Wheel Profile**

The wheel profile currently used by the Operation Company existing vehicles (Series I) is defined in appendix 1.

During the early days of the design phase, the Contractor will submit to ATTIKO METRO S.A for approval a complete track/wheel interface study, which will positively identify the proper wheel profile to be finally applied, in order to increase passenger comfort, to ensure noise requirements stipulated in paragraph 3.10 and to minimise wheel/track wear, taking into consideration the complete track layout, the vehicle speed profile and load.

The wheels shall have replaceable tyres.

## **2.8 Undercarriage design – bogie design**

The type of undercarriage - bogie e.g. bogie, single wheels etc, shall be proposed by the Contractor provided that:

- Maximum wheel static load complies with the values specified herein.
- Easy disassembling and replacement of relevant components (e.g. wheels, gears, motors, disks, track brakes, shock absorbers etc.) and easy manual brake release is to be demonstrated.
- It is compatible with the existing infrastructure of the network.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

12 wheels or 6 axles are foreseen (motorized and idle wheels included). However, the Contractor may propose his own wheel arrangement and wheel number and his own bogie configuration (with axes or independent wheels).

The bidders shall submit a technical description for the proposed bogie and wheel/axes layout. The number of the driving wheels/axes, as well as their related position shall be determined in the bidders' offer. Their Technical Offer shall also include drawings regarding the driving and trailer bogies, their manufacturing material and method, their weight, the un-sprung mass loads, the wheel load distribution, the motor arrangement, accompanied by its supporting/fixing method on the bogies, the transmission scheme, suspension system, lubrication and sanding scheme, description of the measures that have been provided for regarding noise mitigation due to the wheels' rolling on running tracks, the bogies disassembly method from the tramway vehicle and their adjustment to alignment curves.

The Contractor shall prepare a design based on the FE Analysis, in order to ensure the required structural integrity of the vehicles, as well as their strength against fatigue.

## **2.9 Tramway configuration**

The tramway configuration to be used during revenue operation shall be a single tramway vehicle.

## **2.10 Maximum number of vehicles in case of emergency**

As regards the mechanical coupling of the tramway vehicles:

In the event of a vehicle breakdown, which requires vehicles to be towed or pushed towards the Depot, it shall be possible to form a tramway set consisting of a fully enabled vehicle towing or pushing the failed vehicle.

The design must foresee all possible combinations of the two series of vehicles. The vehicle shall have the capability of rescuing a failed tramway, both in AW0 condition, anywhere in the tramway network.

Traction and braking performance shall allow a single vehicle without any failure to pull or push a defective empty vehicle from any point of the existing line and the extensions, over a two-way trip, at reduced performance and taking into consideration the special operation procedures for such cases.

As regards the electrical connections, during the coupling of the tramway vehicles of this Series II:

The electrical connections must make provisions for at least the transmission of the following signals between the two vehicles:

- Safety brakes
- Alarm lights
- Spot lights



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- Stop lights
- Horns
- Brake release function
- Communication among the driving areas

As regards the electrical connections, during the coupling of Series II tramway vehicles with Series I tramway vehicles:

The Contractor shall ensure the electrical interconnection of the signals - out of those mentioned above – that are available in tramway vehicles Series I. ATTIKO METRO S.A. shall provide the relevant drawings.

The vehicles shall be equipped with coupling adaptors – of mechanical and electrical coupling - in case it is needed to satisfy the above requirement. The adaptors should be stored on each vehicle, on an easily accessible position and should be easily handled (mounted/dismounted) by a single person (driver).

The final configuration as well as the operational procedure of towing shall be approved during the review of the final design.

### **2.11 Vehicle Life**

The vehicles to be supplied shall have a 30-year service life as a minimum.

### **2.12 Accessibility to Elderly and Persons with Special Needs**

The tramway vehicles shall be fully accessible by Persons with Special Needs, including wheelchair passengers.

### 3 Operational requirements

The Contractor shall ensure that vehicles will meet the requirements of this Specification and Appendices and will prove their compliance during the testing and commissioning phase.

Vehicles shall operate in the entire network, the connecting lines, inside the depot and in the workshop areas.

As regards the design calculations, the mileage of the vehicle is considered as 60,000 km per year.

#### 3.1 Passengers on-board the tramway vehicles

The tramway vehicles shall be designed to carry passengers of body type ranging from 1m tall (child) to the 95% of the male body type. Passengers might also be mobility impaired persons.

Provisions shall be made for safe accommodation of baby carriages and wheel chairs. The tramway vehicles shall carry passengers either familiar or unfamiliar with the system.

The vehicle shall be designed to carry 190 passengers in AW2 load condition as a minimum. The minimum number of seats, including folding seats, if any, shall be 50.

The passenger capacity of the vehicle in AW2 loading condition shall be also evaluated during the submission of offers. In their technical offer, the bidders shall define the number of passengers carried by the vehicle, providing all necessary calculations.

The number of passengers to be provided by the bidders is binding and shall be further considered as an integral part of this performance specification.

#### 3.2 Headways and operational speed

The current passenger service time tables provides for 6 minutes headway between two consecutive tramway vehicles during peak hours. The mean time distance between two stops is assumed to be 2 minutes, the dwelling time at the stop is assumed to be 20 seconds and 360 seconds at terminal stops.

The Contractor shall submit the required simulations for operation/traction in the tramway network (alignment, longitudinal profile – line characteristics in Appendix 2). Through the simulations, the Contractor shall demonstrate the performance compliance with the respective specifications, which is to be verified at the testing phase. The detailed input parameters for the simulations shall be approved by AM.

The maximum operational speed allowed on the existing network and its extensions is 70 km/h.

The traction system shall be designed to operate at this maximum speed, i.e. 70 km/h, ensuring at the same time no overheating or damage to the equipment, a fact that reduces the life cycle of the tramway vehicle.

When the speed of the vehicle exceeds the maximum, then

- the traction system will automatically interrupt power supply to the motors
- An acoustic and optical warning shall be given to the driver.

### 3.3 Acceleration performance

The acceleration performance requirements are presented in the table below.

#	Measure	Requirement	Comment
1	Response time	$T_{0A} \leq 0.5 \text{ s}$	
2	Acceleration change rate (Jerk) value	$r_1 \leq 1.3 \text{ m/s}^3$	Average value from the beginning till the end of the respective change of acceleration
3	Acceleration change rate (Jerk) value during current turn-off	$r_2 \leq 1.0 \text{ m/s}^3$	During all acceleration phases
4	Constant acceleration	$a_{01} \leq 1.3 \text{ m/s}^2$	After end of jerk till the maximum power has been achieved
5	Average acceleration	$a_m \geq 0.60 \text{ m/s}^2$	From 0 km/h until 70 km/h
6	Average acceleration	$a \geq 1.1 \text{ m/s}^2$	From 0 km/h until 35 km/h

*Table 1. Acceleration performance requirements*

The acceleration performance shall take into consideration the weight of the vehicle and shall be identical for load conditions between AW0 and up to AW2, with new wheels and on a straight - flat line section.

The traction system of the vehicle shall ensure the performance standards stipulated in table 1, under all voltage range from 650 V DC up to 900 V DC with a nominal operation voltage of 750 V DC. At voltages ranging under 650 V DC down to 500 V DC, the performance shall be linearly reduced as the voltage decreases.

Wheel slide-slip protection shall monitor wheel speeds, individually, to prevent the wheels from spinning, sliding or locking under any conditions of reduced grip.

#### 3.3.1 Downgraded operation for acceleration

Should a traction system failure occur, resulting in 25% of the traction power not being available, and with the vehicle in load condition AW3, the vehicle shall be capable of starting at an acceleration of  $0.1 \text{ m/s}^2$  on any point of the existing line for at least 200m without curves and with line voltage remaining higher than the minimum value of 650 V DC. Indicatively for this case, we mention that the grip coefficient value for the existing vehicle/ network is 0.16-0.18.

If during traction and under all possible modes of operation, the vehicle moves backwards for a maximum of 0.5 meters or with a negative speed greater than

1.5km/h (whichever comes first), the vehicle shall automatically apply the full service brakes, until it is stopped.

### 3.4 Braking performance

Unless otherwise specified herein, all braking performance shall be compatible with EN13452-1, as a minimum, and will be tested in accordance with EN13452-2.

The Contractor shall define the grip levels on which his calculations are based as well as the countermeasures applied by the brake system when the grip level is low due to the track conditions.

#### 3.4.1 Service brake

Service braking is used to reduce speed or to stop the vehicle in an accurate and consistent manner throughout the line, in compliance with the comfort criteria. This braking shall not cause regular and intensive stressing of elements subject to wear.

From the maximum down to the minimum speed that activates the mechanical braking to be determined in the design, service braking performance shall be achieved using only electro-dynamic braking, in all conditions of line receptivity up to 100% (maximum regenerative brake). At low speed, electro-dynamic braking shall be blended with the mechanical braking to stop the train, wheel slide-slip protection being operative.

Under partial receptivity conditions, the full electro-dynamic braking effort shall be achieved with rheostat braking in complement. In non-receptivity conditions, full electro-dynamic braking effort shall be achieved with rheostat braking.

The braking values are valid for new wheels, straight flat line, and maximum speed and with loaded vehicle according to EN13452-1 braking guide lines.

The following nominal performance levels (see table 2 below) must be fulfilled by an empty vehicle and a vehicle in loaded condition AW2, and with all braking system in service. Whatever the speed at start of braking, up to maximum speed, the service braking performance shall meet the requirements specified hereunder with all motor bogies in service, in a straight and levelled track.

The traction system of the vehicle shall ensure the aforementioned regenerative electrical braking performance, under all voltage range of the Line from 750 V DC up to 900 V DC. At line voltages ranging under 750 V DC and down to 500 V DC, the performance of the regenerative electrical braking shall be linearly reduced as the voltage decreases.

#	Measure	Requirement	Comment
1	Response time	$T_{0B} \leq 0.5 \text{ s}$	
2	Deceleration change rate (Jerk) value	$r_3 \leq 1.3 \text{ m/s}^3$	Average value from the beginning till the end of the respective change of deceleration

3	Deceleration change rate (Jerk) value at the end of braking	$r_4 \leq 1.3 \text{ m/s}^3$	
4	Continuing deceleration	$a_{03} = 1.3 \text{ m/s}^2$	
5	Average deceleration	$a_m \geq 1.2 \text{ m/s}^2$	From 70 km/h to 0 km/h
6	Maximum deceleration	$a \leq 1.4 \text{ m/s}^2$	
7	Stopping distance	$S_{STOP} \leq 158\text{m}$	From 70km/h to 0 km/h

Table 2. Service brake performance requirements

### 3.4.2 Emergency brake

Emergency Braking shall use all of the electro-dynamic brake, mechanical brake, and electromagnetic track brake effort, wheel slide-slip protection being operative.

Emergency braking shall be initiated manually by positioning the master controller into the emergency braking position.

The minimum deceleration values shall be according to the EN13452-1

Whatever the speed at the start of braking, the emergency braking rate shall be no less than  $2.8 \text{ m/s}^2$ , with the train set being in any load condition between AW0 and AW2, and with all bogies in service. The stopping distance during emergency braking shall be not greater than 75 meters when applied from 70km/hr in all loading conditions between AW0 and AW2. It shall be instantaneously applied with instantaneous initial jerk limited to  $6 \text{ m/s}^3$ .

The braking system shall be capable of 3 consecutive emergency braking stops (when applied from 70km/hr) within 5 minutes in load condition AW2 and with 1 axle / 2 wheels inoperative without decreasing deceleration and stopping distance performance, as defined before.

### 3.4.3 Safety braking

Safety braking performance shall be achieved with only the mechanical brake and the electromagnetic track brakes effort, without the assistance of electro-dynamic braking, with wheel slide-slip protection being automatically inhibited.

The safety braking shall have an average deceleration value of  $a_{m3s} \geq 1.4 \text{ m/s}^2$  at any initial speed and under AW2 load conditions.

### 3.4.4 Downgraded operation for braking

The braking system shall be capable of sustaining a vehicle in AW2 load condition, in operation, with 1 axle / 2 wheel in failure, maintaining the above required performances, specified in paragraphs 3.4.1, 3.4.2 and 3.4.3

## 3.5 Body suspension



The car body is to be suspended in the vertical and horizontal directions. The suspension system should ensure safe trips, as per Standard EN 12299. The suspension shall be designed based on the vibration conditions, which are described in detail in this specification, paragraph 3.10.5 and which apply under the maximum speed on a straight track under normal track conditions.

### **3.6 Vehicle weight and wheel load**

The wheel static load of each wheel will not exceed 60 KN under AW4 loading condition. The bidder shall specify the maximum weight of the vehicle as well as the static wheel load for each wheel on a single vehicle under all load conditions from AW0 to AW4.

The tare load (AW0) of the vehicle shall be part of the technical evaluation of each offer. The tare load provided by the bidders shall be binding and be considered as an integral part of the performance specification. The value provided by the offer shall be validated against the actual weight of the vehicle, which shall be measured during the relevant type test.

### **3.7 Protection against derailment**

The bidders will describe in their offer the protection against derailment features of the vehicle.

The Contractor will provide a complete derailment study during the Final Design review period. The study will include calculations of protection against derailment, especially of “unloading” of wheels gradients with empty vehicle.

The worst condition is to be used i.e. very slow departure from a curve of the highest gradient in the system. The calculation shall take into consideration the vehicle and infrastructures under the maximum wear conditions, as well as under new conditions.

The worst dynamic condition is also to be taken into account. The derailment study will make explicit reference to the case of pushing/pulling a defective vehicle by another vehicle in operation.

The parameters' study will provide conclusions as to the maximum permitted speeds under certain conditions, as well as to the allowable wheel wear limits for safe operation.

The study will conclude to the operational procedure of re-railment as well as to the necessary precautions or measures that need to be introduced during the re-railment procedure under all possible derailment conditions.

### **3.8 Vehicle envelopes**

Based on the requirements of paragraph 1.8 and Appendix 1, which must be met by the offered vehicle, the bidder shall provide:

- The Static envelope
- The Kinematic envelop

- The Dynamic envelope
- The Structural gauge

Moreover, the bidder shall provide the formulas for the calculation of throws (end throw and center throw) in relation to the horizontal curve radius, as well as the detailed throw values for the radii shown in Table 3.1, Appendix 1.

The conditions that must be met and verified in the Tender phase shall be the following:

- 1) The Vehicle's dynamic envelope is lower or equal to that in the specifications.
- 2) The dynamic envelope augmented by the throws for each curve is lower or equal to the dynamic envelope in the specifications, augmented by the respective throws in the specifications.
- 3) The vehicle under the maximum load AW4 is passing through a stop at a speed of 40 Km/h, without the Dynamic Envelope's maximum dimensions at platform level exceeding 1300mm.

### 3.9 Platform Interface

The existing platform level is higher than the track level (TOR) by 275mm, while the horizontal distance of the platform from the wheel axis equals to 1300mm. (Appendix 1/ para. 2.3). The aforementioned is subject to construction tolerances.

The vehicle floor level in the vehicle's doors area, when the vehicle stops at the platform, should be equal to or higher than the platform level, not taking into account the rail wear. The vehicle floor level fluctuation is shown in figure 3.1, Article 20.3 in the Appendices.

The horizontal distance between the edge of the platform and the threshold of the vehicle doors shall be equal to or smaller than 100mm. on straight track.

In their technical offer, the bidders shall submit the following:

- A statement concerning the height difference between the vehicle floor level in the vehicle's doors area and the platform's edge level, when the vehicle stops at the platform for all loading conditions (AW0 – AW4) and wear;
- A statement of compliance of the maximum horizontal distance of the threshold of the vehicle doors from the platform, with the permitted one.

### 3.10 Noise and vibration levels

#### 3.10.1 General

This section defines the performance requirements for the noise and vibration levels that shall be achieved in the whole network and the Depot.

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 other equivalent standards, whichever is more stringent.

The Contractor, at an early stage prior to the installation of any measure for noise & vibration control during operation, shall submit his final proposals to ATTIKO METRO S.A. for them to be thoroughly checked.

In order to ensure the compliance of the noise and vibration levels with the requirements of this Specification, the Contractor shall investigate the necessity of installing at the wheels an additional device for noise and vibration mitigation (e.g. resilient pads between wheels and tires).

Where more than one noise and vibration limit is applicable, Contractor shall apply the more restrictive requirement for determining the compliance.

All requirements of this document as regards the noise and vibration levels shall be checked through the respective type tests.

### **3.10.2 External noise**

The level of noise generated by the tramway vehicles must be compatible with its operation in urban areas and must not create any unacceptable disturbance.

The external noise levels of the vehicle shall be measured per ISO 3095 and on the basis of the following conditions:

### **3.10.3 Stationary Vehicle in an open area**

Stationary vehicle on an at-grade, flat track, in an open area, with all sub-systems operating simultaneously, each under its nominal power. As per ISO 3095, microphones shall be installed on either side of the vehicle, spaced – horizontally – at 7.5m from the centre of the track and at TOR levels 1.2 and 3.5m.

### **3.10.4 Running Vehicle in an open area**

The vehicle shall run on a level, tangent, at-grade track, in an open area, with clean, smooth rails, with all sub-systems operating simultaneously, each under its nominal power.

Consecutive and separate external noise level measurements shall be conducted for vehicles running on road surface asphalt embedded tracks, on grass and on ballasted tracks.

The microphones' layout shall be identical to the layout to be utilized during the measurements of external noise generated by a stationary vehicle.

Three types of vehicle movements shall be assumed, as regards the external noise measurements:

*Passing by vehicle under stabilized speeds:* the vehicle shall pass by the measurement point at stabilized speeds equal to 40 and 60 km/h  $\pm$  5%.

*Vehicle start up:* the vehicle shall start from a stop using the maximum traction power causing spinning of its wheels until it reaches the speed of 30km/h; the vehicle shall

keep this speed level until the entire tramway vehicle – lengthwise – passes by the measurement point.

*Vehicle deceleration:* the vehicle running at a speed of 30 km/h, when approaching the measurement point, shall decelerate until it stops using the normal braking system.

### 3.10.5 Internal Noise

The design of the vehicle shall minimize internal noise, both in the passenger compartment and in the driving cab. The noise levels shall be measured per ISO 3381:2011.

### 3.10.6 Stationary Vehicle in an open area

Stationary vehicle on an at-grade track, in an open area, with all sub-systems operating simultaneously, each under its nominal power.

Microphones shall be installed inside the vehicle along its symmetry axis at a height of 1.6m. from the vehicle floor. The number of the microphones and their exact location shall be subject to AM approval.

### 3.10.7 Running Vehicle in an open area

The vehicle shall run at stabilized speeds of 40 and 60 km/h on a level, tangent, at-grade, clean and smooth track, in an open area, with all sub-systems operating simultaneously, each under its nominal power.

Consecutive and separate internal noise level measurements shall be conducted for vehicles running at the two speeds mentioned above on road surface asphalt embedded tracks, on grass and on ballasted tracks.

The microphones' layout shall be identical to the layout to be utilized during the measurements of internal noise generated by a stationary vehicle.

### 3.10.8 Noise limits

The vehicle shall conform to the noise limits defined in table 3, regardless of the rail support type:

Speed	External noise level (dBA)	Internal noise level [dB(A)]	
		Passenger Compartment	Driver Cab
Stationary	69	68	68
40 km/h	80	74	69
60 km/h	84	78	71
0 – 30 km/h	84	---	---
30 – 0 km/h	84	---	---

*Table 3. Noise level requirements*

The noise level shall derive from the measured raw data, by calculating the  $L_{pAeqT}$ , per ISO3381, when noise is measured

- Inside a stationary vehicle;
- Inside a vehicle running at a stabilized speed, and
- Outside a stationary vehicle.

Level  $L_{pAFmax}$  shall constitute the measured figure, when noise is measured

- Outside a vehicle, when the vehicle is running at a stabilized speed;
- Outside a vehicle, when the vehicle starts up or when it decelerates.

In addition, the noise generated inside the vehicle by the simultaneous operation of all passenger doors, on the one side of the vehicle, shall not exceed 75 dB(A), when measured along the vehicle symmetry axis, at 1.60m. over the floor, at the doors' centres, with the door warning signal/buzzer de-activated.

Exposure of the vehicle drivers to noise generated risks shall be within the limits set by Directive 2003/10/EU. More specifically, level  $L_{EX,8h}$  of the daily driver's exposure to noise shall be less than 80dB(A), while the maximum noise level to which the driver must be exposed shall be less than 112Pa.

In their technical offer, the bidders shall state the noise limit values that can be generated by the vehicle, as per Article 13 of the Invitation to Tender.

Both internal and external noise limit values of the stationary vehicle (0km/h) and of the vehicle running at 60 km/h shall be part of the technical evaluation of each offer. Each value will be evaluated separately according to the provisions of the technical evaluation procedure.

The values provided by the bidders are binding and will be considered an integral part of the performance specification. The values provided by the Contractor's offer shall be validated against the actual values, measured during the relevant type test.

### **3.10.9 Vibrations**

*With a stationary vehicle* and its entire auxiliary equipment operating simultaneously and at its nominal power, no feature inside the vehicle can exceed the following vibration levels:

- 2.54mm – peak to peak range for frequencies below 1.4Hz.
- 0.01g peak acceleration for frequency range from 1.4Hz to 20Hz, and
- 0.762mm/s – peak velocity for frequency range over 20Hz,

or, alternatively, with a stationary vehicle and its entire auxiliary equipment operating simultaneously and at its nominal power, no feature inside the vehicle can exceed the following vibration levels, as per EN 12299:2009.

$$N_{MVx} = 1.0$$

$$N_{Mvy} = 1.5$$

$N_{MVz} = 1.0$ .

### 3.10.10 Ride comfort

The ride comfort of the vehicles shall be evaluated and tested in line with Standard EN 12299 for standees and seated passengers at straight and curved track sections. In any case, the vehicle shall satisfy – as a minimum – the “Comfort” Index.

The Contractor shall measure the ride comfort in any type of articulated vehicle item, in line with a procedure to be approved by AM.

### 3.11 Environmental Conditions

The general environmental conditions under which the tram will operate are detailed below:

#### 3.11.1 Weather data

Mean Maximum ambient temperature	+42°C
Absolute maximum ambient temperature	+48°C
Mean Minimum ambient temperature	-2°C
Absolute Minimum ambient temperature	-10°C
Average annual ambient temperature	18.7°C
Average annual relative humidity	62.9%
Maximum annual relative humidity	100%
Height above sea level	0-200m
Rainfall (max. 24 h)	90.3mm
Snowfall (max. 24 h)	Occasional
Total average annual rainfall (per month)	27.2mm
Max. wind speed	24.4m/s
Air pollution	High
Occurrence of sand and dust	High
Corrosion conditions	High

*Table 4. Climatic values*

It is noted that:

- The tramway vehicle runs along the coastal line and, thus, vehicles are expected to be affected by the proximity to the sea and the salt-laden atmosphere and wind borne sand.

- Due to the solar load, the temperature in the track bed may reach +55°C in the summer period.
- Due to the generally dry climate of Athens, the air contains frequently an increase percentage of pollutants.

The Contractor must take all necessary measures and ensure that all the equipment operates normally under the above environmental conditions.

### **3.11.2 Special slipping conditions**

The conditions developed in the entire tramway network are to be particularly considered, due to falling leaves, falling fruits from trees, as well as due to the slipping conditions developed when rain starts to fall after a long period of dryness, and there is a high level of dust in the atmosphere.

Vehicles should be able to overcome such situations with the aid of their slip-slide protection and/or by their sanding devices.

### **3.11.3 Snow and Freezing conditions**

Snow and freezing conditions can be encountered in Athens. Reference should be made to the weather records of the National Meteorological Service, Statistical Department, Athens.

The Contractor shall ensure that the vehicles and all their equipment will operate satisfactorily in all environmental conditions that may be encountered in Athens.

### **3.11.4 Adverse Weather Conditions**

Tramway vehicles shall operate through floodwater up to a depth of at least 100 mm above rail level. The bidders will detail any restrictions for the operation in water depths above 100mm.

The vehicles shall be able to operate continuously and up to a maximum speed of 70 kph under normal power supply conditions under all snowing conditions that may be encountered in service up to a depth of 50mm above rail level.

## **3.12 Energy Measurement**

The Contractor shall ensure that all tramway vehicles are equipped with energy consumption measurement devices. The proposed devices must:

- be certified for billing by an EU transport/ railway authority.
- ensure Class 0.5R measuring accuracy, as per EN 50463-2 (Railway Applications – Energy metering on board)
- record absolute values of the consumed and regenerated energy
- perform sampling using properly or automatically adjusted time steps
- have sufficient internal data storage capacity for at least 30 days
- be interfaced with the tramway vehicle GPS system and record local coordinates/ vehicle position at each measurement as per standard EN 50463-3

- be equipped with a communication protocol, compatible with the data collection and transmission system of the vehicle through the wireless local Wi-Fi network of the Depot, as described in article 10.5
- be equipped with the appropriate energy recordings analysis and processing software (energy analysis software), supporting display functions compatible with the mapping system of the Tramway network (on the central PC at the Depot), capable of wireless data collection.
- be compatible with EN 50155 Standard (Railway Applications – Electronic Equipment used on rolling stock).
- These measurements shall be either displayed independently or they shall be recorded and announced at the Drivers Display Unit by means of the Train Control and Management System (TCMS) of the vehicle.

The Contractor shall submit the relevant certificates, manuals and the connection diagram of the aforementioned proposed device.

Apart from the aforementioned measuring devices, the TCMS system shall have the possibility to measure the energy consumed at the traction power system and at the auxiliary power supply system independently, as well as break energy regeneration.

The above will be used during revenue service and during energy consumption tests, in line with article 15.

### **3.13 Track curves' and cants' limits**

Vehicles shall be able to operate at:

- A minimum curve radius : 25m. It is especially stressed that at a specific point of the network, namely in the Neos Kosmos area, the curve radius is 23m. At this point, the smooth operation of the vehicles must be ensured, probably with a speed reduction. A curve with a radius of 18m exists in the Depot.
- Maximum longitudinal gradient: 8.05% (as especially encountered in the Piraeus Extension).



## 4 Maintenance

### 4.1 Maintenance Requirements

The vehicles will be designed and manufactured by the Contractor in a way that maintainability is guaranteed for a life-cycle of 30 years. Maintenance services will be undertaken by the Operation Company according to the maintenance manuals provided by the Contractor. To achieve low service and maintenance costs, the following requirements are to be taken into account.

#### 4.1.1 Overhaul intervals

All main devices and vehicle parts must be designed in a manner that an exchange, repair or major refurbishment of these devices does not become necessary until the attaining of the main overhaul period of time after eight operation years or approx. 500.000 km.

#### 4.1.2 Maintenance intervals

In general, no maintenance shall be required on any component for running distance of less than 15.000 km or three operational months of the vehicle, and no inspection shall be required by the maintenance personnel on the vehicle for a running distance of less than 2.500 km or 7 days. This does not include inspection of lighting fixtures, sand-filling, washing fluid, visual and visual inspections, usually carried out before putting the vehicle into service.

Maintenance operations which must be carried out are to be depicted in the maintenance plan, including the information of the necessary time intervals. The maintenance plan shall be part of the maintenance manuals.

The Contractor shall include in his technical offer a preliminary maintenance plan, which will be finalized during the design phase.

#### 4.1.3 Exchange of devices and wear components

In general, all devices and wear components must be easily accessible and easy to be dismantled, with the use of standard tools to the extent possible. The service life of the wearing / consumable parts to be exchanged periodically must correspond to at least a maintenance time interval.

All identical parts must be interchangeable. In case the repair, replacement or the optimisation of the operation of a part requires the set-up of parameters or software application, the Contractor shall make available all necessary means, e.g. lathe calibration axle, for the Operation Company to be able to complete the pertinent works without his assistance and without - however - this obligation on the part of the Contractor to release him from any of his contractual obligations during the warranty period. The supply of all necessary special tools constitutes the Contractor's obligation.

All functional units are to be designed in a modular manner.

#### 4.1.4 Evaluation of maintainability

In their offers, the bidders shall present a general maintenance plan to include both preventive and corrective maintenance tasks (see also article 14.1.3).

Specifically, the subject plan shall include the preventive maintenance tasks, maintenance intervals as well as man-hours required for performing these tasks.

The man-hours required for the entire preventive maintenance for each vehicle over a two-year period will be part of the technical evaluation of each offer, on the basis of the anticipated 60,000 km annual travel distance of a vehicle.

Additionally, the following tasks will be evaluated according to the required man-hours:

- Wheel tyres replacement for a complete car-set. The man-hours will be calculated from the moment the vehicle is at the relevant track ready to be dismantled and will take into account all necessary steps e.g. raising the vehicle, disconnecting bogies (if necessary), disconnecting all necessary components, preparing new ones, reconnecting steps, necessary checks until the vehicle is ready to leave the work track.
- Windows replacement of a complete car-set, including windshields. The man-hours will be calculated from the moment the vehicle is at the relevant track ready to be dismantled and will take into account all necessary steps e.g. unscrewing or cutting of sealants (if applicable), installing new windows, applying all necessary sealants until the vehicle is ready to leave the work track.
- Replacement of all front- and side- exterior panels of one driver's cab. The man-hours will be calculated from the moment the vehicle is at the relevant track ready to be dismantled and will take into account all necessary steps e.g. unscrewing or cutting of sealants (if applicable), installing new panels, applying all necessary sealants until the vehicle is ready to leave the work track.
- Detailed description of the side panel repair procedure in the event of collision.

The values provided by the bidders shall be binding and be considered an integral part of the performance specification. The value provided by the offer shall be validated against the actual values, measured during the first two years of operation.

#### 4.1.5 External cleaning

The external design of the vehicle must be designed in such a way that they can be cleaned by washing machine, without damage to the washing machine or the vehicle.

Vehicles shall be protected by anti-graffiti protection film in order for the graffiti to be easily removed from the car body, side panels, door panels and windows. The anti-graffiti protection shall be easily replaceable, in case needed. The Bidders shall specify in their technical offer the anti-graffiti protection scheme, as well as the replacement procedure.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The Contractor shall describe in the maintenance manuals the exact method, as well as the necessary cleaning agents to be used during automatic external washing and graffiti removal.

**4.1.6 Interior cleaning**

The interior design of the vehicles shall be vandal resistant. Impurities by graffiti shall be easily removable from all interior equipment and panels. No porous or porous painted interior surfaces are favoured for this purpose.

The Contractor shall describe in the maintenance manuals the exact method, as well as the necessary cleaning agents to be used during internal cleaning and graffiti or impurities removal.

**4.1.7 Devices for failure detection**

The Contractor shall provide information on equipment installed on the vehicles to obtain maintenance information, i.e. monitoring equipment and component, equipment status.

Test plugs will be made available for connecting any mobile diagnostic devices. The test plugs must be easily accessible to maintenance personnel.

**4.2 Life cycle cost**

The Contractor shall provide a full Life Cycle Cost (LCC) calculations based on a vehicle service life of 30 years, 16 months upon contract signing. The calculations shall be based on the vehicles maintenance plan. When calculating LCC, a detailed list and calculation of all functional modules should be included.

Maintenance costs are to be separated into preventive and corrective maintenance costs. Furthermore, they are to be separated into labour and materials costs.

All wear and tear parts are to be considered. A list of the parts with price statement and serviceable life is to be included.

LCC calculations have to be carried out for the following cases:

- One vehicle for one year
- One vehicle for 30 years

The following form shall be used as a reference, for LCC calculations.

1	2	3	4	5	6	7	8	9	10
Item	Frequen cy km	Number of Occasions per year	Works Under- taken	Duration of works (hours)  Car hours	Duration of works (hours)  Men hours	Wage	Materials and spare parts used	Price of spare parts and materials	Total



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

	From MDBF			From MTTR					3x (6+8)
<b>Total</b>									

*Table 5. Operation, Maintenance and Repair (Warranty) Costs*

LCC contains costs occurring during the entire life cycle of the vehicle. The expected life of the vehicle is 30 years. The expected annual mileage is 60,000 km/year.

The exact details and assumptions of the LCC calculations will be agreed upon between the Contractor and ATTIKO METRO S.A. during the designs' phase. The following indicative factors shall be taken into account:

- Preventive and overhauls maintenance costs
- Power consumption (operation on AW2, according to current time tables)
- Unscheduled maintenance
- Accidents

The calculations will be provided also in MS Excel format, indicating all formulas that have been used.

**4.3 Existing maintenance facilities**

The Contractor shall check and confirm the compatibility of the major maintenance facilities that exist at the Operation Company installations with the maintenance requirements of the new tram. The Contractor shall assure the compatibility at least with the following major maintenance facilities:

- Underfloor wheel lathe machine
- Bogie press and repair facilities
- Bogie washing plant
- Paint booth
- Automatic washing plant
- Overhead cranes
- Lifting jacks
- Sand refilling plant
- Re-railing equipment
- Roof access gantries with access security system

The maintenance and stabling facilities are detailed in appendix 1. The Contractor shall examine these facilities, confirm the adequacies of the above facilities and equipment in terms of location and size and shall ensure that the tramway vehicles can be maintained on these facilities.

In their technical offer, the bidders shall include a Statement of Compatibility with all the aforementioned maintenance facilities necessary for the vehicles' maintenance, along with the respective methods to achieve the subject compatibility, should this be required.

#### **4.3.1 Underfloor wheel lathe**

The existing underfloor wheel lathe is of the type Heggenscheidt U 2000.

The Contractor shall be responsible to introduce on the wheel lathe the necessary interface in order to allow the axles of the vehicle to automatically restrained and released on the existing facilities.

Should the above prove to be not possible, the Contractor has to deliver all necessary interfaces, adaptors, restrainers and tools to lathe the wheels of the new vehicle on this device. The restraining of the axle on the wheel lathe will require only one technician and less than 5 minutes.

In case the profile or dimensions of the wheel is different from the existing one in ATHENS TRAM Series I, the Contractor shall take all necessary actions in order to allow the wheel lathe to re-profile the new vehicle's wheels (introduce into the wheel lathe memory the necessary profile data in digital format of the new wheels, as well as the necessary changes of the user interface, etc). The effectiveness of the above actions will be demonstrated by a test *in situ*, following the necessary training of the operator.

#### **4.3.2 Bogie press**

The bogie press installation existing in the depot is of type LC Service S.r.l. Costruzioni meccaniche with raised track type. The Contractor shall confirm that the bogies of the new vehicle will be properly maintained - if necessary- on the existing installation.

Otherwise, the Contractor shall supply all the necessary adapting interfaces.

#### **4.3.3 Bogie Washing Plant**

The bogie washing plant is supplied by Raimondi, and is suitable for the bogies of the Tramway Vehicles Series I. The supplier should confirm the suitability of this equipment for the washing of his bogies and indicate/supply any protective covers that might be necessary for protecting sensitive parts on the bogie during the washing cycle.

Otherwise, the Contractor shall describe another method for the efficient and safe cleaning of the bogies.

#### **4.3.4 Paint booth**

The facilities provided are detailed in appendix 1. The Contractor must conform to the use of these facilities for exterior and interior painting.

The Contractor will make recommendations for any additional facilities that may be required up to the life of the trams.

#### ***4.3.5 Automatic Washing Plant***

The AWP is constructed as a stable machine (Raimondi) and the moving vehicle passes through it with a maximum speed of 3 km/h. The maximum height of the lateral washing brushes is 3.60 m.

The vehicle must employ a speed restriction switch, in order to pass through the AWP. When the switch is operated, the vehicle speed shall be limited and shall not exceed 3km/h.

#### ***4.3.6 Overhead Cranes***

The Workshop is equipped with two cranes. One travelling crane located in the bogie repair area with lifting capacity of 10 ton and one swing crane located in the roof gantry area with lifting capacity of 3.5 ton.

#### ***4.3.7 Lifting jacks***

The Contractor will ensure that the new vehicles are fit to be lifted by the existing lifting equipment of type SEM 105 by CESP, incorporating twelve (12) lifters and one (1) controller per set. For details see the appendix 1.

Should this not be possible, the Contractor will investigate the technical possibility and, shall, subsequently, supply, test and commission safe and proper adaptors for lifting his vehicles using the existing lifting equipment, at no additional financial claims. In this case, the Contractor shall submit the technical documentation and operational procedure of the adaptors, for ATTIKO METRO S.A approval.

#### ***4.3.8 Sand refilling plant***

The vehicles are supplied with sand by nozzles located on two positions on track 8 of the workshop. Each position is equipped with four sanding stations (Klein) and feeding nozzles, two on each side located near the front and rear bogies. The Contractor shall ensure that the vehicle can be properly fed by the existing sanding stations and nozzle interface. Details are provided in appendix 1.

#### ***4.3.9 Re-railing equipment***

The existing re-railing equipment is provided by the suppliers Lukas and Heggenscheidt (parts to re-rail LRV). The height of the smallest Heggenscheidt jack is 180mm. The Contractor shall confirm in his technical offer the compatibility of the vehicle to the specified equipment.

During the design phase, the Contractor shall provide a complete re-railing procedure indicating the lifting points on which the re-railing device can be adapted on the vehicle and bogies, as well as any restrictions that apply during the re-railing process.

### **4.4 Wheel skids**

The Contractor shall provide one bogie set of skids, which will allow the tram to be hauled back to the depot in the event of failure of a wheel set.

It must be possible to install these skids under the failed vehicle at the point of the failure, anywhere in the existing line.

During the design phase, the Contractor shall submit to ATTIKO METRO S.A. for approval the technical specification and the necessary drawings of this equipment, as well as the operation procedure.

#### **4.5 Accommodation bogies**

The Contractor shall provide one set of accommodation bogies, which will allow the vehicle to be hauled everywhere inside the Depot by another vehicle and the existing service vehicle (Unimog).

The Contractor must take into account the curves, turnouts, crossovers, maintenance tracks, type of rail used etc., which exist in the Depot, in order to make sure that a vehicle to be placed over the accommodation bogies is able to be hauled on every track and maintenance position of the Depot.

The accommodation bogies must have the necessary lifting points, which will allow the bogies to be lifted and transported by the crane.

The accommodation bogies must be properly treated and painted to be protected against corrosion. The life time of the accommodation bogies must be not lower than that of the vehicle.

During the design phase, the Contractor shall submit to ATTIKO METRO S.A. for approval the technical specification and the necessary drawings of this equipment, as well as the operation procedure.

#### **4.6 Adaptor for the service vehicle**

The Contractor shall provide two mechanical/electrical adaptors, which will allow a totally failed vehicle to be coupled with the existing service vehicle, and hauled from any position of the network back to the Depot.

The following operational requirements must be fulfilled:

In the event of a vehicle breakdown, which requires vehicles to be towed towards the Depot, it shall be possible to form a train consisting of the service vehicle towing an incapable vehicle.

The electrical connections must make provisions for at least the transmission of the following signals between the two vehicles:

- Safety brake
- Service brake
- Alarm lights
- Stop lights
- Headlights
- Horns

- Brake Release

The adaptor should be manufactured in such a way to be easily handled (mounted / dismounted) by a maximum of two persons.

During the design phase, the Contractor shall submit to ATTIKO METRO S.A. for approval the technical specification and the necessary drawings of this equipment, as well as the operation procedure.

#### **4.7 Special Tools and Equipment**

During the design phase, the Contractor shall maintain and update a list containing all special tools and equipment necessary to perform the normal maintenance, troubleshooting, repair and overhaul of the vehicles, up to the Lowest Repairable Unit level, based on the maintenance and overhaul manuals.

The list shall be submitted to ATTIKO METRO S.A for approval, twelve (12) months upon the contract signing, together with the Operational Analysis of the maintenance requirements.

All special tools and equipment shall be delivered at the Depot of the Operation Company upon the arrival of the second vehicle.

The tools will also include any computing/diagnostic hardware, interface connections, and software required for measuring, monitoring, troubleshooting and adjusting any equipment and component installed on the vehicles.

The use of these special tools should be described in the maintenance manuals.

#### **4.8 Cleaning fluids**

During the design phase, the Contractor has to submit to ATTIKO METRO S.A. for approval instructions for the cleaning operations as regards the interior and exterior cleaning of the vehicles. The instructions should include methods, equipment, time periods, and details of the cleaning material (chemicals) including danger classifications (MSDS) used for normal and special (graffiti) cleaning.

The cleaning fluids should be available “off the shelf” from local cleaning material suppliers.

#### **4.9 Battery electric vehicle, auxiliary tractor**

A battery electric road/ rail shunting tractor shall be supplied. The tractor shall have a driver’s cabin and will be able to:

- circulate and provide services in both directions
- pull or push series I and II vehicles on Depot tracks
- be re-railed and de-railed using its own equipment
- the underfloor wheel lathe freely passes over the tracks
- be remotely controlled when operating on the tracks.



The general requirements are presented herebelow:

Shunting Speed	0-25 m/min
Creep Speed	0-10 m/min
Solo Speed	0-32 m/min 30m/min minimum
Curve radius	Approx. 2500 mm
Battery Capacity	Sufficient capacity to perform the anticipated operations during an 8-hour shift
Auxiliary equipment, including as minimum:	<ul style="list-style-type: none"> <li>▪ Driver Cabin, complete, with doors, windows, wind screen wiper and reverse mirrors</li> <li>▪ Couplers and adaptors compatible with series I and II vehicles</li> <li>▪ Remote control equipment with interlocking ability</li> <li>▪ Built-in battery charger monitoring the charging current and the batteries temperature</li> <li>▪ Emergency push-buttons on the Driver console, the remote control and at the four (4) outmost ends of the vehicle</li> <li>▪ Lighting</li> <li>▪ Left/right flash lights</li> <li>▪ Emergency Flasher</li> <li>▪ Warning buzzer activated before the vehicle starts moving</li> <li>▪ Horn</li> </ul>
Gauges, including as a minimum:	<ul style="list-style-type: none"> <li>▪ Motor and battery temperature gauge</li> <li>▪ Battery charging indicator</li> <li>▪ Hour counter</li> </ul>

#### **4.10 Existing maintenance infrastructure**

Information is presented below regarding the existing maintenance infrastructure as follows:

- Six (6) drawings / photographs of the lathe



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- One (1) drawing for the washing plant
- The height of the roof galleries is 2.87m. The smallest horizontal distance between two galleries is 2.50m.
- The gate distance is 79.6m. The first sand-filling station is at a distance of 7m from the gate and the second at a distance of 26.5m from the first station. Sand-filling stations are equipped with rubber hose, 4.5m long. The nozzle diameter is  $\Phi 35\text{mm}$  and its length is 100mm.

In the framework of the bidders' declaration of vehicle compatibility with the Depot equipment, the option is provided to the bidders for an arranged visit to the Depot, in order to collect further data.

## 5 Car Body Structure

### 5.1 General design criteria

In their Technical Offer, the bidders shall submit the general design criteria, the manufacturing methods of the vehicle bodies, as well as the materials to be used for their manufacturing. The car bodies shall be designed and manufactured in a way so as to withstand all types of fatigue within the Athens Tramway Network for a 30-year period. The Contractor shall submit a documented proof of his competence to meet the aforementioned requirement.

All parts of the car body must be manufactured and assembled in absolute compliance with the approved specifications, including the tolerances indicated in the drawings that have been approved by ATTIKO METRO S.A. During the design phase, the appropriate measures shall be introduced so that, during all repair or replacement works, all parts mounted on the car body or constituting part thereof can be replaced by any other parts of identical design without this requiring the execution of any special works.

The Contractor shall design the vehicle body based on the FE Analysis, in order to ensure its required structural integrity under normal operation conditions and under fatigue, circular loading and crashworthiness conditions. The analysis shall satisfy the principles of:

- VDV 152 – Structural Requirements to Rail Vehicles for the Public Mass Transit in accordance to BOStrab and,
- EN 12663 category P-IV – Railway applications – Structural Requirements of railway vehicle bodies.

The body structure shall withstand without permanent deformation a passenger loading of AW4 under full operation.

Deflections of the body structure under an AW4 passenger static loading shall not be greater than 1.5‰ of the dimension at any point between the supporting points of the underframe.

The Contractor shall provide all relevant data regarding the rigidity of the car body shell, the calculations and the tests' certificates.

The Contractor shall submit the appropriate repair procedures due to tram vehicles crashes with road vehicles, for minor damage to the parts of car body shell that do not bear any structural load, for damage to the frame, as well as for damage due to vandalism (bumps, graffiti, etc.) to be approved by ATTIKO METRO S.A.

The car body shells shall be designed to be water-proof, in line with IEC 61133. No water shall ingress the vehicles when passing through the washing plant. Special care must be taken for the doors, windows and side panels.

## 5.2 Underframe

The Contractor shall provide information about lifting points for lifters, re-railing equipment to be used, mounting of couplers and mounting of undercarriage and shall control the compatibility of the vehicle with the existing equipment for these purposes.

All lifting points will be clearly marked on the car body.

## 5.3 Side panels

Especially low-floor vehicles being mainly street-operated are more susceptible to damage in a side-on collision, as compared to high-floor vehicles.

The Contractor shall specify the protection provided that will ensure the safety of passengers.

The bidders should detail in their Technical offers the repair procedure for repairing side panels in the event of collision.

## 5.4 Front design

The Contractor shall specify details of the energy absorbing system provided at the front and rear of the vehicle.

The design should prevent sharp-edged corners, hard waves, e.g. for the windscreen wiper, or other possibilities to injure pedestrians. Residual rims etc., that can cause injuries, shall be covered. The design of the convex windshield and the side windows should provide a good view angle on the tracks in front of the vehicle, but also on both sides and on the traffic signs.

The front and side part of the vehicle mask shall be designed, so that in case of collision with a person, the maximum safety can be provided and the person's "trapping" underneath the vehicle be prevented. The Contractor shall submit the relevant design to ATTIKO METRO S.A.

## 5.5 Roof

The roof shall be designed to support the entire roof-mounted equipment and shall not allow for any serious elastic bending or any permanent deformation in case the maintenance personnel walks along the roof.

Where maintenance staff is required to walk or stand, a slip free electrically insulated surface shall be provided.

The roof will support the loading of the roof attached passenger handrails.

For a better centre of gravity, the equipment mounted on the roof should be as few and lightweight as possible. The Contractor shall give a mounting plan including the weight for each component.

The arrangement of the equipment shall ensure that the length of the cabling is as short as possible.

All items of equipment must be installed in water-proof containers.

The overall back-up equipment shall comply with the requirements of Shock and Vibration European Standard EN 61373 (for Railway environment).

The car body-bogie connection shall withstand maximum loads deriving from:

- The maximum longitudinal accelerations of the bogie of the order of  $\pm 3g$ ;
- The maximum transversal accelerations of the car body of the order of  $\pm 1g$ ;
- The vertical loads deriving from the lifting of the car body with the bogie attached thereto.

## 5.6 Articulation

The structure must transfer pulling and pushing forces between the vehicle's sections without structural deformation.

The structure must provide smooth running when negotiating a curve. It should be smooth running over all normal track conditions, track deformations and cants in the track. Squealing or ratchets during operation is not allowed.

The Contractor shall specify the design of the outer and inner covering of the articulations of the vehicles. The bellow of the articulation should be double-walled for a better insulation from noise and dust.

The crossing of the passengers must be possible without danger. The articulation section shall allow for a smooth flow of passengers between the various modules or passenger compartments and will include passenger grab rails, for use by passengers standing in that area.

The articulation interior and exterior surfaces shall be arranged to prevent injuries to passengers and operating personnel.

The articulation covering shall be weatherproof and dust tight.

The floor shall be smooth and free of steps in the entire area of the articulation.

All parts of the articulation pane are supposed to be separately removable to be acceptable for maintenance purposes.

## 5.7 Corrosion Protection

The vehicles will be operating under aggressive corrosive environment (salty and humid conditions, due to coast line).

In their Technical offers, the bidders shall state a detailed plan for the protection of the car body against corrosion to include as a minimum: manufacturing materials, design options and methods to be applied for prevention of corrosion, including also the cases of joints between different material (electrochemical corrosion), if any.

To provide corrosion protection, multiple layers of materials and cavities, which would allow accumulation of condensed water, are not allowed.

The metal structure has to be effectively protected against corrosion. Water accumulation in any part of the vehicle's body or extension is not accepted. Especially

drainpipes for rainwater, washing water and condensation are to be made of corrosion resistant materials.

Bolted connections in areas of the car body that are likely to be splashed with water shall be made of corrosive proof material.

All cavities are to be sealed hermetically for protection against corrosion.

### **5.8 Thermal and acoustic insulation**

The side and end walls, floors, roofs as well as cavities and resonance prone areas shall be covered or lined with water resistant, sound absorbing and heat-insulating materials.

The average heat transition coefficients shall not exceed the values laid down in the recommendations VDV 180 or equivalent.

### **5.9 Crash protection**

The vehicle's resistance against collisions shall be ensured by means of the design's compliance with EN 15227, category C-III. All collision scenaria described in EN 15227 shall be taken into consideration and the vehicles design's compliance with the Standards shall be achieved through its comparison with designs and calculations already applied.

The car body shall be designed and manufactured as a rigid compartment to shelter the passengers and to integrate characteristic features at the vehicle's ends for the energy absorption in the event of a collision. The concept for the management collision generated energy shall constitute part of the Bidders' Technical Offer.

The analysis of the collision generated energy management system shall be extensive. Its design shall be based on studies to include time-dependent stress calculations using the FEA for major permanent deformations. All collision scenarios shall be examined.

The graphical display of the aforementioned time-dependent calculations shall include the creation of a "film" representing the reactions of the car body under the dynamic loading that the vehicle is subject to due to collision, including the permanent deformations.

The vehicle shall have energy absorption ability in the event of a crash situation without damaging the structure of the car body.

- Empty vehicle with a speed up to 15 km/h: energy absorption through a buffer or bumper according EN15227.
- The front of the vehicle will have a crumple zone (deformation controlled zone) which will absorb the energy and protect the structure in the event of a crash at speeds above 15 km/h, in line with Standard EN 12663, category P-IV.

The Contractor shall set the details of the energy absorption system located on the front and rear part of the vehicle.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

All devices used in critical circuits – in terms of safety - shall be placed in such a way so as, in case of collision, the status of the contacts cannot to be affected, causing, thus, a dangerous situation.

All designs shall be submitted to ATTIKO METRO S.A. for review and approval.

## 6 Car Interior

### 6.1 Passenger compartment

The passenger compartment layout design shall facilitate passenger circulation within the vehicle without passengers bunching or crowding in specific locations such as door areas. Special attention should be paid to:

- The relation and relative positioning between the doors and the seats,
- The aisle width when all seats are occupied,
- The size of the entrance vestibules, and
- The arrangement, location and the size of the spaces for baby carriages and wheelchairs.

The interior finishes shall be made of non-aging, anti-glare materials that are easy to clean. The finishes will be resistant to graffiti and vandalism. All interior lining should be easy to change.

All materials and components, in particular those in the passenger compartment, should offer a sufficient resistance to the initiation and spreading of fires. Fire resistance of all materials shall be compliant with DIN 5510 class 1 or equivalent standard.

The bidders will include in their technical offer, the best possible interior design (seat layout, grab poles, colour scheme, etc.) in order to fulfil this technical specification, according to their best experience.

Upon contract award, the Contractor will produce three different artists' impressions for the internal design of the passenger compartments. These impressions will be produced following discussion with ATTIKO METRO S.A., clearly depicting the internal layout of the equipment, such as seats, windows, grab poles, interior panels, as well as the material and colouring scheme.

Six weeks after submitting these artists' impressions, ATTIKO METRO S.A. will select the final interior design layout. The selected layout shall not have any impact on the contractual price.

#### **6.1.1 Design of entrance vestibules**

The door entrances vestibules shall provide an initial standing area for passengers allowing the passenger to make a decision regarding where to go in the tramway vehicle.

The design of the entrance vestibule shall encourage passengers to circulate into the tramway vehicle and not congregate at doors causing congestions and impeding other boarding and alighting passengers.

#### **6.1.2 Provisions for transport of baby carriages and wheel chairs**



Provisions are to be made for the transport of baby carriages and wheel chairs. Two spaces symmetrically placed and positioned to the sides of the tram are to be provided. Each space will accommodate at least:

- One wheel chair –or–
- One baby carriage;

The spaces will be immediately accessible from an adjacent door and when occupied shall not impede passenger movement.

In each location there will be means to safely secure the wheel chair or baby carriage, a stop request button and all the necessary equipment to ensure communication with the driver suitably designed, located and easily accessible to the users.

Folding seats may be provided in these areas, which are to be used by passengers, in case the space is not occupied by a wheel chair or baby carriage.

### **6.1.3 Windows**

All side windows (including door windows) shall be equipped with glass panes made of toughened tempered laminated double glass bonded by means of a transparent membrane.

The dimensions and the positioning of the windows shall ensure unhindered view for both seated passengers and standees.

Window assemblies shall be retained using endless (with joints of especially processed rubber) synthetic rubber glazing sections easily replaceable.

The design of the windows frames shall permit easy and fast replacement of the glass panel that has been seriously worn or has been subjected to vandalism or has been crushed. In his offer, the Contractor shall provide a detailed description of the works required for the replacement of the glass panel, as well as the required time period.

Assuming that the glass panel is in-between a passenger and an object, the passenger will not perceive any optical distortion of the object, regardless of the angle formed between the glass panel surface and the eye-sight line of the passenger to the object.

The panes shall be made of tinted glass and the visible radiation that can pass through them shall be 40-50% of the visible radiation to which they are exposed. The colour tint of the glass panes, the solar radiation reflection coefficient (Solar Factor), and thermal permeability  $U_g$  shall be subject to ATTIKO METRO S.A. approval at the design stage of the vehicles.

The upper portion of passenger compartment windows shall contain a section that could be opened by the passengers in order to introduce fresh-air in the event of failure of the Air Conditioning system. The aforementioned portions of the windows shall be equipped with a locking mechanism that the Operation personnel could easily lock and unlock. Windows shall not rattle when vehicles are in service.

The vehicles shall also be equipped with emergency exit windows and special hammers. The number, locations and dimensions of these windows, as well as the type of their glass panes shall be determined in line with the relevant Standard. The

colour tint of the glass panes, the solar radiation reflection coefficient (Solar Factor) and the permeability of the visible radiation of the aforementioned glass panes shall be such that any person passing by or any passengers shall not perceive a visible difference between them and any other windows of the vehicle.

Glass panels shall be resistant against breaking and bending under loading conditions and shall comply with the requirements of UIC 566. In addition, the resistance of the glass panes against collision shall comply with NFF31-129 (French norm for toughened glass) and NFF31-250 or equivalent Standard.

All windows shall be effectively protected against vandalism (i.e. by application of an anti-scratch film of a thickness of 100µm). The protective means will be applied internally on all tramway vehicles' windows including door panes. The anti-scratch film on the interior side of the windows is also desired in order to keep glass fragments from scattering in the passenger area in the event of a shattered window.

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

The glass shattering requirements shall satisfy the relevant Standards.

#### **6.1.4 Floor**

The floor shall not have any access covers for maintenance purposes. Provisions against noise transmission are to be made.

The installed floor covering shall be continuously glued or seamlessly bonded. The floor covering should be pulled up to the sidewalls and be sealed.

The flooring must fulfil at least class R9 according to DIN 51130 or equivalent.

#### **6.1.5 Passenger Seats**

The passenger seat arrangement shall be designed in such a way, so that the horizontal symmetry axis of each seat be in parallel with the longitudinal symmetry axis of the vehicle. A number of passenger seats can be installed perpendicular to the longitudinal axis of the vehicle, should this be imposed by technical or spatial reasons.

The number of passenger seats shall be 50 as a minimum. The width of a single seat shall be over 400 mm. The width of a double seat shall be over 800 mm.

The seats' layout shall be subject to ATTIKO METRO S.A. review, revision and approval.

Both single and double seats shall be installed on cantilevers, whose one end shall be fixed on the side walls of the car body. There shall be no floor supports, to facilitate the cleaning of floors. The Contractor's attention is drawn to the need to substantially increase the structural strength of the car body sidewall posts to which the seats are attached in order to limit seat/sidewall deflection. Under a full loading of the seat, there shall be no visible deflection of the outer skin of the car body shell, while unsupported edges of the cantilevers shall not deflect more than 2mm.

In case certain parts of the vehicle floor cannot but being elevated, due to the geometry of the bogie in the area where the wheels are supported, and in case there must be an equipment box next to the inner walls of the vehicle in the passenger compartment area, then it shall be permitted to support the seats on the elevated section of the floor or on the equipment box, given that:

- The vertical distance between the aforementioned seats surface and the floor shall not be substantially different than the corresponding vertical distance between the surfaces of the seats that are installed on the side walls of the car and the car floor;
- The equipment boxes shall not have any opening;
- There should be provision of space intended for the feet of the seated passengers, *i.e.* the projection of the seat on the floor of the vehicle will be wider than the equipment box, or the elevated part of the floor, onto which the seat has been installed;
- The seats shall adjoin the upper horizontal surface of the box or the elevated part of the floor.

In general, the design and installation of the seats shall be such as not to create non-accessible surfaces and to prevent accumulation of dust, dirt and liquids. Moreover, their design and installation shall ensure easy and effective removal and re-installation of the seats for the conduct of any scheduled cleaning works.

The seats shall be ergonomically designed to ensure comfortable trips for the seated passengers. The seats will be equipped with cushions, covered by upholstery, which will have gone through treatment so that dirt, stains or liquids accumulation is minimised, while it shall be durable to vandalism. Underneath the seat upholstery, a stainless steel grid, or a thin flexible synthetic layer, will be placed, so that the cushion fill is protected against sharp objects cuts, *e.g.* knife.

Particular attention should be made so that the structure of the seats and the seat fabric of the upholstery do not inflict any damage (*eg.* tearing, hitching) to the clothes of the passengers.

As a minimum, the seats shall be subject to a static load test, in line with UIC 566 and to a structural stress test and to a fire resistance test on the basis of EN 45545 or equivalent. It is stressed that the compliance with all Standards mentioned above or their equivalent is required.

#### **6.1.6 HVAC air ducts and diffusers**

The Contractor shall specify the arrangement, position and size of HVAC air ducts, air entries and exits, and temperature sensors, in order to meet the performance requirements of the HVAC system.

All ducts and other large construction elements shall be lined or coated with sound absorbing materials.

The air ducts and diffusers must be designed in such way that passengers are not influenced or feeling discomfort due to hot or cold air circulation coming from the ceiling, blowing directly over the passengers.

#### **6.1.7 Passenger handrails, grab rails and straps.**

Adequate handrails and holds are to be provided. They should be designed to serve the passenger needs under AW3 load. The number and positioning of holds shall be proposed by the Contractor and approved by ATTIKO METRO S.A. Above the passenger seats, there must be a sufficient number of rails and handrails.

Handrails and straps should not obstruct circulation of passengers within the tramway vehicle.

Handrails adjacent to doors should assist in the rapid boarding of passengers and not obstruct people with large baggage.

Handrails can be provided in the form of vertical poles and horizontal handrails, running along the entire length of the tramway vehicles. All horizontal handrails must end to a support. Grab rails and stanchions shall be made of stainless steel. The grab rails and stanchions shall incorporate a circumferential-brushed finish, shall have a warm feeling during holding and must have been approved by ATTIKO METRO SA. The material and finish to be used shall be proposed by the Contractor and approved by ATTIKO METRO SA at the time the interior finish scheme is developed.

The fastenings of the handrails and straps must safely resist a single point force of 2,000 N, measured at any location and for all direction of force.

There shall be no centrally located grab rails in the door entrance that will impede entry and exit.

#### **6.1.8 Interior lighting**

Lighting in the passenger compartment shall be constant and glare-free. An average light intensity of approx. 200 lux shall be ensured in the seating area. LED type lamps with colour reproduction level 3 according to DIN 5035 or equivalent should be used.

The lights will be divided into two groups: service and emergency. When the battery charger(s) are out of charge, the service lights, following an adjustable time delay, will automatically switch off, while the emergency lights will remain on, ensuring a minimum light density of 30 lux on the floor.

The vehicle will be equipped with a daylight intensity detection system, which will automatically switch on and off the groups of lights, depending on the intensity of the daylight. The driver shall be given the option to switch on and off the lights individually and override the automatic system.

#### **6.1.9 Passenger emergency handle**

In each entrance vestibule - close to one of the doors - a device for activating a passenger alarm shall be provided. The mounting of the emergency handles shall be

such that cannot be used accidentally. It shall be placed at a height of approx. 1800 mm above floor level, and shall have a red grip, which will be sealed.

Appropriate labelling in Greek and English will be installed closed to the handle. The exact text shall be agreed upon between the Contractor and ATTIKO METRO S.A during the design phase.

The activation of the emergency handle shall apply the brakes and at the same time:

- Notify the driver by visual and audio signals,
- Automatically enable communication with the driver (driver to passenger)
- Record the event in the fault recording system

The type of brake to be applied (service, safety, emergency) shall be proposed by the Contractor and approved by ATTIKO METRO S.A during the design phase.

The driver shall be able to by-pass the emergency handles, by the use of a sealed by-pass switch from the driver's cab.

#### **6.1.10 Door release handle**

At each door, a mechanical door release handle shall be provided. The mounting of the door release handles shall be such that cannot be used accidentally. The door release handles will be recessed into the door pillar and covered with a sliding door, which will be sealed. It shall be placed at a height of approx. 1800 mm above floor level, and shall have a red grip.

Appropriate labelling in Greek and English will be installed closed to the handle. The exact text shall be agreed upon between the Contractor and ATTIKO METRO S.A during the design phase.

Activation of the handle shall result in cut of traction and mechanical unlock of the door leafs. The driver will be informed by visual and audio signal. The passengers shall be able to manually open the door panels, only when the vehicle is stopped.

The Contractor can propose for approval a design alternative to that detailed above, but the functionality shall be equal or better compared to the functionality described.

#### **6.1.11 Fire extinguisher**

Fire extinguishers, according to relevant European Standards, (e.g. a powder fire extinguisher, 2kg, class ABC), must be placed in the passenger compartment, at locations clearly indicated to the passengers.

There shall be one extinguisher located at each end of the passenger compartment (2 extinguishers for passenger compartment in total). The mounting of the extinguisher will be such that can be easily spotted by the passenger but not accidentally used. Recessed mounting is strongly recommended. The fire extinguisher shall be protected by a transparent cover that will be sealed and easily removed –when necessary- by the passenger.

#### **6.1.12 Stop request push buttons and “stop request” display**

There shall be at least four “stop request” buttons, illuminated when pushed, between opposite doors, along with the “stop request” buttons required at the locations of the wheelchairs’ transportation, which can be activated by the passengers. Additional “Stop request” buttons in a sufficient quantity and arrangement shall be proposed by the Contractor and approved by ATTIKO METRO S.A.

Stop request indications shall appear on the screens of the Passenger Information System, as described in chapter 13 of this Performance Specification. The indications shall be energized when the first stop request button is pressed and will be cleared when the doors open at the subsequent stop.

The driver’s cab shall be equipped with both audible warning (adjustable in volume and frequency) and visible indicator. The audible warning shall be energized only once per each stop.

## 6.2 Driver’s cab

The design of the driver’s cab should take account the fact that the vehicles are to be driven by “line of sight” and should include the recommendations of DIN 5566 part 3 “Additional requirements for working places in tram” or UIC 651 “Layout of Driver’s Cabs in Railcars” and VDV 234 “Driver working places in busses”. In a normal tramway vehicle driving position, the driver must have a forward sight distance of 2.5m to the front of the vehicle at track level.

During the design phase, the Contractor will provide to ATTIKO METRO S.A a full-scale (1:1) mock-up of the driver’s desk to find out the best position for all operation devices, push buttons, switches, display units, drive and brake elements. The design must take into account the existing vehicle cab layout and shall assure the maximum operational compatibility with it. The design of the driver’s cab, shall take into account the following:

- An ergonomic design, employing Human Factor Principles shall be employed (Arrangement of devices)
- The design shall be suitable for all drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population
- Procedure of “self-dispatch” of the vehicle by the driver
- The master controller shall be activated/de-activated by means of a key
- The unit supporting the feet shall be ergonomically designed and its height shall be easily adjusted, when the driver is seated
- Sliding window opening downwards, to supply fresh air.

### 6.2.1 Operational requirements

The cabs of all vehicles shall be identical. Switches and miniature circuit breakers that will be necessary to be operated by the driver during normal or downgraded mode of operation, shall be installed in the driver’s cab.

The controls and the read-out devices needed for normal operation and for emergency operation shall be arranged ergonomically in the driver's cab in functional groups.

It should be possible to easily recognize or read the read-out devices on the driver's desk under all lighting conditions; lamps must not dazzle. All controls and read-out devices shall be marked permanently and in adequate sizes in order to avoid incorrect use. The intensity of the light indicators shall be adjustable by the driver using a dimmer.

Buzzers or other audio signals shall be adjusted in terms of frequency and volume during the commissioning phase and the option shall be given for them to be adjusted by the maintenance personnel.

The cab shall include a folded seat for the driver's instructor.

Driver's cab shall be equipped with internal mirror in order for the driver to be able to monitor the passenger compartment. The position of the mirror shall be defined in a way that the driver is able to see without excessive body movement from the normal driving position.

The arrangement of the instrumentation inside the driver's cab shall be determined during the final design review and shall be approved by ATTIKO METRO S.A prior to realization.

Provisions shall be made for the installation of an additional portable control panel for use by the driver's instructor by means of a connector. The additional portable control panel shall include at least the following functions:

- Emergency brakes
- Safety brakes
- Bell / Horn buttons

Five (5) pieces of the additional portable control panels, which will be identical, shall be provided at the time of the third tramway vehicle delivery.

### **6.2.2 Drivers seat**

The driver's seat shall be a service-proven product, able to provide the necessary comfort to the driver while driving. It must meet ergonomic design principles, and be adjustable to size and weight of all drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population. The seat will provide the following adjustments:

- Seat Height;
- Seat longitudinal position;
- Back inclination;
- Seat's cushion longitudinal position with respect with the seat base;
- Seat's cushion inclination;
- Infinitely adjustable, mechanical, 4-way (up/down-front/back) lumbar support;

The seat will have a 4-way (up/down-front/back) adjustable headrest, covered by easily dry-cleanable fabric.

The seat will be equipped with retractable and adjustable in height armrests.

The foam of seat's cushion and back will have appropriate design to limit driver perspiration, considering the local weather conditions.

The seat will be rotational assisting the drivers entering/leaving the cab conveniently.

The seat will be of the bucket type and shall have provisions for lateral, adjustable and lockable shock absorption and will present the maximum capable stiffness against the lateral accelerations. The seat cover must ensure the best possible seat comfort, non-slippage and easiness during replacement and cleaning. The seat cover must be machine washable, while the seat, including its mechanical components, will be easily maintainable.

The design of the driver's seat will follow the VDV 234 Standard or equivalent. During the design phase, the Contractor will provide an ergonomic study of the driver's position inside the cab, which will prove that all frequently used elements are within the comfort zone of all drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population, as well as the product specification of the appropriate seat and the service proof references.

The driver's seat will be approved by ATTIKO METRO S.A.

### **6.2.3 Partition between driver's cab and passenger areas**

The driver's cab is to be separated from the passenger compartment by panels, glass panels and a door, which will be equipped with a glass panel covering at least 50% of its surface. Alternative configuration can be proposed and submitted to AM for approval.

The section of the partition made of tinted glass shall be equipped with an internal blind or other equivalent means, which will protect the driver against glare particularly during night driving. The glass panels shall be of safety and laminated glass.

The cab door is activated by hand and must be held in closed and opened position and must remain steady. The door must be fixed in such a way, so that during the car body torsion the free function be maintained. A sliding door is preferred, in order to easily and quickly open under all passenger loading conditions. The locking/opening mechanism shall employ the use of Master Controller key from the outside and a simple handle from the inside. The door opening from inside the driver's cab shall ensure instant driver exit in case of emergency. The door will be half glazed and have an internal blind or other means, which shall protect the driver against glare particularly during night driving.

### **6.2.4 Wind screen and side windows**

The windscreens must be shatterproof and made of multi-layer security glass according to ECE 43 or EN 15152 or equivalent and shall exhibit effective penetration strength.



Windscreens and side windows of driver's cabs are to be so designed that they ensure good sight, and avoid reflections/glare from the passenger compartment lights.

The view for all drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population should make it possible, to notice a child with a tallness of 120 cm next to the vehicle's front side. This view must be given from the normal seating position.

The windscreens and all side windows will be tinted and must absorb the solar radiation which is harmful for the driver. The windscreens shall be either provided with an integrated heating or be heated with warm air and be easily replaced in the event of damage.

The windscreen heating shall be variable and shall clean condensation or frost from inside and outside of the screen within 5 minutes, after standing overnight (for external and internal conditions).

The windscreen heating will keep the screen clear for safe driving during normal operation.

Driver's perforated pull down sun visors will be provided to windscreen and side windows, allowing the driver to see through them.

Driver's cab shall be equipped with side windows, which shall be designed as sliding windows (lockable from inside). This applies also in case of integration of the side windows into external doors of the driver's cab (if applicable).

View of the internal mirrors shall be unobstructed.

#### **6.2.5 Driver's desk**

The surface of the driver's desk shall be wear-resistant, reflection-free, thermally insulated and without any sharp edges. The driver's desk will provide a free space at the size of A4 paper with a clipping mechanism, for the driver's notes.

Push buttons activation forces must range between 2.8 and 11N and travel must range between 3 and 6mm. The most frequently used buttons, shall be located on the right side of the desk.

The area under the driver's desk must have sufficient space for the legs of the driver.

The metal parts of the driver's desk shall be earthed.

The armrests shall be incorporated either in the driver's desk or in the driver's seat and will comply with the ergonomics principles, having adequate height in accordance with the Master Controller's potential positions during traction and braking and for all drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population.

#### **6.2.6 Master Controller**

The position of the master controller is to be placed on the left hand side and will be controlled by the left hand.

The arrangement shall be such that the arm of the driver is ergonomically supported across all different positions of the controller and the fatigue of the driver's left arm is minimized. The driver shall be able to use the Master Controller using his left hand's palm with more than one different postures, preventing continuous operation on the same posture.

The master controller shall be of vertical and not-sliding type; the control handle shall be positioned vertically, requiring short movements between full traction and full braking positions, keeping the left hand's palm inside its comfort zone, concerning drivers within the 5<sup>th</sup> percentile of female up to the 95<sup>th</sup> percentile of male population.

The driver shall control the vehicle through the driving, coasting and braking commands, through the master controller. The analogue signal (traction or braking force) shall be picked up and transferred to the relevant control units.

When the master controller is moved forward, the vehicle will enable traction with a force according to the value selected by the position of the master controller, provided that all necessary conditions are met.

When the master controller is moved backwards, the vehicle will switch to service braking with a force according to the value selected by the position of the master controller. Preset positions of the master controller shall activate the full service and emergency braking.

The bell button shall be incorporated on the master controller.

The master controller shall be mechanically interlocked with the driver's key. The driver's key shall be identical with the existing key used on Series I (TA1) of the existing tramway vehicles.

#### **6.2.7 Driver's vigilance monitoring (dead man)**

An automatic driver's vigilance system will be provided. The system will be passive and shall require no mechanical action by the driver in order to be activated. The driver's vigilance shall be detected through an inductive or capacitive sensor, incorporated on the control handle of the Master Controller. If the driver releases the handle during driving, a visible signal will immediately warn the driver. After an adjustable time delay, the driver will receive an audio signal, too. After an adjustable time delay in which there has been no reaction, the braking system shall apply. The same applies in case the driver is constantly in touch with the handle. The Contractor will propose the necessary time delays required for this function, as well as the type of brake to be applied, to be approved by ATTIKO METRO S.A.

All the time parameters of this function will be adjustable by the Operation Company in tenths of a second. The audio signal will be adjusted during the commissioning phase, in terms of volume and frequency.

A driver / traction interlock function shall be provided. The vehicle shall not be allowed to start moving, unless the driver's presence is detected through the sensor.

#### **6.2.8 Self-dispatch of trains**

The tramway vehicle driver shall be able to execute “self dispatch” (i.e., different than the scheduled trip) without causing hazards to passengers within the tramway vehicle, those boarding or disembarking, those waiting at stops, and other road users.

### **6.2.9 Lighting**

The interior lighting of the driver’s cab shall be designed in such a way so not to dazzle or hinder discerning the read-out devices and indicators of the driver’s desk. The luminance level in the driver’s cab must be adjustable from 0% to 100% by a dimmer controller.

The floor, under the driver’s desk, will be lightly illuminated using a light of appropriate colour (e.g. red) not obstructing night driving. Lighting fixtures shall not interfere with driver’s legs.

### **6.2.10 Miscellaneous equipment**

The following equipment must be included in each driver’s cab:

- Point lever, securely fixed in an easy to reach position
- Coat / jacket hanger
- A rechargeable torch with a fixed charging device. The torch will be lead-sealed.
- A waste paper basket.
- A water bottle holding device
- First aid kit
- Space for storing personal belongings
- TETRA charger

The driver’s cab shall be equipped with a fixed TETRA charger.

Any equipment required for normal or degraded operation, provided for by the design, shall be located in suitable locations in the driver’s cab.

### **6.2.11 Fire extinguisher**

A small fire extinguisher (powder type) has to be mounted in the driver’s cab. The extinguisher will be suitable for electric fires, according to European Standards, (e.g. a powder fire extinguisher, 2 kg, class ABC)

There shall be one extinguisher located at each driver’s cab (2 in total).

## **6.3 Signs**

The material of all signs shall be vandal and graffiti resistant, and the signs shall be edge-sealed. The artwork, number and location of the signs and the materials used will be proposed by the Contractor and 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
- System routes maps
- Door warning and operational notices
- Emergency notices
- Car number (one at each end)
- Notices for persons with special needs

System route maps shall be color printed and glued over each doorway. The layout shall be proposed by the Contractor and approved by ATTIKO METRO S.A.

Stainless steel or aluminum frames shall be provided for the mounting and display of advertisement posters, the quantity and size of whose shall be defined as the interior design progresses. The design shall prevent the advertisement card from sagging or migrating and shall cover all edges of the card. The design shall allow the advertisements posters to also be replaced by unskilled staff in short time period.

#### **6.4 Provisions for the installation and operation of Automatic Fare Collection System**

Automatic fare collection equipment (ticket validating machines, central unit for controlling the subject ticket validating machines, equipment and antenna for wireless data transmission, auxiliary equipment) is foreseen to be installed on-board the tramway vehicles by an independent contractor. The same contractor shall install the necessary infrastructure (central computer, wireless network, antennas, etc) in the depot, which concerns the operation of the automatic fare collection system.

The Contractor shall implement the necessary provisions on the stanchions and/or at other locations within the tramway vehicle, including the power supply and data cabling. The independent contractor shall install the central control unit of the fare collection system equipment on the vehicle, with auxiliary equipment on each driver's cab.

The Contractor is obliged to cooperate with the aforementioned independent fare collection system contractor for the final positioning and installation of the ticket validating machines (up to 7 per vehicle), for the equipment requirements within the driver's cab or elsewhere on the vehicle, and for the installation of the data transmission equipment as well as the antenna that will be installed on the vehicle.

The Contractor shall also cooperate with the aforementioned independent fare collection system contractor in order to ensure the required power supply to the fare collection equipment installed on-board the vehicle.

The connection of the central control equipment of the fare collection system on-board the vehicle, for the wireless transmission of the subject data to a central computer unit intended for the fare collection system in the Depot, shall be implemented through an independent wireless system to be installed by the aforementioned independent contractor of the fare collection system, via a separate contract and separately to the foreseen Wi-Fi system (see article 10.5).

## 7 Car Exterior

### 7.1 Design and colour

The Contractor will produce three artist's impressions for the exterior design of the tram. These impressions will be produced following discussion with TRAM SA. If one of the proposals is contradicting to technical demands given in this performance, the Contractor has to indicate this to TRAM S.A.

Six weeks after submitting these impressions TRAM S.A. will approve a final exterior design scheme.

A similarity with the existing design and colouring is preferred. The existing RAL-codes are given as follow:

- |  |            |          |
|--|------------|----------|
| a. Car body outside:                   | silver     | RAL 9006 |
| b. Strips above the doors and windows: | light blue | RAL 5012 |
| c. Front cover:                        | dark blue  | RAL 5011 |

The visible parts of the bogies as well as all construction parts are to be coloured in black RAL. It is possible to investigate the option of alternative color schemes, if proposed by the Contractor and approved by AM.

Finishes and exterior markings shall be durable and shall facilitate cleaning and replacement. This includes its corrosion protection capability, its appearance and its bonding to the applied substrate. The paint system shall be capable of repair for minor damage at maintenance facilities. The paint gloss finish shall withstand mechanical train washing over its life. A high quality, high gloss, low ripple, no runs finish shall be achieved.

For environmental reasons the use of water-based colours is required.

### 7.2 Lights

#### 7.2.1 General requirements

Headlights, brake lights and taillights must be provided at each end of the vehicle. The circuit design must be such that whatever end of the vehicle is being driven the corresponding headlights, brake lights and taillights are operational. Simultaneous operation of headlights, brake lights and taillights at both ends should not be possible.

#### 7.2.2 Headlights-Driving Lights

Two headlights of XENON or LED type with low (dipped) beams shall be installed on the front of the tramway vehicle symmetrically located.

The headlights must provide at least 8 lux of illumination at 25 m from the tram front on the centre-line, measured in the longitudinal axis of the Track at the same height as the headlights. At least 4 lux shall be measured at 1.75 m sideways from the track centre line axis, at 25m distance and headlight height, and 0.8 lux at the distance of 35 m.

The circuit design of the headlights must not allow simultaneously normal and dipped beam operation.

The colour of the headlight beam must be white.

Blue indicators installed on the driver's panel must show the status and the mode of operation of headlights.

### **7.2.3 Taillights**

Two red taillights of LED type must be installed on the rear of the tramway vehicle.

The taillights must have at least 50cm<sup>2</sup> red light emitting surface, using their own coloured material.

Under normal climate conditions, the taillight must be visible from a distance of 150 m. The taillight must not dazzle.

### **7.2.4 Brake lights**

Two red brake lights of LED type must be installed at the back of the tramway vehicle, while a third brake light is also required.

The brake lights must indicate the deceleration of any of the brake systems. In daytime, the signal of these brake lights must be clearly visible from a distance of 150 m. The brake lights must be clearly distinguishable from the taillights; the illumination power must be at least twice that of the taillights.

### **7.2.5 Pilot lights (direction indicators)**

The vehicles must be supplied with amber, flashing pilot lights. The pilot lights must be visible from any direction.

The operation of these lights shall be indicated on the driver's panel.

### **7.2.6 Volume lights**

The vehicle shall be equipped with volume lights (lights defining the shape & volume of vehicle), with colouring and turning on scheme according to Greek Traffic Regulations.

## **7.3 Passenger doors**

The doors shall be two-winged, electrically operated, sliding type (Sliding plug in). The first doors behind the driver's cab can be single leaf doors, provided that the leaf is adequately dimensioned for a smooth embarking-disembarking of the passengers. The opening movement shall be first towards outside (lateral) and then as sliding (longitudinal) along the outer panel of the vehicle.

There shall be no exposed grab rails on the vehicle exterior when the doors are closed.

The doors must be equipped with fixed window-panes made of safety glass.

The passenger door opening buttons are to be illuminated and to be fixed on the door panels on the right height, so that these are accessible by all passengers.

At the door edges, flexible rubber profiles, to prevent passenger injury, are required. The lower seal must be designed, that a penetration of dust or water is prohibited, e.g. by installing a broad rubber seal in adjustable form. This rubber seal must be separately exchangeable. A continuous pressure balance must be given at any time. Against the wedging in finger protection rubbers with blast wave or contact groins are to be positioned. The maximum tolerable opening-closing force and when obstacle is detected shall be in accordance with standard EN 14752. The dimension that the doors protrude, when these are open, from the exterior skin shall be defined by the Contractor and should be compliant to the vehicles dynamic envelope and doorsill-to-platform distance.

In order to facilitate boarding and disembarking of passenger with wheel chairs or strolls, an additional protrusion shall be installed on all door threads. This protrusion will be easily exchangeable and shall be made of resilient material to withstand accidental contacts with the platform. The final dimensioning of this protrusion will be determined during the detailed final designs related to the tramway vehicles.

The Contractor shall ensure that water accumulation at passenger doors is avoided. Rain and washing water has to be drained properly. Rainwater shall not drip on passengers when boarding on or disembarking from the vehicle. Any drainage of water from the vehicle shall not discharge onto passengers waiting at stops.

In their technical offer, the bidders shall propose the door arrangement and shall submit a detailed description of the door system characteristics and their control equipment. Their technical offer must also include drawings and a technical description of the doors' mechanism, as well as the description of the obstacle detection system.

### **7.3.1 Door arrangement**

The doors shall be of light structure but strong enough to endure violent actions. Appropriate securing at floor level shall be provided to prevent the movement of the doors due to train movement or wind effect.

The door panels and doorways shall be weather stripped to be watertight when the vehicle is being washed and for all specified service speeds with the worst possible combination of climatic conditions.

The doors shall have the strength to avoid any disturbances in the operation, such as passengers leaning on the doors. Closed doors should withstand a force of 3,500 N without permanent deformation (Standard EN 14752).

Doors must be arranged in such a way so to minimise the dwell time at tram stops for the unloading and loading of passengers. In addition, the doors arrangement and width should be capable of meeting the evacuation times of one minute from one side only, in case of emergency. Bidders are required to propose door arrangements, width and number of doors that give optimum passenger flow. Consideration should be given to emergency passenger evacuation.

The total capacity of passengers should not exceed 20 passengers for one single door lane in AW2 load conditions, in order to avoid crowding in front of the doors and not to impede passenger boarding / detraining. This requirement must be taken into account in the configuration of the seats, so that the length of the free lane configured between the doors does not exceed 2 m.

Passenger doors are to be arranged symmetrically along the vehicle sides. The door arrangement on each side will be identical. Six doors (four double, two single) per side are foreseen. The Contractor may propose alternative arrangement, but this must be approved by ATTIKO METRO SA.

The inside height of passenger doors shall be 1950 mm as a minimum.

The inside width of passenger doors shall be 1300 mm as a minimum.

In case a single door is placed adjacent to the driver's cab, this single door shall have a width of 650mm as a minimum.

### **7.3.2 Door control**

Doors must be centrally operated so that all doors on one side of the tramway vehicle should open and close simultaneously. This condition must also be fulfilled when doors are operated in a selective manner. An external button for selective door operation may be installed on the external and internal surface of the door in question. The driver, using the respective push buttons, shall be able to:

- Release the doors on the right side for opening, from the buttons on the doors
- Open the doors on the right side
- Release the doors on the left side for opening, from the buttons on the doors
- Open the doors on the left side
- Close the doors on both sides

Before the driver opens or releases the doors on the left-hand side, he will need to "unlock" the doors using a separate push button.

The doors will open, only if the vehicle speed is below 3 km/h.

The opening and closing time of doors shall be no more than 3.5 seconds for the double doors and 4 seconds for the single doors.

The locking device of the doors must not allow the door panels to open when the vehicle is in motion. The locking mechanism must be of high resistance and durability.

All doors shall be interlocked and consequently safeguarded against unintentional opening. Doors to which faults arise shall remain closed.

If the door mechanism fails to operate, or in case of emergency, manual operation of unlocking mechanism must be available to the staff in order to open the doors.

The status of the passenger doors shall be monitored and faults shall be reported and stored in the diagnostic system.



### **7.3.3 Doors closing**

Acoustic and visual warning signals shall be provided before and during the execution of the close command. The warning signals should be recognized by passengers-persons with special needs.

When the driver closes the doors, the warning signals will buzz for 3 seconds, before the doors begin to close. During door closing, the warning signals will continue to buzz, but with a slightly different characteristic (such as frequency). The volume, frequency and time duration of the warning sounds will be proposed by the Contractor and finalized during the commissioning phase.

Warning signals shall operate before and during door closing only. The rest of the time will remain silent.

Once the doors are closed, they will be mechanically locked. It will not be possible for the doors to open, even if no power is applied on the control mechanism, unless the emergency open handle is operated.

### **7.3.4 Doors released**

When the driver releases the doors, the passenger shall be able to open the door by pressing the illuminated opening push button, located on the door panel. The button will be operative on both sides (inside and outside). When the doors are released, the illuminated push button will be flashing, in order to attract the passenger's attention.

When a passenger opens a door, this door will automatically re-close, after a specific time has been elapsed. This time is defined to 30secs, but will be finalised during the commissioning stage. After automatic re-close, the door will remain in the released state.

If the cab goes inactive while the doors are released, the doors will remain released.

### **7.3.5 Obstacle detection**

When a passenger or an object is trapped in the closing door, the doors should open without causing injury to the passengers and they must re-close automatically. An optional setting for multiple re-opening must be available. The factory setting shall allow three consecutive re-openings before the door remains completely open. The final number of retries will be defined during the detailed final design phase.

If the door fails to close after the specified number of retries, the driver will receive a failure notification. The driver shall be able to isolate a defective door in the closed and locked position, in order to continue the service.

The obstacle detection protection shall follow standard EN14 752 and shall be able to detect a 30mm-diameter horizontal circular bar.

### **7.3.6 Door loop**

The door loop will be closed when all doors are closed and locked. If at least one door is not locked or released, then the door loop will be open and the vehicle will not enable the traction command. The driver shall be able to by-pass this restriction

through a lead-sealed switch. The status of the door loop (opened or released) will be clearly indicated on the driver's desk.

In case the switches are bonded, doors will automatically close, when vehicle speed is above 3 km/h.

### ***7.3.7 Door isolation***

When a specific door fails to operate properly for whatsoever reason, the driver shall be able to isolate this door and continue normal operation.

The door will be electrically isolated and mechanically locked in the closed position. Subsequent open and close commands will have no impact on the isolated door. The isolated door will be clearly indicated on the driver's desk and on the door's location inside and outside.

### ***7.3.8 Emergency door operation***

In emergency cases, it must be possible for the passengers to open the doors from inside the vehicle. The door-opening actuator is to be placed close to each door. The actuator is to be designed in such a way that improper use is discouraged.

Emergency door release will be possible from inside. There will be clear, succinct instructions on the use of the actuator in close proximity to the actuator.

It will be possible for the driver to recognise that the emergency door opening has been activated. Doors shall not open until the vehicle stops.

The door control system is to be designed so, that without power the closed door remains locked and an open door can be pressed from outside or inside into the locked position.

### ***7.3.9 First door opening***

The first left and right doors behind the driver's cab will be individually operated through a separate control and emergency door opening mechanism operated by a special handle/recess on the outer side of the vehicle. Its activation speed shall be less than 3km/hr and the vehicle's traction power system shall be interrupted.

The doors will be able to open and close electrically, either from inside or from outside, even if the vehicle is de-energized. The control mechanism shall be protected against unauthorized use (to be used only by the driver or the technician). An emergency release mechanism operated from outside of the vehicle, shall be provided, in order to open the doors in case of power failure.

## **7.4 Coupler**

The vehicles must be equipped on both sides with a tow bar mechanism, able to comply with the requirements defined below.

The purpose of the tow bar is to allow the driver to move a totally failed vehicle by an operational vehicle and bring it back to depot, in order to clear the line. The tow bar

shall also be used inside the depot, to move the vehicles between depot tracks, using another vehicle or the general purpose service vehicle (Unimog) or the trailer cars.

The design of tow bar must ensure mechanical coupling between two vehicles in any combination (pulling or pushing, side A or B). The necessary safety electrical signals will be exchanged like braking command, parking brake, emergency brake command, emergency lights, pilot lights, brake lights, headlights, cab to cab communication, horns, brake release and any other signals that are deemed necessary for safety purposes.

The design of the tow bar must be such that its operation is simple and safe and the driver will be able to couple and uncouple the failed to the operative tram alone.

The tow bar, when not in use, must be fully protected by a cover and locked in the closed position. The design of the cover will minimise accident injury / damage and shall allow ease removal by the driver without the need of special tools (e.g. simply by using the square key).

Coupling between any series of vehicles shall be possible at any location on the tram network. The swept area of tow bar shall be within the tolerances of the swept envelope, defined in the appendix 1.

The Contractor must submit the towing operational procedure to ATTIKO METRO S.A for approval.

#### ***7.4.1 Compatibility with Series I vehicles***

The design must ensure the same requirements as above. In case the provided tow bar is not compatible with the coupler of the Series I vehicles, the Contractor must design, supply and commission the coupling adapter. One coupling adapter must be provided for each vehicle which should be stored on an easily accessible position and should be easily handled (mounted / dismantled) by a single person (driver) on the tow bar.

The couplers of the Series I vehicles are of Dellner Type 371, automatic mechanical couplers. A drawing of the coupler mounting on Series I vehicles is provided in appendix 1.

#### ***7.4.2 Compatibility with the Service Vehicle***

The design must ensure the same requirements as above.

#### ***7.4.3 Electrical coupling***

Electrical coupling between the vehicles, responsible for the provision of the necessary control signals and power lines, shall be undertaken manually by jumper cable. Each jumper cable shall be provided with an electrical coupler connection capable of making all necessary 24V low voltage electrical connections between adjacent vehicles to permit control of the vehicles in a train from the driving cab. A percentage of 10% (but no less than eight) additional unused electrical pins shall be provided in the jumper coupler to be used for future needs.

Any signal interruption in the event of an involuntary separation between vehicles or the Service Vehicle will result in the activation of the safety brake.

There will be easy access for realizing the electrical connection when the vehicle is in coupling condition.

### **7.5 Movements through the wheel lathe**

Suitable towing location points shall be located on the tramway vehicle for pulling and pushing a tram through the wheel lathe.

### **7.6 External viewing**

For the rear view and the control of the passenger boarding and disembarking, the vehicles will be equipped with rear view cameras.

Two cameras shall be installed on each cab end, one on the left and one on the right side (a total of 4 cameras per vehicle). The cameras shall be arranged in such a way as to provide the driver a full and clear view of the rear of the vehicle.

The cameras are not included in the static gauge of the vehicle, as shown in Annex 1. However, the Contractor must include the cameras in the static gauge of his vehicle.

Colour monitors will be installed on the driver's desk allowing the operator to view the images from the cameras. As a minimum, the monitor should display at least the concurrent image from both vehicle sides. The exact location and the configuration of the display unit shall be submitted for approval and shall be finalized further to the co-operation with the Operation Company as well (see also article 13.9).

The cameras should have automatic adjustment of the contrast and brightness depending on the conditions encountered.

Monitors switching on and off shall be realised automatically as the vehicle stops and starts from the platform. The full control concept shall be proposed by the Contractor and approved by ATTIKO METRO SA. The driver shall have the possibility to bypass the automatic mode and manually switch on the monitors with the selected view.

### **7.7 Wheel flange lubricator**

All vehicles to be equipped with flange lubricators. The Contractor shall propose the wheel flange lubrication system for the approval of ATTIKO METRO S.A.

The vehicles shall be supplied with proven equipment to dispense solid or liquid lubricant to the flanges of wheels. The number of wheels and axles so equipped, and their arrangement, shall be carefully chosen by the Contractor based on specific lubrication needs of the wheel and rail-head.

The lubricant used shall be environment friendly.

If solid lubricant is used, shall be in stick form, mounted in spring-loaded cassettes. The access to the cassettes shall be easy and no tools shall be required during reloading with lubricant. The lubricator arrangement shall ensure that adjacent areas of the under frame and the bogies are not fouled by excess lubricant. Should it be

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°C.

If liquid lubricant is used, the design must ensure that the lubricant removed off the wheels will be collected over properly installed guards, which will be easily accessible and cleaned. The control scheme of the actuator will be triggered by any combination of the following conditions:

- By the driver.
- When the vehicle enters a curve with  $R \leq 50\text{m}$ .
- By accumulated distance.
- By vehicle speed

The exact conditions of the actuator triggering as well as the quantity of the dispensed lubricant will be defined during the design phase.

## **7.8 Miscellaneous**

### ***7.8.1 Drainage (rain and washing water)***

Water from the roof has to be channelled inside a pipe through a roof rail, without splattering the sides of the tramway vehicle or the passengers.

### ***7.8.2 Windscreen wiper and washer***

The windscreen is to be provided with quiet operating windscreen wipers which can operate in intervals and which go into their rest position out of view of the driver when turned off.

The sweep of the windscreen wiper shall give the driver sufficient viewing area to safely drive the tramway vehicle at normal line speeds.

Additionally, an effective windscreen washer (spray nozzles) is to be provided for external washing of the windows in the forward viewing area.

### ***7.8.3 Locking system***

The Contractor shall provide a reliable key locking system for the entire vehicle. The locking system shall have three hierarchy levels:

1. Maintenance Level (full access)
2. Driving Level
3. Cleaning Level (minimum access)

Cleaning workers shall have access to a completely de-energized vehicle, for cleaning purposes. The cleaner shall be able to enter the vehicle and switch it on with a key. The minimum functions enabled during cleaning will be: Lighting, HVAC and doors control. Traction will be positively inhibited. The pantograph will be raised and lowered automatically, when the vehicle is switched on and off by the cleaners key.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The Contractor has to deliver a locking level plan. This plan will be approved by ATTIKO METRO S.A.

***7.8.4 Clearing plough***

Before the first wheel set in driving direction, a clearing plough shall be mounted in order to clear the track from objects and prevent the danger of derailing of the vehicle.

***7.8.5 Vandalism protection***

All exterior surfaces, susceptible to vandalism, shall be protected by anti-scratch/ anti-graffiti film. The film will be coloured in accordance to the vehicle colouring scheme. The film shall be so selected in order to resist cleaning agents for removing graffiti impurities as well as to allow ATTIKO METRO SA to apply and remove printed advertisements on the exterior surfaces of the vehicles without peeling. In their technical offers the bidders must include details of the selected anti-graffiti protection, in order to prove his compliance with the above.

The maintenance manuals shall include application and removal/repair instructions.

## 8 Electrical and Auxiliary Equipment

All electrical components shall be installed in a manner that allows easy access and disassembly. Other components may not impair the replacement.

The assembly and installation of electrical equipment and their cabling shall be such that any fire hazard be eliminated.

The design of the electrical components shall be modular and interchangeable. All hardware shall be compatible with EN50155 or equivalent.

All insulations for power lines and cabling are to be made of highly inflammable halogen free material, compatible with EN 45545 and the equivalent European Standards about smoke, flammability and toxicity. The insulation of the cables shall not deteriorate with age. The life duration of power lines and cabling shall conform to the expected life of the vehicles (30 years).

All cables and lines used in the vehicle shall be identified through a unique cable number. The numbering system shall be proposed by the Contractor for ATTIKO METRO SA Approval.

Sudden changes of the overhead voltage, as well as over current must not overload the electric equipment and influence the driving behaviour of the vehicle. The components are to be combined functionally in device containers and to be provided as a tested unit for assembly.

Bidders shall submit information on the following:

- Number of APSE static inverters
- Drawings and characteristics of the APSE system, including the battery arrays
- Analysis of the APSE system under normal operation and in operation without traction voltage
- Description of protection equipment against current input
- Drawing of the APSE protection devices

For operation without traction voltage we quote in detail the following loads that must be served in total:

- coupling/ uncoupling of the couplers for two cycles
- two cycles of hydraulic brake release from the cabin
- raising/ lowering the pantograph two times
- two cycles of door opening/ closing
- 1/3 of installed lighting for 30 minutes
- Dipped beam, rear lights, flash indicators, braking lights and position lights for two hours.
- TCMS function

- Miscellaneous systems, communications.

### **8.1 Auxiliary Power Supply Equipment (APSE) - Static Inverter**

Each vehicle shall be equipped with an Auxiliary Power Supply Equipment (APSE), which shall include static inverters, output transformers, battery chargers, control systems accompanied by related software and other auxiliary equipment.

Each vehicle shall be equipped with at least two (2) Static Inverters (SI). The SIs will produce the necessary power for the 400V / 230V AC and DC (LV) loads and will incorporate a battery charger to produce the low voltage power to charge the batteries.

If a static inverter goes out of operation, then the operating inverter shall supply - as a minimum - the entire braking equipment, the lighting system, the equipment intended for the Train Control and Monitoring System (TCMS), as described in Chapter 10 of the Performance Specifications, the Integrated On-board Information System related equipment, as described in Chapter 13 of the Performance Specifications, approximately 50% of the air-conditioning equipment and the entire installed equipment intended for the ventilation-cooling of the traction inverters, static inverters and batteries. The Contractor during the design phase shall submit for approval by ATTIKO METRO S.A the load distribution scheme under normal and downgraded conditions.

Configurations with one static inverter per vehicle could also be accepted under the safeguarding, that in case of failure of the inverter, the vehicle shall be able to return to the depot without problems, from the most remote location of the tram network, without the need of towing. In parallel the reliable operation of vehicles with one inverter in the auxiliary power supply system should be certified (with documents from other Tram operational networks) ensuring that inverters failures do not lead to operational problems in the Tram network.

The SI output shall be galvanically isolated via a transformer, and the secondary windings shall incorporate a ground fault protection system.

The transformer will be so arranged as to avoid unwanted buzzing and vibrating (e.g. resilient mounting).

When designing the SI, the proper software applications shall be incorporated, so that the simultaneous starting of large auxiliary loads (such as heating or conditioning) and the consequent oscillation be avoided.

The SI and battery charger shall use a control scheme that contains extensive self-diagnostic logic. The diagnostics system shall identify a range of credible faults, identify whether a component is responsible for the fault, and whether the component must be replaced or the system merely reset. The diagnostics system memory shall be retained when the train is powered down.

If the train is de-energised and the battery supply drops below a certain voltage, the battery charger should start charging the battery, provided that power is available to the vehicle.



The battery charger shall be able to start, even when the batteries are fully discharged, utilizing a “dead battery starter” function, as soon as the traction power will become available. There must be a restriction, as regards the charging current at the rate indicated by the battery manufacturer.

The SI must be of IGBT technology, except the charger that can be of semi-conductors’ technology.

The Contractor shall provide all necessary hardware and software tools, in order to read and analyse the diagnostic memory, identify the defect component, monitor the values of vital operational parameters and perform the necessary functional tests of the units.

The SI and the battery charger shall be tested as per IEC 61287-1, except the shock and vibration testing, which shall be in accordance with IEC 61373 and EMC which shall be effected according to EN 50121-3-1.

There shall be at least four (4) outlets for 230V/16A supply inside the vehicle, with one in each driver’s cab. The remaining outlets shall be installed in the passengers’ compartment areas and shall not be accessible by the passengers.

On either external side of the vehicle, there shall be a sufficient number of 400V plugs, as well as low voltage (DC) plugs intended for loads functioning inside the Depot.

## **8.2 Battery**

Batteries shall be designed for a life of 15 years.

The vehicle shall be equipped with nickel-cadmium storage cells. It is preferable for the cell groups to be separated by suitably treated spacers. The battery box shall be designed in such a way that the cells will be prevented from bouncing in the box during normal operation and will be retained in position in the event of a serious incident. The production of battery gases shall be negligible, and the battery box shall be suitably ventilated.

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. Cells shall be individually renewable. Battery cells shall be easily accessible for maintenance reasons (inspection, refilling etc).

The battery shall be designed to withstand the shock and vibration conditions associated with a rugged railcar environment.

The output of the battery shall be suitably fused. 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 supplier. Batteries shall be rated and tested in accordance with the requirements of IEC 60623. The battery-set shall be equipped with an on/off switch.

### **8.3 Bell / horn**

A warning bell (gong type) emitting a continuous signal is required on all vehicles to warn other road users. The sound of the warning bell must reach 100 dB(A), measured at the distance of 7 m from the front of the tramcar track centre line, 1.6 m above track level.

The warning bell will only sound when activated by the driver and in case of emergency brake.

A second warning bell of lower intensity (gong type) suitable for warning pedestrians or being used where less ambient noise is produced shall be installed. The push button for this bell, which will be different from the first one, will be installed on the traction / braking controller lever.

### **8.4 Sanding equipment**

The sanding devices must positively feed the sand to the rail surfaces at all operational vehicle speeds and at all parts of the rail encountered in regular service.

The amount of sand dispensed must not jeopardise the traction power return current.

The sanding devices shall operate for bi-directional driving. At least two axles /four wheels in each driving direction shall be supported by sand.

Sanding must be activated automatically in slip/spin situations as well as with the emergency and safety brakes. It should be also possible for the driver to operate the sanding manually. For maintenance reasons, the sanding device must be activated by maintenance personnel under the vehicle, when the vehicle is stopped in the workshop – maintenance pit.

The sand boxes must have external filling inlets.

The sand boxes are to be equipped with easily visible fill level indicators. Should such visible indicators not be possible, then the sand boxes shall be equipped with appropriate sensors for indicating to the driver's panel the sand level of each box. The subject boxes and their covers must be dust- and pressure- tight. The sand boxes should be of sufficient size to allow sanding for one week without refill, under normal operating conditions and wet weather conditions.

The Contractor must take all necessary measures, so that the sanding tubes that eject the sand on the track not to get blocked, due to rain water or moisture.

The design of the sanding devices shall be submitted for approval by ATTIKO METRO S.A.

### **8.5 Safety and security devices**

#### **8.5.1 Safety loop**

All safety devices of the vehicle will be connected in series and compose the safety loop. The safety loop will include –as a minimum- the following devices : The

mushroom of the driver's desk, the dead man device and the passenger emergency lever, should this be suggested by the Contractor for ATTIKO METRO S.A. approval.

During normal operation, the safety loop will be closed. In case any of the safety devices is activated, the safety loop will open, the traction will be disabled and the safety brakes will be applied.

### **8.5.2 By-pass switches**

Each cab will be equipped with the necessary amount of by-pass switches. The purpose of these switches will be to allow the driver to by-pass a certain safety device that has failed and to return to Depot, in order to clear the line.

Both cabs will include by-pass switches for the following functions, as a minimum:

- Safety loop
- Door loop
- Mechanical brakes (all bogies / axles)
- Zero speed
- Dead man device

The operation of the by-pass switches shall be recorded in the event recorder. The switches will be lead-sealed.

### **8.6 Mounting of electrical cables**

All wiring should be secured and protected against movement chafing and any contact with sharp or abrasive objects. All wiring shall be located and secured so that normal equipment motions, maintenance access, heat sources and the Athens environment not to damage or reduce the life of the wiring.

Cable cross section and insulation sizing shall conform to the latest European standards.

## 9 Traction System

The vehicle shall be so designed so as there is uniformity and interchangeability between the traction systems on each bogie.

The minimum remaining traction power following a single traction system failure (to the motor, inverter or respective inverter control unit) shall be 75% of the nominal one. In this case, the traction system shall be able to make one full round trip under the following conditions:

- The term “round trip” means the round trip from Voula Stop to Syntagma Stop under normal operation conditions
- AW2 load
- Line voltage 750 V
- Available only the rheostatic brake (no electric regeneration)
- Mechanical brake system acts on all axes

The traction system shall ensure that in the event of a 50% failure, the vehicle can return to the depot under its own power from any point on the network with a load AW0.

The above requirements for 75% and 50% failure shall be verified during testing phase.

Back-up hardwiring for critical control functions will be supplied.

The traction system shall be energy-saving, by electric regeneration during electrodynamic braking.

Especially as regards the maximum permissible wheel diameter difference, the traction power will automatically offset wheel diameter differences above a certain value. For differences below this value, the motors must be dimensioned so that the vehicle performance is not affected.

Bidders shall submit information on the following:

- Layout drawings and description/characteristics of the traction system
- Wheel diameter offset
- Traction motor disconnection system and removal method
- Description of the protection equipment against current input
- Motor cooling system description
- Description of motor characteristics
- Degraded operation characteristics, supported by calculations (maximum operational speed, maximum acceleration, mean accel. 0-35 Km/h with jerk  $\leq 1.3\text{m/s}^3$ ) at 75% traction, load condition AW2, 0% gradient, line voltage 750 VDC.
- Degraded operation characteristics, supported by calculations (maximum operational speed, maximum acceleration, mean accel. 0-35 Km/h with jerk  $\leq$

1.3m/s<sup>3</sup>) at 50% traction, load condition AW0, 0% gradient, line voltage 750 VDC.

## 9.1 Pantograph

The 750V (nominal) DC Power Supply shall be fed to the vehicle from the overhead wire via a single pantograph, located on the vehicle roof. It is to be mounted in that way, that the middle of the contact strip in working position is about the railway track middle axis and preferably about the pivot of the second or middle bogie.

The pantograph shall be service-proven, single-arm design, capable of stable bi-directional operation at all specified vehicle speeds at all locations on the track and in all environmental conditions likely to be encountered.

The design of the pantograph shall be such that it shall not substantially increase the risk of dewirement, contact with support structures or detrimental wear to the contact wire.

The shoe device and contact insert shall be replaceable with common hand tools.

Means to reduce arcing between pantograph and overhead wire shall be integrated and demonstrated in the design.

The pantograph raising and lowering circuit shall be operable from any cab. The driver shall have the possibility for manually unlatching, lowering and raising the pantograph in the event of a loss of power or control.

The pantograph shall be mechanically locked during the maintenance period.

The final position of the pantograph shall be mechanically locked and indicated on the driver's panel. The presence of the overhead power supply voltage should be indicated in the driver's panel.

The mean operational upward nominal force shall be 80 N, adjustable in the range from 60N to 100N. Double contact strips with a radius of 10.000 mm are to be employed.

### 9.1.1 Pantograph components

The pantograph components and its wiring shall adhere to the following principles:

- Simple assembly
- Maintenance and service friendliness
- Improved electromagnetic compatibility (EMI)
- Short starting times
- Protection of the components against dirt and moisture
- High degree of availability and reliability
- Weight reduction for the entire vehicle
- Minimal amount of cabling work and plug-in connections
- Easiness of cleaning the pantograph mounting area

- All high voltage cables shall have appropriate insulation.
- Easy replacement of worn out collector head strips

## 9.2 High Speed Circuit Breaker

The vehicle will be equipped with the appropriate High Speed Circuit Breaker (HSCB), which will provide the necessary protection to the traction system.

During the design and material selection stage, care shall be taken to provide adequate protection from over voltage, overcurrent, ground fault and any other circuit protection deemed necessary to protect the traction system components (return of nominal 750V DC system current via improper paths).

The drive equipment shall be protected against high transient voltage peaks from the power supply like lightning strokes.

The Contractor shall demonstrate the traction power protection scheme.

## 9.3 Traction Control and Inverter

A suitably sized traction inverter will convert the 750 V DC power to variable voltage – variable frequency power and drive the traction motors, using state of the art IGBT power modules.

No less than 32-bit technology traction control system shall control and monitor the drive units in accordance with the current motoring or braking reference values specified by the driver.

The traction control shall be arranged to ensure optimized performance and ride characteristics, for instance jerk limitation during braking, wheel slip and slide protection when accelerating or decelerating, as well as monitoring of the permissible values and limitations concerning motor characteristics, acceleration and deceleration.

The Traction Control Unit (TCU) should be so housed that no outside dust ingress is possible. All hardware modules of the TCU unit shall be secured safely in the retaining rack.

A built-in function should not allow the vehicle to exceed the maximum speed limit.

The Contractor shall submit for approval a list of software settings permitted by the maintenance personnel. The wheel diameter values settings shall be displayed, evaluated and eventually corrected through the data bus system.

For the reading of the TCU and all other electronic units required for troubleshooting an up-to-date diagnostic program shall be delivered. Its detailed description shall be submitted for approval.

The reading of the TCU data should also be enabled through the TCMS.

#### **9.4 Traction Motors**

The Contractor shall determine the motor number and characteristics. The motors' operation shall have been demonstrated in other Tramway networks. Motors shall be three-phase alternating current asynchronous motors or synchronous-permanent magnetizing motors of sufficiently calculated power; they must fulfill the demands of the EN 60349-2.

The Bidders shall determine the type of cooling and motor enclosure. Air-cooled motors are preferable.

The motor characteristics shall ensure all performance characteristics as laid down in chapter 3 with wheel diameter differences within the tolerances. The tolerances of the wheel diameter differences for the correct operation of the traction system shall be substantiated in the bidder's technical offer.

Motor insulation category shall be at least 200, as per EN 60349-2.

The wear and life duration of the bearings shall be laid out in accordance with the life of the vehicles. The motors and gears must be designed in that way, that an entire service life of at least 2,0 Mio km is reached. Also is a service distance of 1 Mio. km to guarantee without opening the motors.

Motors and gearboxes should be easily dismantled from the bogie and disassembled (see chapter 4.1.4.).

Unsprung mass of the motor-gear unit assembly shall be kept to a minimum.

Terminals, leads, and motor frames shall be clearly marked for positive identification.

Motor connections to the vehicle shall be secured to avoid insulation chaffing and shall be routed to accommodate all undercarriage motions without interference or excess strain.

The traction motor shall be designed for a life of 30 years in accordance to the expected life of the vehicle.

#### **9.5 Braking Resistors**

If during braking, the systems (auxiliaries, power supply system) are not receptive to receiving regenerated electrical loads, the energy shall be converted to heat in the braking resistors.

The resistors shall have sufficient capacity to provide full power dissipation during operation at full service braking over the specified profile and passenger loadings up to, and including, AW4, assuming no regeneration into the line or elsewhere. The resistor grids shall be convection or force ventilated and roof mounted. The roof shall be insulated thermally against the resistor. All resistor components shall be selected both for their thermal and mechanical properties and corrosion resistance.

By reaching the temperature limit a single emergency braking shall still be possible under full load, maximum speed at any location on the alignment.

The driver shall be informed if and when the temperature limit is reached.

#### **9.6 Earthing devices**



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The vehicle will be equipped with earthing devices, properly sized to accommodate the return current. The Contractor will take all necessary measures to make sure that no current will go through the axle bearings.

Traction return current will flow through individual earthing devices. The traction inverter return cables will be connected directly to the earthing devices.

The traction return path shall be independent from the remaining return / earthing cables of the vehicle.

All metallic surfaces of the roof will be grounded through the car body to the running rails.

The earthing concept will be proposed by the Contractor and approved by AM.



## 10 Train Control and Monitoring System (TCMS)

The vehicle shall be equipped with no less than 32-bit Train Control and Monitoring System (TCMS), which shall perform the highest level control and monitoring tasks in the vehicle and shall integrate, monitor and control all individual subsystems of the vehicle, such as heating & cooling, doors, traction and braking, dead man, safety function monitoring and the management of all the bus systems interfaces.

The system will monitor the health of all subsystems and, regardless whether the subsystem utilizes microprocessor controls, shall provide a wide variety of accurate operating information and current and historical fault data.

The system will be modular, distributed and redundant. Remote I/O units will be installed on the different vehicle segments, which will communicate with the Central Control Unit through a fast and reliable vehicle bus (MVB). A Driver's Display Unit (DDU) will be placed in each driver's cab.

The MVB network cables shall be routed one on each side of the vehicle for redundancy purposes.

The exchange of data and commands between the functional units shall be realized over vehicle bus (MVB), in order to minimize cabling, connections and coupling pins.

A high data rate exchange (1Mbps or better) is expected.

Failsafe commands (braking for example) will be provided as simple wire train lines for safety reasons, in order to allow the vehicle to run and clear the line under downgraded conditions, when the vehicle bus is not available.

All the hardware will be compliant to EN50155, IEC 61375-1 or equivalent, under the condition that the same or better levels of functionality and performance shall be attained, in comparison to the system based on IEC 61375-1 which is described in the articles of the present specification.

Hence, other network solutions shall also be acceptable, such as the Controller Area Network (CAN), the Attached Resource Computer NETwork (ARCnet), Ethernet based networks, etc.

The system will implement the master clock concept, updated via GPS. All control units attached to the vehicle bus will share the vehicle's master clock settings. The clock will be changed through the use of portable test equipment or by the DDU. Corrections for daylight savings time will be made automatically.

The data collected from the TCMS via the data bus lines shall be monitored and processed in order to enable control functions or be displayed and recorded.

Data of importance to the driver shall be classified and displayed in the driver's panel.

All diagnostic information has to be accessible to maintenance personnel with a commercially available PC (laptop or notebook) via an easily accessible and fast service interface (wired or wireless). The interface ports shall be one (1) per driver cab and two (2) in the passenger compartment, exclusively accessed by the maintenance personnel. The data and fault registers of all components connected via

the bus line shall be accessible to the maintenance personnel. (For instance: TCU, door control, brake control unit (BCU) etc.)

Any improvement, modifications, or quality improvement modifications for all the software (not exclusively TCMS) supplied with the vehicles, shall be installed free of charge during the warranty time of the vehicles. Moreover, it shall not be necessary to update after the expiry of the guarantee period the TCMS software and/or any individual software in view of the proper functioning of the system.

In the event of the TCMS or a bus line failure, an emergency mode of operation shall be made available, enabling the vehicle to clear the line and return to the Depot. The following conditions shall be in force during the degraded mode:

- Speed shall not exceed a specified speed (proposed 30km/h)
- Allow the vehicle to move to the next stop, from any location, and detrain passengers. The vehicle is to be loaded to AW3 condition.
- Returning to the depot from any point on the alignment

A message shall appear on the DDU instructing the driver to switch over to the degraded mode. The concept of the degraded mode of operation shall be detailed in the offer and finalized during the design phase.

Bidders shall submit information on the following:

- Description of System's main operational characteristics and capacities
- Diagnostic features of the system
- Description of System's redundancies (System architecture, stand-by controllers, cable routing, independent cabling at certain systems such as Traction, Breaking, Doors, safety loop)
- Proposed lines of the vehicle's communication channel and the features accommodating the exchange of data

Description of the vehicle's capacities, performance and operation in downgraded (backup) mode

### **10.1 Driver's Display Unit**

The Driver's Display Unit (DDU) shall be at least 10", a high contrast colour touch screen display of the TFT or LED type or other approved better type, with associated processors and logic, and will be suitable for use in a rugged railcar environment. The information displayed on the screen shall be clearly visible both during the daytime and night time periods. If contrast adjustment is required to achieve this, the contrast shall be adjusted automatically without the driver's intervention, but manual override shall also be possible. The DDU will support both text and graphic presentation of information both in the English and Greek language, with the option to select the preferred language.

The DDU will provide different type of information to the driver and maintenance personnel, by the use of special screens. The menu and navigation hierarchy, the layouts of the screens will be proposed by the Contractor and approved by AM.

All screens will display at least the current time (24 hours clock), date, the vehicle number and speed reading.

Information will be divided among screens and presented in a logical and orderly manner. Information will be displayed textually and/or graphically, depending on the clearest and most efficient method.

All screen contents and the navigation scheme will be proposed by the Contractor and approved by AM S.A.

#### ***10.1.1 Information to the driver***

The default screen will present information and control functions useful to the driver when the vehicle is under normal operation. The information will be presented in graphical form using a standard colour pattern to depict the status of the vital and important systems of the vehicle. The main purpose of the default screen will be for the driver to know immediately the status of the critical vehicle systems, such as the traction and braking, the doors, the HVAC etc.

The driver will be able to navigate through different graphical or text screens to obtain more precise and online information about the values of operational parameters of individual systems. This information will include the status of by-pass switches, the safety loop, overview of various systems status such as braking, traction, inverters, auxiliary power inverters, battery charger, doors, pantograph, HVAC units, etc.

Finally the driver will be able to navigate to the currently existing faults screen and check the faults that are currently active. The faults will be classified automatically according to severity and/or the date/time of appearance and/or per system. There shall also be brief instructions about the further actions need to be undertaken by the driver.

#### ***10.1.2 Information to maintenance personnel***

The system will provide a range of screens for the maintenance personnel. The access to these screens will be protected by password.

Status screens will display real time status information from all sources. The status will include also active and rectified faults.

Fault logging screens will display the major failures of each system. The fault data will include the date / time, location (position and the previous station at least), the system, the criticality level and a brief description of the fault. The format of the individual system fault logs will be consistent, regardless of the source of the fault data. The maintenance screens will allow scrolling through all logged faults by system. All the faults in each system shall be displayed in a chronological order and will show their criticality level, whether or not they are microprocessor-controlled. The maintenance personnel will be able to scroll through the content of individual system

fault logs resident in the subsystems. All fault logs will be available to the maintenance personnel for review on the screen or to be downloaded to portable laptop computer for archiving purposes and future evaluation.

Downloading fault information to a laptop computer or to other storage media shall not automatically clear the fault log.

When memory is full, deleted older records shall be replaced by new.

Other than the faults, the vehicle history log shall also be recorded (vehicle status conditions and driver actions from shift start to end), such as door operation, braking, traction, etc.

The content of the vehicle history log shall be proposed by the Contractor to be approved by AM at the design stage.

Moreover, the maintenance personnel shall have the option to set certain system parameters, such as passenger compartment temperature, bogie wheels diameter, door function parameters, etc.

## **10.2 Fault announcement system**

The TCMS shall store every irregularity detected, shall evaluate them and consequently shall indicate them to the driver.

Each fault shall be stored in the diagnostics memory together with the other operating data (e.g. time of occurrence, vehicle number). The maintenance personnel using a commercially available PC shall read the faults from this memory. Each irregularity shall be classified into one of four classes according to how it affects operation of the vehicle as a whole. The fault classification shall be as follows:

<b>Fault class</b>	<b>Description</b>
<b>A</b>	Vehicle is not able or not safe to perform revenue service. Evacuate passengers and return to Depot. Possible downgraded mode of operation.
<b>B</b>	Restricted operation; drive to next terminal station, evacuate the vehicle from passengers and consequently drive to the Depot.
<b>C</b>	Slightly restricted operational readiness; the vehicle must be repaired in the workshop at the end of the shift
<b>D</b>	Slightly restricted operational readiness; the fault is stored in the diagnostics memory for maintenance personnel to read, but it is not indicated on the diagnostics display

*Table 6. Fault classification*

For faults that belong to the three first categories, the driver shall be notified of the fault immediately by means of a visual indicator and a buzzer for specified faults. The

buzzer will stop, as soon as the driver acknowledges the fault. The fault acknowledgment interface will take place only in the active cab.

Faults that belong to category D shall not be announced to the driver. These will be only stored into the diagnostic memory.

The list of faults, as well as their classification into the above categories will be proposed by the Contractor and agreed with AM.

Fault signals or status signals that are important for the safe operation of the vehicle, will be displayed to the driver through status or fault indicator lamps for redundancy reasons. Such signals include the failure of the traction or the brake control units, the status of the mechanical brakes (applied / released), the status of the HSCB, the presence of high voltage, etc. The Contractor shall provide the complete list if these signal to AM SA for approval.

### **10.3 Event Recorder**

Each vehicle shall be equipped with an event recorder, located above floor level in a secure location and inaccessible to unauthorized personnel.

The dedicated, removable memory unit shall retain at least one week of data history before write-over and all data channels shall be sampled and recorded every 100ms. 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 both by removing the memory unit and via a notebook computer. A data download using a computer shall be possible via password. The memory unit shall be secured by a lockable cover. The Contractor shall supply the required hardware (see chapter 19) and software to analyse the data and to be able to present the data in a form readily understood by the personnel. The software shall be capable of displaying data in tabular and graphical form (including colour) and it shall readily interface with Microsoft Access, Excel and Word. Moreover, the suitable number of card readers shall be provided in order to read and analyse the event recorder data.

Removal and replacement of the buffer memory and/or removal of the entire event recorder device shall be possible in less than 5 minutes.

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

- A printout of the state of all inputs over 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 to store the contents of the event recorder storage device on another medium for archiving and later analysis.

All data to be recorded shall be submitted to AM for approval. The following minimum data shall be recorded.

- Brake Cylinder Pressure
- Bypass Switch Status (all)
- Distance Travelled Since Event
- Door Status (closed, opened, isolated, etc)
- Operator's Vigilance System Status
- Application of all Brake types (e.g. Electric, electrodynamic, safety, service, emergency brake, etc.)
- Friction Brake Application
- Line Voltage / current
- Master Controller reference value
- Vehicle Direction (Forward, Reverse)
- Vehicle Speed
- Traction system status
- Auxiliary power supply system status
- Synchronization control with the vehicle master clock.

The event recorder shall incorporate its own real time clock, generating year, month, day, hours, minutes and seconds. This clock shall be constantly synchronized with the vehicle master clock. It shall be accurate within  $\pm 3s$  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 the summer – winter time change.

Stored data shall be retained for a minimum of 2 weeks 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 analysis, to demonstrate compliance with this requirement.

The event recorder shall be designed and installed in the vehicles to protect critical data in incidents such as derailments, collision, flooding, fire, accidents, etc., to be readily available to support an accident investigation. The event recorder shall be protected from the above conditions, whether by the design of the data storage units or insertion in a box meeting the requirements of British Railways Board Group Standard GM/RT2472 Part B-5.2, or equivalent. The protection shall be IP67 per EN 60529.

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 submitted for approved by AM.

The Contractor shall provide a Failure Modes and Effects Analysis to classify failures as follows:

Class A: The self-test detects and annunciates that the recorder fails to make a true and accurate recording of the inputs.

Class B: The recorder fails to make a true and accurate recording of the inputs and this is not detected by the recorder.

The Mean Time between Failures for Class A shall be no less than 100,000 operational hours per recorder. The Mean Time between Failures for Class B shall be no less than 500,000 operational hours per recorder.

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

#### **10.4 Subsystems Control units**

Whenever a fault or a defined operating state arises in a monitored part of the control and drive systems, this shall be automatically stored in a diagnostics memory together with any other operating data. Each control unit shall have its own diagnostics memory. The stored data shall be accessible to the maintenance personnel and enable them to localise and eliminate the causes of any faults timely and accurately. All units shall have an interface with the MVB Bus and the service ports will be easily accessible from inside the vehicle.

Any malfunction of the control units, or peripheral devices connected with the control units, shall be signalled to the DDU.

The diagnostic system shall run a self-test that excludes the case that the diagnostic system itself is faulty.

#### **10.5 Wireless communication between the vehicle and the network in the depot**

The Contractor shall equip all areas of Elliniko Depot with the appropriate wireless communication hardware and software (communication protocol 802.11n – Wi-Fi) in order to ensure wireless communication between vehicle/Depot; this hardware shall be fully compatible with the respective on-board equipment.

Wireless communication shall be implemented using desktop workstations, fully equipped and with the functionalities described in paragraph 13.11

The vehicle shall be properly equipped, so that whenever it enters the Depot this equipment shall be wirelessly transmit to the Depot (Rolling Stock Workshop) various useful information (failures, systems operational status etc.) concerning all vital functions of the vehicle sub-systems (e.g. traction/braking, door system, HVAC system etc.).

Moreover, the equipment shall be capable of informing the Depot (Rolling Stock Workshop) about each subsystem's software version and in the event a newer version of the OCC data base is available, the possibility will be provided for replacing the existing version via WiFi with a user's command.

As regards the systems for which automatic updating is required, e.g. PIS, itineraries etc., these shall be defined by the Contractor at the design phase.

Whenever a software update is attempted, the system shall display in the driver's cab and the Depot (Rolling Stock Workshop) the progress of the installation or any failed attempt. Whenever an update attempt has failed, the system shall automatically repeat the attempt up to three (3) times. After the third time, an error message shall be displayed in the driver's cab and the Depot (Rolling Stock Workshop) and downloading of the update shall be carried out manually.

Emphasis shall be placed on the safety of the wireless communication system of the vehicles with the Depot (Rolling Stock Workshop). The system must be protected against malicious acts or unauthorized intervention or data theft by intruders.

The data and software versions transmitted on the network shall relate to all subsystems controlled both by the TCMS and the OBC system.

The rolling stock Contractor shall provide the second workstation (described in article 13.11) to the OCC (at the Depot). For the operational connection of the subject terminal unit with the central equipment and software in the OCC (e.g. for the transmission of the vehicles' statistic data, vehicle kms, safety related incidents, alarms or failures of vehicles, etc.) the Rolling Stock Contractor shall cooperate with an existing independent AM Contractor involved in Tramway OCC (Contractor of the Tramway extension to Piraeus), in order to ensure communication of the new system with the system to be installed in the OCC by the above independent Contractor.

## **10.6 Maintenance requirements**

Self-diagnostic failure identification systems controlled by micro-processors shall be utilized and all associated data shall be collected either through a portable PC or wirelessly, as described above, by the Central Control Unit (TCMS) of each vehicle towards the central Computers to be installed by the Contractor in the Depot (see paragraph 13.11).

The technical characteristics on the selected subsystems and devices shall fulfil the requirements pertaining to effective maintenance. All required signals and data concerning the status of the devices, any failures etc. shall be visible and readily accessible. Readings to obtain data concerning error/failure shall be taken as frequently as possible, enabling thus to determine accurately the correct failure curve.

The type and the accuracy of the data shall fulfil the requirements concerning vehicle maintenance. The submitted hardware documentation shall facilitate the Operation Company in troubleshooting any failures to individual devices, connection boards etc.

Under normal circumstances, all stored data shall remain intact after a power failure for a period exceeding six (6) months.

All diagnostic data shall include information related to the failure of any sub-system.

In time and as the vehicle fleet expands, the maintenance system shall be capable to foresee possible future failures. Based on this data, the Operation Company shall carry out an effective preventive maintenance.





**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Therefore, the Contractor shall supply the proper software tool for maintenance purposes.

The collected diagnostic data shall be evaluated and filed for further processing.

The Contractor shall propose the method for filing and evaluating all this data.

The maintenance software shall provide at least the following functions:

- Data filing;
- Display of diagnostic data in an easy-to-understand format consisting in Tables or Diagrams;
- Comments shall be appended to each error for reasons of documentation. Therefore, the software tool shall generate reports in case of similar repeated errors;
- The error data shall be utilized in generating error statistics for individual components;
- Selection criteria shall be applied, so as to provide data for different application levels. For example, data shall be selected based on the train number and for a specific time period;
- Diagnostic data evaluation shall be based on search, classification and statistic elaboration tools;
- There will be printouts of Tables and Graphic Diagrams, while selected diagnostic data shall be exported to an independent data base to be used with other software applications;
- There shall be criteria for selecting access levels for various users. Error statistics shall be generated for each system/sub-system. Additionally, data shall be selected based on the train number and on a specific time period;

A group of graphs and error troubleshooting processes shall be provided as part of the maintenance software. The maintenance software tool shall include procedures for error and status searches and for producing the relevant graphs, while it will provide the Operation Company with the possibility to create independent operations and graphs.

## 11 Heating, ventilation, air conditioning (HVAC)

### 11.1 General

The tramway vehicle shall be equipped with an HVAC system, able to meet the requirements of this specification. The HVAC system must be of direct expansion. The use of intermediate liquid is not allowed.

Air conditioning of the passenger and driver compartments shall be completely separated and independent systems, with completely independent functions.

Air conditioning shall comply with standard EN 14750, while a/c provided to the driver's compartment shall additionally comply with standard EN 14813 or, alternatively, with UIC-651.

The A/C units shall operate in the environmental conditions defined in paragraph 3.11.1 herein and shall be tested on the basis of the requirement of standard EN 14750-2.

Each A/C unit intended for passenger compartments shall have at least the following components:

- Two condenser fan assemblies
- Two condensers
- Two independent cooling cycles, including two completely sealed compressors
- A/C control unit
- Emergency inverter (if the inverter is part of the A/C unit)
- Evaporators
- Electric heat element
- Evaporator fan assembly
- Miscellaneous components

The HVAC units shall be mounted on anti-vibration pads in order to minimize noise and vibration transfer to the passenger or driver compartments. The air ducts supplying cool air to the various areas shall be thermally insulated in order to avoid condensation.

The HVAC system shall be capable of achieving the performance defined in this specification, utilizing fresh, recycled air, as well as mixture thereof.

Fresh air shall be supplied to the HVAC unit through filters and shall be mixed with the recycled air in a mixing chamber. Subsequently, this mixture shall be driven to another compartment of the HVAC unit through another filter, where it shall be cooled or heated and then driven to the associated air ducts. The filters performance shall comply with Standard EN 779.

The a/c system shall be fed through the three-phase line 400V / 50 Hz of the Auxiliary Power Supply System.

All electrical connection shall be made through quick release connectors that will meet the requirements of this specification.

In their Technical Offer, the Bidders shall submit drawings and technical description of the HVAC system layout, in terms of units on-board the vehicles and in terms of equipment items layout included in each HVAC unit. The subject drawings shall be accompanied by the technical and operational characteristics of the system, including its weight and cooling capacity. The HVAC failure indication system shall be also described therein.

## **11.2 Passenger compartment**

The HVAC system must be so dimensioned and comply with EN14750-1, category B Standard. The HVAC system shall be tested according to EN14750-2.

The HVAC system of the passenger compartment shall be based on at least two independent units. In case of failure of one of the units, the system design shall ensure that cooling or heating produced by the operating unit shall be uniformly distributed to the entire length of the vehicle.

The HVAC unit shall be capable of achieving all performance values specified in this chapter during ten door opening-closing cycles.

The duration of the door opening – closing operation shall be as follows:

Status	Duration (sec)
Doors closed	120
Doors open	20

Table 11.2.1 Duration of the door opening – closing operation

The HVAC system shall work automatically. Nevertheless the driver shall have the possibility to select the mode of operation as below:

- Auto: The system selects the mode of operation automatically, depending on the internal and external temperature readings.
- Heating: The system may run only in heating or ventilation modes.
- Cooling: The system may run only in cooling or ventilation modes.
- Ventilation: The system may run only in ventilation mode.
- OFF: The system turns completely off, including ventilation.

The driver shall be able to select the mode of operation from a selector switch in the driver's cabin during the normal service operation.

The HVAC system shall provide temperature control function through the TCMS system.

Heating shall ensure de-misting of all windows.

The ventilation system balancing shall ensure a positive pressure of up to 30Pa within the vehicle area, with all doors and windows closed. The level of the positive pressure provided in the driver's compartment shall be agreed with ATTIKO METRO S.A.

In the event of a cooling or heating system failure the ventilation function shall remain available. Any failure shall be recorded and displayed on the DDU by the TCMS.

Diffusion of air shall be as even as possible. The air speed values shall conform to the comfort provisions specified in EN14750-1.

Air renewal shall provide at least 12 m<sup>3</sup> of fresh air per hour per passenger in a running vehicle, under normal passenger loading (AW2). Special care must be taken, such that the diffusers do not direct the air to standing passengers.

For both heating and cooling modes the temperature difference between any point in the tramway vehicle between 200 mm and 1800 mm above the floor, and one meter away from the ventilation outlets shall be less than 8° C.

### **11.3 Driver's cab**

The HVAC system of the driver's cab shall be independent from the systems of the passenger compartments.

The driver shall be able to select the climatic conditions and temperature settings for the cabin, independently from the climatic settings in the passenger's compartment. As regards the driver cab, the driver shall also have the option to direct and adjust the volume of the supplied air using the appropriate louvers.

The HVAC system must be so dimensioned and comply with EN14813-1, category B Standard.

The cab HVAC system shall ensure a minimum of 30 m<sup>3</sup> of fresh air per hour.

In the event of a cooling or heating system failure or in case the heating or cooling system shut off by the driver, the ventilation function shall remain available.

The HVAC shall be independently operable in each of the two driver's cabs.

### **11.4 Cooling–Heating System Performance**

The HVAC system shall guarantee as a minimum the automatic preservation of the climatic conditions inside the vehicle which are set forth in the following paragraphs. It is noted that by no means any other requirement of this specification or of the European standards is revoked.

#### **11.4.1 Cooling mode**

For a maximum ambient dry bulb temperature of 40°C, relative humidity at 40%, in the following conditions:

- Standstill vehicle

- Solar load
- Lighting load
- AW2 load and
- the minimum fresh air supply

the average interior temperature shall be 28 °C , relative humidity at 60%.

The cooling capacity of the A/C unit in the driver's compartment shall be calculated as above, assuming the presence of two persons in the cab and the minimum fresh air supply.

The cab temperature shall be adjustable by the driver between 18°C and 28°C, however, with reference to the above maximum ambient temperature of 40°C, the temperature inside the cab shall be adjustable between 24 °C and 28 °C.

#### **11.4.2 Heating Mode**

For an outside temperature of 0°C the heating equipment should be capable of maintaining the temperature at 24°C in the passenger compartment under AW0 load conditions.

The driver's cab temperature shall be capable of being adjusted between 18°C and 28°C by the driver.

#### **11.5 Maintenance and troubleshooting**

During any repair works, all components of the HVAC units shall be replaceable by any other components of an identical design. Moreover, HVAC units of an identical design shall be fully interchangeable.

The HVAC system shall be fully operational inside the maintenance track, without the need of high voltage power. The design of the tramway vehicle will provide for an alternative power source for the HVAC system, in such way that it will be possible for the Operation Company personnel to perform all necessary maintenance, troubleshooting and functional tests in a safe manner.

## 12 Brake System

### 12.1 General

The present chapter describes the requirements and the equipment of the braking system and its controls.

The following braking systems are required:

- Electric-dynamic brake
- Friction (mechanical / hydraulic) brake
- Track-brake

Vehicles are to be capable of stopping when there is an interruption to the power supply or a complete power loss. Each braking system must be capable of stopping the vehicle independently, without the assistance of other braking systems.

Should the electrical-dynamic brake develop a fault or total failure, the hydraulic brake system must take over automatically, replacing the missing electrical-dynamic braking effort.

The Contractor shall detail the braking equipment arrangement for both powered and trailer wheels according to the braking requirements of this performance specification.

In their technical offers, the Bidders shall submit a technical description of all three aforementioned brake systems, accompanied by general layout drawings. In case of electric-dynamic brake, a part of the system's description may be presented in the description of the traction system. In addition, the bidders shall submit a description of the brake blending system, which shall include, as a minimum, a determination of the speed intervals of the vehicle in which the brake system - under normal operation - shall be electric-dynamic, mechanical or blending (electric-dynamic and mechanical). Moreover, there shall be a determination of the minimum speed of the vehicle in which electric-dynamic brake shall apply.

The vehicle shall include a weight measurement system and the braking performance shall be identical under all load conditions between AW0 and AW2. Performances are to be demonstrated at the maximum operational speed in all load conditions between AW0 and AW2 loading.

The Contractor will supply the necessary hardware and software tools, to allow maintenance personnel to properly maintain the system. The tools shall make possible to easily read the diagnostic memory, perform functional tests, acquire real time values of the system operational parameters, etc.

#### **12.1.1 Brake Control Unit (BCU)**

The control system (Brake Control Unit – BCU) shall operate using modern microprocessor technology and process the data using no less than 16-bit computers.

BCU shall monitor the healthy operation of all brake components. The normal operation and all malfunctions have to be recorded and to be signalled to the driver. The BCU shall include an extensive diagnostic system. All faults will be recorded in the diagnostic memory, which shall retain its contents, even when the power is lost.

#### **12.1.2 Electric-dynamic Brake**

The normal (service) brake system will be based on electrical regeneration, which if the overhead line is not receptive the power generated is to be dissipated to the braking resistors of the vehicle. Electrodynamics braking must function effectively even if the overhead line is not receptive.

#### **12.1.3 Friction (mechanical) brake**

The mechanical friction brake will be a hydraulically powered.

Spring loaded braking callipers are envisaged (passive system) and will be activated as detailed in the various braking modes.

The friction brake also supplements the electric-dynamic brake of the motorized wheels, in case a percentage of the electrical braking force is not available.

Friction brakes also operate in conjunction with the electric-dynamic brake of the motorized wheels (e.g. during brake blending for a full stop).

The friction brake shall provide for two independent modes of release, in case of a primary failure (blocked axle):

- Electric mode: The driver will be able to isolate and release the failed axle, without leaving his cab. The hydraulic release mechanism shall be based on a completely independent from the primary braking cylinder system.
- Mechanical mode: In case of failure of the electric mode, the brake release will be effective manually, through the provision of the necessary special keys to mechanically release the failed calliper.
- The mechanical mode for the brake release shall be realised by a mechanism, easy to handle and able to guarantee a quick release under any given circumstances.

The driver at any operation condition shall be able to easily handle the brake release system.

#### **12.1.4 Magnetic (track) brake**

The magnetic brake drastically shortens the braking distance in emergency by applying additional friction brake on the rail. The magnetic brake will be activated through the emergency brake mode or the safety brake mode. An additional activation button is to be placed in the drivers cab and will be only activated when the vehicle speed is other than zero.

## 12.2 Braking modes

The following braking modes are envisaged for the vehicle:

- Normal (service) braking (Electric-dynamic brake + friction brake),
- Emergency braking (Electric-dynamic brake + friction brake + electromagnetic brake + sanding),
- Parking braking (Friction brake),
- Safety braking (Friction brakes + magnetic brake).

### 12.2.1 Braking under normal operating conditions (service braking)

The traction / brake control system will combine all brakes smoothly to satisfy the safe braking requirements while minimising brake wear and maintenance.

Service braking is normally realized by electrodynamic braking, from max. speed, down to a speed of approx. 5 Km/h, below which, brake blending takes charge.

The mechanical (friction) braking system must be available all time to provide braking force when the electric-dynamic brake fades out until the vehicle comes to stand still (blending phase)

In the case of missing or failure of the electric braking force, the friction brake must be capable of stopping the tramway vehicle under all possible operational conditions. In this case, the mechanical brake system should be activated automatically and shall compensate the missing electrodynamic braking effort, in order to meet the same braking performance and stopping distance and keep the total braking effort evenly distributed across all braking axles.

The braking force of the service brake must be adjusted infinitely under the complete speed range of the vehicle, in order to give maximum cohesion between the wheels and the rails and allow the driver to control the vehicle's speed.

The service brake performance must be designed for non-stop operation on the tramway network alignment and routes.

### 12.2.2 Emergency braking

Under emergency braking, the vehicle employs all available braking systems in order to achieve the highest deceleration rates, as requested by this performance specification.

Emergency braking is selected by the driver, through the master controller.

Slip / slide protection is available during emergency braking.

### 12.2.3 Parking/holding brake

The parking braking mode is automatically applied by the vehicle, when the vehicle is totally switched off.



The holding brake force shall be able to hold the vehicle under AW3 load conditions on the steepest slope of the network. This immobilization shall be ensured for 1 hour, with one axle/2 wheels inoperative and under the most degraded environmental conditions specified for continued operation.

The holding force shall suffice for an AW4 load at network locations with maximum grading with all axles active. It is not permitted to use any external item on the wheels in order to achieve / maintain hold under maximum gradient.

#### **12.2.4 Safety braking**

The safety braking is passive mode of braking, activated when the vehicle's safety loop is open. In addition, the track brake is also activated, if power is available.

During safety braking mode, slip /slide protection and weight compensation shall not be available, but sanding will be operating.

Safety braking shall be initiated by the interruption of the safety loop. The safety loop shall include at least the emergency mushroom push buttons in both driving cabs. The inclusion into the safety loop of other systems or components, such as the passenger emergency handles or the vigilance system, will be decided during the DFD phase. The Contractor shall make his proposal, taking into account the safety of the passengers and the vehicle, the frequency of the safety loop interruptions and the risk of producing flat on the wheels.

#### **12.3 Slip – slide protection**

Braking in all weather conditions must not cause wheel flats.

Particular attention must be paid to achieving effective wheel to rail contact in of low grip conditions. For example: during wet or snow conditions or leaf fall on the line. Brake control system shall employ a sophisticated slip / slide protection scheme to make the best use of the available grip, as well as to protect the vehicle from having wheel flats.

#### **12.4 Priority arrangement**

The traction and braking requirements are to be designed, as per BOStrab, or similar regulations, so that:

- Braking commands have precedence over traction commands.
- Braking command logic is fail safe
- Traction and braking forces are altered with the minimum jerk.

#### **12.5 Braking mode table**

The use of the different brake systems according to the different braking modes is envisaged in the following table:

**PERFORMANCE SPECIFICATIONS**

Braking mode	Electric-dynamic brake	Mechanical brake	Track brake	Bell	Sanding	Anti slip protection system
Service Braking	<b>X</b>	<b>X</b>			<b>X</b>	<b>X</b>
Emergency braking	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Parking Braking		<b>X</b>				
Safety Braking (safety loop is open)		<b>X</b>	<b>X</b>		<b>X</b>	

*Table 7. Braking mode table*

## 13 Integrated on Board Information System

### 13.1 General

The tramway vehicle will be equipped with an Integrated on Board Information System (IBIS), which will comprise of the necessary hardware and software to perform the functions specified in this chapter.

All systems defined in this chapter will be based on the standard VDV 300 Integrated on Board Information System (IBIS), shall comply with EN50155 or equivalent and will be suitable to operate on a rough railway environment.

The system comprises a number of specified below subsystems, integrated in a unique environment through the IBIS On Board Computer (OBC). All the equipment will be installed inside the vehicle and will be easily accessible to the maintenance personnel. Installation of the equipment on the roof of the vehicle is not allowed, except only for the wireless communication antennas.

All communication protocols between the OBC and its subsystems will be proposed by the Contractor and approved by ATTIKO METRO SA. The communications protocols shall become property of ATTIKO METRO SA.

All hardware will be interchangeable. Any software parameter or information related to a specific vehicle will be easily changed (for example by the use of a standard laptop and the necessary application software).

All functions provided by the IBIS system shall be compatible with existing infrastructure of the Operation Company.

### 13.2 On Board Computer

The On Board Computer (OBC) is the master control unit of all systems and functions specified in this chapter. The OBC is responsible to integrate all subsystems by collecting the necessary information and delivering configuration or other data to these subsystems. Its minimum configuration will be:

- Central Processing Unit (CPU)
- Two terminal stations (MMI), one in each driver's cab.
- GPS receiver and antenna (one (1) set for the entire vehicle)
- Wireless LAN (802.11n or newer) enabled
- Necessary hardware interfaces to connect with the peripheral devices and subsystems defined below. At least a serial (RS232 or RS485), a USB connection and/or an Ethernet connection for the interconnection with a maintenance P/C shall be provided.

The functions of the OBC are the following:

- Calculate the vehicle position continually and distribute to TCMS. Subsequently, TCMS shall update the sub-systems as required.
- Distribute the date and time to the subsystems, as required through TCMS, as with the vehicle position.

- Synchronize and broadcast video and audio (auto / manual) information announcements to the passengers.
- Control the traffic priority system and the point switch system.
- Provide vehicle information to the OCC.
- Receive configuration information and commands by the driver through the MMI.
- Inform the driver about the scheduled departure time and delays of the schedule.
- Transfer and receive information through the wireless LAN to the depot workstations (See also 10.5).

In order to perform the above functions, the OBC shall need to be loaded with the following configuration information:

- The network configuration (number, name and sequence of stations, distance between stations, number and position of traffic controllers etc).
- Geographic coordinates of the complete network
- Timetable information (number of routes, time tables).

The necessary configuration information will be defined during the design phase. The complete software architecture will be build up in such a way, in order to accommodate not only the existing station and network configuration, but also future extensions. In order to cope with future extensions, the memory of the OBC and its subsystems (where necessary) will be sized to accommodate a network configuration four times bigger than the existing.

The terminal stations (MMI) will be operating when the driver's cab is active. The functions from both cabs will be equivalent.

The communication of the OBC with the several subsystems will be based on the IBIS protocol or equivalent. The Contractor will propose the details of communication protocols to the AM S.A. for approval, during the design phase.

### **13.2.1 Driver's MMI**

In each driver's cab the Contractor will install the necessary Man Machine Interface (MMI), which will consist as a minimum by a colour 8" touch screen.

The driver shall be able through the MMI to perform the following indicative but not limited to, functions:

- Define the operation mode (according to schedule, dynamic, no service)
- Define the line number, time table route and current position of the vehicle
- Define the destination station (when in dynamic mode)
- Control the destination indicator messages
- Define the possible delay in relation to the specified time table route

- Initiate playback of prerecorded messages
- Manually request priority from the traffic controller or another direction from the track switch controller

The complete design MMI will be proposed by the Contractor and approved by the AM S.A. The design of the menu hierarchy will be as simple as possible, in order for the driver to quickly and safely enter the data. The most common function will be selected by the pressing of a single key (function keys).

The MMI shall include also forms with diagnostic information, password protected for maintenance and troubleshooting reasons, for all the subsystems described in this chapter.

A special diagnostic operation shall permit the maintenance personnel to fully simulate the vehicle's movement in all positions of the network, while the vehicle is in the Depot, in order to confirm the correct operation of the vehicle when it runs in the network. The technical staff shall record the desired starting up and destination stops of the vehicles. The GPS signal shall be temporarily isolated by the software responsible for identifying the position of the vehicle and shall be simulated by the track related data available in the OBC data-base, as if the vehicle was moving from its start up stop towards its destination stop and was making all intermediate stops. All remaining systems shall operate normally based on the simulated location of the vehicle.

### **13.2.2 Automatic Vehicle Positioning**

The calculation of the tramway vehicle position will be made continually, based on:

- Information received by the GPS receiver.
- Information received by the vehicle's speed sensors (odometers).
- Opening and closing of the doors in combination with zero speed detection (for the fine trimming of the vehicle position)
- Information keyed in by the driver from the keyboard (during start up / initialisation or reset) regarding the current position and service route.

The algorithm will calculate the position (km position) of the vehicle on the track with an accuracy of 5m or better. The algorithm must take into consideration that in certain areas the satellite signal will not be available or will be disturbed by nearby tall buildings. The algorithm must continue calculating the vehicle's position under the above conditions, based on the vehicle's speed sensors. The algorithm of vehicle position calculation will be proposed by the Contractor and approved by AM S.A.

The calculation of the vehicle position is essential for the remaining functions performed by the OBC. For this reason, the vehicle position shall be continually displayed and updated on the driver's display unit (MMI) with a graphical and user friendly mode. The MMI shall also display the distance travelled since the last stop and/or the distance to the next.

### **13.2.3 Video and audio announcements**

The OBC will communicate with the audio and video controller to request the appearance of the appropriate information screen and the playback of the appropriate pre-recorded message, depending on the vehicle's position.

The driver will have the possibility to broadcast a pre-recorded audio message, entering the necessary command from the keyboard.

### **13.2.4 Communication with traffic and point machine controller**

When the vehicle approaches a traffic controller or a point machine, the system shall automatically recognize the identity of the local traffic controller or point machine and shall display it on the respective MMI.

Depending on the vehicle's position, as well as on the traffic database controllers information defined in its memory, the OBC shall initiate a communication with the traffic controller in order to acquire priority for the vehicle. The driver shall be informed of any possible problem on the failure of this communication. The driver will have the possibility to manually require priority from the traffic controller, in case of the previous communication failure, by selecting the traffic controller already displayed on the MMI and by entering a command from the keyboard.

Depending on the route selected by the driver, the OBC shall request the necessary direction from the point machine controller.

The driver will have the possibility to manually cancel the predefined and select a different direction from the point machine controller, entering the appropriate command from the keyboard.

The necessary communication protocols with the traffic and point machine controllers will be provided by Attiko Metro SA and the Operation Company during the design phase.

### **13.2.5 Communication with OCC**

The OBC will transmit in regular intervals to OCC via the TETRA radio equipment telegrams (SDS) containing at least the following information:

- Vehicle, line and route number
- Vehicle position and direction
- Vehicle speed
- Number of passengers, wherever the Passenger Counting System is installed
- Driver identification
- Next station / Terminal station
- Estimated time for the next station / terminal station
- Mode of operation (automatic, dynamic, no service)
- Diagnostic information of individual subsystems

The period of the transmission will be defined during the commissioning phase and will remain adjustable by the Operation Company in the range of 15 to 90 seconds.

The exact transmission protocol will be handed over to the Contractor by AM during the design phase, in cooperation with AM's independent Contractor (Contractor

responsible for the Tramway Extension to Piraeus), who has been assigned with the task to upgrade the existing data transmission system in the OCC.

The OBC shall receive from OCC via the TETRA radio equipment telegrams (SDS), containing commands and configuration parameters, such as:

- Short messages, which will appear on the driver's MMI.
- Setting of the vehicle's operating mode (automatic, dynamic)
- Setting of the time table number (automatic mode) or next terminal station (dynamic mode)
- Messages for the destination indicators

#### **13.2.6 Timetable information to driver**

According to the time received by the GPS receiver, the defined by the driver service route, the time table information included in it's memory and the vehicle's current position, the OBC will inform the driver about the scheduled time of departure from the terminal stations, as well as about the time in advance or on delay of the current route on each station in relation to the time table. This calculation shall be only possible in automatic mode.

Implementation details of this function will be defined during the design phase.

### **13.3 Public Address System**

#### **13.3.1 General**

The vehicles will be equipped with a sophisticated, high sound quality, state-of-the art public address system. The system will be responsible for the following functions and features:

- Two way cab to cab communication
- One way (driver to passengers) communication.
- Two way (driver and passenger) communication, when the passenger triggers the emergency alarm signal.
- Automatic playback of the station information.
- Playback of pre-recorded messages, on driver's demand.
- Playback of pre-recorded message, based on time schedule and/or the vehicle's position.
- Automatic Volume Control

Sufficient number of high quality loud speakers will be installed in the passenger compartment, in such way the announcements are clearly heard from all the passengers. The system will be equipped with Automatic Volume Control (AVC), to dynamically compensate the noise that exists in the passenger compartment. The volume of the announcements, as well as the AVC parameters will be adjustable by the Operation Company. All necessary adjustments for the operation of the PA system shall be made from within the passenger compartment.

Due to the low level of the audio signals, the Contractor must take all necessary measures on the type and routing of cables to limit the amount of noise present on the loud speakers. The noise coming from the PA system when it is energized will be

lower than 40db(A) at a distance 0.3m from the loud speakers, under all possible vehicle modes (full traction or braking, downgraded modes etc) of operation.

### ***13.3.2 Driver announcements and Passenger-Driver communication***

The system will allow the driver to make announcements to the passengers by pressing the relative push button (PTT) of the microphone installed in the driver's cab, no matter which microphone the driver uses. The driver announcements to passengers have a priority over the automatic or pre-recorded announcements. One hand-held microphone and one Gooseneck-type microphone shall be available in the driver's cab.

The system will allow the communication between the two cabs, even when no cab is activated. Activation of the PA system to deliver announcements to the passengers shall be properly displayed in the driver's cab. Additionally, it shall also be displayed in the second cab whenever the communication is between the two driver cabs.

The appropriate equipment shall be installed, enabling a passenger to communicate with the driver.

The system will establish a two-way communication between the driver and the passenger who has activated the emergency alarm signal. The communication will be terminated either by the driver or when the passenger resets the alarm signal to its original position.

When the system is activated, the passenger's request shall be displayed in the driver cab and communication shall take place only after the driver has acknowledged this request. Request acknowledgment by the driver shall be displayed to the passenger.

Equipment location and type shall be approved by AM.

### ***13.3.3 Automatic announcements***

The system will be able to produce automatic announcements, including but not limited to: Next station, Arrival to station, Transfer to another Transport Mode, Doors opening, Doors closing. The announcements will be in two languages (Greek and English). The exact number of automated messages, which will be minimum fifty (50), will be defined during the design phase.

The system will be able to re-produce predefined audio messages, selected by the driver through the keyboard.

The system will be able to re-produce pre-recorded audio messages, based on the journey and /or the current position of the vehicle.

All pre-recorded audio messages will be recorded by the Operation Company and provided to the Contractor for initial loading. The system will allow the Operation Company to modify (update, delete or insert) the pre-recorded announcements, as well as to modify the audio message and their relative broadcasting time schedule, through the use of an appropriate software interface. Any specialized hardware or software necessary to perform the above functions will be provided by the Contractor.

Each individual input source shall have its own gain (volume) control. The system will implement a priority scheme, to select the appropriate input source, when more than one audio source is available at the same time. The system will smoothly interrupt the lower priority source and introduce the higher priority source (fade out/in). The priority system will be proposed by the Contractor and approved by the AM S.A. during the design phase.



## 13.4 Traffic Control System

### 13.4.1 Traffic priority system

According to the existing signalling design and the relative implementation regarding the street crossings of the tramway vehicle routes, the transmission of three commands (for each movement direction of the vehicle) to the local traffic controller is required:

- Priority demand command, when the tramway vehicle approaches an intersection and within a distance that varies depending on the special characteristics of each cross section,
- Occupation command when the tramway vehicle front enters the cross section;
- Release command when the tramway vehicle tail passes through the cross section.

These three commands are necessary to traffic controller for the application of the active signalling program, in order to control the street and tram traffic lights and provide for the necessary priority to the tramway.

The OBC calculates continuously the current position of the vehicle. Based on the information stored in its memory related to the traffic controllers of the network and the relative distance / time parameters, the computer will transmit automatically the commands to the traffic controller, using the necessary radio interface (spread spectrum modem). Taking into account that many stations are located close to cross sections, the priority demand command shall be triggered by the door status also (open / closed) in combination with the predefined distance.

The system must be compatible with the existing fixed signal reception equipment. The transmission of the “demand”, “occupation” and “release” commands from the tramway vehicle to the local traffic controller is done through a radio link. The communication protocols will be defined by the Operations Company during the design phase. The radio communication with the traffic controller is made on the public area of 2.4GHz.

The driver will receive an audio and/or visual confirmation about the successful completion of the communication with the traffic controller. In any case, the driver will have to possibility to resend the necessary commands to the controller, using the keyboard of the MMI.

The system will allow the Operation Company to modify and extend in the future the traffic controller configuration information stored in the memory of the OBC, through the necessary software interface.

### 13.4.2 Point machine control

The following points of the existing operational network are equipped with automatic electric point machine control systems:

- SEF terminal station (to be an intermediate station, after the extension)
- Syntagma terminal station
- Piraeus terminal station
- Pikrodafni shunting station

- Poseidonos-Achileos triangle
- Poseidonos-S3.8 triangle
- Voula terminal station
- TRAM Depot in Helliniko

The control of the point machine will be done in two ways:

- Automatically by the OBC. In automatic operation mode, OBC selects the proper point direction, taking into account the existing (selected by the driver) tram route and the exact tramway vehicle position.
- Manually by the driver. With the manual operation the driver selects the desired point direction, by entering the necessary commands on the keyboard through a touch screen.

In both cases, the tramway vehicle shall be equipped by the Contractor with a system which wirelessly transmits the command to the local controller, through the same hardware interface as with the traffic priority system described above (in this case, only the “demand” command is transmitted).

The train system must be compatible with the existing fixed signal reception equipment. The information related to the existing equipment and the communication protocols will be defined by ATTIKO METRO S.A. during the design phase.

The driver will receive an audio and/or visual confirmation about the successful completion of the communication with the point machine controller.

The system will allow the Operation Company to modify and extend in the future the point machine controller configuration information stored in the memory of the OBC, through the necessary software interface.

## **13.5 Video passenger information system**

### **13.5.1 Internal system**

A well-proven internal electronic information display system shall be provided.

This system shall comprise a LED screen to display the destination information and at least one LED screen shall be placed on each articulated bracket.

The display unit shall automatically display messages about the next stop, as well as useful information for the passengers, such as transfers to other modes of transport, disembarking reminders when arriving at the terminal stop etc. The name of the current stop shall be also displayed. The messages shall be in Greek and English and shall correspond to the tramway vehicle location.

When the message is too long to fit in the display screen, it will scroll.

Details concerning the functions and display of the messages (font, font size, etc.) shall be proposed by the Contractor to AM for approval.

Once the respective button has been pressed by a passenger, a stop request indication shall be displayed on the screen area, which shall turn off when doors open.

In case of emergency, the option shall be provided to the driver to project scheduled messages to the passengers, which shall take priority over all other messages.

The dimensions, locations and final number of the information display units shall be proposed by the Contractor to AM for approval.

### **13.5.2 External video passenger information system**

The external passenger information system consists of 6 destination indicators. Two will be placed on the fronts of the vehicle and four will be placed symmetrically on the left and right sides (two per side).

The indicators will be legible under direct sunlight, while, at the same time, the lighting intensity could be increased/decreased depending on the external light conditions to achieve the best possible clarity.

The indicators will consist of LED, in yellow colour, which will correspond in 10mm diameter. The LED combination for the creation of characters will be selected freely. The dimensions of the indicators will be approximately 1250 mm (width) X 260mm (height). The indicators will display the following information:

- The Line number and name
- The destination station
- The route number of the vehicle
- Additional messages, as defined by AM S.A.

The exact layout of the information displayed will be proposed by the Contractor and approved by AM.

The indicators will have the possibility to display the messages in two languages (Greek and English). When the message is too long to fit in the width of the indicator, the message will scroll.

During start-up of the vehicle, the driver will key in the keyboard the necessary information of its current route. The OBC will communicate this information to the destination indicators. When the driver changes the cab (direction), the OBC will automatically detect this change and update the destination indicators as necessary.

The indicators will include a number of predefined messages, to be displayed on demand by the driver. The driver will select the predefined message from a list of messages included in the memory by the keyboard. The indicator will scroll the predefined message together with the destination station in time intervals specified by the system. The system will allow also the driver to select a predefined message to appear permanently on the indicators, independent of the selected route or line (without scrolling).

The Contractor will supply the necessary hardware and software tools to allow the Operation Company to configure the parameters and messages of the indicator.

### **13.6 Communication with OCC**

For the voice and data communication between the vehicle and OCC standard TETRA terminals appropriate for use in rail vehicles will be provided in each driver's cab. Each terminal will be composed of:

1. One Train Radio Unit (TRU)
2. One Control Head with keyboard and display unit
3. One Handset
4. One loudspeaker

5. One omni directional antenna

The control head and the handset will be placed on an ergonomic position in the driver's cab, so that the driver may easily access the functions and operate the handset.

The communication between OCC and other tram vehicles shall be broadcasted inside the driver's cab through the loud speaker. In order for the driver to reply to a call from OCC, he has to pick up the handset. In this case, the loud speaker shall be disabled.

The driver shall have access to the necessary adjustments and functions of the device. Indicatively but not limited to are the volume adjustment, the communication channel selection, etc. The driver shall not have any access to settings of the device which are not relevant for his job.

The OBC will use either of two terminals to transmit the vehicle position to the OCC.

The system shall be compatible with existing infrastructure of the Operation Company. The device for reception / transmission of digital data installed in OCC is of type MOTOROLA MTM700.

### 13.7 Special Panel for PSN

There shall be a panel specially designed to be used by Persons with Special Needs (PSN) and the persons foreseen to use the area designated for PSN, installed in this area.

The panel shall be activated by the driver and shall permit the user to:

- Request a stop
- Notify the driver to start the tramway vehicle
- Ask for help

The functions shall be similar to those in the existing vehicles. The number and positions of these panels and the associated switches in the driver cab shall be proposed by the Contractor to AM for approval.

### 13.8 Passenger Counting System

The Contractor will install a Passenger Counting System in all vehicles.

The system will communicate with the OBC to transfer the data of passenger ridership. The data will include the station code, date and time, number of passengers entering and disembarking from the vehicle. The OBC will be aware all the time of the number of passengers transferred by the vehicle and will communicate this information to OCC through the TETRA radio. The current number of passenger shall be also indicated to the driver through the MMI.

The Contractor will install the suitable number of directional sensors over the doors in order to accurately calculate the number of boarding and disembarking passengers. The accuracy of the system will be no less than 95%.

The Contractor shall also provide a Passenger Counting Analysis software application, (including data base application, if necessary) which will collect, analyse and project the collected data on the complete network. The application will be installed on the Operation Company central PCs and will be provided with at least 3

licences. During the design phase, the Contractor shall submit the specifications of the system for the approval of the Operation Company.

### **13.9 Closed Television Circuit (CCTV)**

Every car shall be equipped with Closed Circuit Television surveillance cameras to record pictures from the whole of the interior, without leaving any blind spots, as well as from the external sides views of the vehicle. Moreover, the front and rear fields of view shall be covered by cameras.

The Closed Circuit Television system shall meet the local regulations for picture quality, storage time, level of encryption, continuity of evidence (law / police requirements) and data protection act.

The cameras shall be located in such a manner that they cannot be subject to vandalism.

The location and the quantity of cameras, as well as the operation and surveillance method shall be agreed with AM.

The system shall be activated automatically when the power is supplied.

The system shall be able to record pictures at 12 frames per s (fps) during 24 hours at a minimum.

When the specified recording time is reached, the system shall start to write over the oldest stored images.

Following activation of a passenger emergency intercommunication device or on demand from the Driver, the system shall record the pictures at 12 frames per s, starting 5 minutes before the event is triggered and up to 5 minutes after.

This record shall be protected against erasing until the maximum number of alarm events is reached.

The system shall be able to store up to 10 events.

Images shall be recorded together with information about date, time, camera identification, camera location, train location.

Time and location synchronization shall be received from another system.

All images shall be stored in one location on a common storage media.

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 of the color type.

All visible faces of cameras shall be painted to a color proposed by the Contractor and approved by AM.

All finished parts must facilitate the removal of graffiti and not readily degrade as a result of the removal process.

Surface coating methods used must allow local retouching following damage repair.

As a minimum, the quality of the picture recorded in all normal operating lighting conditions in the cameras shall be according to EN 62676-4.

This quality shall be measured by playing the records on a playback station.

The system shall perform a self test in the start up sequence.

The Closed Circuit Television system shall be modular and it shall be possible to expand a system configuration with more functionality without replacing, or replacing only a limited number of, the existing components.

The display unit(s) where pictures from the CCTV system are projected shall be touch screen(s) and shall include pictures from external and internal cameras. The number, the layout, the exact size and the arrangement of the screen(s) shall be approved by AM.

The Closed Circuit Television system devices shall be connected to the Train Control and Management System.

By connecting a laptop or a dedicated monitor to a service port, it shall be possible to view recorded images onboard the train from any connected recorder in the train.

The on-train playback time shall be limited to the last 5 minutes of recordings and access to this function shall be access protected by the use of a security procedure.

A playback station shall be provided to decode and display the data recorded on the removable recording media from the trains.

A playback station shall allow playing full motion 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 by 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 only be accessible for use after a special security procedure, e.g. user identification and password.

### **13.10 Diagnostic functions**

The system will be supported by a powerful and comprehensive diagnostic system monitoring the correct function, identifying and registering the faults.

All communications both with internal and external to the vehicle subsystems will be recorded on special log files, together with the necessary information (like time and vehicle position). These files shall be accessible to maintenance personnel with a friendly and comprehensive way, through a laptop computer and the necessary diagnostic software. Information included in these files will be retained cyclically for at least one month.

Any faults of the normal function of the system, together with the necessary information, will be recorded on a separate diagnostic memory and will be retained also for at least one month. Maintenance personnel will have easy access to the diagnostic memory through a laptop computer and the necessary diagnostic software and will be able to read, transfer and erase the diagnostic memory. The diagnostic software will be able to support fault process functions, such as sorting, filtering, printing etc in order to facilitate the maintenance personnel in troubleshooting.

The entire diagnostic system of the Onboard Information System shall be incorporated in the vehicle's TCMS system and shall report every information, failure or incident occurring to the supervised systems, such as but not limited to them:

- Automatic vehicle tracking system (GPS)
- PA system
- PIS system (visual and audible messages)
- Traffic priority system
- Point machine control system
- TETRA communications system
- Passenger counting system.

### **13.11 Support Equipment**

The Contractor will provide two (2) workstations to be installed in Depot (one in the Rolling Stock Workshop and one in the OCC), with all necessary hardware, software and related licenses to transmit and receive information from OBC of each vehicle, in order to fulfil the application of the functions defined in this chapter and in chapter 10. The two workstations shall be made up, among others, by standard desktop, reliable heavy duty PC with standard commercial operating system, color printers for A3 pages, at least etc. The communication with the vehicle will be effected through wireless LAN (802.11 or newer), as described in paragraph 10.5 and will be possible only when the vehicle is in the vicinity of the Depot. The workstations will be identical in terms of hardware and software and the functions will be performed on any of them. Any cabling works to be required for the data transmission are not included in the scope of the Project.

The Contractor will provide the necessary application software of the workstations, in order to perform the functions stated below. These functions include:

1. Automatically triggered data collection function. This function will be triggered automatically by the software system, whenever a vehicle enters in the field of

the wireless LAN. The same functions will have the option to be triggered manually (paragraph 10.5 already incorporates a corresponding provision).

2. Configuration functions. Whenever deems to be necessary, the parameters of the OBC will be changed according to the operational needs. This includes - for example- change of audio or video messages and their broadcasting schedule, change in the configuration of the network (stations, traffic lights etc), change of the vehicles time table, etc. The application software shall warranty that all tramway vehicles are loaded with the most updated configuration information automatically.
3. System log information and diagnostic fault messages function. All data communications which refer to a specific vehicle will be registered with the necessary data (date, time, event, kind of communication packet exchanged, result, error message etc). The system will provide a powerful search mechanism to the end user, in order to trace the system log and diagnostic fault database. The search engine shall be capable to accommodate the following search criteria: vehicle number, date, system, type of failure etc., The log data and diagnostic messages will be available for at least one year.

The Contractor will propose the menu interface and the software architecture to AM for approval. Details of the different operations and functions will be defined during the design phase.

The Contractor shall also propose to AM for approval the composition of the workstations.

All data collected by the vehicles will be saved in tabular format and standard file format, such as MS Excel spreadsheets or MS Access tables. All data shall be saved in a commonly accessed network location and shall be accessible to the maintenance personnel.

In case of the wireless LAN failure, all functions described above shall be able to be performed locally within the vehicle, by the use of a standard laptop and an appropriate network interface connector with the TCMS system and the on board computer (OBC).

### **13.12 Provision for installation and operation of Automatic Fare Collection System**

Fare collection equipment (validating machines, central control unit, data transmission equipment and antenna, auxiliary equipment) are foreseen to be installed on-board the vehicles as well as in the depot (central computer, wireless network, antennas, etc) by an independent contractor (see Article 6.4). In this context, cooperation shall be necessary between the Contractor and the automatic Fare Collection System independent contractor.



## 14 System Assurance

### 14.1 Reliability, Availability, Maintainability and Safety (RAMS) Requirements

#### 14.1.1 Reliability requirements

The Contractor shall provide data concerning the availability of his equipment, unless this equipment is characterized as non critical. Non critical equipment is not subject to such analysis. However, without AM's concurrence, this requirement shall not be removed.

The Contractor shall provide reliability data in a form to be agreed with AM.

The reliability requirements will be:

$MDBF_1$  (Mean Distance Between Failures)  $\geq 100.000$  km and  $MDBF_2 \geq 20.000$  km

The aforementioned distances, namely  $MDBF_1$  and  $MDBF_2$  will be calculated respectively by the formulas:

$$MDBF_1 = D/F_1$$

$$MDBF_2 = D/F_2$$

where D is the total operating distance cumulated by the fleet of tramway vehicles during the measurement period,  $F_1$  is the total number of chargeable failures resulting in a service interruption and  $F_2$  is the total number of chargeable failures resulting in a service degraded condition.

In both the above failure definitions, chargeable failure means a failure of an item that results in a loss of function of that particular item including:

- A fault of an item while operating within its design and environmental specification limits.
- Fault caused by improper operation, maintenance or testing of the item as a result of contractor-supplied documentation.
- Item degradation, discovered during the recommended preventive maintenance interval, which causes the loss of function or near loss of function of that item (excluding consumable items).
- Consumable items requiring replacement for reasons other than normal fleet wear/ageing.

$F_1$  failure resulting in a service interruption is defined as:

- A failure that causes immobilization of the vehicle in the network and it gives rise to the need for the vehicle to be towed by another vehicle
- Failure that causes an immediate withdrawal of the vehicle to the depot without passengers.

Below, an indicative and not exhaustive list of  $F_2$  failures resulting in a service degraded condition is presented :

- A failure resulting to four minutes delay or more in revenue service at the end of the journey, or at the departure in depot,
- Failure of the passenger HVAC system resulting in a loss of performance equal or greater than 50%,
- Failure of the driver's cab HVAC system.
- Failure that requires two or more door pairs on the same side of the vehicle to be isolated.
- Failure of the Vehicle's Positioning System.

MDBF shall be measured by using the following formula:

$$MDBF = \frac{\sum_{i=1}^n km_i}{\sum_{j=1}^n F_j}$$

Km = total sum of kilometres run by each vehicle

i = number of vehicle

F = failure, occurred during the verification period in question

j = number of failure

The Bidder shall specify in his technical offer the reliability figures  $MDBF_1$  and  $MDBF_2$  of the fleet, as described above, based on an expected annual travel distance of 60,000km/vehicle.

Especially for this Tender, the failures evaluated in the framework of the calculation of the  $MDBF_1$  index values are the following:

- (i) Loss of communication between passenger area – driver's cab
- (ii) Pantograph failure
- (iii) Loss of traction power leading to vehicle towing
- (iv) Loss of master controller
- (v) Complete failure of battery charging system
- (vi) Complete failure of the TCMS
- (vii) Failure of the vigilance (dead man) system
- (viii) Failure to close a door

Especially for this Tender, the failures evaluated in the framework of the calculation of the  $MDBF_2$  index values are the following:

- (i) Failure resulting to four minutes delay or more in revenue service at the end of the journey, or at the departure in depot,
- (ii) Failure of the passenger HVAC system resulting in a loss of performance equal or greater than 50%,
- (iii) Failure of the driver's cab HVAC system.
- (iv) Failure that requires two or more door pairs on the same side of the vehicle to be isolated.
- (v) Failure of the Vehicle's Positioning System.

The values provided by the Bidder are binding and will be considered as an integral part of the performance specification. The values quoted in the offer shall be validated against the actual reliability figures, measured during the RAMS demonstration period.

Indicatively, it is mentioned that the average speed on the existing Line 5 (Voula – Syntagma) is 18.55 km/h, on Line 4 (SEF – Syntagma) 19.06 km/h and on Line 3 (Voula – SEF) the average speed is 22.21km/h. The average service time of the tramway vehicles is 18 hours and 39 minutes per day and the average days of service are 226 days per year.

#### **14.1.2 Availability requirements**

Availability shall be calculated by using the following formula:

$$As = \frac{\sum_{i=1}^n F_{Fi} - F_i}{n}$$

As = Availability over at the time in question

n = Observed period, number of days.

F<sub>Fi</sub>= Total number of vehicles less those scheduled for maintenance, or not able to perform the service operation due to accident, act of vandalism or failure not chargeable to the Contractor.

F<sub>i</sub>= Number of vehicles unavailable for deployment at the time in question chargeable to the Contractor.

The minimum average monthly availability of the fleet shall be 92%.

One random measurement per day shall take place during service hours. For the intensions of this measurement, service hours will be between 06:00 and 22:00.

The random time shall be selected using a well-proven and approved selector and a selection point in any 30min interval.

The Bidders shall specify in their Technical Offers the availability of the fleet. The value provided by the bidders is binding and will be considered an integral part of the performance specification. The value quoted in the offer shall be validated against the actual availability, measured during the RAMS demonstration period.

The term “mean time to repair” (MTTR) of a system/ subsystem is assumed as the time required for the repair of a failure to any system or subsystem, so as to render a vehicle operational.

#### 14.1.3 Maintainability requirements

The Contractor shall provide a maintainability analysis for AM’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, the Contractor shall provide information regarding the recommended maintenance procedures for his 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 AM.

In addition to the maintenance manuals, the Contractor shall provide a Maintainability Design Checklist. The content and format of this checklist shall be as agreed upon with AM. 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 full Life Cycle Cost (LCC) analysis for the vehicle, according to EN 50126.

At the Final Design Review, or other mutually agreed upon time, the Contractor shall provide a listing of the lowest level replaceable units (LLRU) in the equipment supplied.

The Bidders, in the framework of their Technical Offer, shall submit the following:

- the total of working hours required for the preventive maintenance of each Tramway vehicle in a 2-year period from the commencement of the revenue service
- Presentation of the general plan for preventive maintenance
- Presentation of the general plan for corrective maintenance
- Description and documentation of the compatibility with all maintenance facilities that are necessary for the vehicle’s maintenance, as well as respective method to achieve this compatibility, if required.
- A reference to the MTTR each of the following six systems from failures that render the vehicle inoperative:
  - Bogies
  - Doors System
  - HVAC system
  - Electrodynamic, Mechanical and Magnetic Brake
  - Traction Motor and Inverter
  - APSE

Subsequently calculate and submit an average value for the above six subsystems, a value to be evaluated on the basis of the relevant criterion.

- the mean time required for replacing wheel tyres of the entire Tramway vehicle
- the mean time required for replacing windows of the entire Tramway vehicle, including windshields
- the mean time required for replacing all front and side exterior panels of the driver cab (one cab)
- detailed description of the procedure for the repair of the side panels in case of vehicle collision.

#### **14.1.4 Safety requirements**

The Contractor shall provide the following for review and approval by AM:

- Vehicle Safety Management Plan
- List of Vehicle Critical Safety Issues, including interface risks, and
- Vehicle Safety Analysis.

The safety of the vehicle personnel, the maintenance personnel, the passengers and passers-by must be taken into consideration.

Moreover, the Contractor shall provide supporting documentation indicating the Objectives of the Vehicle Safety System for review and approval by AM. To that effect, the Contractor must be ready to demonstrate the inherent safety of the entire vehicle equipment.

The safety requirements shall be described according to the terminology defined in Standard IEC 60050.

Moreover, the Contractor shall provide documentation to demonstrate:

- Quantification of inherent risks of vehicle equipment, and
- The vehicle safety system study.

Moreover, the Contractor shall develop a quantitative assessment of risk analysis for the vehicle during the final design stage.

The analysis of failures, impact and criticality shall be prepared and provided according to Standards IEC60812 & EN50126.

All risk analyses for the Vehicle's systems and sub-systems shall be carried out in accordance with the requirements set forth herein.

The Contractor shall take measures to minimize the impact of the above risks. This will be implemented by means of designs (interlocking, fail-safe designs, redundancy design, safety override design, protection devices, etc.) preventive maintenance procedures, training of operators, warnings or combinations of the above. Classification of the seriousness of any risk shall take into consideration the various mitigation factors (if any).

It is hereby clarified that the general safety cases and the application safety cases for the vehicles shall cover:

- The entire vehicle
- All control systems onboard the vehicle, including their interfaces.

#### **14.2 RAMS demonstration plan**

In order to demonstrate the satisfaction of the RAMS requirements, the Contractor will submit during the design phase, a RAMS demonstration plan for approval by the AM, according to EN 50126 or equivalent.

For each vehicle, the “commissioning into service” time will be agreed upon and signed jointly by the Contractor and AM. The RAMS demonstration plan shall begin six (6) months after the “commissioning into service” of the last vehicle.

The RAMS figures will be monitored on a monthly basis on a commonly agreed procedure based on the RAMS demonstration plan, during a period of 12 months. At the end of the RAMS demonstration period, the Contractor shall demonstrate that the fleet has achieved all the RAMS targets, as specified in his technical offer, in which case the program shall be successfully ended.

If even one of the RAMS targets has not been achieved, the period will be extended so as to simultaneously and successfully achieve all RAMS targets during a period of 12 successive months.

In order to apply the RAMS demonstration plan, the Contractor shall provide a computer including a software application, operating on a network environment such that AM/Operation Company will have the necessary access to the data therein. The system will be operative during the entire 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 AM for approval. At the end of the warranty period, the electronic system (hardware and software) will become property of the Operation Company.

Irrespective of the aforementioned twelve-month period of the program, the Contractor shall operate the failure monitoring system regarding the RAMS of the equipment, from the moment the first train is commissioned up to the end of the vehicle’s guarantee period. All input to this system shall be agreed upon on a monthly basis among AM/Operation Company/Contractor.

#### **14.3 Failure Analysis**

In the event of any failure as the term is defined in paragraph 14.1 herein, during the contractual testing period or the guarantee period, the Failure Monitoring System shall be updated. Subsequently, the Contractor shall submit a full Failure Analysis Report which will clearly identify the root causes of the failure, the corrective actions that need to be taken, along with the relevant time schedule for failure rectification.

Whenever corrective actions are needed, the Contractor shall propose them to AM for approval.

The data presented in the Failure Analysis Reports can be utilized as evidence in order to classify a piece of equipment as defective in the sense of paragraph 14.4 herein.

The Failure Analysis Reports shall be submitted to AM/Operation Company for approval.

#### **14.4 Systematic Failures – Defects**

In case that 10% of the total number of identical pieces of a particular type of equipment (software or hardware) suffer independent – uncorrelated failures, that type of equipment shall be characterised as defective and be declared as a fleet defect or a systematic failure.

On this basis, the Contractor shall develop and implement a corrective action program to eliminate the pattern failure. The corrective action program must be approved by AM before application. The correction of a systematic failure demands a fleet retrofit, and in such cases a three-year warranty period for the retrofitted or new equipment will begin after installation and acceptance by AM.

#### **14.5 Applicable International Standards**

The System Analysis will be carried out in accordance with the Standards quoted below, while the requirement is not revoked 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.

#### **14.6 Main Interface Issues**

This section identifies the minimum interface issues that should be considered in order to achieve safe operation of the Tramway vehicles.

- Compatibility between Tramway vehicles and Electrification Systems (i.e. System Voltage, Line Current, Harmonics, System Performance, Current Collector Performance, etc).
- Electromagnetic Compatibility between Tram Infrastructure and Tramway vehicles.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- Compatibility of Tramway vehicles and Track and Structures (for example, tracks, alignment, point machines etc.)
- Compatibility of Tramway vehicles with Control and Communication Systems
- Compatibility of Tramway vehicles with Signalling System
- Compatibility of Tramway vehicles with Other Tramway vehicles of the Operation Company (TA1, TA2, etc.)
- Compatibility of Tramway vehicles with the overhead catenary system, platforms and environmental conditions, in general.
- Compatibility of Tramway vehicles with the special needs of Passengers (e.g. pace-makers)
- Compatibility of Tramway vehicles with Emergency Procedures (for example, fire, detrainment, crashworthiness/structural strength, emergency equipment, emergency access, etc).

**14.7 Documents deliverable to AM to demonstrate system assurance**

System assurance shall be demonstrated through the submission of the documents listed in the table below, as the Contractor's exclusive responsibility. Approval by AM of all the documents shown below constitutes a precondition in order to demonstrate system assurance.

<b>TITLE</b>	<b>DELIVERY DATE</b>	<b>EXPLANATION</b>
<b>System Assurance Plan</b>	within one month from Contract signing	will contain the Contractor's proposals for undertaking the System assurance activities during the project life
<b>Preliminary Hazard Analysis</b>	at the end of the Design, Equipment Configuration and selection stage	
<b>Fault Tree Analysis (FTA)</b>	at the end of design stage	
<b>Failure Mode Effect and Criticality Analysis (FMECA)</b>	at the end of design stage	



<p><b>Interface Hazard Analysis, System Hazard Analysis, and Operating Hazard Analysis</b></p>	<p>at the end of design stage Equipment Configuration and selection stage.</p> <p>Updated during the following stages:</p> <ol style="list-style-type: none"> <li>1. Manufacturing, Construction and Installation Stage</li> <li>2. Testing and Commissioning</li> <li>3. Before the end of the warranty period.</li> </ol>	
<p><b>RAM Modelling Allocation and Prediction</b></p>	<p>at the end of the Design, Equipment Configuration and selection stage and updated during the following stages:</p> <ol style="list-style-type: none"> <li>1. Manufacturing, Construction and Installation Stage</li> <li>2. Testing and Commissioning</li> <li>3. End of the warranty period</li> </ol>	<p><b>RAM Testing</b> will be carried out during the following stages:</p> <ol style="list-style-type: none"> <li>1. Design, Equipment Configuration and selection</li> <li>2. Manufacturing, Construction and Installation Stage</li> <li>3. Testing and Commissioning</li> <li>4. RAM demonstration period.</li> </ol>
<p><b>Safety Case Document</b></p>	<p>at the end of Test and Commissioning period.</p>	
<p><b>RAM Performance Demonstration Report</b></p>	<p>at the end of the RAM demonstration period.</p>	

<p><b>System Assurance Report</b></p>	<p>Deliverables at the end of the following stages:</p> <ol style="list-style-type: none"> <li>1. Design, Equipment Configuration and selection</li> <li>2. Manufacturing, Construction and Installation Stage</li> <li>3. Testing and Commissioning</li> <li>4. End of the RAM demonstration period.</li> </ol>	<p>will enclose the current status of the above deliverables and will summarise any findings</p>
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#### **14.8 Electromagnetic compatibility**

The electromagnetic emissions shall not put at risk the control systems that are critical to the railway operation.

All vital systems (e.g. wire/wireless communications) which are essential, especially in downgraded operation mode and emergency operation mode, shall not be affected by E/M emissions.

The induced voltage shall not affect the train identification equipment and the signalling priority equipment. The Contractor shall take all reasonable measures to restrict electromagnetic emissions.

There will be electromagnetic compatibility inside the vehicles, from one vehicle to the other, with other vehicles running on the line, with the existing signalling and communication systems and with the trackside equipment. The vehicles shall not be capable of carrying out any function that can lead to unsafe conditions for the signalling systems.

The Contractor shall carry out a plan to achieve and document electromagnetic compatibility. This plan's requirements shall apply for all subsystems and their suppliers. The Contractor shall ensure that the entire equipment, both individually and as a whole, shall conform to the electromagnetic compatibility requirements. The Contractor shall ensure that each vehicle complies with the E/M compatibility requirements at every possible operation mode, including downgraded operation mode and failure mode.

The vehicles shall comply with all requirements of the European Directive 2004/108/EC about E/M compatibility. The Contractor shall provide all required documentation in order to demonstrate this compliance.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The Contractor shall be requested to demonstrate through testing that the EMI levels conform to the standardization EN 50121-1, EN 50121-2, EN 50121-3-1, EN 50121-3-2, EN 50121-4, EN 50121-5.

Moreover, the magnetic flow density at any location inside the vehicle shall not exceed  $1 \times 10^{-3}$  TESLA, a value to be verified by tests at specific locations, as agreed upon with ATTIKO METRO S.A.

The Contractor shall support certificates of compliance with the above standards issued by a Accredited Laboratories.

## 15 Test, Commissioning, Delivery and Acceptance

### 15.1 Testing

The vehicles shall be tested according to the International Standard IEC 1133 and the additional tests listed in this chapter, as well as on the other chapters of this Performance Specification.

The Contractor must submit to the Operation Company a Test Plan and a matrix of compliance with IEC 61133, listing all the test procedures, tests and test 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 Contractor must submit the Test Plan for approval six months before the beginning of the tests.

The Contractor must update the Test Plan on a monthly basis to reflect the actual submittal status of all test documentation.

The Contractor shall submit to ATTIKO METRO S.A. for approval the test procedures at least two months before test commencement.

After each test the Contractor shall write 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 the tests and any other associated operations, including necessary tests at the suppliers and sub-contractors premises. The Contractor will invite in advance ATTIKO METRO S.A. to witness any test or FAI at his sub-supplier's premises, requesting confirmation about ATTIKO METRO S.A. participation.

For any unit previously qualified, or with a railroad proven service history, the Contractor may request a waiver from performing the test. The request for a waiver must be accompanied by a duplicate test report or certification 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 the same as those in the current qualification requirements.

Only with the written consent of ATTIKO METRO S.A. will Test or Certification requirements be waived.

The minimum tests requested by ATTIKO METRO S.A. are described in detail below and fall under the following categories:

#### 15.1.1 1<sup>st</sup> Category

These are the tests of the following tables:

Table A.1- Tests at standstill

	Routine Tests	Type Tests	Other tests
Mechanical tests at standstill - Clearance:		Required Required	
Weighing tests	Required	Required	
Brake tests at standstill	Required	Required	
Dielectric tests	Required	Required	
Tests for correct operation of assembled equipment	Required	Required	
Check of the earthing and return connections	Required	Required	
Running tests on auxiliary electrical equipment and auxiliary power supplies - Direction of rotation etc. - Starting tests	Required Required	Required	
Checks of the battery charging arrangement	Required	Required	
Test for sealing of body and external equipment boxes - Initial checks - Openings and covers - Mounting of filters, etc.	Required Required Required	Required	
Check for the prevention of accidents		Required	
Checks on working conditions and amenities - External noise levels - Vibration		Required Required Required	
Tests on safety related equipment	Required	Required	
Impulse tests			Required

Table A.2 - Tests on line

	Routine Tests	Type Tests	Other tests
Tests for safety of running and ride quality		Required	
Running tests over track with curves and track with changes in gradient		Required	
Current collector tests (pantograph)		Required	
- Operation of collector	Required	Required	
Starting and acceleration tests		Required	
- tractive effort/speed characteristics	Required	Required	
Line braking tests		Required	
- General	Required		
- Stopping distances	Required		
- Electrical braking			
- Smooth transitions	Required		
- Smooth build-up	Required		
- Loss of line	Required		
Interference tests		Required	
Traction and braking capacity tests		Required	
Tests for resistance to motion			Required
Energy consumption tests			Required
Interruption and voltage jump tests		Required	
Checks of internal over-voltage levels			Required

### 15.1.2 2<sup>nd</sup> Category

Type tests to assure the compatibility of the Series TA2 tramway vehicles with the following existing equipment and vehicles of the Operation Company:

- Lifting jacks
- Washing plant for the external washing of the vehicles
- Bogie washing plant
- Underfloor wheel lathe
- Sand refilling system

- Coupling functionality Series TA2 tramway vehicles – Series TA1 tramway vehicles of the Operation Company.
- Coupling functionality Series TA2 tramway vehicles – existing service vehicle (Unimog) of the Operation Company.

Additional type tests are foreseen to assure the compatibility of the Series TA2 tramway vehicles with the following:

- Alignment
- Platform edge
- Control and Communications Systems (TETRA, wireless network)
- Signalling
- Track switches
- Traction Power supply
- Overhead equipment
- Line equipment
- EMC compatibility

#### **Simulation Revenue Service Type Test**

In order to confirm overall performance, a tram shall be subjected to a Simulated Revenue Service test for a minimum period of 30 days, 20 hours per day. The vehicle shall be loaded to the AW3 loading 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 tramway vehicle shall be required to make station stops, and the passenger side entrance doors shall open and close at each stop. This testing shall also be utilized to train the Operation Company's staff.

During the Simulated Revenue Service test, critical system parameters, such as traction motor temperature, brake disc temperatures, etc., shall be monitored. The test procedure shall be approved by ATTIKO METRO.

#### **15.1.3 3<sup>rd</sup> Category**

Additional routine tests required.

#### **Shakedown routine test**

In order to "shakedown" all vehicle systems and components before being placed into revenue service, each vehicle shall be subjected to a Shakedown test. The vehicle 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. During this test it must be assured that all systems and subsystems function. The tramway vehicle shall be required to make station stops, and the passenger side entrance doors shall open and close at each stop. Each tramway vehicle will be required to undergo this testing for 24 hours. Should any tramway vehicle exhibit a failure during

the last eight hours of testing, the eight hours of testing shall be repeated until the tramway vehicle has completed eight hours of testing without any failure, before it is accepted by ATTIKO METRO. If the vehicle exhibits a failure during the first sixteen hours, the test will be repeated from the beginning. Also during this test, evidence should be given that all systems and subsystems function properly and within safe parameters in static and dynamic conditions. The test procedure shall be approved by ATTIKO METRO.

#### **15.1.4 4<sup>th</sup> Category**

The Contractor must ensure the Compatibility of tramway vehicles with Emergency Procedures as:

- Fire Load
- Detrainment
- Crashworthiness/Structural Strength
- Emergency Equipment, Etc.

### **15.2 Delivery and Acceptance Arrangements**

#### **15.2.1 Delivery Arrangements**

Following completion of manufacture and issue of a Quality Certificate the tramway vehicles will be transported from the manufacturer's premises and off-loaded on to the tram network by the Contractor at the following address:

Operation Company  
End of Aeroporias street  
Elliniko  
Attiki  
Greece

#### **15.2.2 Acceptance Arrangements**

Acceptance for Use of the tramway vehicles will be performed by AM/ Operation Company on the Operation Company lines when, in addition to the stipulations in chapter 15 of the CC:

- The vehicles have successfully completed all testing and commissioning requirements
- Documentation of manufacturing and quality assurance has been completed in accordance with the quality requirements of the Contract
- The vehicles have met the technical quality and performance requirements
- AM is responsible for the approvals of the vehicles and the Contractor shall present all required certificates.



### **15.2.3 Contractor's responsibility**

The Contractor shall be responsible and shall bear all the expenses for the transportation of the contractual scope to the Operation Company premises. In due time before the arrival of the first vehicle, the Contractor shall submit a vehicle unloading plan to the Operation Company and arrange for their transfer to the Depot.

The following are the obligations of the Contractor during the period of the commissioning, testing and acceptance:

- The Contractor will be responsible for the vehicles up to acceptance by the Operation Company.
- The Contractor will arrange and provide all transport, necessary permits and certificates.
- The Contractor will arrange and provide all lifting equipment and unloading ramps required for the delivery of the tramway vehicles.
- The Contractor will provide all the labour, tools for undertaking the delivery and acceptance arrangements.
- The Contractor will provide all accommodation for his staff together with any stores accommodation for materials and equipment required for the delivery and acceptance arrangements.
- The Contractor will arrange for utilities, telephones and any office furniture and equipment he requires.
- The Contractor will allow access to ATTIKO METRO S.A./ Operation Company to its site or trams for the witnessing of any tests.
- The Contractor will arrange his own insurance cover for his staff involved in the commissioning and testing and hand over arrangements.
- The Contractor will arrange insurance cover for any ATTIKO METRO S.A./ Operation Company staff who are witnessing any tests on tramway vehicles or are on the premises deemed to be the responsibility of the Contractor.

### **15.2.4 AM/ Operation Company responsibility**

The following are the obligations of the Operation Company during the period of the commissioning, testing and acceptance:

- the Operation Company will provide the off loading site for the tramway vehicles.
- the Operation Company will provide the test track for undertaking the commissioning and testing and acceptance of the tramway vehicles.

the Operation Company will provide Offices for the Contractor's personnel. If this proves unfeasible, the Operation Company shall provide a suitable free space where the Contractor can install a temporary structure, e.g. container, to accommodate the



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

commissioning, testing and administration staff and any other staff required by the supplier.

## 16 Documentation and Training

The Contractor shall provide listings on a monthly basis that record the status of all documentation provided to AM.

Specific details (such as document numbering, drawing guidelines, etc.) regarding the production of drawings and documents are given in the AM Drawing Office Manual (DOM). The Contractor shall take into consideration the documents and drawings production general guidelines given in the AM DOM and shall in turn submit a document describing all the mechanical and electrical equipment designation coding, numbering and symbols and the notation and guidelines used by the Contractor in the production of drawings and other technical documents including all electrical, connection and wiring diagrams. Once approved by AM, this numbering, coding and notation 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 designation coding for the main system categories as proposed in the DOM, but the basis of the document numbering system shall not be modified. Adherence to international standards shall be required, as also mentioned in par. 16.1.4.

The International System of Units (SI) shall be utilized for all drawings and documentation

### 16.1 Drawings - General

All drawings and technical documents furnished by the Contractor shall be in accordance with the following guidelines:

1. All drawings and technical documents shall be supplied in hard copies and electronic format, the specific format requiring the approval of AM.
2. The drawings submitted shall be of a quality capable of being reproduced clearly.
3. The drawings shall have a legend presenting the drawing number, its title, date of issuance, the drawing's producer, reviewer and approving person on the part of the Contractor and its revision letter; moreover they shall have the appropriate space for drawing review category, as per the contractual stipulations, as well as for the signatures of AM's reviewers.
4. When revisions are made to drawings resulting in re-submittal, such drawings shall be accompanied by a cover letter detailing the changes made.

#### 16.1.1 Drawings to be Submitted for Approval

The drawings to be provided by the Contractor for approval by AM shall include, but not be limited to, the following. AM reserves the right to request additional drawings, as required, to clarify and amplify the intent of the drawings supplied, and reserves the right to approve such drawings. All drawings shall be production drawings. The Contractor shall also supply a Drawing Tree, delineating all major categories of drawings entering into the construction of the vehicles, and indicating construction and system logic.

### **System Requirements**

- Exterior side elevations of a vehicle
- Electrical schematic (750Vdc equipment)
- Electrical schematic (24Vdc, 12Vdc equipment)
- Electrical schematic (3-phase, 400V AC equipment)
- Electrical schematic (1-phase, 230V AC equipment)
- Electrical equipment (split in separate functional system groups)
- Grounding scheme
- Hydraulic schematic (hydraulic brake equipment)
- Interface control drawings
- Clearance drawings
- Vehicle interrelationships during curving

### **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.)

### **Bogies**

- Bogie assemblies
- Bogie frame assemblies
- Suspension details
- Wheel details
- Axle Box bearing details
- Grounding brush installation

### **Couplers and Draft gear**

- Coupler assembly and installation
- Coupler electrical (built-in or via cable) connector details
- Electrical connection details

### **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
- PA 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
- Elevations of Driver's cab

- Cab equipment layout
- Cab console layout
- Assembly and installation of master controller and mode switch
- Driver's seat assembly and installation

#### **Doors and Door Controls**

- Door system electrical schematic
- Door operator assembly and installation
- Door assembly, details and installation (all)
- Door threshold assembly and installation (all)

#### **Air Conditioning**

- Air Conditioning unit assembly, details and installation
- Air Conditioning system electrical and piping schematics
- Air Conditioning unit electrical and piping connections
- Refrigerant compressor assembly
- Evaporator and condenser coil assemblies

#### **Braking System**

- Disc brake assembly and installation
- Brake actuator calliper assembly and installation
- Brake pad details
- Electronic control unit assembly and installation

#### **Traction System**

- Traction system electrical schematic
- Power conversion equipment assembly and installation
- Traction 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

#### **Auxiliary Electrical Supply System**

- Auxiliary power supply system electrical schematic
- Auxiliary power supply equipment assembly and installation
- Battery assembly and installation
- Battery box assembly and installation
- Miniature circuit breakers details and installation

#### **Communications System**

- Communications system electrical schematic
- PA module assembly and installation
- Radio equipment assembly and installation
- Passenger Information system electrical schematic
- Passenger Information system assembly and installation
- Closed Circuit Television schematic
- Closed Circuit Television assembly and installation

- Wireless data transmission system architecture

#### **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 change and then be resubmitted for AM's 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 change in a separate revision history document, or to reference the engineering change notice number.
4. A list of parts and required quantities shall be provided on each drawing, or as a separate bill of material.
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 to the European system.
6. A clear area shall be made available in the lower, right hand side corner of the drawing for AM's title block. At a minimum, the title block shall include space for AM Project Manager and Responsible Engineer approval, and the AM 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 be applied as appropriate to the equipment concerned.

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 IEC 61082. Graphical symbols on electrical drawings shall comply with IEC 60617DB.

All electrical and electronic equipment shall be documented in accordance with IEC 60571.

Mechanical drawings shall be delivered in Autocad format.

Electrical drawings shall be delivered in a format such that all drawings will be linked. The electrical design software package shall be capable to produce automatically cable lists and terminal connection tables. Any change or modification on any 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:

1. Important dimensions.
2. Mounting arrangements and their tolerances. Also, wherever needed, the applicable tightening torques.
3. Panel, enclosure, frame, etc. construction, material, and finish.
4. Direction of rotation (where applicable), speed or frequency, and amount of unbalance.
5. Location of center of gravity, mass (in full working order), and mass carried at each mounting point.
6. Location and size of grounding straps or grounding facility.
7. Location of maintenance features and clearance requirements for removal of all normal maintenance items.
8. Labelling and location of notices and signs.
9. Special mounting instructions.
10. Equipment arrangement, including fastening hardware.
11. 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:

1. Operating voltage, power consumption, power factor, and tolerances thereof.
2. Type of windings (for transformers and machines) and type of insulation.
3. Resistance and tolerances.
4. Contact ratings.
5. Operating parameters relevant to type of device.
6. Type and size of cables and wires used.
7. Wire codes, and marking methods of wires and devices.
8. 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 to assemble a collection of independently-produced subcontractor drawings into a single document. Circuit diagrams shall be in book form, no larger than A3 size.

Circuit diagrams must show:

- Grid reference 1,2,3,4,5,6 horizontally and A,B,C,D vertically,
- Brief functional description related to grid reference (Train prepared, Dead man, e.t.c),
- 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 will be provided automatically by defining equipment and components,
- Connection terminals on the drawings lines,
- Connection numbers on the right hand side of the connection terminal symbol,
- Brief description on control lines crossing the train as bus lines (door close command, emergency brake, 3Km/h, shoes down, 750 V presence, e.t.c)
- 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 book based on the train circuits and automation shall be provided.

#### **16.1.3.4 Circuit diagrams explanation**

The circuit diagram explanations will explain in full detail 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 AM 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 relays, switches, buttons, circuit breakers, terminal block strips, cable trays, instruments, etc, will 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.

#### **16.1.4 Special Design Requirements**

For all the scopes for which the aforementioned drawings will be prepared and submitted, the relevant corresponding calculations, designs and technical documentation concerning the vehicle's technical and functional options must be also prepared and submitted.

Subjects to be covered on the above-mentioned documentation are, but not limited to, the following:

##### **Mechanical**

- Vehicle description and troubleshooting with relevant diagrams
- Static calculations with the results of the car-shell stress-strain analysis
- Brake calculations and brake matrix
- Load distribution
- Smoke and flammability data for E&M components (in table format) including any certificates
- Technical data/ calculations of envelopes and fulfilment of the dimension-related requirements presented in Annex 1
- Complete construction description with project drawings

- Drawings of car shell and bogies/wheel sets, as well as the relevant component drawings with reference to the upper level drawings, parts and identification number
- Complete list of all components and equipment including data of the supplier, the component description and typical technical data
- Proof of derailment safety
- Calculation of the shock absorbing capability
- Diagrams for speed / traction & braking torque, driving motor current and voltage, etc.
- Driving diagram (traction / coasting/ braking)
- Amended weight control of E&M components in relation to their arrangement, moreover the weights of the bogies/wheel sets with data on the size of the unsprung masses
- Proof of welding integrity
- Calculation of seating and standing capacity
- Hydraulic schematic diagrams
- Lubrication schedule
- Repair of car body

#### **Electrical**

- Vehicle description
- Schematic diagrams
- Component arrangement drawings
- Assembly drawings and assembly instructions
- E-component description with block diagram and component circuit diagrams
- Software description
- Fault finding with explanation on functions and measure points as well as troubleshooting techniques
- Maintenance instructions
- Earthing concept
- Testing instructions
- Cabling and line drawings (including cable lists per component and cable route diagrams throughout the vehicle)
- Terminal drawings
- HVAC details and calculation



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- EMI

**Maintenance - miscellaneous**

- Maintenance instructions
- Testing instructions
- Assembly drawings and instructions
- Maintenance plan listing all tasks as per mileage and time intervals
- Special tools, tooling, materials, consumables and quantities required for performing the tasks (including alternative materials or relevant norms)
- Safety instructions and safety equipment prior to working on specific tasks

Step by step instructions with drawings (2-D and exploded) and pictures describing the tasks to be performed.

**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 AM, but must allow AM 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 AM 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.

The Contractor shall provide two fully equipped workstations with which to modify the electronic drawings, including all required hardware and software (Autocad for mechanical and the appropriate software package, used by the Contractor, for electrical drawings). The software licenses shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for four of AM's Designers to be able to adequately utilize the workstations. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

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). The drawing and document submittal schedule shall allow for the review of a maximum of 100 drawings and other technical documents within any 30-day period. AM will not be obligated to review in excess of this number.



### **16.3 As-Built Vehicle Specification**

Upon finalization of the design, manufacturing and testing the Contractor shall be required to provide an electronic copy of this Performance Specification, updated and modified to reflect the as-built condition of a train.

### **16.4 Maintenance Manuals**

#### **16.4.1 General**

Fully integrated, modern maintenance manuals shall be provided, which provide step-by-step instructions on how 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 have familiarity 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 catalogue 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 AM.

The maintenance manuals shall provide all necessary detail to perform the work required, and shall include the judicious 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. Manuals shall identify all tools (special and standard) needed to perform the work. This listing of tools shall be provided in the section describing the discrete task being performed. The Contractor shall provide an appropriate number of all special tools for AM's use. Special tools shall include diagnostic test equipment for all electronic assemblies and circuit boards, and to test all train lined systems. Suitable manuals shall be provided for pertinent special tools (diagnostic equipment, etc.)

All manuals shall be provided in electronic format, the format to be approved by AM (which must allow AM 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.

The Contractor shall provide one fully equipped workstation with which to modify the documentation, including all required hardware and software. The software license shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for two of AM's staff to be able to adequately utilize the workstation. The Contractor shall be responsible for the associated travel, accommodation and meal costs to complete the training.

All manuals shall be approved by AM.

The maintenance manuals shall be divided into three parts: Running Maintenance, Scheduled Maintenance, and Overhaul.

#### **16.4.2 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. Recommended cleaning procedures shall be provided, 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.

#### **16.4.3 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 traveled. 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.

#### **16.4.4 Overhaul Manuals**

The Overhaul Manuals shall describe all work 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.

### **16.5 Illustrated Parts Catalogues (IPC)**

The Illustrated Parts Catalogues 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 AM'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 one alternative supplier for all components.

Moreover, desirable is the option to update the initially declared spare parts using the Contractor's online support system.

Any changes to the documentation needed as a result of service experience during the warranty period, shall be incorporated at no cost to AM.

Near to the front of the IPC shall be a list cross-referencing the part number, page number and the item number of the part.

Parts common to different assemblies shall bear the same Contractor's part number. The next level assembly of all parts shall be clearly identified.

The judicious use of cutaway isometric and exploded drawings, photographs, illustrations, etc., shall be used to clearly identify all components down to the LLRU.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The IPCs shall be provided in electronic format, the format to be approved by AM (which must allow AM 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.

The Contractor shall provide one fully equipped workstation with which to modify the documentation, including all required hardware and software. The software license shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for two of AM's staff to 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 AM.

### **16.6 Operator's Manuals**

The Contractor shall provide AM 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 the location, function and operation of all controls, switches, indicators, gauges, etc. Any changes to the documentation needed as a result of service experience during the warranty period, shall be incorporated at no cost to AM.

The Operator's Manuals shall also be provided in electronic format, the specific format to be approved by AM, which must allow AM to clearly document future changes.

The Contractor shall be required to provide one fully equipped workstation with which to modify the documentation, including all required hardware and software. The software license shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for two of AM's staff to 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 AM. This manual shall be placed in a separate clipboard in the Driver's cab and shall be easily accessible by the driver.

### **16.7 Training Manuals**

The Contractor shall provide AM with the required number of properly bound Training Manuals, which will be used to train AM's personnel to operate and maintain the vehicles.

The Training Manuals shall also be provided in electronic format, the specific format to be approved by AM, which must allow AM to clearly document future changes.

The Contractor shall be required to provide one fully equipped workstation with which to modify the documentation, including all required hardware and software. The software license shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for two of AM's staff to be able to adequately



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

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 AM.

### **16.8 Car History Books**

The Contractor shall provide AM 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 AM to record inspection, servicing, overhaul and repair activities.
- Shipping documents.

The Car History Books shall be provided in electronic format (which must allow AM to clearly document future changes), the format to be approved by AM, and in the required number of properly bound oil and dirt resistant hard copies.

The Contractor shall be required to provide one fully equipped workstation with which to modify the documentation, including all required hardware and software. The software license shall be purchased in the name of AM. Also, the Contractor shall be required to provide the required training for two of AM's staff to 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 AM.

### **16.9 Copies of manuals and documentation**

Manuals in hard copy to be supplied as part of this Contract are as follows:

Manual	Number of copies	
	Greek	English
Operator's Instruction and Troubleshooting Manual	10	6
Maintenance, Servicing and Heavy Repair (Overhaul) Manuals including maintenance plan	8	6
Illustrated Parts Catalogs	8	6
Technical Specifications (Detailed Final Design) drawings, circuit diagrams etc for Vehicle, Systems, Subsystems, and Components level	4	4

Training Manuals	30	6
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*Table 8. Total Number of hard copy manuals*

The above-mentioned documentation shall be supplied both in hard copies and electronic copies in CD-ROM (5 pieces). The files should be both in PDF or equivalent format and in editable format. Wherever possible, deliverables shall include interactive multimedia documentation. The documentation shall be delivered in CD-ROM in order to enable navigation through a combination of text, graphic and video sequences. The user shall be enabled to access circuit diagrams in multiple levels of definition as well as lists of spare parts of various components. The contents of the documentation shall be also used for computer-based training. Practical training will take place in situ as per training schedule.

### **16.10 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 AM has specifically requested monochrome photographs. The Contractor shall also supply the negatives, and the copyright of the photographs shall be vested in AM.

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.

### **16.11 Training**

#### **16.11.1 General**

The Contractor shall train, the nominated by the Operation Company personnel. 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 vehicles 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. Training shall consist of two major categories listed below:

1. Operator training (vehicle operation including how to detect and resolve in-service problems and operations during emergencies and degraded modes); and
2. Maintenance & troubleshooting training (including preventive, trouble shooting, corrective, overhaul and repair of components, equipments and assemblies).

All manuals shall be delivered in electronic format as well (CD).





**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

The operator trainees will in turn provide training to the drivers.

The training is included in the scope of supply of the Contractor. The training must be completed prior to commencing Revenue Operation with the Series II vehicles (TA2).

The Contractor shall, within twelve (12) months after Contract signing, submit a draft training program and a schedule for approval by ATTIKO METRO, that identifies milestones for submitting the course outlines. The Contractor's submittals shall include in detail, lesson plans and contents, instructor and student guides, instructor curriculum vitae, audio and visual aids, mock-ups, simulators, written and practical tests, and conducting classes.

The Contractor shall submit to AM for approval the training manuals upon delivery of the first vehicle.

The program shall be conducted at the Operation Company facilities or other premises as directed by the Operation Company in Athens, Greece, and include classroom and "hands-on" instruction for a selected group, whose make up shall be:

Train drivers Instructors	6
Maintenance Supervisors	5
Maintenance technicians	25
Engineers Mechanical & Electrical	5

The courses will be suitably constructed to the training needs of each group. In the event that the training premises are outside the Operation Company offices or the Depot, the Contractor must be prepared to undertake the costs related to providing the training premises in a manner that satisfies the training purposes.

**16.11.2 Training method and equipment**

The training programs for the personnel shall be in accordance with recognized European standards. The training shall be planned and carried out in a manner suitable for the intended occupation, and shall consist of:

- Formal off-the-job theory and practice.
- Practical on-the-job follow-up experience.

The Contractor shall demonstrate that the trained staff of the Operation Company has achieved the minimum objectives established for each trainee post, as defined herein. The methods for monitoring progress shall relate to:

- Theoretical tests and systems of assessment.
- Practical test pieces and objective systems of assessment.
- Progress reports.

Records of each trainee's progress shall be kept up-to-date and made available to the Operation Company 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 the Operation Company on completion of each training course.

The Contractor shall provide an adequate supply of high quality, professionally prepared material, to impart the essential knowledge of the people involved and leave them with authoritative and up-to-date reference material. Professional qualified instructors and experienced technicians should undertake the training. The curriculum vitae of the instructors shall be submitted to the Operation Company in due time for approval prior to commence of the training.

Manuals and other training material to be used by the Contractor during training shall be delivered to the Operation Company 60 days before training is conducted; the manuals shall be accurate, complete and of professional quality. The aforementioned documents shall be delivered in both Greek and English prior to commence of the training. The translation shall be of professional quality. The training courses shall be conducted in Greek language. The use of interpreter is permitted.

All training materials, such as training aids and lesson plans, shall become the property of the Operation Company at the completion of the training program.

#### **16.11.3 Operator training**

Hands on training may be conducted on the trams during the commissioning and testing of vehicles. However, safety of the line and other road users should be ensured.

Training is to take place in the alignment, Depot and access tracks of the Athens tramway system.

#### **16.11.4 Maintenance & troubleshooting training**

The Maintenance staff and Engineers of the Operation Company shall be exposed to the depth of the detail that is necessary for the performance of preventive, trouble shooting, corrective, overhaul and repair operations as well as troubleshooting and fault finding for all the vehicle systems and subsystems.

Classroom instruction for maintenance courses shall include not only the details and functioning of parts under discussion, but the essentials of their routine care, including:

- Dismantling and reassembling instructions
- Lubrication schedules,
- Materials,
- Contractor's recommendations for test frequency,
- Adjustments, tolerance limits, and
- Method of testing, including instruments and special tools required, when applicable.

Overhaul procedures shall be included.

The use of computer-based interactive multimedia sessions for the classroom training is preferred. The relevant documentation shall be delivered in CD-ROM in order to enable navigation through a combination of text, graphic and video sequences. The user shall be enabled to access circuit diagrams in multiple levels of definition as well as lists of spare parts of various components. Practical training will take place in situ as per training schedule.

Field instruction for maintenance courses shall include both on-vehicle demonstrations and demonstrations of basic overhaul procedures using the Operation Company Depot facilities.

Complex overhaul functions that require the destruction of components shall be demonstrated by film.

At the conclusion of the warranty period, one additional training course shall be provided for up to 10 representatives of the Operation Company, focusing on heavy overhaul of the vehicles and equipment.

The Contractor's attention is drawn to the fact that heavy overhaul training will take place on all subsystems including e.g. hydraulic brake units, traction motors, etc.

The Contractor shall bear in mind that during the warranty period his staff will provide practical demonstration on all training material as the need arises for troubleshooting and fault finding (with demonstration of use of diagnostic software) as well as maintenance works (with demonstration of use of special tooling).

#### **16.11.5 Instruction requirements**

Instruction shall include, at a minimum, the following:

1. Introduction to the equipment, including terminology, identification of major components, location on the vehicle;
2. Detailed theory of operation (including diagrams and schemes);
3. Routine care, including lubrication schedules, adjustments, limits inspection criteria;
4. Problem symptoms, troubleshooting techniques, and repair procedure;
5. Equipment components removal from the vehicle and replacement
6. Disassembly and reassembly and any special processes;
7. Instruction to the use of all special tools and processes, including diagnostic equipment and software.

#### **16.11.6 Required subjects**

The maintenance & troubleshooting training shall, at a minimum, include in-depth instruction covering the following subjects:

1. Exterior and interior panels, covers, fairings, glasses etc.
2. HVAC systems, including their controls;



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

3. Auxiliary power supply systems, including battery, battery charger, inverter, and controls
4. Braking systems, including controls and all braking components;
5. Lighting
6. Traction system, including traction motors, inverter and controls;
7. Cabling & circuit diagrams
8. Repair of car body components (underframe, side panels etc)
9. Replacement of wheels
10. Bogie disassembly and dismantling
11. Passenger doors
12. Low Voltage systems, signals, control units
13. TCMS IBIS System, including OBC and all its subsystems
14. Testing / verification procedures
15. Floor repair.

## 17 Project management requirements

### 17.1 General

Within 90 calendar days from contract signing, the Contractor shall submit to ATTIKO METRO for review and approval of the following documents concerning the Project execution method:

#### *Project Management Plan*

- It shall define the organizational structure of the Contractor, as regards the Project. It shall specify the responsibilities of each group involved in the Project needs and shall present the names of the personnel placed in key positions, accompanied by their qualifications and experience. Any changes in the Organizational structure and key personnel shall be subject to AM's prior approval.
- It shall define the method in which the Contractor shall sufficiently check all the main suppliers and sub-suppliers and ensure that they meet the requirements of this Performance Specification. Based on the above check, AM reserves the right to approve changes of the Contractor sub-suppliers.

#### *Designs Catalogue*

- The Contractor shall submit a complete catalogue with all future design submittals (Preliminary, Final and Detailed Final Designs).

#### *Weight Control Plan*

- It shall define the monitoring method of the overall vehicle weight resulting based on the individual weights of the various subsystems and the entire auxiliary equipment.
- It shall be updated throughout the Project's design and construction period and shall be submitted to AM on a monthly basis.

#### *Noise Control Plan*

- It shall define the vehicle planning monitoring process, as well as the monitoring of the design choices that will ensure that vehicle noise emissions shall conform to the Specifications and the International Standards.
- It shall record the noise produced by each system and shall be updated throughout the Project's design and construction period.
- It shall be submitted to AM on a monthly basis.

#### *System Integration Plan*

It shall describe in detail all means whereby the Contractor shall ensure that all vehicle systems and subsystems:

- are compatible and smoothly cooperating with each other in order to satisfy the requirements of this Performance Specification (e.g. traction, braking, TCMS)
- are compatible with the interfacing systems and subsystems of the network (e.g. station platforms, power supply, point machines, light signalling, OCC, etc.)
- are compatible with the Depot areas, as well as with the equipment existing therein
- are compatible with the Operation Company Road/Rail Tractor.
- are compatible with the Information system (chapter 13).

The submittal method of the above documents to AM, their review process and the necessary revisions that shall render their content acceptable to AM shall not conflict with the requirements set forth in paragraph 17.2 herein.

The Contractor shall provide a responsive written reply to all letters. It shall not be acceptable for the Contractor to merely confirm receipt of the Operation Company correspondence, or not to provide a thorough and considered response.

## **17.2 Engineering schedule and reviews**

### **17.2.1 General**

The preparation of technical designs by the Contractor as well as their revisions shall comply with the approved Project Time Schedule. It shall be the responsibility of the Contractor to promptly inform AM in writing of any anticipated delays in drawing or document submittal, with the justification for such delays, so that the impact may be assessed and appropriate measures are taken.

During the Design Review process, the Contractor shall submit the complete design and drawings of all major systems, subsystems and equipment of the tram, in order to ensure AM of the adequacy of all individual systems and the entire vehicle, and to confirm compliance with the Specification requirements.

The Contractor shall submit descriptions of all systems, describing in detail the nature and the functions of the system and its components, as well as how the system interfaces with any other system. The form and the content of this description shall be subject to AM's approval.

At a minimum, the engineering design of the following systems shall be submitted to AM for review:

- Car body Structure
- Traction Inverter
- Driver's cab layout
- Vehicle underframe layout
- Car Roof Layout
- Radio communications equipment

- Safety equipment
- Diagnostic test equipment
- HVAC equipment
- Power inverter equipment
- Auxiliary power supply equipment
- Braking Equipment
- PIS equipment
- Current collector equipment
- Lighting Equipment
- Car Interior Arrangement
- Couplers
- Seats
- Gearbox
- Traction Motor
- Door activation and control equipment
- TCU
- Windows and Glazing
- Battery
- IBIS system and subsystems
- Traction System
- Wheel sets
- Bogies
- TCMS & DDU
- OBC

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 Specification requirements.
- 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 personnel safety.
- To optimise product reliability.
- To ensure adequate maintainability.

- To identify the quality assurance techniques to be utilized, and any improvement potentials.

Each system's design document shall be submitted to AM for review, attached to a cover letter. Each cover letter shall accompany the design of one single system. Attaching more than one system designs to a single cover letter shall not be accepted by AM, unless the subject designs concern similar equipment and they are not extensive.

Each design document shall contain a Compliance Matrix prepared by the Contractor, which shall reference all pertinent sections of the Performance Specification and Contract, and shall clearly delineate how the proposed design meets these requirements.

Once the technical review of a design submitted to AM is completed, AM shall transmit to the Contractor its comments through the appropriate AM comments form. The Contractor shall resubmit the design, accompanied by a response sheet, providing responses and clarifications to AM's questions raised in the aforementioned comments form. Moreover, the main body of the design shall be updated – corrected in order to avoid repetition of the same comments. Whenever AM's corrections are mainly remarks on drawings, these drawings shall be corrected and resubmitted by the Contractor for review. Any modification to the text of the design shall be clearly indicated in the body of the text (using a different font); in parallel, it is absolutely essential to register any changes/corrections in the relevant changes log matrix. The response sheets and the changed log matrix shall be fully updated and attached to any resubmitted design. This procedure shall be repeated until the design is finally approved (see 17.2.5 herein).

The Contractor shall transmit the designs to AM as specified in the CC document; in addition, he shall also transmit them in a digital form. The type of the digital files and the manner of their transmittal shall be decided after contract signing.

The design and design review process for each vehicle subsystem will develop in three different levels of details, i.e. Preliminary, Final and Detailed Final design, according to paragraphs 17.2.2, 17.2.3 and 17.2.4, respectively.

### ***17.2.2 Conceptual Design Review***

The purpose of the Conceptual Design Review is to establish early agreement on the Contractor's approach to the design of the vehicle and its systems. Also, the system and subsystem requirements shall be finalized. The review shall be based on, and be consistent with, the Contractor's offer and the requirements of the Performance Specification, and shall provide the required additional detail necessary to fully describe the design approach, to eliminate ambiguities, and to define the specifications of the systems to be supplied by the Contractor's sub-suppliers. The conceptual design review may be accomplished progressively on a system-by-system basis. Sub-supplier representation shall be as selected by the Contractor and as deemed necessary to support the presentation of the design concepts.

The Contractor shall submit for review the conceptual design package to AM. This



package shall include descriptions of the major subsystems proposed by the Contractor and the sub-suppliers.

As a minimum, the Conceptual Design package shall concern the following features of each system:

- Equipment outer dimensions
- Piping sizes
- Estimated mass and centre of gravity
- Access for equipment control
- Access for equipment maintenance
- EMI envelope
- Direction of noise discharge
- Direction of cooling air intake and discharge
- Power requirements (nominal, inrush)

The conceptual design submission and review process shall be completed in accordance with the Project's approved time schedule, while the submittals shall not be submitted later than 120 days after contract signing.

#### ***17.2.3 Preliminary Design Review***

The Preliminary Design Review shall represent approximately 60% completion of the total engineering effort required for the vehicles to be supplied. All interface requirements are finalized. Included as part of the preliminary design package shall be:

- Equipment drawings
- Assembly and installation drawings
- Schematic diagrams
- Data sheets
- Performance calculations
- List of line replaceable units (LRUs)
- Mass and center of gravity of equipment and cars
- System performance descriptions
- System functional descriptions
- System interface descriptions
- Fire safety data
- Noise control plan and calculations
- Calorific data
- EMC technical information
- Etc.

The Preliminary Design review process shall be completed according to the approved project time schedule.

#### ***17.2.4 Detailed Final Design Review***

Hardware designs are finalized and the final versions of all documents are submitted.

All mockups are reviewed and any changes/modifications are implemented in the finalization of the hardware designs.

The Detailed Final Design review process shall be completed according to the approved project time schedule.

#### ***17.2.5 Design approval process***

All documentation corresponding to each of the above design stages, i.e. Conceptual, Preliminary and Detailed Final, shall be submitted to AM for review, revision and approval within the period of the corresponding stage.

It is recommended that the designs for all sub-systems belonging to a specific design stage have obtained the final approval prior to the submittal for review of the designs belonging to the next design stage. In other words, it would be preferable not to have designs for various sub-systems belonging to different design stages reviewed concurrently.

The Contractor's manufacturing schedule shall allow for a period of 30 calendar days from the date of receipt of submittals by AM to the issue of comments or approval. Five prints of drawings/documents shall be submitted to AM for review. After review by AM, the Contractor will be informed of the category into which each such drawing/document is placed, according to the following:

- a) Category 1 - Approved
- b) Category 2 – Approved, upon integration of the comments attached
- c) Category 3 – Revise and Resubmit
- d) Category 4 – For information - No review is required

Category 1 shall mean that the Contractor may proceed to manufacture in accordance with the accepted design.

Category 2 shall mean that the drawing/document shall be modified to the extent noted by AM and resubmitted to AM until it obtains the final approval, i.e., it is classified to Category 1. The Contractor may proceed to manufacture in accordance with the accepted design, subject to the modifications noted by AM being incorporated in full.

Category 3 shall mean that the Contractor must revise the drawing/document and resubmit it to AM for review until it obtains final approval. The Contractor may not proceed to manufacture.

Category 4 shall mean that AM has noted the information submitted on the drawing/document, that it is a detail not required for the drawing to be classified in Category 1 and that no further review is required. The Contractor may proceed to manufacture.

Drawings/documents in Category 2 or 3 shall be revised and resubmitted to AM for approval within 30 calendar days, calculated from the date of receipt by the Contractor of AM's comments. All revisions to drawings by the Contractor shall be plainly marked on the drawings, together with the date when the changes are made.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Meetings between AM and the Contractor, with/without sub-contractors presence are desirable for the purpose of providing clarifications about the designs/submittals.

In addition, the Contractor:

- shall transmit to AM for approval the agenda of the meeting prior to the proposed meeting date
- shall take all steps to ensure the presence of its specialized personnel
- shall draft the minutes of the meeting which are to be submitted to AM for approval.

The Contractor is reminded that approval by AM shall not does not constitute acceptance of the design's adequacy and accuracy and does not absolve the Contractor from any of his duties, responsibilities or liabilities under the Contract.

## 18 Quality Management requirements

### 18.1 General

The Contractor shall implement a Quality Management (QM) and Project Quality Plan (PQP) (QA) to assure the delivery of vehicles, equipment and provision of services meeting the requirements of this Specification.

A complete Quality Management and Project Quality Plan in accordance with ISO 9000 and IRIS or equivalent following the design, manufacture, delivery, testing and commissioning of the Tramway vehicles shall be produced within 60 days of contract signing.

Within the framework of submission of the aforementioned documents, the Contractor shall submit to AM for approval the curriculum vitae of the executive who will fill in the position of the person in Charge of the Quality Management.

AM shall return the QMS and the PQP to the Contractor 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 AM for review and approval.

In case the Contractor is a Consortium, the Quality Management System and the Project Quality Plan shall universal application documents and shall determine all quality procedures and objectives set by the Contracting Consortium.

The Consortium shall be represented by a mutually accepted Person In Charge of the Quality Management, as specified in the CC. The individual participating Companies of 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 documents proposed by AM must be implemented. Any acceptance of the QMS by AM 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 the Quality Inspection. Every provision of the final QMS and PQP versions must be in full compliance with the Contract.

All work and all material shall be produced and controlled in accordance with the standard ISO 9001, IRIS or equivalent.

### 18.2 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.
- Quality Manual describing the QMS overall structure and clarifying, among others, 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 one, which was finally approved by AM.
- Analytical Operational Procedures provided for by Standard 9001 and/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.

#### ***18.2.1 Structure of the Quality Management System and the 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, Interior Inspections, Corrective and Preventive Actions, Personnel Training, interior communication, personnel hiring and evaluation and the interior Non-Conformance Reports.
- Procedures related to the Project Management with reference to the Contract Management, the Worksite 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 Measurement Sheet Forms, Account and Protocol Forms, so that these may conform to the Legislation requirements. 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 the Project. 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 the 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 AM'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 Accepted 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, 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 encompass 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 demonstrable experience in the control of Rolling Stock material.

The proposed agency must be submitted to and approved by AM.

All independent laboratories employed in the execution of Non Destructive tests by any involved party must be accredited per ISO 17025.

- Time Schedule of Works responding to the contract and 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 Subcontractors, 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-conformance that may be identified during the execution of the Project and the corrective actions to prevent their re-occurrence. It also defines the procedure related to the verification of the effectiveness of the measures.
- Quality Inspections. The PQP defines the implementation method, its frequency and connection with the work phases.
- Action Plans. For every Construction/ Main Equipment (e.g.: car body, bogies, motors, brakes, doors, HVAC, gangway / couplers, pantograph, inverter, etc.) Manufacturing Phase they describe the individual actions required for its completion, the Person(s) in charge, the Checking Points of every action, which are classified in Approval Hold Points and in Attendance Points, the applicable Specifications, Regulations and Standards, the Recording Forms and the Control Agencies.
- Approval Hold Points concerning construction manufacturing works are the points where the presence of AM aiming at the issuance of a Permit for the Continuation of the Work is deemed necessary. Similarly, Attendance Points are defined as the points where the presence of AM 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.

### **18.2.2 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 at the Contractor's Quality Management System. This management includes the evaluation of the Suppliers by the Contractor, the submission and approval by AM, the handling of 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 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 material or system incorporated in the Project shall be subject to final approval by AM, following a respective submission of data concerning the Material/Equipment/System and the Supplier. The minimum required criteria for the approval of incorporated Material/Equipment/Systems are as follows:

- Provision of the Material/Equipment/Systems 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 AM 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 AM.

Based on the aforementioned approvals, the Contractor keeps a "List of Approved Material/Equipment/Systems of the Project", which has a unilateral validity for specific parts of the Project or specific applications. The list of Approved Material/Equipment/Systems includes, *inter alia*, a report of the approval document and constitutes an accompanying item of the already performed payments, as well as an item concerning the Project deliverables.

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 through the use of 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 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 AM, 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 Interior Non Conformance of the Contractor's System and is monitored through the method provided for by the QMS

### **18.2.3 Inspections on the application of the QMS and PQP**

According to ISO 9001, the implementation of the QMS is also checked, *inter alia*, through Interior 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 Interior 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 in 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 Checking Points Lists, focusing on the method of implementation of the Approval Hold Points by AM.

- **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 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, AM reserves the right to ask the Contractor to offer his support to AM personnel in terms of hardware (e.g.: 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.

### **18.3 Configuration Control**

#### **18.3.1 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 AM 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 subject.
- Reason for change.
- List of related documents.
- ATTIKO METRO S.A. & Contractor part numbers, serial numbers, quantities and location of affected parts or assemblies.
- The parts required to make the change.
- The effect of the change on interchangeability.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- Special tool requirements.
- Material disposition (rework, 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 test that the change achieves the desired result.

No changes shall be made to equipment until the ECN has been approved by AM.

For changes required to be made to equipment having been already delivered, the ECN shall also be accompanied by a Field Modification Instruction. 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 express approval of AM will the above procedure be waived. The Contractor shall submit to AM for review a monthly listing of all active design change requests and their implementation status.

## 19 Spare Parts and Tools

### 19.1 Warranty period

The Contractor shall provide all spare parts, including consumable spare parts required to support normal operation of the vehicles throughout the 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, brake pads, fuses, light bulbs, pantograph contact strips, wheel flange lubricating sticks, wheel rings, etc. Should they be prohibitively expensive to repair, printed circuit boards shall be regarded as consumable items. Cleaning agents shall not be regarded as consumable items. The Contractor shall not be responsible for damage to the vehicles caused by misuse or vandalism. Within 180 days of contract award, the Contractor shall be required to provide a complete listing of all such parts to be supplied, including the following information:

- Part description
- Contractor part number
- Original Equipment Manufacturer part number
- Quantity of each
- Unit price, CIF Depot
- Total price per item
- Maximum guaranteed delivery time from placement of order

It is clearly stated that the value of the consumables is included in the Lump Sum Price. The prices provided with the above list will be used only for reference.

### 19.2 Delivery time

The maximum allowed delivery time for any spare part is one month during the warranty period. To fulfil this requirement the supplier will receive the permission for his own storage area in the depot, if necessary.

### 19.3 Capital spare parts

Within 60 days of the delivery of the first vehicle, the Contractor shall supply the following capital spare parts to the Operation Company designated warehouse in Athens. Parts requiring any change in configuration as a result of experience during the warranty period shall be upgraded at no cost to the Operation Company.

With respect to quantities, the following definitions shall apply:

Vehicle set: The total quantity of the specified item used on one vehicle, including any special hardware required to complete the installation, or associated hardware that is normally destroyed during the removal of the item.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Where only a number is used in the quantity column, the required number of complete units/assemblies/items 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 only a “number per type” is used in the quantity column, the required number of complete units/assemblies/items of each different type of the specified component 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.

<b>Part Description</b>	<b>Quantity</b>
<b>Vehicle Body</b>	
Front end mask of driver cab	5
Driver's cab windshield, including seals	5
Driver's cab lateral windows right side, including seals	10
Driver's cab lateral windows left side, including seals	6
Exterior lateral panels (driver's cab) right side	20
Exterior lateral panels (driver's cab) left side	10
Exterior lateral panels (driver's cab) front side	10
Gangway assembly, complete (including interior and exterior bellows, movable and fixed floor parts, dumpers, sealing), ready to install on the car.	1 vehicle set
Articulation shock absorbers, complete ready to install on the car	1 vehicle set
Windshield wiper motor	6
Windshield washer assembly, complete, ready to install on car (including tank and pump)	5
Windshield wiper blade	10
Headlight assembly, complete, ready to install in car	5 vehicle sets
Taillight assembly, complete, ready to install in car	5 vehicle sets
Turn indicator light assembly	15 vehicle sets
Horns (all types)	15 per type
<b>Bogies</b>	
Motor bogie assembly, complete, ready for installation under car and immediate operation	1 vehicle set



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Trailer bogie assembly, complete, ready for installation under car and immediate operation	1 vehicle set
Bogie frame	2
Motor bogie axle wheelset, with gear	2
Trailer bogie axle wheelset	2
Gear box assembly (for one axle), complete	2
Wheels complete (with hubs, rims and earthings)	1 vehicle set
Bearing assemblies	2 vehicle sets
Primary spring assembly	2 vehicle sets
Secondary spring assembly	2 vehicle sets
Weight valve assembly, complete with linkage	2 vehicle sets
Secondary vertical, longitudinal and lateral dampers	2 vehicle sets
<b>Couplers and Draftgear</b>	
Towing bar complete, ready to be installed on the vehicle	2
Draftgear assembly.	5
<b>Car Interior</b>	
Exterior destination sign assembly	1 vehicle set
Passenger seat assembly	1 vehicle set
Stanchion assembly, complete with all installation hardware	1 vehicle set
Passenger grab handles complete	2 vehicle sets
Interior finish panels and trim strips and mounting provisions	1 vehicle set
Rubber floor covering	1 vehicle set
Floor panels	1 vehicle set
Light fixture assembly	1 vehicle set
Driver's seat assembly, complete, ready to install in car	2
Driver's seat cushion, fully upholstered	5
Driver's seat back, fully upholstered	5
Master controller assembly	4



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Set of master controller switches	4
Passenger compartment window assembly, complete, including seals	2 tramsets
Interior signs and decals	2 tramsets
<b>Doors and Door Controls</b>	
Passenger side entrance door panel assembly, complete, including weather-stripping, frames, ready to install on car	2 tramsets
Passenger side entrance door actuator assembly, complete, including DCU, ready to install on car	1 tramsets
Passenger side entrance door weather stripping	1 tramset
Passenger side entrance door glazing, including seals	1 tramset
Driver's cab door assembly, complete, including hinges, seals, lock, striker plate	2
Driver's cab door seal	6
Driver's cab door locks / handle	6
<b>HVAC Equipment –Driver's Cab</b>	
HVAC unit, complete, ready for installation on the car and immediate operation	2
Set of HVAC controls, complete	4
Set of HVAC system printed circuit boards	4 per type
HVAC system refrigerant compressor assembly, including electric motor	4
HVAC system evaporator blower assembly, complete with electric motor	4
HVAC system condenser coil assembly	4
HVAC system evaporator coil assembly	4
<b>HVAC Equipment –Passenger Compartment</b>	
HVAC unit, complete, ready for installation on the car and immediate operation	1 vehicle set
Set of HVAC controls, complete	4
Set of HVAC system printed circuit boards	4 per type

HVAC system refrigerant compressor assembly, including electric motor	4
HVAC system evaporator blower assembly, complete with electric motor	4
HVAC system condenser coil assembly	4
HVAC system evaporator coil assembly	4
Heating resistors assembly, complete, ready for installation on the car	4
<b>Braking System</b>	
Brake Control Unit (BCU) assembly	1 vehicle set
BCU printed circuit boards	2 per type
Hydraulic brake control unit	2 vehicle sets
Brake disc assembly	4
Brake actuator assembly, complete	4
Brake pads	4 vehicle sets
Brake actuator flexible hoses	2 vehicle sets
Set of speed sensors	5 per type
<b>Traction System</b>	
Traction Inverter assembly, complete, ready to install in car	2
Traction Control Unit (TCU), complete, ready to install on the car	2
TCU printed circuit boards	4 per type
Set of Traction Inverter power electronics modules	2
Set of Traction Inverter control equipment	2
Traction Inverter power conditioning equipment	2
750 Vdc high speed circuit breaker, complete	2
Pantograph complete, ready to install on the car	4
Set of pantograph strips	5
Traction motor	4
Set of speed sensors	5 per type



<b>Auxiliary Electrical System and battery charger</b>	
Auxiliary power supply and battery charger equipment assembly, complete, ready to install on the car	2
Auxiliary power supply and battery charger equipment printed circuit boards	2 per type
Set of auxiliary power supply and battery charger equipment power electronics modules	2
Set of auxiliary power supply and battery charger equipment control equipment	2
Auxiliary power supply and battery charger equipment power conditioning equipment	2
Battery cells	1 vehicle set
<b>Electronic Systems</b>	
Train Control and Monitoring System (TCMS) equipment complete, including cables connecting the distributed equipment, ready to install on the car	1 vehicle set
TCMS printed circuit boards	4 per type
Driver's display unit assembly complete	6
Event recorder complete, ready to install on the car	2
OBU assembly complete, ready to be installed on the car (including MMI)	2 vehicle sets
Video controller assembly complete, ready to be installed on the car	2
Video screens assembly	1 vehicle set
Audio controller complete, including amplifiers, ready to be installed on the car	2 vehicle sets
TETRA radio assembly complete, including control head, handset, loudspeaker	2 vehicle sets
Passenger counting system assembly, complete, including sensors, remote units, controller etc.	1 vehicle set
Antennas	2 per type
Communication modules (modems, access points etc.)	2 vehicle sets



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

<b>Miscellaneous equipment</b>	
Driver's console pushbuttons and switches	10 per type
DC/DC, DC/AC converters	5 per type
Control relays	20 per type
Circuit breakers	2 vehicle sets
Timers	10 per type
Power contactors	1 vehicle set
Power contactor tips	2 vehicle sets
Special electrical connectors	10 per type
Special mechanical fasteners	10 per type
Mechanical fasteners	1 vehicle set
Tram (TA2) to tram (TA1) adaptor	2 pieces

#### **19.4 Special tools and Diagnostic Equipment**

The Contractor shall supply any special tools and diagnostic equipment required for normal maintenance, overhaul, troubleshooting, functional testing and adjustment for all systems and equipment of the vehicle.

Four months before the arrival of the first tram, the Contractor shall submit to ATTIKO METRO S.A. an Operational Analysis, describing all the above functions, which will conclude to the list of special tools and diagnostic equipment required for this purpose. The Operational Analysis and the list of special tools and diagnostic equipment must be approved by ATTIKO METRO S.A..

Special tools include but are not limited to any test benches, test equipment, jigs, fixtures equipment, hand tools, power tools, or other tools and equipment necessary to test, maintain, repair, overhaul, assemble, and disassemble the vehicle, subsystems or components, that are not commonly available from commercial tool suppliers.

All special tools and diagnostic equipment have to be delivered before start of warranty of the first vehicle.

Diagnostic equipment include but are not limited to commercial or proprietary hardware and software, that are necessary for troubleshooting, functional test and adjustment of vehicle systems, subsystems or components.

All special tools and diagnostic equipment shall be supplied with the following documentation -as applicable- in every case:

- Operator's Instruction
- Maintenance, Calibration, Servicing & Overhaul Manuals
- Illustrated Parts Catalogues
- Technical Specifications (Detailed Final Design)



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

- Training Manuals
- Data sheets

The above mentioned documentation shall be supplied both in hard copies and electronic copies in CD ROM. All documentation in its final form shall be submitted in Greek (6 copies) and English (6 copies). Any intermediate arrangements concerning approval of documentation shall be proposed by the Contractor and approved by ATTIKO METRO S.A.

The Contractor shall supply five laptops loaded with all necessary operating system and application software (along with the relevant licences) for:

- Troubleshooting
- Functional tests
- Diagnostic memory reading/ clearing
- Adjustment and/or parameter setting

for all different control units existing on the vehicle (CCU, TCU, BCU, DCU, OBU, etc).

The laptops will be delivered with full operating system and application software licences. The software and licences shall also be delivered as back-up copy in CD-ROM.

These laptops shall be heavy-duty type, suitable for connecting to the vehicle's interfaces and shall be equipped with the necessary cables and adaptors required for connecting to the vehicle's devices.

## 20 Appendix 1 : Vehicle Interfaces with the existing systems, vehicle envelopes and the depot

### 20.1 Depot and Workshop

In addition to the information provided in this unit, the Bidders have the option to visit the Depot, in order to collect more information.

#### 20.1.1 Track layout drawings

A depot layout plan as built is given in the attached drawings.

#### 20.1.2 Maintenance Workshop

The maintenance workshop location within the worksite is shown in the attached drawings. More information are available upon request.

#### 20.1.3 Lifting jacks (CESPA)

The depot at Elliniko is equipped with 3 groups of lifting jacks, each composed of 12 jacks. The jacks of each group operate in full coordination, so that the entire vehicle is lifted by 12 lifting jacks.

The main technical characteristics of the lifting jacks available in Elliniko Depot are presented in the following table.

**Table 20.1.3.1:** Technical characteristics of CESPA lifting jacks

Lifting jack capacity	10.500 Kg
Lifting speed	0.2m/min
Vertical course of the jack's lifting surface	1.800mm
Maximum height of the jack's lifting surface in relation to the jack's rolling surface (i.e. the floor)	1.875mm
Minimum height of the jack's lifting surface in relation to the jack's rolling surface (i.e. the floor)	75mm
Dimensions of the jack's lifting surface. In any case, the entire area of the lifting surface must come in contact with the vehicle	120x200mm <sup>2</sup>
Minimum horizontal distance between two successive vehicle surfaces where the jack is attached	1200mm

The plan and side views of the jacks in Elliniko Depot are presented below.

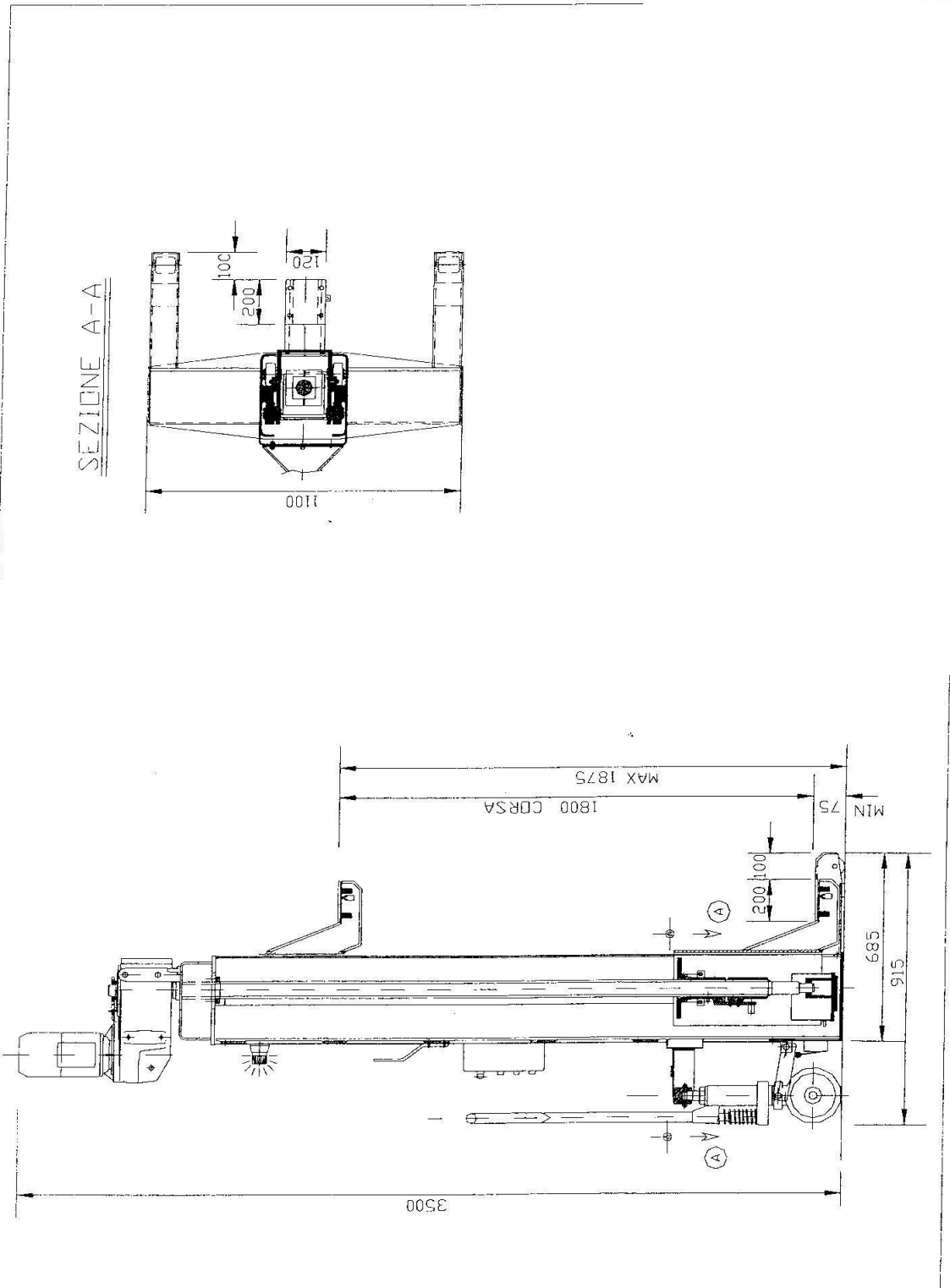


Fig. 1.3.1: CESPAs lifting jacks

#### **20.1.4 Sand refilling system (KLEIN)**

The sand filling system installed in Elliniko Depot is composed of 4 sand nozzles, 2 on each side of the track 8. The distance of the nozzles installed on the same side of track 8 is 30m from each other. Flexible tubes, each one 4m-long, are connected to the above sand nozzles.

At the end of each flexible tube, there is the sand flow control device, part of which is the sand nozzle, equipped with a grip. The sand nozzle is made of a metal tubular straight pipe with an outer diameter of 35mm and a length of 100mm.

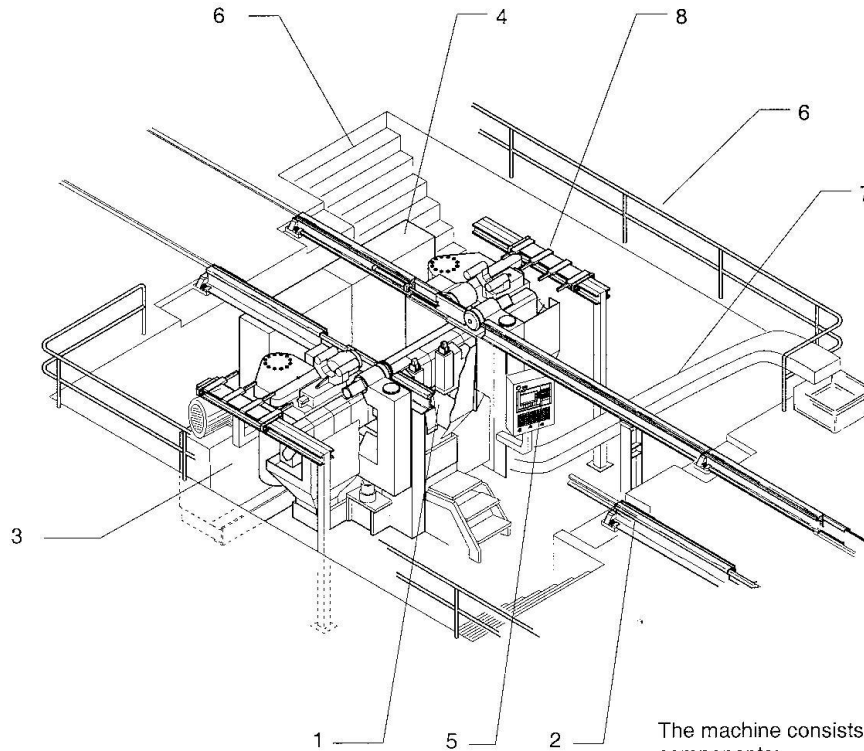
#### **20.1.5 Under floor wheel lathe (HEGENSCHEIDT)**

The underfloor wheel lathe installed in Elliniko Depot is type Heggenscheidt U 2000, year of manufacture 2003. The vehicle wheels to be machined are rolled on pulleys which come in contact with the wheel tread, while the bogie is fastened on the lathe by a means of bolts which tighten the bogie on the lathe's main body.

A simplified 3-D view is presented below.

### Short description

Construction example:



The machine consists of the following components:

1. Machine stands
2. Rail system
3. Hydraulic unit
4. Electrical cabinet
5. Main operating panel
6. Stairs, railings (construction example)
7. Chip disposal system (construction example)
8. Linear magazine \*
9. Dust extraction unit \* (construction example)
10. Supporting blocks \*

\* if existing

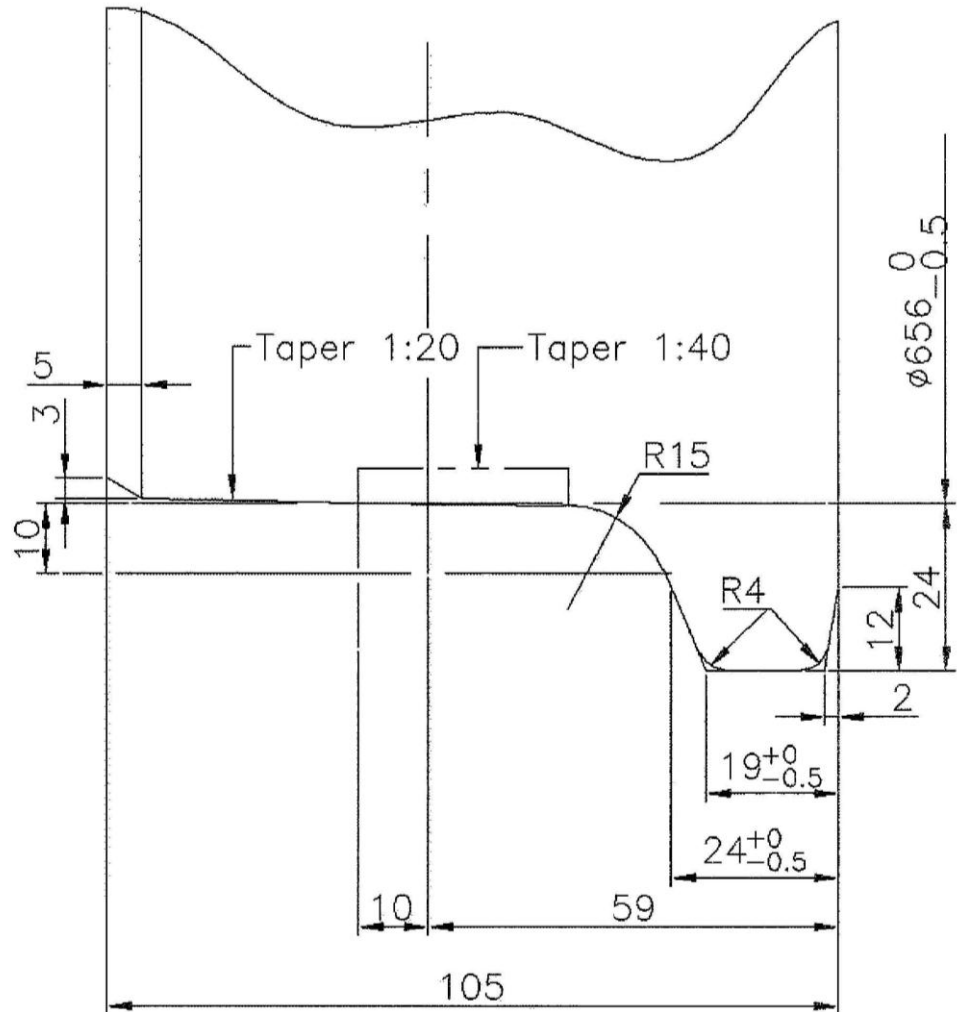
**Fig. 1.5.1:** 3D-view of the Hegenscheidt U2000 underfloor wheel lathe.

#### **20.1.6 Current wheel profile**

The existing vehicle wheel profile is provided below as a reference.

Drawing of the wheel profile

## WHEEL PROFILE



**Fig. 1.6.1:** Current wheel profile

The back-to-back distance of the wheels on an axle is  $1382_{-1.5}^{+0.5}$  while the minimum permissible flange thickness (worn) is 18.5mm.

### **20.1.7 Paint Booth**

The main dimensions of the paint booth are presented in the following Table:



**Table 1.7.1:** Main dimensions of the paint booth

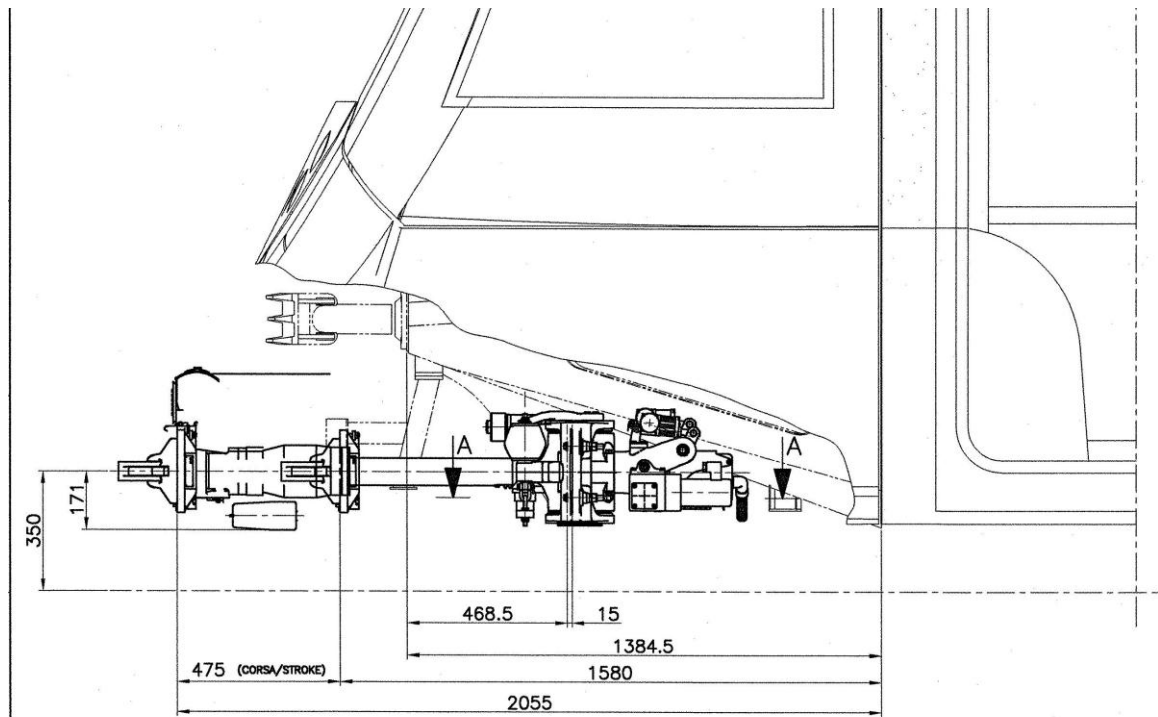
#	Description	Value
1	Internal length	36.5m
2	Internal width	5.5m
3	Internal height	5.0m
4	Front opening (net width x height)	4.8m x 4.3m <sup>2</sup>

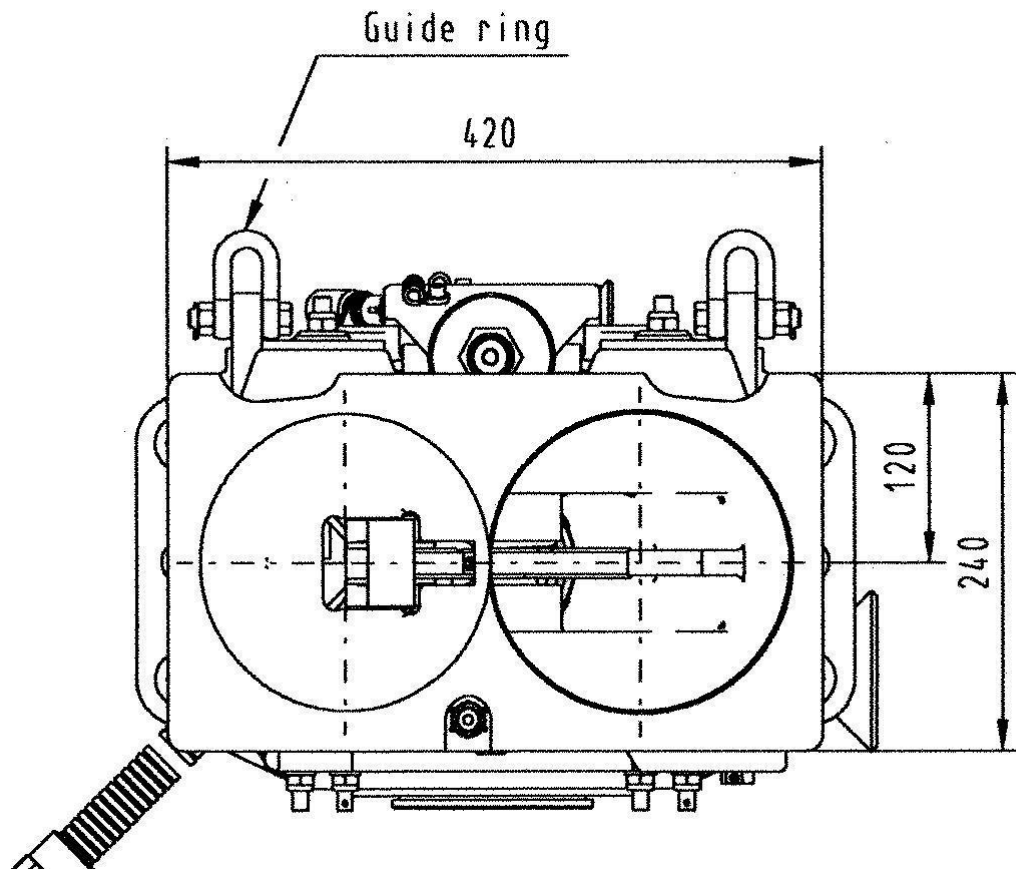
The floor of the paint booth is flat and it is not fitted with a manhole/corridor.

The vehicle paint booth is equipped with two metal platforms moving in parallel on either side of the vehicle and in independent horizontal and vertical directions. The distance between the two platforms when one faces the other at the same level is 3.2m.

#### **20.1.8 Coupler interface**

Series I vehicles are equipped with automatic coupler type 371 from Dellner. The following drawings indicate the mechanical interface with the Series I vehicle.





**Fig. 1.8.1:** Side and front views of the automatic coupler for the existing vehicles (371 Dellner)

## 20.2 Traction Power System (TPS)

### 20.2.1 Description

The existing TPS of the Tramway constitutes of the following installations:

- 14 Traction Power sub-stations for serving the commercial lines of the Tramway and 1 Traction S/S for serving the Depot of the Tramway, located in Elliniko area/Athens. Another Traction Power S/S will be constructed near Piraeus to cover the needs of the extension.
- Over-head (catenary) main power lines constructed over the central line of the Tracks along the Tramway lines.
- Overhead (catenary) power lines for Depot and stabling area, electrically separated from both the main power commercial lines of the Tramway (by means of a section insulator in the overhead Line Equipment and insulating rail joints in the tracks).
- Rails of the tracks and cables for returning the current to the rectifier of the TPS S/S.

### 20.2.2 TPS Power Supply

The power to the Traction substation is supplied for every S/S from the PPC 20KV AC, 50Hz local network at the various locations along the route of the Tramway.

The traction substations transform the power from 20KV AC to 635V AC, rectify the power from 635V AC to 750VDC and supply the overhead line contact wire with the D.C. positive pole.

#### 20.2.2.1 Reference Values

#	Description	Reference
1	Nominal voltage	750V DC (+20%, -30%).
2	Lower voltage on wire	500V DC (EN 50163)
3	Insulation	1.5 KV DC with double insulation according to EN 50122-1
4	Maximum acceleration current for each vehicle	950 A
5	Maximum current for overhead line protection	appr. 4 kA
6	Maximum current for recuperation	950 A
7	Maximum voltage for recuperation	900 V
8	Track to earth voltage (network)	120V (EN 50122)
9	Track to earth voltage (Depot)	60V (EN 50122)

### 20.2.3 General configuration of Traction S/S

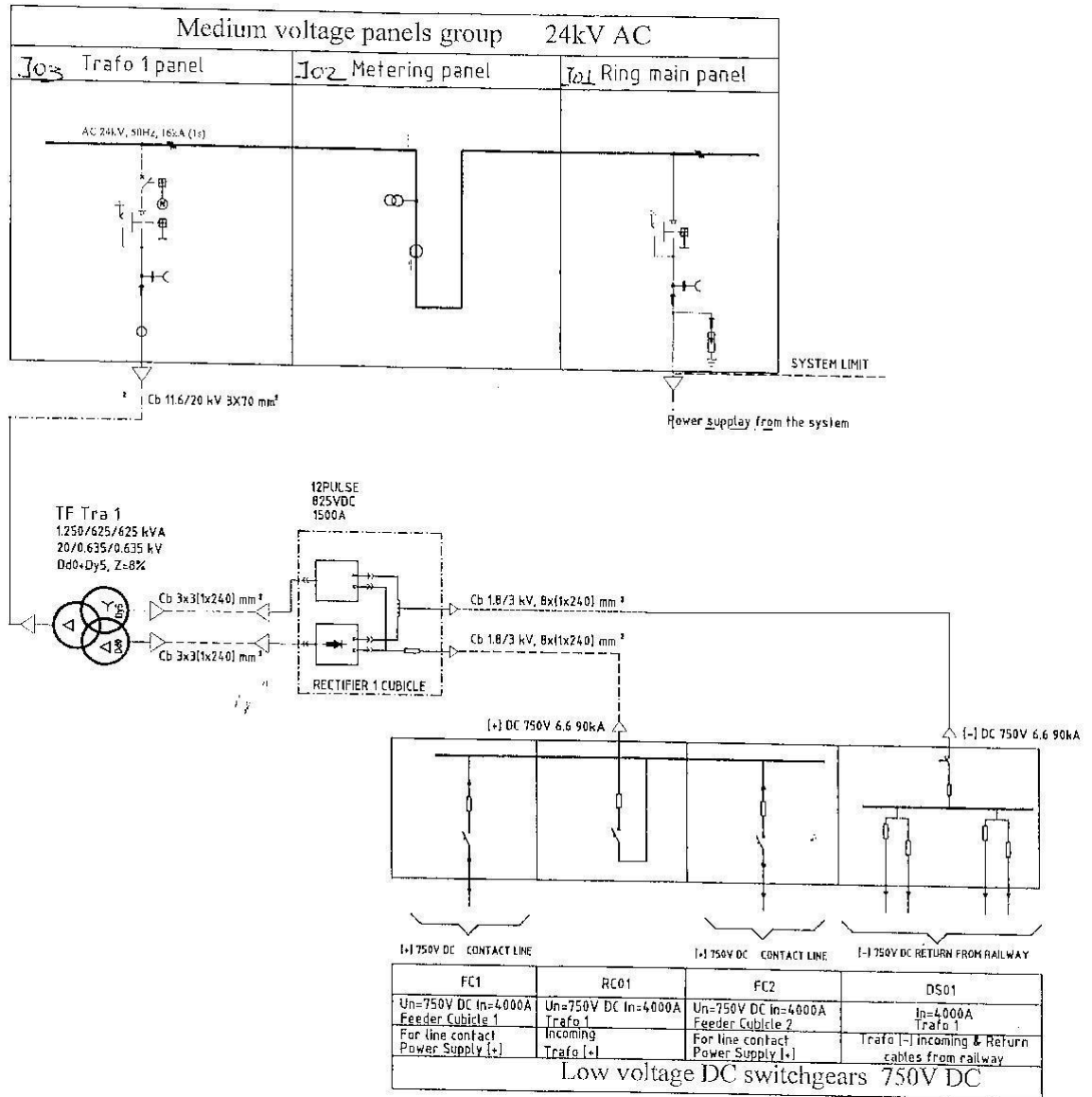
The typical substation is made of:

- 1 set transformer / Rectifier (1 x 1250KVA / 1 x 1500A DC = 1250KVA / 1500A DC)

or

- 2 set transformer / Rectifier (2 x 1250KVA / 2 x 1500A DC = 2500KVA / 3000A DC)

The typical configuration of a Traction S/S with 1 set Transformer / Rectifier (1 x 1250 KVA / 1 x 1500A DC) = 1250KVA / 1500A DC, is presented in the single line diagram in the following figure.



**Figure 2.3.1:** Typical configuration of a Traction S/S with 1 set Transformer / Rectifier

#### 20.2.4 TPS Overhead Line (catenary)

The Overhead Line (catenary) carries, distributes and supplies power to the Tramway vehicles- by means of the contact wire.

The contact wire is supported and restrained over the tracks along the Tramway line in such geometry, so that the current received by the Tram pantograph is effective without causing wear to the pantograph and to the contact wire. This is achieved by means of an automatic tensioning system (in combination of adjustable and fixed tensioning wheels and counterweights).

The existing catenary network is extended to the routes indicated in the following table:

**Table 2.4.1: Tramway network – contact wire**

Route	From – to	Km	
S1 / S3	SEF – Voula	0.000 – 15.413	Contact wire Ri 120, one or two messenger copper wires 120mm <sup>2</sup> each.  Contact wire 2xRi 120 (120mm <sup>2</sup> ), without suspension cable (Glyfada-Voula section).  Contact wire Ri 120 (120mm <sup>2</sup> ), without suspension cable (Voula terminal stop).
S2	Paleo Faliro - Syntagma	5.700 - 14.130	Contact wire Ri 120, one or two messenger wires, feeder copper cable 400mm <sup>2</sup> .  Contact wire 2xRi 120, without suspension cable (locally).
S3.8	S3 - Depot	0.0 – 2.6	Contact wire Ri 120, one or two messenger copper wires, 120mm <sup>2</sup> each.
P1	SEF - Piraeus	0.0 – 5.450	Contact wire 2X120mm <sup>2</sup> without messenger wire

With the specified contact wire dimensions, the traffic on which the calculations are based utilizes contact wire CuAg-0.1 120mm<sup>2</sup> grooved, minimum tensile strength 340N/mm<sup>2</sup> according to the standard DIN 43141 or equivalent.

Cross section for messenger wire 120mm<sup>2</sup> with two copper stranded wires (37 single wires) E-Cu F 37 according to standard DIN 48201 or equivalent.

Connection between contact wire and messenger wire by droppers Cross-Section 25mm<sup>2</sup> flexible copper wire (135 single wires), tensile strength 589N/mm<sup>2</sup> according to DIN 43138 or equivalent.

#### **20.2.4.1 Contact Wire Stagger**

The stagger of the overhead contact wire ensures a nearly constant wear of the contact strips of the pantograph. The nominal contact pressure of the pantograph is 80N. The stagger is normally 400mm to each side. In spans of less than

approximately 35m, the stagger is reduced to maintain a maximum stagger sweep of 10mm/m. On curved track, the contact wire is staggered towards the outside of the curve depending on the curve radius up to a maximum of 350 mm.

#### **20.2.4.2 Contact Wire Heights and Gradients**

The following limitations have been considered in the design of the Overhead Line Equipment.

**Table 2.4.2.1:** Geometrical characteristics of contact wire location

Minimum contact wire height	4.00 m (TOR)
Minimum contact wire height on public streets	4.70 m (TOR)
Maximum contact wire height	6.10 m (TOR)
Nominal contact wire height	5.50 m (TOR)

The minimum contact wire height will be maintained with consideration being given to wire sagging due to temperature rise and installation tolerances.

The indicative maximum gradient of the contact wire relative to the track is less than 5:1000 on main tracks and 15:1000 on the Depot areas. However, the system is designed for normal gradient or less than 1:400.

#### **20.2.4.3 Overhead line equipment for Depot and stabling area**

##### **20.2.4.3.1 General**

Both Depot and stabling areas are electrically separated from the commercial mainline overhead line system by means of both a section insulator in the Overhead Line Equipment and insulating rail joints in the tracks. Section insulators and insulating joints can be bridged by a special bridging system.

Each overhead catenary entering one of the workshop buildings is sectionalised in front of the entry doors by non-bridgeable section insulators.

Section insulators will separate each internal Depot and stabling area electrically. Therefore, the Depot area consists of electrically independent sections (without workshops) to allow independent vehicle operation in the different Depot sections.

##### **20.2.4.3.2 Stabling area**

The catenary system for the stabling area is designed and constructed as rigidly anchored single contact wire system. Outside the stabling area, the single contact wire system is mounted to cross span arrangements and cantilevers by means of wire sliders and lateral holders and/or curve extension devices. The span for the rigidly anchored single contact wire construction design is 25m.

The masts are designed as concrete poles.

#### **20.2.4.3.3 Workshop Building**

The catenary in the workshop building is also designed as a rigidly anchored single contact wire system. The building entries are provided with folding doors, the contact wire – coming from the open areas into the hall without termination before.

The tracks in the building are supplied via a line circuit breaker. Distribution to the individual feeding sections within the hall is from Depot sub-distribution systems. Feeding of the catenary is via motorised feeding switches with attached earthing wire.

#### **20.2.5 Lightning protection**

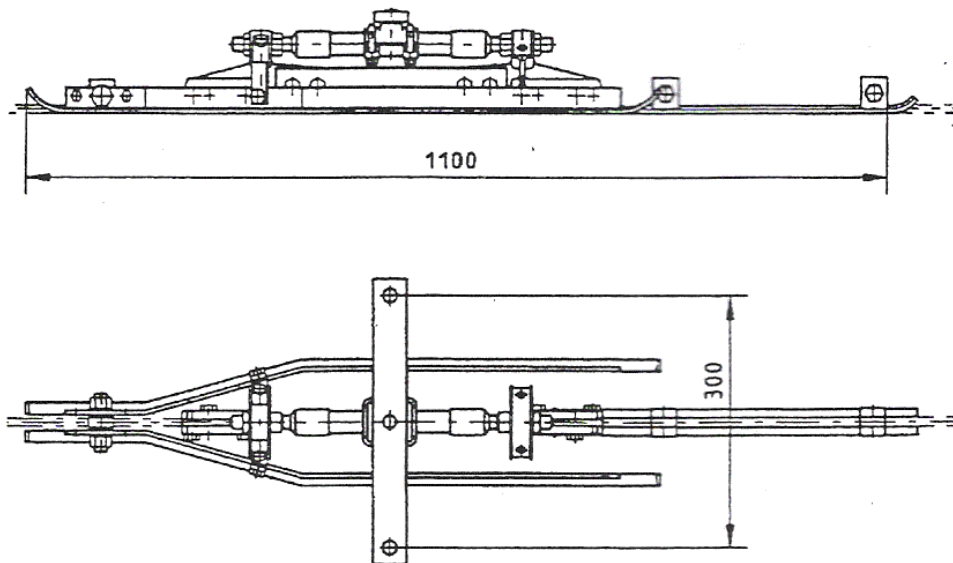
Surge arresters are connected by 70mm<sup>2</sup> copper wire between the OHLE and rail and are suitable for a rated voltage of up to 1000 Volts DC. Nominal discharge current is 10kA. Permissible short circuit loading is 20kA/0.2s.

The lightning protection air gap for a rated voltage up to 1500Volts DC is connected with the OHLE and both are linked by the shortest path with physical earth/protection earth. Depth earth bars are driven into the ground until the earth resistance is < 2 Ohm.

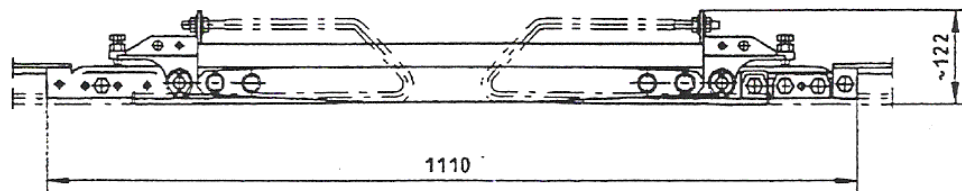
#### **20.2.6 Section insulator**

The installed section insulator is of the standard design commonly employed on rail or tramway system. The section insulator is equipped with two insulator plates made of resin bonded glass fibre beams. All parts of the section insulator that are in contact with the pantograph are made of copper to ensure continuity in the contact material. This excludes the section insulators to the workshops, which will be of the non-bridgeable design. The design will permit installation without previously cutting the contact wire.

##### **20.2.6.1 Switching and Sectioning**



**Fig. 2.6.1.1:** Section insulator for the lines



**Fig. 2.6.1.2:** Non-bridgeable section insulator for Depots

Knife blade type track switches mounted on top of the masts supporting the overhead contact system are utilised. Track switches are installed at traction power substation feed-in locations. The track switches are able to carry up to 2000A continuous load in the closed position. The track switches for the OHLE of the workshop buildings are equipped with an additional earth contact if switched into the open position. All the above-mentioned track switches are motor operated in order to improve the operational properties.

The type of isolating switch requires to be operated under No-Load Conditions. In cases of emergency, the track switches are equipped with arching horns so that arching will not damage the track switch.

### 20.2.7 Earthing concept



Each Substation building has its own foundation grounding system. All the masts and the station equipment are connected on a common grounding wire, which runs along the tramway. This grounding system is connected to the negative pole of the power system through several Voltage Limiting Devices. All structures in the Depot are also interconnected and grounded through a separate grounding system. All masts along the tramway route are grounded in groups and connected to the stray current system.

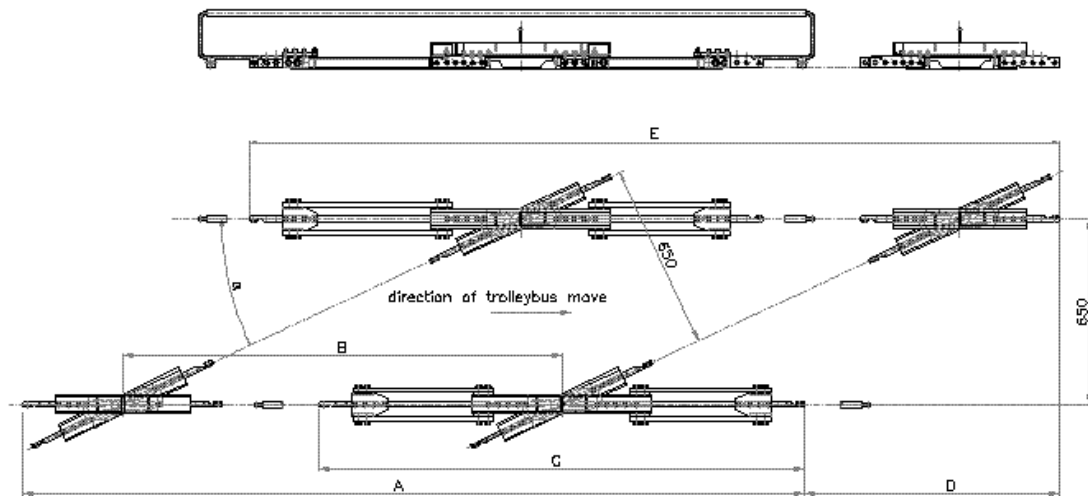
### 20.2.8 Crossing of Tramway with trolley-Bus Network

There are several crossings between Tramway and Trolley-Bus Overhead electrical network in the S2 route of the Tramway.

The crossings are manufactured by:

Kummler & Matter. Types are: Crossing ETB–TW 15o–16o bridging ETB for 2C.W TW Flat profiles and crossing ETB–TW 35o–65o non-bridging ETB for 2C.W TW, both types without current interruption.

Elektroline Model types 262-XXX with current continuity and 265-XXX with power interruption for the tram (power gap 2.7m)



**Fig. 2.8.1:** Elektroline Series 262-XXX. Electrical continuity for tram

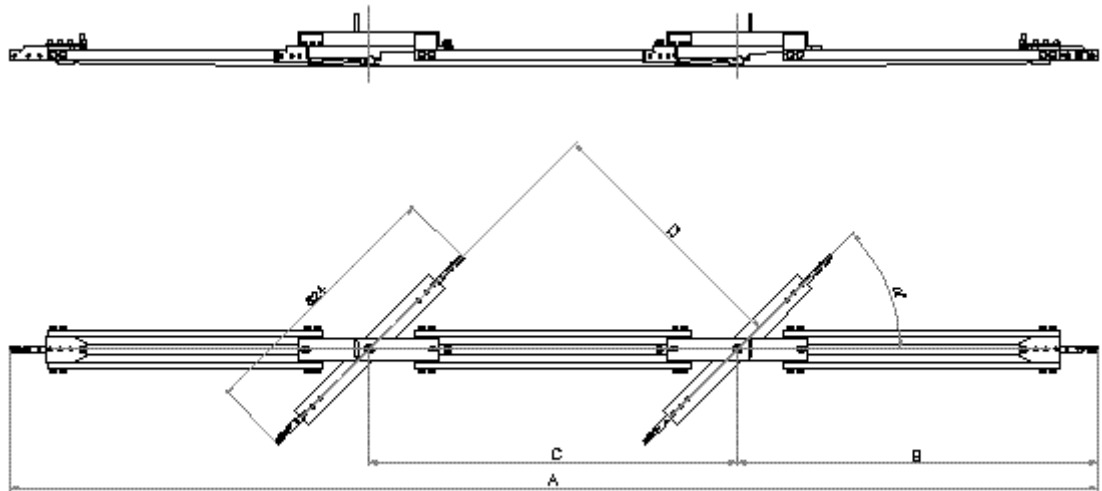


Fig. 2.8.2: Elektroline Series 265-XXX. Electrical discontinuity for tram

### 20.3 Envelope of vehicles

Figure 3.1 presents the dimensions of the vehicle gauges and envelopes, which refer to a straight flat track. In the platform area (shown in the Figure), the distance between the platform edge and the threshold of the stopped vehicle must not exceed 100mm.

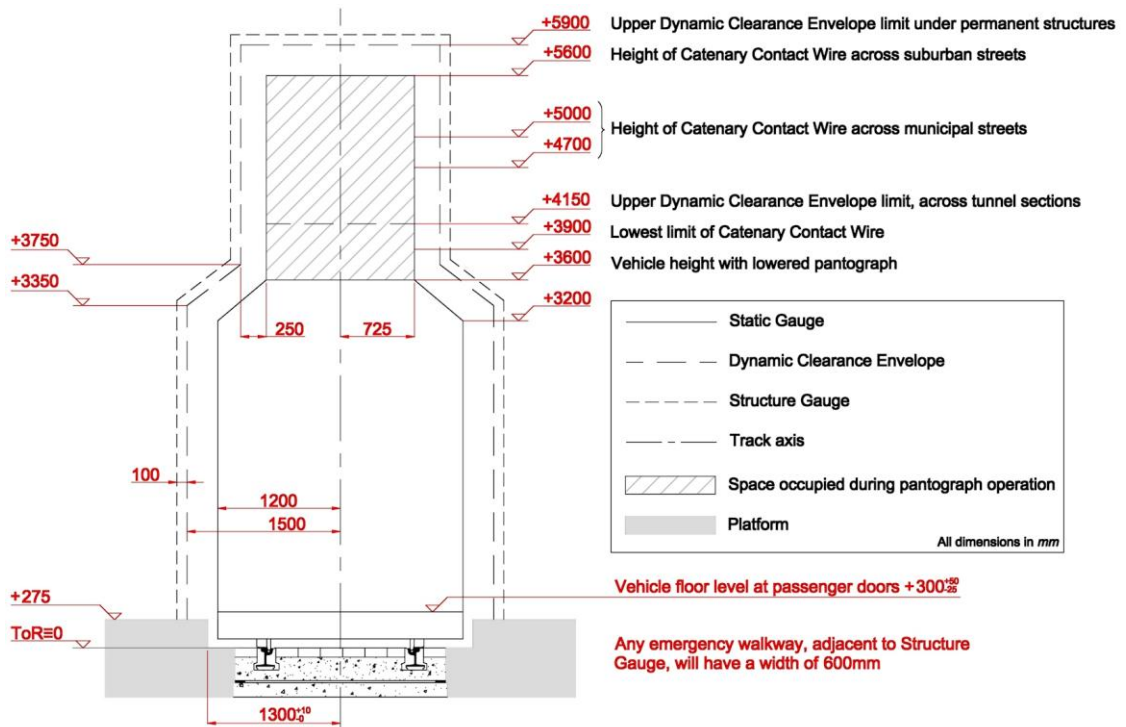


Fig.3.1: Vehicle gauge

#### 20.4 Gauge enlargement due to horizontal curves (throw)

While a vehicle with straight sides is moving on a horizontal curve, parts of the vehicle drift away or, in other words, “there is a throw” as to the track axis. Thus, throw at any point of a vehicle on a curved track is the difference of the distance between the location of the point of throw (along a normal coordinated axis) and its location on a straight track. The maximum vehicle throw at the exterior side of the curve is called End Throw and the maximum vehicle throw at the interior side of the curve is called Centre Throw. The values of these throws (which are added to the vehicle gauge), based on which the tracks of the network have been designed, are quoted in table 3.1 below.

**Table3.1:** Maximum vehicle throw at curved tracks

Curve Radius (m)	End Throw (mm)	Centre Throw (mm)
18	372	261
19	354	247
20	338	234
21	323	223
22	309	213
23	297	204
24	285	195
25	274	187
26	264	180
27	255	173
28	247	167
29	238	161
30	231	156
31	224	151
32	217	146
33	211	142
35	199	133
36	194	130
38	184	123
40	175	117
42	167	111
44	160	106
45	156	104
48	147	97
50	141	93
60	118	78
75	95	62

80	89	58
90	79	52
100	72	47
150	48	31
200	36	23
300	24	16
400	18	12
500	14	9
750	10	6
1000	7	5
2000	4	2
4000	2	1
5000	1	1

In the case of Series TA1 vehicles, when running on tracks with a cant equal to E[mm], the value of the vehicle's structural gauge on the inner side of the curve is increased (additionally to the centre throw value) by a factor equal to  $2.13 \cdot E$ .

## 20.5 Trackwork

### 20.5.1 Type of rails

The types of the used rails are:

- 49E1 (S49)
- 55R1 (Ri55NK)
- 60R2 (Ri60N)

and they are replaced when wear reaches the maximum allowable limits, i.e.:

- 25mm - sides (at the edge of the track gauge),
- 22mm – vertically (at the TOR) or
- 35mm - cumulatively (sum of the above two values).

The maximum allowable widening of the rail groove towards the centre of the track is 16 mm.

### 20.5.2 Track gauge

The track gauge value is  $1435_{-1}^{+2}$  on straight and curved sections of the track.

### 20.5.3 Type of turnouts

The typical layout of the turnouts is given in the drawings attached to the Appendix.

## 20.6 Alignment

The maximum allowable cant gradient value is 1/300mm while the maximum allowable cant value is 150mm. In sections with constant or zero cant, cant application tolerances are  $\pm 5$ mm, while in sections with variable cant the respective tolerance is  $\pm 3$ mm.

Finally, the vehicles shall be capable in all cases to move in both directions on all tracks and throughout their length.

## 20.7 List of Drawings

### Extension to Piraeus

Type	File name	Refers to
Horizontal layout	HOR_ALN-REV-3_2000	PIRAEUS
Long. Profile	VER0001_1	PIRAEUS
Long. Profile	VER0002_1	PIRAEUS
Long. Profile	VER0003_1	PIRAEUS
Long. Profile	VER0004_0	PIRAEUS

### Extension to Voula

Type	File name	Refers to
Horizontal layout	DFD_DR_ALN_S3_HOR_V001_0	VOULA
Long. Profile	DFD_DR_ALN_S3_VER_V001_0	VOULA

### Base Project

Type	File name	Refers to
Horizontal layout	ASBhor0001_B	S1
Horizontal layout	ASBhor0002_B	S1
Horizontal layout	ASBhor0003_B	S1
Horizontal layout	ASBhor0004_B	S1
Horizontal layout	ASBhor0005_B	S1
Horizontal layout	ASBhor0006_B	S1
Horizontal layout	ASBhor0007_B	S1
Horizontal layout	ASBhor0008_B	S1
Horizontal layout	ASBhor0009_B	S1



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Horizontal layout	ASBhor00010_B	S1
Horizontal layout	ASBhor00011_B	S1
Horizontal layout	ASBhor00012_B	S1
Horizontal layout	ASBhor00013_B	S1
Horizontal layout	ASBhor00014_B	S1
Horizontal layout	ASBhor00015_B	S1
Horizontal layout	ASBhor00016_B	S1
Horizontal layout	ASBhor00017_B	S1
Horizontal layout	GroundPlan1	S1 (all)
Long. Profile	NASBver0001_A	S1
Long. Profile	NASBver0002_A	S1
Long. Profile	NASBver0003_A	S1
Long. Profile	NASBver0004_A	S1
Horizontal layout	ASBhor0044_B	S2
Horizontal layout	ASBhor0045_B	S2
Horizontal layout	ASBhor0046_B	S2
Horizontal layout	ASBhor0047_B	S2
Horizontal layout	ASBhor0048_B	S2
Horizontal layout	ASBhor0049_B	S2
Horizontal layout	ASBhor0050_B	S2
Horizontal layout	ASBhor0051_B	S2
Horizontal layout	ASBhor0052_B	S2
Horizontal layout	ASBhor0053_B	S2
Horizontal layout	ASBhor0054_B	S2
Horizontal layout	ASBhor0055_B	S2
Horizontal layout	ASBhor0056_B	S2
Horizontal layout	ASBhor0057_B	S2
Horizontal layout	ASBhor0058_B	S2
Horizontal layout	ASBhor0059_B	S2
Horizontal layout	ASBhor0060_B	S2
Horizontal layout	ASBhor0061_B	S2
Horizontal layout	ASBhor0062_B	S2
Horizontal layout	ASBhor0063_B	S2
Horizontal layout	ASBhor0044_B	S2
Horizontal layout	ASBhor0044_B	S2



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Horizontal layout	ASBhor0044_B	S2
Horizontal layout	ASBhor0044_B	S2
Horizontal layout	ASBhor0076_B	S2
Horizontal layout	GroundPlan2	S2 (all)
Long. Profile	ASB.VER.0001.A	S2
Long. Profile	ASB.VER.0002.A	S2
Long. Profile	ASB.VER.0003.A	S2
Long. Profile	ASB.VER.0004.0	S2
Long. Profile	ASB.VER.0005.0	S2
Long. Profile	ASB.VER.0006.0	S2
Long. Profile	ASB.VER.0007.0	S2
Long. Profile	ASB.VER.0008.0	S2
Long. Profile	ASB.VER.0009.0	S2
Long. Profile	ASB.VER.0010.0	S2
Long. Profile	ASB.VER.0011.0	S2
Long. Profile	ASB.VER.0014.A	S2
Long. Profile	ASB.VER.0015.0	S2
Long. Profile	ASB.VER.0016.A	S2
Long. Profile	ASB.VER.0017.A	S2
Long. Profile	ASB.VER.0101_A	S2
Horizontal layout	hor0018_B	S3
Horizontal layout	hor0019_B	S3
Horizontal layout	hor0020_B	S3
Horizontal layout	hor0021_B	S3
Horizontal layout	hor0022_B	S3
Horizontal layout	hor0023_B	S3
Horizontal layout	hor0024_B	S3
Horizontal layout	hor0025_B	S3
Horizontal layout	hor0026_B	S3
Horizontal layout	hor0027_B	S3
Horizontal layout	hor0028_B	S3
Horizontal layout	hor0029_B	S3
Horizontal layout	hor0030_B	S3
Horizontal layout	hor0031_B	S3
Horizontal layout	hor0032_B	S3



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**

Horizontal layout	hor0033_B	S3
Horizontal layout	hor0034_B	S3
Horizontal layout	hor0035_B	S3
Horizontal layout	hor0036_B	S3
Horizontal layout	hor0038_B	S3
Horizontal layout	hor0039_B	S3
Horizontal layout	hor0040_B	S3
Horizontal layout	hor0041_B	S3
Horizontal layout	hor0042_B	S3
Horizontal layout	hor0043_B	S3
Horizontal layout	GroundPlan3	S3 (all)
Long. Profile	ASB.VER.001.A	S3
Long. Profile	ASB.VER.002.A	S3
Long. Profile	ASB.VER.003.A	S3
Long. Profile	ASB.VER.101.A	S3
Long. Profile	ASB.VER.102_0	S3
Horizontal layout	GroundPlan	S3.8 - depot
Long. Profile	VER_0001_A	S3.8 - depot
Long. Profile	VER_0002_A	S3.8 - depot



## Elliniko Depot

Type	File Name	Refers to
"As Built" Depot	01	Depot
Depot Track Alignment	02	Depot

## Existing Maintenance Infrastructure

Type	File Name	Refers to
Washing Plant - Bogies	01	Depot
Τόπος	02 - 07	Depot

## Wheel Profile

Type	File Name	Refers to
Wheel Profile	01 - 02	Wheel Profile

## Coupler

Type	File Name	Refers to
Coupler	01 - 03	Coupler

## Traction System

Type	File Name	Refers to
Traction	01	Traction



## **21 Appendix 2: Tramway network alignment – profile and characteristics**

A CD with a series of alignment drawings is attached hereto.

A general layout of the Tram network in Athens (in operation, under construction and under design) is shown in the attached map.



**SUPPLY OF ROLLING STOCK (SERIES II)  
OF THE ATHENS TRAMWAY NETWORK  
PERFORMANCE SPECIFICATIONS**

**RFP- 273/15**



Athens Tramway Network Map