ΜΕΤΡΟ ΘΕΣΣΑΛΟΝΙΚΗΣ
ΑΤΤΙΚΟ ΜΕΤΡΟ Α.Ε.

TITLE OF THE TENDER: **"PROCUREMENT, INSTALLATION AND COMMISSIONING OF THE SIGNALLING & AUTOMATIC TRAIN CONTROL (ATC) SYSTEM AND OF THE AUTOMATIC TRAIN SUPERVISION (ATS) SYSTEM IN THE THESSALONIKI METRO EXTENSION TO KALAMARIA"**
RFP-335/18, Α.Σ. 59046

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DESIGN, PERFORMANCE, MATERIALS AND WORKMANSHIP SPECIFICATIONS

Spec. Code	Specification Description
T_DP15250	**SIGNALLING SYSTEM**

CONTENTS

1 INTRODUCTION

1.1 General

This Specification concerns the Signalling and the Automatic Train Control (ATC) System. It constitutes the first out of the two parts forming the Specifications for to the entire Signalling and the Automatic Train Control (ATC) System of the Thessaloniki Metro Extension to Kalamaria. The second part of the specifications concerns the Automatic Train Supervision System (ATS) and constitutes a self-standing document. The two parts of the Specifications form the entire specifications. For brevity reasons, the subject system can be referred to as Signalling System.

This Specification shall be read in conjunction with the remaining Tender Documents and, more specifically, with the Conditions of Contract, the Technical Description, the General Specifications and the Design, Performance, Material and Workmanship Specifications for the Automatic Supervision System (ATS), while the on-board equipment shall also be taken into account. In the event of contradictions among the documents, their order of prevalence shall be adhered to.

In addition, consideration shall be given to the information to be provided by ATTIKO METRO S.A. (AM) or – through AM – by other parties (contractors) involved as concerns the following items, namely:

- Respective Signalling and ATS systems and sub-systems of the Base Project implemented by the Contractor of the Base Project (Specifications, Technical Descriptions and Designs);
- Related systems and sub-systems of the Base Project (e.g. Platform Screen Doors (PSDs), Safety Management System (SMS), Data Communication System (DCS), Passenger Information System (PIS), Clocks System, Earthing System, etc.) implemented by the Contractor of the Base Project (Specifications, Technical Descriptions and Designs);
- Coordinated systems and sub-systems of the Extension to Kalamaria (e.g. PSDs, Power Supply System, Traction Power System, Earthing System, etc.) implemented by the Main Contractor responsible for the Extension to Kalamaria (Specifications, Technical Descriptions and Designs);
- Related systems and sub-systems of the Extension to Kalamaria not included in the scope of works of Main Contractor responsible for the Extension to Kalamaria (e.g. radio communications system – TETRA, CCTV System, etc.) and are to be implemented by independent contractor(s) of the Base Project (Specifications, Technical Descriptions and Designs);
- Detailed Final Designs and operation principles regarding the central Signalling and Train Control systems and all remaining control systems, as these are applicable - as

concerns their extension in the framework of the Kalamaria Extension project - to the Operation Control Centre (OCC) and to the Emergency Control Room (ECR);
- Planning Manual of the Base Project;
- Planning Manual of the Extension to Kalamaria (with a priority as compared to the respective Planning Manual of the Base Project, which is older);
- The initial Rolling Stock of the Base Project (18 train-sets) that is provided by the Contractor of the Base Project (Specifications, Technical Descriptions per sub-system and Designs);
- The new Rolling Stock (15 train-sets) required for the smooth operation of the Base Project and the Extension to Kalamaria that will constitute the scope of a new Tender (Performance Specifications);
- Design, Performance, Material and Workmanship Specifications for cable trays, piping, trunk cables of the main contract of the Kalamaria Extension project.

This Specification constitutes the physical and operational extension of the Signalling and the ATC System of the Base Project by 4.8km, lengthwise, with 5 new stations of the Metro Line to Kalamaria. The works for the extension and upgrading of the ATS system shall not downgrade the operation of the Base Project trains and stations.

The scope of the contract shall also include all relevant works required for the installation and operation of the overall signalling and ATC system in all 15 new trains that will be required for the operation of the both Base Project and Extension. Finally, the Contract shall also include all necessary works for modifying or upgrading or supplementing the Signalling and Automatic Train Control System of the Base Project.

The scope of works shall also include the modifications/additions - utilizing additional items of equipment (hardware) and software – to the Signalling and Train Control System on the 15 new trains and on the 18 trains of the Base Project, as these are described in the relevant article concerning the Automatic Train Protection (ATP) System and concern the automatic coupling of trains. Since the scope of the Project includes both the extension of the Signalling system of the Base Project and the new trains, as well as modifications to the initial 18 trains, which (initial and new trains) shall circulate in the entire network and in the depot, this specification covers all requirements of the signalling system in the line, in the stations, in the depot and in the trains of Thessaloniki Metro network, regardless of the geographical location of the new hardware and software, wherever its installation may be deemed necessary.

It is stressed that, in the Base Project, the terminal station at the western end of the Line is the New Railway Station (NRS); however, there is always the possibility for SINTRIVANI Station to be assigned as the temporary terminal station for the Partial Operation of the section Pylea – Sintrivani. This must be taken seriously into consideration during design and implementation stages, to the extent that this concerns and affects the operation of the

Signalling and Automatic Train Control System in the Extension to Kalamaria and the consequent analysis, designs, simulations and, finally, the operation itself.

1.2 Form of Specification

This Performance Specification consists of thirteen (13) Sections as follows:

- Section 1 Introduction
- Section 2 Scope of Specification
- Section 3 Operation Requirements.
- Section 4 System Description
- Section 5 Technical Requirements
- Section 6 Technical Requirements Train borne systems
- Section 7 Design Requirements
- Section 8 Testing for the Signalling System
- Section 9 Quality assurance
- Section 10 MTBF values and Defects Liability Period
- Section 11 Installation requirements
- Section 12 Parts List, Spare Parts, Special Tools, Test Equipment, Manuals and Maintenance
- Section 13 Training

1.3 List of abbreviations

AM	Automatic Mode
ATB	Automatic Turn back
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
AVI	Automatic Vehicle Identification
CBTC	Communication Based Train Control
CEC	Commission of the European Communities
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CENELEC	Comité Européen de Normalisation Electrotechnique
DCS	Data Communication System

DOO	Departure on Order
DMI	Driver machine interface
DP	Danger Point
EB	Emergency Braking
ECR	Emergency Control Room (although the "ECR" is a Control Room, the term "ECR" refers to all rooms (facilities) supporting the operation of the control room, i.e. technical rooms, etc.
EDP	Emergency Driving Position
e-IXL	Electronic Interlocking
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Standard
ENV	European Prestandard
EoA	End of Movement Authority
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
GoA 4	Grade of Automation, Level 4, per EN62290
IEC	International Electrotechnical Commission
IMS	Incident Management System
LED	Light Emitting Diode
LEU	Lineside Electronic Unit
LOW/LWS	Local Operator Workstation
MMI	Man Machine Interface
NST	Non-stop Train
OCC	Operation Control Centre
OL	Overlap
PA/CIS	Public Address / Customer Information Screen
PABX	Private Automatic Branch Exchange
PC	Personnel Computer
prEN	draft European Standard
PSD	Platform Screen Doors
RAM	Reliability, Availability, Maintainability
GoA 4	Grade of Automation, Level 4, per EN62290
RAMS	Reliability, Availability, Maintainability, Safety
RAP	Roll Away Protection
RH	Relative Humidity
RDP	(*train)* Route Destination Point
RSP	(*train)* Route Start Point
SCADA	Supervision, Control and Data Acquisition
SIL	Safety Integrity Level
SL	Sleeping mode or Supervised Location
SMM	Supervised Manual Mode
TFT	Thin Film Transistor

UPS	Uninterruptible Power Supply
WSF	Wrong Side Failure
WM	Washing Mode

2 SCOPE OF SPECIFICATION

2.1 This Design, Performance, Material and Workmanship Specification covers the principles and requirements for the design, manufacture, supply, factory testing, shipment, delivery to site, installation, testing on the construction site of the Project, commissioning, training, setting to work and defects liability for the warranty / maintenance period of the Signalling System in the Metro Extension to Kalamaria, i.e., from Patrikiou (25th Martiou) crossover up to the forestation and the terminal shaft of Mikra Station, as well as the installation of signalling systems on board the 15 new trains foreseen for the Extension to Kalamaria and for the Base Project.

2.2 This Specification covers the supply of the following systems:

- A system of signalling to ensure the safe movement of trains to established Railway Signalling Standards and in conformity with the requirements for specified headway and performance requirements.
- A signalling and data transmission system based upon safe, fully automatic train control system.
- A train control and automatic train operation system, which permits a fully automatic driverless train operation without any need for staff intervention, except for certain movements within the Depot and in case of emergencies.
- An ATC – identical to the system described above – on board the trains and a data transmission system for all service trains, which permits safe manual driving during off-service hours as well as during service hours between automatic revenue trains.
- A signalling system to ensure safe and efficient movement of vehicles within the depot.
- Uninterruptible Power Supply (UPS) for signalling equipment.
- Training plant which permits practical on the job training and fault simulations for operators and maintenance staff.
- Safe and operations Interfaces to other systems, such as trains, ATS, trackwork, power supply, passenger information, earthing, train radio communication, platform screen doors -PSDs, CCTV on board the trains, depot equipment, etc.
- The Contractor shall submit a study for verifying the option for simultaneous transmission of the train-borne Signalling – ATC system's data, the train-borne CCTV system's data, other diagnostic data on board the trains and of other data, e.g. projection of advertising and other type information that may be on the passengers' interest, through the system provided for data transmission purposes, to and from the trains. This study shall constitute the basis for identifying the systems that may transmit data through the data transmission system that the signalling system supports (DCS in

the Base Project). The respective implementation shall be based on the aforesaid study.

2.3 The Contractor shall provide the systems and equipment described in this Specification, as well as all items necessary for a safe and reliable operation of a driverless automatic train control system as described in the Planning Manual (operation concept).

2.4 The Contractor shall design and implement a signalling system, which will be capable of fulfilling the need for the phased operation of the Extension. The Contractor shall ensure that the opening of further stages shall not cause any impact on the section already in service, during the commissioning, trial and training operation on the new section of the network.
A new Interlocking with local or central control workstations shall be provided at the Depot, at the Operation Control Centre, the ECR and at any other location as required by the offered interlocking system to monitor and control the Extension. The new interlocking shall be equipped with operator workstation(s), as required, for emergency operation, ensuring full compatibility with the Base Project.

2.5 The connection turnout of the Line to Kalamaria shall be integrated – both physically and operationally - in the interlocking system of the Base Project and shall not be part of this Contract scope of works. The movement of the subject turnout towards the extension shall lead the trains of the line towards the extension to Kalamaria and therefrom the new interlocking system – which is part of this Contract scope – shall take over. On site, the turnout shall be mechanically neutralized, as required, for the safe execution of the works in the Extension and the unobstructed operation of the main line.

2.6 Provision shall be made in the design and installation of equipment to minimise the alterations necessary for further line extensions and line connections to Kalamaria. However, no specific equipment shall be provided for further extensions and connections under this Contract.

2.7 The signalling design including the length of track sections for train reversing and train berthing shall be designed for a train length of at least 50 meters.

3 OPERATION REQUIREMENTS

3.1 The Thessaloniki Metro comprises of one line from "New Railway Station to Nea Helvetia (approximately 9.68 km, 13 stations) with a Depot connected via a double track to Nea Helvetia. Line connections are planned from Dimokratias Branching to Stavroupoli and from Patrikiou (25th Martiou)branching to Kalamaria/Mikra, which is the scope of this Contract. In addition, future extensions are planned from New Railway station to Kordelio / Evosmos and from Kalamaria to the Airport.

3.2 The provisions for the main line connections to the extension / branches and, especially, for the extension to Kalamaria, as concerns civil works, trackwork and signalling up to the level of securing the turnout, as this one, that has to be "locked" so that the trains cannot move towards the direction of the Extension until this is allowed, shall be made during the execution of the Base Project and shall be supplemented and properly tested – in terms of signalling – under this contract, so that the turnout towards Kalamaria can become feasible.

3.3 All platforms of the stations of the extension have been designed and constructed as central platforms, while two tunnels will exist between stations.

3.4 The Signalling and Train Control System shall work fully automatically from unstabling of trains (awakening of trains) until stabling of trains (setting to sleep) without any need of operator intervention from train borne personnel (train attendant) during normal operation.

3.5 The following movements shall be managed automatically without need for intervention by the train attendant by the signalling system of the Extension to Kalamaria, which shall be at least of an equivalent operability and compatible with the respective system of the base project of the Line:

- Unstabling of train in the Depot for entering into revenue service
- Unstabling of trains from each stabling position on the line for entering into revenue service
- Reversing of trains in terminals and on line following route commands
- Reversing movements from unstabling to start position
- Performing of all train missions in compliance with the time table
- Station stop, door opening, door closing and station departures
- Automatic Re-positioning of trains at platforms in case of overshooting of platform stops or up to 2 meters or in case of too early train stop.
- Transfer movements in the Depot from and to the transfer section to the Stabling Shed

- Stabling and setting to sleep of trains at the end of the shift in the pre-defined stabling position
- Running to and passing through the washing plant after revenue service with following stabling
- Reversing movements from a stabling track in the Depot to another stabling track or through the washing plant
- Downgraded operation scenario, midline turn backs, reverse running
- Change of train sequence in case of a train failure or a train that cannot be woken up including unscheduled change of direction
- Rescue operation – coupling/uncoupling of trains operation.

3.6 Not necessarily automatic controlled movements are:

- Movements in other modes than ATO mode due to train or ATC failures
- Transfers on the connection track to the Running Shed from the automatic controlled area to the manually controlled area as defined in the Planning Manual of the Base Project and Kalamaria.

3.7 The Tasks and responsibilities of the train attendant on board of the Train shall be the following:

- Driving of the train via the EDP in other modes than ATO mode in special down graded cases, for rescue operation or in the Depot after request from the OCC.
- Operating of emergency brake button – if required - in the case that the EDP is active.
- Isolation of train doors in case of door failures.
- Emergency opening and closing of train doors and emergency command of PSD in case ATO command fails after radio request from the OCC.
- Re-set, in communication with the OCC, of emergency train stop plunger inside the train as well as on platforms – in case operated by a passenger.
- Key-in the staff number in a key-in instrument which is activated by a staff key but independent from the emergency driver panel
- All actions related with passenger evacuation in case of emergency.
- Passenger care.

The Contractor shall be responsible so that the Metro can operate without any train attendant on board, both in the Main Line and in the Extensions. The Contractor shall describe in his offer the measures to be taken for a Metro operation without train attendant.

3.8 The running modes for passenger trains shall be as follows:
Fully Automatic Signalling Modes

- Full automatic driverless operation under ATO including automatic turn back

- Washing mode with a maximum speed of 5 km/h for automatic running through the washing plant

Signal Protected Running Modes with train operation by the train attendant

- Supervised manual mode under ATP with continuous speed supervision and over speed control – maximum line speed 80 km/h.
- Permissive mode under ATP with supervised limited speed driving of max.15 km/h and over speed control of 15 km/h

Train Modes

- Manual mode forward with speed control performed by the train propulsion system at a maximum speed of 15 km/h
- Manual mode back ward with speed control performed by the train propulsion system at a maximum speed of 15 km/h

3.9 Train running modes for service trains shall be the same as for passenger trains without automatic mode (AM) and without washing mode.

3.10 The line shall be fully signalled for Bi-directional operation on all tracks, including reversing areas in the terminal stations. During normal operation, trains will run on the right hand tracks as viewed in the running direction.

3.11 Trains will comprise of 4 cars with an overall length between 50 and 55 meters (it is anticipated that the trains of the Base Project will be of similar length with an eventual small deviation - as related to the initial 18 trains - which the signalling system can accommodate). Each train end will be equipped with an Emergency Driving Position (EDP). The splitting of trains is not planned for normal operation.

3.12 The coupling of trains is not planned for normal operation. However, the signalling system shall support the coupling of trains for rescue operation.

3.13 Engineering trains (service trains) shall be able to run safely under ATP protection between automatic passenger trains in cases of an emergency. Automatic operation of service trains is not required.

3.14 Train status information and train diagnostic data shall be continuously transmitted from the trains to the OCC and processed at the OCC

3.15 Under normal conditions, trains of shorter length will not operate in passenger service but they may operate in emergency or for stock transfer purposes. Coupling and uncoupling of service trains, except in emergency, shall take place in the Depot or in stabling sidings. Service trains of variable length, up to a maximum of 60 metres, may operate throughout the system and they will normally be equipped with ATP.

3.16 In case of rolling stock failure, a second train may be used to assist the failed train from the front or the rear part. The signalling shall be able to handle such a train, twice the length of the typical train, operated with or without ATP at a maximum speed of 15 km/h.

3.17 The traction supply is a bottom contact bi-metal (aluminium – steel) third rail located beside the running rail. The nominal traction voltage is 750V DC. Both running rails shall be used for return of traction current except at short length at crossovers.

3.18 Design headway is defined as the theoretical time interval between successive trains on a through track without station stop-time. The headway time shall be maintained without any speed limitation to the train caused by approaching another train, except where unavoidable to meet headway and station stop times at specific stations, which shall be declared in the design acceptance stage. Any such limitation in speed shall be justified to and approved by AM.

3.19 The design headway on all tracks between terminals used by passenger trains shall be 60 sec.

3.20 The operational headway shall be at initial operation 150 seconds. At a later phase and according to the passenger demand the headway shall be reduced to 90 seconds. The system shall be designed for an operational headway of 90 seconds including reversing in terminals through forestations. The exact separation of trains to Nea Elvetia and Kalamaria/Mikra towards the town centre shall be made, initially, as foreseen by the Planning Manual of the Extension to Kalamaria (for example, for every three trains, the two trains shall be directed to Kalamaria/Mikra and the third one shall be directed to Nea Elvetia). The option must be also provided for the on-line configuration of the number trains towards both branches. The subject design for the junction of Patrikiou (25th Martiou) branching towards both directions shall constitute a special task that must be submitted and approved by AM.

3.21 The maximum speed on the line in normal and reverse direction shall be 80 km/h

3.22 The speed within the Depot and in downgraded operation without ATP shall be 15 km/h.

3.23 The speed of a train passing through a station without stopping shall be limited by the signalling system to 50 km/h maximum provided that platform screen doors are closed and locked.

3.24 The Contractor with regards to the safe speed profile shall define the speed of a train passing through crossovers on deviation side and through curves; the permitted civil speed through the crossover shall be in compliance with the requirements for headways and reversing times.

3.25 The scheduled minimum headway for train movement in either direction between Depot and the adjacent Stations shall be the same as for the mainline.

3.26 The headway for reversing trains at terminal stations requires a special design study in relation to the track layouts, which shall be subject to AM's approval. It shall be possible to reverse trains at all terminal stations at the schedule service applying the operational minimum headways of 90 seconds.

3.27 Auto reversing shall take place beyond a terminal station (forestation) and / or in front of a terminal station without any intervention by the train attendant. For initial operation a scheduled layover in the terminal platforms or forestations of approximately 90 seconds shall be applied for regulation purposes.

4 System Description

4.1 General

4.1.1 The entire signalling system shall consist of items of equipment in

- The Operation Control Centre (OCC) (see also Specifications for the ATS)
- The Emergency Control Room (ECR)
- Local or central signalling system including the interlocking equipment and the line train control system
- Line side equipment
- Data transmission systems
- Train borne train control system

4.1.2 The Signalling system shall be in compliance with this Specification, shall include automatic signalling and shall comprise but not limited to the following:

- Basic Interlocking functions between points, signals, track sections.
- Automatic and manual operation of train routes
- Train describer system
- Automatic and manual operation of points
- A moving blocksystem or a quasi movingblock system
- Uninterruptible power supply system
- Line side or central train control system
- Interface for connection of Automatic Train Supervision system (ATS). The interface must be able to receive vital and non-vital orders from the ATS system and transmit vital and non-vital indications to the ATS system.
- Interface with platform screen doors
- Local operation of Interlocking from a workstation should it be installed in the same station as the Interlocking is housed.

4.1.3 The line side signalling equipment shall be in compliance with this specification and shall comprise the following:

- Point machines and locking devices
- Signals
- Track vacancy detection by track circuits
- Beacons, fill-in loops or other transmission devices
- Plungers and buttons
- Cables.

4.1.4 The data transmission system shall be in compliance with this specification and shall comprise the following:

- Transmission system of vital data from track to train and from train to track
- Transmission of non-vital data from track to train and from train to track.

4.1.5 The train borne signalling system shall be in compliance with this specifications and shall comprise the following:

- Fully Automatic driverless Train Operation (ATO).
- Automatic train protection system (ATP), which shall continuously determine and supervise the train speed according to conditions of the track and shall ensure that the train never exceeds the limit of the routes set and supervised for it.
- Driver-Machine–Interface (DMI) integrated in the Emergency Driving Position (EDP)
- Interface to the train propulsion and train braking system

4.2 Electronic Interlocking (E-IXL)

The Contractor shall furnish and install a computer controlled Electronic Interlocking System (E-IXL). The hardware employed shall ensure a high level of availability and reliability. The software shall be modular in design, thoroughly tested during the implementation phase and able to control and monitor the entire system. The entire interlocking system shall be subject to final approval by the Service. The electronic interlocking system shall consist of multiple computers; fully redundant using a configuration of 2-out-of-3 or an equivalent of 2 by 2 by 2 fault tolerant system.

Redundant and independent power supplies, with adequate reserve, shall be provided for each computer system. A number of different interface modules shall establish the connection between the interlocking computers and the outdoor equipment (points, signals, track circuits, axle counters, etc.). The interface modules shall be failsafe.

The electronic interlocking system shall comprise fully configured cabinets with appropriate numbers of interface PC boards to match the number of outdoor equipment. Between the central computers, the interface modules and the outdoor equipment, the entire process of control and monitoring shall be fail-safe. The necessary power supplies shall be provided for the interface modules.

The electronic interlocking system shall be able to communicate with the outdoor equipment using a dedicated fully redundant fibre optic transmission network, configured for fail-safe communication with the remote control and monitoring system.

4.2.1 General Functions of an Electronic Interlocking System

4.2.1.1 Local operation

Each local interlocking (if any, based on the architecture) shall be equipped with a local operating workstation, which shall be installed in the station master room and in signalling room 3.4s. The operator workstation of the Depot shall be installed in the OCC operator room. Nea Helvetia station and the Depot shall have two independent interlocking. In case of central interlocking system, the local station is not deemed necessary.

4.2.1.2 Safety

On the safety level, routes shall be set, interlocked, detected and released again. It shall be impossible to set conflicting routes. The commands coming from the local or the central operating workstation or ATS via the interface shall be transmitted to the safety level and processed by the signalling logic functions. The resulting status and fault indications shall be transmitted to the local or the central operating workstation and the ATS in the same way.

4.2.1.3 Control and Monitoring

Control and monitoring of the outdoor components shall be processed. The circuits of the outdoor equipment shall be switched in a fail-safe manner. The actual status of the outdoor equipment (signal aspect, point position, etc.) as well as any faults (cable defects etc) shall be continuously detected.

4.3 Interlocking Functions

In the following description, the track vacancy detection system is detailed for the application of track circuits. CBTC system is given the priority, as regards trains' detection, while track circuits shall be the secondary method for trains' detection purposes. This may impose differentiations to the description below, as detailed in the sub-paragraphs of this paragraph 4.3. These differentiations shall be analysed and be submitted to AM for approval.

4.3.1 Track circuit processing functions

As trains pass correctly from one track circuit to another, any functions in the interlocking relying on this tack circuit function shall operate correctly. Various factors may introduce significant changes in the relative delays in passing the states of track circuits going clear or occupied from the point of rail/wheel contact through to where these states are used in the interlocking. The standard measures include the additional delay in the interlocking registering a track circuit clear over registering it occupied.

The design shall ensure that any intermittent operation of vehicle detection equipment from whatever cause shall not cause premature release of interlocking or any other unsafe condition. Releasing of interlocking whilst a train is within a route with sequential release based on passage track circuit boundaries or manual releases shall be delayed in order to prevent early release of a route due to transient release of a track circuit. The delay time shall be proposed by the Contractor and approved by the Service. The Contractor shall support his

proposed delay time by the validated generic safety assessment of his proposed interlocking. This requirement shall be applied to each track circuit section of all routes within the interlocking.
Each section of route locking shall not release until:

- The section track circuit has been occupied.
- The section track circuit has been cleared and a delay time elapsed and
- The section track circuit is clear and the track circuit ahead in the direction of the set route is occupied.

4.3.2 Point Handling

The electronic interlocking system shall provide facilities for manual operation of any point, from either the local workstation or from the OCC. Request for manual operation of points shall be verified by the Interlocking system before being executed.
Points operated automatically by interlocking shall remain in the last position until required to be operated to the opposite position by a new route setting or for providing new flank protection, with exception of certain points located in terminal stations, where automatic return operation may be implemented in order to reduce headway.
Any operation of points, by interlocking shall be monitored by a timer. If detection is not achieved within max 8 sec. from start of a point operation, power to the point shall be cut and an alarm shall be initiated on the operator workstation.
The interlocking shall prevent new movement of track switches when the track circuit containing the track switch indicates an occupation condition. However, should occupancy of a track circuit containing a track switch occur after the track switch has started moving, the movement in progress shall not be stopped.
Operation of points shall be interlocked - at least for the following reasons:

- Route setting through the point.
- Overlap condition extending through the point.
- Flank protection provided for a route, overlap or stabling track.
- Occupation of the point track circuit
- Manual locking of a point

Multiple points shall not be allowed to start operation at the same time. Point staggering control shall prevent this. If due to route setting, several orders for operation of points have been formed, the points staggering control shall initiate the operation of points one after the other in intervals of 500 milliseconds. Manual operations of points shall not be controlled through the points staggering control.
Points shall be able to be locked locally (blocked against any operation) from the local workstation as well as from the OCC/ECR. Unlocking shall be performed by a vital registered operation from the same location as the locking.

4.3.3 Route Handling

Any route is defined to start at an "Route Start Point (RSP)" and end at a Route Destination Point (RDP)"

RSP are

- Point indicators
- Signals in the Depot
- Track sections (track circuits).

RDP are

- Point indicator
- Signals at the Depot
- Track end signals or track end signs
- End of track sections (track circuits)

The track sections mentioned, as destination point, shall be a part of the route. Associated to a route can be certain elements located beyond the destination point. The process of route setting shall take place in two clearly defined parts, validation check and setting. Validation check means that all necessary elements belonging to a route can be set. Setting shall mean selection of elements that shall be locked in order to form or set the route. In case the check for one element of the route fails, the route shall be rejected. Setting of a route shall not depend on whether elements located beyond the destination point can be locked. The last task to be performed is to provide a movement authority to the ATP system and to clear the aspect of the point indicator provided that a point indicator is the starting point.

4.3.4 Type of Train routes

A train route shall consist of the following parts:

- The signalling elements such as track circuits, points and crossings between RSP and RDP
- The flank protection elements of the train route consisting of points, track circuits and signals protecting the flanks of the train route between RSP and RDP
- The overlap elements, which forms a protection section of sufficient length beyond the RDP consisting of track circuits and points
- Flank protection of the overlap consisting of points, track circuits and signals protecting the flanks of the overlap length beyond the RDP.

The following type of train routes shall be applied:

- Standard train routes consisting of the parts described above, which shall permit one train only on the train route
- Multiple train routes, consisting of the parts described above, which shall permit more than one train on the train route.

4.3.5 Conditions for routes

Prior to commencing design and programming work related to routes and conditions for routes, the Contractor shall produce and submit for approval by AM, a set of documents called Main Documents, which shall describe route possibilities and route management based on the rules given in this specification and complemented by rules successfully applied by the Contractor in fully automatic operated Metro systems. The main documents shall contain, but not be limited to the following documents/drawings:

- A schematic track layout showing track circuits, points, beacons, loops, signals and other geographical information.
- Interlocking Conflicting route setting. The document/drawing shall show in schematic form which routes are in conflict with other routes.
- Interlocking Conditions for route setting. The document/drawing shall show the entrance and destination point of any route, which conditions shall be fulfilled for setting any route, which conditions shall be fulfilled for achieving and maintaining a movement authority for entering a route, which conditions shall occur for automatic release of any route and which conditions shall occur for emergency cancellation of any route. In addition, the main document shall contain any conditions related with overlap per route and any other relative information per route.
- Interlocking/ATP interface. The document/drawing shall show the information, which can be transmitted to the line side ATP equipment by the interlocking and vice versa, as imposed by the train detection technology (primary and/or secondary detection system). Whenever possible, the information exchange in the document/drawing shall be organised per route, otherwise per track circuit or as miscellaneous information. All information transmitted between interlocking and the line side ATP equipment shall be listed in the document/drawing.
- Interlocking Remote control. The document/drawing shall show the type of information, which the interlocking shall be able to receive from the Central Control System and the type of information, which the Central Control System shall be able to receive from the interlocking. Whenever possible, the information exchange in the document/drawing shall be organised per route, otherwise per outdoor equipment/track circuit or as miscellaneous information. All information transmitted between interlocking and the remote control system shall be listed in the document/drawing.
- Interlocking of points. The document/drawing shall show how a point located in the route or in any overlap to a route or which provides flank protection to routes or overlaps shall be locked as a function of which route has been set and in which track circuit a point is located.
- Any other documents/drawings that are needed in order to describe the functions of the interlocking system.

4.3.6 Main Route Setting

Setting of a train route shall hand over information to the line side ATP equipment. Before any movement authority is given, interlocking shall verify that the entrance point indicator shows green aspect provided the RSP is a point indicator. Once the route is established and it has been verified that the green light is present, the movement authority shall be given to the ATP line side equipment, in order to release the ATP stopping point and to set target speed to the train.

Route oversetting from the route start point of route number "n" to the route destination point of route number "n+1" shall be possible as fare as operationally practicable. For example, train routes for train movements from the platform track 1 of Mikra Station until the point indicator of Patrikiou (25th Martiou) branching shall be set in one single action.

4.3.7 Automatic route release

Detecting correct sequence as the train moves over borders between track circuits, starting from the approach track circuit to the RDP is a function of automatic release of routes.

For releasing of a route the following sequence shall be performed:

- Approach track circuit. ↓
- First track circuit of the route. ↓
- Approach track circuit. ↑
- Second track circuit of the route. ↓
- First track circuit of the route. ↑

After the above sequence, the route locking is released for the first section of the route

To release the rest of the route, on a track circuit by track circuit basis the following sequence shall be performed:

- First track circuit of the rest of the route. ↓
- Second track circuit of the rest of the route. ↓
- First track circuit of the rest of the route. ↑

After the above sequence, the first track circuit of the remaining section of the route is released. The releasing process continues until the movement of the train has released all track circuits.

A necessary condition for release of any route or part of route is the presence of power. Any interruption in the power supply shall cause the automatic route release to be stopped.

4.3.8 Manual Route Cancellation

Manual cancellation of routes takes place from either the currently assigned workstation for operation or from the OCC whenever the control centre is enabled.

Any route to be manually cancelled must have been set as a complete route. No section within the route must be occupied or already released. Time delay for cancelling the route must not be started (no other cancellation in progress). The cancellation shall take place in the following steps:

The entrance point indicator shall be set to stop immediately provided the RSP is a point indicator otherwise each movement authority will be removed:

- When the approach section is vacant the manual cancellation is performed immediately.
- When the approach section is occupied and no movement authority was given to ATP or/and the start point indicator continually shows red aspect, the manual cancellation is performed immediately.
- When the approach section is occupied and the movement authority to ATP was issued and/or the entrance point indicator shows green aspect, manual cancellation causes removal of the movement authority and the point indicator to show red aspect, however, the route shall remain locked/set and controlled by a timer, which shall guarantee that under worst-case conditions, the train will come to a stop before the timer expires. For each route an independent timer shall be implemented and set to a time not exceeding 20% of the minimum time needed to guarantee safety. The time shall be optimised by a study of the operating conditions and it shall be subject to approval by the Service. The Contractor shall provide to the Service for approval the method and detailed calculations for the approach sections of each route.
- Automatic route cancellation occurs when the train enters the section beyond the RDP.

Any manual route cancellation shall be logged in the operational log at OCC and interlocking level.

4.3.9 Reversing in Line

It shall be possible to reverse automatically in all sections of the line under full ATP protection. Such movements shall be controlled either automatically in case of scheduled emergency operation or manually from ATS.

4.3.10 Opposite Locking

On a two-way working destination, the setting of a route shall prevent the selection of the opposite direction route. The opposite route locking is released with the last track locking release.

4.3.11 Setting Overlap with Approach Sections

For multiple train routes, which can cover several trains moving along, the overlap can be switched on only when designed overlap approach sections are passed. By means of this the following shall be achieved:

- The overlap shall be set for each train moving along.
- The overlap shall not be set too early in order not to hinder other train movements

In the main line and in case of long routes, overlap information shall be transmitted to ATP equipment as soon as the designed approach section is occupied. The design of the approach section shall allow the overlap information to be transmitted to a train controlled by ATP without any irregularities in train speed. The safety principles for overlap control, in case of moving block, shall be defined in compliance with the moving block algorithms.

The Contractor shall describe the functionality and safety of his system regarding overlap protection and calculation of overlap length. The document shall be submitted to the Service for approval during GFD design phase.

4.3.12 Overlap Release with Time Delay

The elements of the overlap are released after a customised time has elapsed. The release with time delay begins when the customised overlap approach area is occupied (this approach section is different from the approach for locking the points in the overlap area). The duration of the delay time depends on the braking distance of the train. In case of train reverse operation, the overlap release with time delay is continued. The overlap shall remain claimed and shall be released as soon as that time has elapsed. If a second train is in the approach section for claiming the overlap, or between this section and the penultimate section (included) of the route, then this train shall get an overlap after the first train leaves the route and the overlap sections. A subsequent train route shall overwrite an overlap where the elements of the overlap are part of the train route.

4.3.13 Flank Protection

Providing flank protection as configured shall be a component of route setting. If primary flank protection cannot be set due to a fault, substitute protection as configured shall become effective. This substitute protection shall continue for the set route even if primary protection becomes available again.

4.3.14 Staff protection Function

Staff protection shall be implemented in order to provide safe working conditions for maintenance personnel in the tunnels or Depot tracks. The contractor shall provide a strict system to guarantee the safety of the possession either by applying safe centralize staff protection using vital collars associated with strict rules or to use wayside key – release instruments. In both cases the use of smart carts is preferred.

The Contractor shall provide various operating commands in order to support maintenance and operation.

Such commands are but not limited to:

- Blocking of points against throwing
- Blocking of point indicators and signals against clearing
- Blocking of track section against route setting over that element
- Blocking of points against route setting over that point
- Blocking of station platforms for train departure

Blocking commands shall be recorded in the operator log.

Unblocking functions shall be vital registered operations from the local workstations or the OCC.

Setting of blocking commands shall be possible from the local workstation or from the OCC and shall be identified in the operational log.

4.3.15 Temporary Speed restrictions

It shall be possible to set and release temporary speed restrictions via the local operator workstation and via the OCC. The steps for temporary speed restrictions shall be 5 km/h .

Setting of speed restrictions shall be recorded in the operator log. Release of temporary speed restrictions shall be a vital registered operation from the local workstations or the OCC.

When temporary speed restrictions are applied on sections where permanent speed restrictions are implemented, then the more restrictive speed shall prevail.

Temporary speed restrictions shall be at least possible for the line and the Depot for

- Each platform track,
- Section between each station platform for each track,
- Each point, individually for each direction of the point,
- Each stabling and end track

4.3.16 Signal Filaments.

The total current flowing through filaments of LED signal's and point indicators shall be monitored.

Each aspect (colour) shall be monitored separately. Whenever the current comes out of the regular range (this is the range, where enough LED's work to recognise the signal aspect) the behaviour should be the same as with normal signal where the main and secondary filaments are broken and a failure message shall be generated and transmitted to the LWS and ATS.

In case green aspect cannot be displayed, red aspect shall be turned on.

4.3.17 Emergency Stop Plunger

Operation of a plunger located on any platform shall cause a stop order to be transmitted to any train borne ATP equipment located in the track circuit alongside the platform and/or the track circuits located before and after the platform, thus forcing an emergency brake application, if the train is close to a platform, or a service brake application when the distance between the train and platform is sufficient to bring the train to stop outside the platform limits by service brake application. In case the train detection system - where the circuit is not but the secondary one - in other words, the CBTC train detection, which is the primary system, exists and operates normally, then the primary CBTC system shall respond as if the track circuit were occupied and shall trigger the appropriate braking power that will allow it not to exceed the limit of the platform upstream the related stopping point, towards the direction of the approaching train.

On each platform for each side of the track a signalling emergency plunger shall be installed. Both plungers shall be installed on the Emergency Control Unit (ECU) located in the middle of the platform. Whenever an emergency plunger is activated, the plunger shall stay in the operated position until reset by an authorised member of the operation staff. Activation of emergency plungers shall be indicated in the relevant Local Workstation (room 3.4.s), at the OCC/ECR and in the stationmaster rooms of the stations, as required, while in a Signalling System with central control architecture, the subject activation shall be indicated in the workstations of the ATS and the Central Interlocking in the OCC/ECR. Operation of the signalling emergency plunger shall

- Remove all proceed codes of trains on the platform section
- Prevent all trains entering the platform,
- Stop all departing trains if one of the cars is still at the platform section.

Emergency brake shall only be applied if the service brake is not sufficient to bring a train safely to a stop before the platform.

It shall be possible to override the signalling emergency plunger and the related traction power tripping from the OCC in order to proceed with operation without attending the manual reset. The signalling emergency plungers of the concerned station platform are not effective until manually reset and cancelling of the override function is made.

4.3.18 Departure Inhibition Switch

A Departure Inhibition Switch (DIS) shall be installed for each track at the end of each raised walkway in the Depot Stabling Shed. Operating of the switch shall inhibit automatic train departures from the stabling. The status of the switch shall be indicated on the switch, at the OCC and at the ATS and Interlocking workstations supervising this area.

4.3.19 Departure–On-Order

For all stations, the electronic interlocking system shall transmit Departure-On-Order (DOO) signal to the train borne ATP/ATO equipment. It shall be allowed for the signal to be sent from

the central ATS system to ATP line side equipment without the intervention of the electronic interlocking system. This order shall be rated in relation to the safety – Safety Integrity Level SIL 2 – as per the stipulations of standards EN50128 and EN50129.

4.3.20 Non-Stop Train.
For all stations, the electronic interlocking system shall transmit Non Stop Train (NST) signal to the train borne ATP/ATO equipment. The signal shall be sent from the central ATS system to ATP/ATO line side equipment, with or without the intervention of the electronic interlocking system. The Non-stop command shall release the forced station stop and permit a train passing through a station without stop.

4.4 Automatic Train Protection (ATP)

4.4.1 The Automatic Train Protection System consists of two main parts, ATP Line Side equipment and ATP Train Borne equipment.

4.4.2 An Automatic Train Protection (ATP) system shall be provided on all running lines, junctions, terminal stations, sidings, Depot and test track in the Depot. As a minimum, the ATP equipment shall provide the following vital functions:

- Transmit line characteristic data to the ATP train borne system for calculation of permitted speeds, distance to go values. Transmission of line data is not required if the line characteristic data are stored on-board.
- Transmit to the ATP train borne system interlocking states, route supervision status, availability of safety distances, track circuit status and speed restrictions. It is also permitted to process such information first in the line side unite and to send the movement authority to the train born ATP
- Prevent a train from entering a non-permitted area without an irrevocable emergency brake application.
- Check that the track section ahead of the train is powered and the line voltage is sufficient for train passing.
- Transmit emergency stop information to trains whenever an emergency stop order is sent to a train.
- Transmit PSD lock information to the train
- Receive permanent rolling stock number from the train
- Position of the side of the platform doors (left, right, both)
- Transfer Test whenever a Train/vehicle enters an ATP controlled area.
- Direction of travel (orientation of the train) including set locked route and detected train.

- Except the train rescue procedure - through the manual operations of the involved sub-systems - and the strict adherence to the coupling procedure applied in the base project of Thessaloniki Metro, in the Kalamaria Extension project this procedure shall be automated and the subject upgrading shall also integrate the base project network. The fully automated procedure without any superintendent (GoA4 based on safety standards for automated trains, IEC-62267, IEC-62290 and obligatory application of EN1474 part 1, paragraph 4.5.2) shall be also feasible even in case the on-board Signalling equipment fails and the train – any train - is at standstill at any location belonging to the automated area of the Thessaloniki Metro network. This means that a "healthy" train – as far as its signalling systems are concerned – regardless of whether it carries passengers or not – shall approach the standstill train, under the commands of the OCC, and shall execute a specific mode of operation of the ATP, in coordination with the Rolling Stock systems. This mode of operation of the ATP shall allow the rescue train, after the automatic coupling of the standstill train, to provide to the OCC the necessary indications and commands regarding its monitoring and towing. The passengers of the coupled trains shall disembark in two stages of the "opening-closing" operation of the PSDs in the subsequent station, where the coupled trains shall stop – one operation for each alignment of each train constituting the composite train-set. It is noted that during the automatic coupling, the involved sub-systems of each train are bonded with the respective sub-systems of the other train, so that the composite train-set executes the commands coming from the ATP system of the "healthy" train. Indications and commands necessary for the operation of the automatic coupling shall be provided to the ATS system (SIL2) and/or to a safety sub-system of the signalling system (SIL4).

The ATP line side equipment shall have the ability to, but not be limited to, transmit the following information to the ATP train borne equipment:

- Departure on Order command (DOO)
- Non-stop train command. (NST)

4.4.3 The ATP equipment shall among other:

- Be able to receive time information from the local Master Clock in DCF or equivalent format
- Be able to transmit time information to all train borne ATP/ATO equipment.
- Record safety related events with the reference time in the ATP line side cabinets. Loss of external time source shall be alarmed.
- The Contractor shall explain how time changes between summer and wintertime shall be performed in the time transmission and how re-synchronisation will be met after temporary loss of the central time source.

4.4.4 Train spacing function shall be a vital function of ATP and shall be based on relative train positioning system of track circuits or loops (pilot line) or other train positioning systems, which have been proven safe and reliable in Metro applications for driverless operation. The safety principles for train spacing, in case of moving block, shall be defined in compliance with the moving block algorithms, which shall be proposed by the Contractor and approved by the Service. The Contractor shall provide together with his offer a technical description of his offered train positioning system and application references. The future shortening of headways to 90 seconds shall not require any change to the system.

4.4.5 The ATP system shall also be used to ensure the setting and observance of permanent or temporary speed restrictions and to provide safe stopping profiles for train movements. The ATP shall monitor normal train operations for both directions of driving.

4.4.6 The ATP Line Side equipment shall be fail-safe, highly available and designed to comply with all Safety Level SIL 4 requirements as defined in standard EN 50126. The Contractor shall furnish together with his offer authenticated evidence of fail-safe implementation together with references of in-service installation of the proposed ATP system in other metro systems. This shall be supported by a full technical explanation of the equipment principles, including failure modes.

4.4.7 Thessaloniki and the Kalamaria Extension Metro trains shall be operated in four possible signalling modes:

- Fully Automatic Train Operation (ATO mode) with the train driven fully automatically, even without the presence of the train attendant (UTO-Automation Level 4) from unstabling (awakening of the train) until stabling (setting to sleep) including stopping and restarting as required by operation conditions, as well as towing of a train stalled due to a failure.
- Supervised automatic washing mode with a vehicle driven automatically at a restricted speed. This shall apply when a train enters the Deport and runs through the washing plant at a restricted speed of ≤ 5 km/h.

- Supervised manual mode (ATP mode) with the Train driven by the train attendant in accordance with received cab signal information. This operating mode is for downgraded operation in case ATO fails.
- Supervised manual mode with restricted speed (Permissive Mode) with a vehicle driven manually by the train attendant at a restricted speed. This shall apply within the Depot (Manually Controlled Area) and in the mainlines in the event of a failure of the ATP system. The speed limitation in this mode is 15 km/h.

4.4.8 ATP Line side equipment shall issue a movement authority to a train that ensures that all points are detected (controlled) and locked in the appropriate final position, the route in front of the train is supervised including flank protection and a sufficient safety distance, which consist of the overlap and a safety margin to the train ahead, is available.

4.4.9 The Contractor shall describe in detail in a separate document the method and all the parameters used for the safety distance calculation including overlaps. This shall include allowances in brake application for all variables such as, equipment reaction, poor wheel/rail adhesion due to wet weather etc. Each allowance shall be identified and quantified. The procedures to be used for the checking and approval of these calculations must be given. The principles of calculations shall be submitted after award of Contract for approval by the Service in accordance with procedures agreed with and approved by the Service. Provisions shall be made for several wheel – rail adherence coefficients for different track conditions in tunnels and in open air.

4.4.10 The Contractor has the obligation to provide a software package running on PC enabling the Service to perform the above calculations with sufficient accuracy.

4.4.11 The Contractor shall describe the design and the method of operation of the proposed ATP equipment. The description shall be detailed.

4.4.12 The ATP equipment shall be capable of supporting train operation in reverse direction without receiving an emergency brake on any section of the line, provided that the interlocking conditions are met:

4.4.13 Information transmitted to train borne ATP equipment shall not contain any permissions to proceed with target speed, in case a Point Indicator or Depot signal located in front of the train shows red aspect or is dark. Excepted shall be the case involving CBTC technology only if the ATP equipment on board the train calculates and reports – with safety level SIL 4 – that the train will safely stop in front of the danger point protected by the aforesaid indicators or signals.

4.4.14 An ATP Service and Diagnostic industrial PC shall be installed in each ATP cabinet containing line side ATP equipment.

4.5 Automatic Train Operation (ATO) line side equipment

4.5.1 The Automatic Train Operation system consists of three main parts, ATO, ATO Line side and ATO Train borne. This part of the specification deals with the central ATO and the ATO line side equipment unless otherwise noted. The central part of the ATO is specified in the performance specifications for the ATS. The function of the line side ATO is mainly founded in receiving, processing and transmission of information between ATS and the train borne ATO system. Therefore it is permitted to use subsystems of interlocking or station computers for the ATO function provided that the systems are redundant.

4.5.2 An Automatic Train Operation (ATO) system shall be provided for the Thessaloniki Metro Main Line, connection track to depot, stabling track in the Depot, test track in the Depot. The various functions and information to be transmitted are specified in the train borne ATO system. The ATO system shall support automatic train operation in normal and reverse direction of traffic.

4.5.3 All line side ATO equipment, if any, shall be interconnected and shall be connected with the central ATO equipment, installed in the OCC technical room. Optical fibres specified in the Communication Facilities specification shall be used to interconnect all line side ATO equipment, if any, and to connect the line side ATO equipment to the central ATO equipment. The fibre connections shall be redundant in each tunnel. Dedicated fibres shall be used.

4.5.4 ATO line side equipment and the other parts of the ATO system are not required to be fail-safe, line side ATO equipment shall be fully redundant in all levels in compliance with the requirements for driverless operation.

4.5.5 The Contractor shall bear in mind the environmental conditions in Thessaloniki in which the ATO equipment shall operate. (See the General Specifications -Environmental Conditions)

4.5.6 The Contractor shall supply detailed information to the Service on how his ATO equipment works. Additionally, a system layout shall be provided and all major components shall be clearly identified.

4.5.7 The Contractors application software shall be approved by AM and shall include the following:

- Support of real time operating systems.
- Well structured with sufficient documentation.

4.5.8 The Contractor shall deliver to AM all documentation necessary to obtain complete understanding of the system logic.

4.6 Service PC for Line side ATP and ATO Equipment

4.6.1 Service and diagnostic information from line side ATO equipment shall be accessible on the ATP service PC through the ATP line side equipment.

4.6.2 The service PC shall be of an industrial type and it shall able to display any menu from the ATP cabinets together with service and diagnostic information from ATO equipment. Non safety related functions shall be allowed to be performed from the Service PC.

4.6.3 The ATP equipment shall be connected with the Master Clock in the OCC via the signalling time distribution system. The re-synchronization after temporary loss of central time reference shall be made automatically.

4.7 Local Operation in non-central architectures of the ATC system

The components on this level shall communicate with the fail-safe levels of control and safety via a permanently defined interface. On the local operation level basic automation shall be available in order to ensure an appropriate level of operation in case central operation failed. At central operation level, valid shall be the content of Specification ATS for MCR and ECR.

4.7.1 Train Describer System

4.7.1.1 A system of train identification shall be provided as an essential part of train control. The train Identification system shall use the vital train – track transmission system for transmission of the permanent rolling stock number to the line unit.

4.7.1.2 The train number shall consist of a permanent rolling stock number, an operational train running number and a staff number.

4.7.1.3 The permanent rolling stock number, the operational train number and the staff number shall have at least 3 digits each.

4.7.1.4 The permanent rolling stock number shall be transmitted periodically at least during each station dwell and at stabling positions to the OCC and to the local interlocking.

4.7.1.5 The train borne ATC system shall receive the proper operating number from the ATS system in compliance with the timetable and the permanent rolling stock number.

4.7.1.6 The train attendant shall key the staff number in when he enters the train. The staff number shall be reset by the train attendant when he leaves the train or automatically during each setting to sleep of the train.

4.7.2 Automatic Train Routing System

4.7.2.1 The automatic train routing system shall be interfaced with the central ATS Automatic Train Route Management system for routing commands in compliance with the train number and the timetable. In case the central command fails, the local automatic of the train routing system shall control train routes based on interlocking logics. The system shall be able to manage automatic route setting for

- Reversing in terminals, using pre-selected reversing routes
- Turn backs on the line via the cross-over

- Train runs from terminal to terminal
- Line connections.

4.7.2.2 In case the central control fails partly or totally the local train routing system in each interlocking shall be able to perform basic automatic functions.

In case of central architecture without the local control logic, the control of the network is conducted in 15 minutes – as a maximum – in the Emergency Control Room, which shall be a replica – in both hardware and software – of the Main Control Room, as concerns the Signalling equipment. The same is valid for the respective Technical Rooms that support the Control Rooms, i.e. for the Main Technical Room and Emergency Technical Room.

In any other case, the train routing system shall be able to perform the following:

- The local train routing system shall automatically set reversing routes for train reversing in the forestation.
- The local train routing system shall automatically set train routes for front station reversing using alternating tracks – where applicable
- All train routes on open line over turnouts with an unambiguously pre-defined position of turnouts for normal train missions shall be controlled automatically with the approaching train.
- The local train routing system shall be able to automatically control midline turn backs at the line crossings at Sintrivani and at Analipseos station for all possible movement in the normal direction of traffic based on pre-defined operating scenarios.
- The local train routing system shall be able to control train routing to the future line connections to Kalamaria and Stavroupoli based on loop ratio management.
- The local train routing system shall automatically prevent dead locks of trains.

The Contractor shall submit his proposed train routing system to the Service for approval.

4.7.2.3 Due to the fact that only a few stations are equipped with a crossover and only a small quantity of point indicator signals are required, which could serve as route destination and route start signal, a special analysis of the signalling principles is required, so as to ensure a minimum level of performance for the Extension to Kalamaria, similar with the performance of the main line, as a minimum. More precisely, in case of a CBTC technology system, the special analysis of the concepts governing signalling shall concern downgraded operation due to failure of the CBTC, ensuring a performance level for the Extension to Kalamaria similar – as a minimum – to the corresponding performance level in the event of downgraded operation of the main line. The Contractor shall make a proposal together with his offer how to manage train reversing at station platforms and midline turn backs as specified above with his proposed signalling system. Physical wayside signals (except for point indicators) are not the preferred solution.

4.8 Train Spacing Function

4.8.1 General

For initial operation of the entire Thessaloniki Metro System, a headway of 150 seconds is planned. In future the headway shall be reduced to minimum of 90 seconds operational headway. The design headway concerning the signalling system for the line shall be 60 seconds. The train spacing and interlocking system shall comply already during initial operation with the future operational headway requirements of 90 seconds. The exact spacing of the trains towards Nea Helvetia and Kalamaria/Micra shall be as foreseen in the trips' electronic table of the ATS system, to include Kalamaria Extension as well. The following options – functions shall be included therein, namely:

- Outbound direction, e.g. every three trains, two shall be leading to the branch towards Kalamaria/Micra and one shall be leading to the branch towards Nea Helvetia
- Inbound direction – the signalling systems shall operate so as to ensure safe combination of trains coming from the two branches and heading to the centre of the city
- Possibility for on-line configuration of the train ratio to both branches shall be provided.

The train spacing function shall be performed by either a moving block system or a quasi-moving block system.

The Contractor shall propose the most suitable train spacing system as outlined below and provide a description of his proposed system supported by calculations of achievable headways together with his offer.

4.8.2 Moving Block System

The moving block system shall permanently ensure a relative safety distance between two trains. The required relative safety distance of a train to the previous train shall be continuously calculated based on information such as line characteristics, absolute position of the previous train and its actual speed taking into account all possible tolerances and wrong system reactions. Based on the distance to go information, the train borne unit shall calculate its own safe running profile and movement authority. For the absolute train positioning and the moving block system only a proven and safe system, which is already in successful operation and certified for metro applications, shall be proposed. The quantity of track circuits can be reduced by applying a train positioning system, which is independent from track circuit processing with respect to:

- Minimum operation performance in down graded mode

- Basic interlocking functions in order to ensure safety in down graded mode.

Axle counter systems are permitted in relation with moving block.

4.8.3 Quasi - moving block system

A quasi - moving block system shall perform train spacing function based on short physical or electrical block sections. The block sections shall be based on track circuit status processing or block sections made by inductive loops (Pilot line) or other certified proven systems. The required distance between a train and the border of the block section, which is occupied by the previous train shall be continuously calculated by the train, based on vital information received from the line side ATP such as line characteristics, position of the previous train and the actual speed of the following train taking into account all possible tolerances and wrong system reactions. The ATP system shall ensure that the safety distance between a train and the border of the block section, which is occupied by the previous train, is always maintained. In case of CBTC system, the provisions of Standard EN 1474 shall apply.

4.9 Train Communication Systems

Various vital and non-vital train communication systems are required between train and track and between track and train communication. The systems shall be based on spot transmission via beacons and on continuous transmission via track circuits, loops, microwave guide systems, power line or digital radio. Balises and loops for spot transmission systems shall be installed at stabling positions, at platforms and at platform stop positions and at all other positions required for the proposed system.

The following description forms the minimum requirements for transmission of information, which shall be complemented by the Contractor in compliance with his proposed systems applied in driverless metro systems. Continuous transmission instead of spot transmission is preferred.

For all systems and application the generic safety case must have been certified for other Metro applications. The Contractor shall submit together with his offer a documentation of his proposed communication concept together with the generic safety case. The Contractor in his offer as outlined below shall identify deviations from the described transmission principles.

4.9.1 Vital Spot Communication Train –Track via beacons and/or loops

- Permanent train number
- Train stand still information - 0 speed
- Opening of platform screen doors
- Leading end

- Other data as required by the system

4.9.2 Vital Spot Communication Track - Train via beacons and/or loops

- Train berthed information
- Fine train position
- Platform screen door status
- Train holding command at platforms
- Door opening (left / right / both)
- Other data as required by the system

4.9.3 Vital Continuous Communication Train – Track

To be defined by the Contractor according to his offered system.

4.9.4 Vital Continuous Communication Track - Train

- ATP line parameters required to process movement authority or distance to go values
- Other ATP related data
- Permanent and temporary speed restriction
- Release of train front and tail doors for passenger evacuation – if any
- Train borne short circuiting device
- Emergency stop
- Release emergency stop
- Other data as required by the system.

4.9.5 Non-Vital Spot Communication Train –Track

- Train ready to start
- Train diagnosis data
- Train mileage information
- Train maintenance information
- Routing information
- Status of individual train doors
- Closing of platform screen doors

- CCTV recording
- Other data as required by the system

4.9.6 Non-Vital Spot Communication Track - Train

- Train awakening
- Setting a train to sleep
- Setting a train to washing mode
- Release a train from washing mode
- Platform screen door status of individual doors
- Passenger information
- Other data as required by the system

4.9.7 Non-Vital Continuous Communication Train – Track

- Passenger Alarm information
- CCTV pictures
- Train diagnostic data
- Other data as required by the system
- Via the digital TETRA radio system or other

4.9.8 Non-Vital Continuous Communication Track - Train

- Non-stop train information
- Public address, triggering of pre-recorded announcements
- Train performance information for ATO functions.
- Other data as required by the system

4.9.9 Vital transmission might be made via non-fail to safe transmission systems. In such cases an appropriate coding or ciphering strategy shall achieve SIL 4 level.

4.9.10 Balises used for spot transmission from train to track and from track to train shall be of ERTMS EUROBALISE type.

4.10 Local Operation

4.10.1 For each electronic interlocking system of local architecture one local operating workstation shall be installed, in the Station Master Room at selected stations, for control and

supervision of the assigned local area. The operational borders between different local workstations shall be defined during the system design. For local architecture systems, there shall be a workstation for interlocking in the OCC/ECR.

4.10.2 Operational control and supervision shall be allowed from local workstations. For each predefined area to be operated from a local workstation, forced transfer of operation to local control and central control shall be implemented. In case of central architecture systems, a workstation shall be provided for monitoring the assigned local area.

4.10.3 All indications necessary for operational requirements shall be displayed in geographical form and shall include vehicle detection, point indications, routes, train numbers, Other indications shall be displayed either by use of graphics or in alphanumerical form. The Contractor shall propose together with his offer a command catalogue showing all commands and indications required to operate his proposed system. The vital commands shall be identified. The final command and indication catalogue shall be defined during detailed design phase.

4.10.4 Any local workstation will be used by authorised technical staff for test purposes and by operational staff in the event of failure of the central command via ATS in case of systems with local architecture. All local workstations shall be equipped with a plastic card reader in order to limit access to authorised personnel only.

4.10.5 The system shall provide at least a quantity of 8 different authority levels

- Level 1- System Administrator
- Level 2 – Local Operator
- Level 3 – Depot Operator
- Level 4 – Maintenance 1 with full access
- Level 5 – Maintenance 2 with limited access
- Level 6 – Data logger and reporting
- Level 7 -8 – Spare – will be defined at design stage

4.10.6 Access to a specific authority level shall be password protected. Access to traffic views, diagnostic data, alarms without commands should not require any authority level. Details of permitted commands and views for each authority level shall be defined during detailed design.

4.10.7 All functional units, forming part of local architecture systems, which are needed for operating a certain predefined area, shall be grouped together and shall be installed in the operating desk normally located in the Station Master's Room. The hardware used for an operating desk shall be an industrial grade, high quality PC with keyboard, mouse, TFT flat-screen 21-inch colour monitors and a printer. Installed software in the PC shall be suited for handling safety-related information. All installed application software in the workstation shall be dedicated to the operating system.

4.10.8 The printer for the workstation shall be a low-noise printer, suitable for use in an office environment.

4.10.9 Workstations that are not operational (Operation transferred to central control) shall be updated with indications from the central computer. It shall be possible to switch the workstation off without affecting the operation of the system.

4.10.10 Each local workstation shall be furnished with ports for connecting auxiliary equipment for archiving and for connecting a colour printer for print out of events requiring special attention.

4.10.11 All local workstations and printers shall be fed from the Signalling UPS through a power frame located in the signalling power room in the associated interlocking station.

4.10.12 An event counter shall be provided at each local workstation for counting the number of abnormal operations of the workstation. This function shall be agreed to by the Service after award of the Contract.

4.10.13 Train number display on local workstations
The train number of each train shall be displayed on the corresponding track section on the flat screens of the local workstation. The train number shall be forwarded from section to section according to the movement of the train. The train number shall be periodically updated according to the movement of the train. The train describer system shall be functional on local operator workstation with or without the central ATS system. All train numbers of each train in operation shall be indicated permanently.

4.11 Service and Maintenance Equipment

A service and maintenance system shall be implemented. As a minimum this system shall provide the following functions:

4.11.1 Service and Diagnostic System

Each electronic interlocking system shall be equipped with a service and diagnostic system in order to implement efficient faultfinding and maintenance by means of user-guided online diagnostic. Faults and failures shall be detected and analysed by this system and shall be grouped in different levels depending on the type of fault. For each fault indication, the service and diagnostic system shall display the faulty element, an analysis of the fault and the measures for rectifying it. An electronic maintenance manual shall be accessible via the service and diagnostic system, which shall provide the maintenance personnel with definitive information on how to rectify a fault. The service and diagnostic system shall display the state of the controlled equipment, shall record and display continuously any fault indications, and shall provide quick and easy guidelines to certified users. The service and diagnostic system shall be located within the signalling technical room. Any fault shall remain on the display until the service and diagnostic system has registered that the fault has been rectified. In addition to monitoring system messages, the service and diagnostic system shall be used to activate test programs and utilities in the interlocking computers.
The service and diagnostic system shall consist of a PC and a logging printer using endless paper. A low noise printer of the latest technology shall be provided. To duplicate the graphic displays of the local workstation in the SMR, a separate 21-inch flat screen monitor shall be furnished and installed in the signalling room.

4.11.2 Operational Log

The interlocking system shall have an operational log function implemented, in which information regarding operational issues shall be stored. The operational log shall be rolling and information shall be stored for at least 1 week.

4.11.3 Fault Log

The interlocking system shall have fault log function implemented, in which any fault shall be stored together with a fault identifying code or fault classification. The faultfinding log shall be rolling and information shall be stored for at least 1 month. The performance and functions of the service and diagnostic system shall be subject to approval by the Service.

4.11.4 Centralized Diagnosis and Recording Facilities

The interlocking buses shall be provided at the Operations Control Centre (OCC) in the Depot for connecting the local interlocking with a centralized Service and Diagnostic system for the purpose of remote diagnostic, fault analysis and data logging. All information of the local interlocking shall be made available at the OCC.

4.12 Train Detection Equipment in Areas and Depots where Automatic Train Operation and Automatic Train Protection is Used

4.12.1 Vehicle / train detection systems shall be employed for all tracks on the mainline, on turnouts and crossovers, at the connection track to the depot and within the depot except on maintenance tracks within the depot. Each turnout shall be equipped with its own individual vehicle / train detection circuit.

4.12.2 Vehicle / train detection shall be based on track circuit systems. The track circuits shall be of joint less audio frequency track circuit type. In case of CBTC systems, the primary system for train detection shall be ensured through radio waves, while the line circuit shall be the secondary detection system

4.12.3 The vehicle / train detection system shall be able to operate, under all possible environmental conditions that may be encountered in tunnels and in open land. The vehicle / train detection equipment shall be highly reliable, approved to be fail-safe and must have been applied successfully in other Metros for at least 5 years.

4.12.4 The track bed between rails shall be kept free from any obstacles, which could prevent the track bed for use of passenger evacuation or access for rescue teams. Vehicle / train detection equipment, bonding, beacons and connections shall not form any trap or risk for rescue team or passengers. The contractor shall supply together with his offer detailed drawings of all typical installations of his proposed vehicle / train detection and bonding equipment.

4.12.5 The vehicle / train detection system shall serve for interlocking functions and for train traffic management in down graded operation mode. It is also permitted but not mandatory to use vehicle / train detection system for train spacing functions in form of a quasi-moving block.

4.12.6 The vehicle / train detection equipment shall be applicable to the applied track-form. The equipment shall be able to handle train movements in both, normal and reverse directions.

4.12.7 The primary and secondary – if proposed by the Contractor - vehicle / train detection system and associated equipment shall be immune to false operation or any adverse effects. Immunity shall be ensured against any influences from traction power system, from vehicle traction and auxiliary equipment. With regard to wireless digital systems for train position communication, these shall be also immune against malicious actions, e.g. deliberate interference, interception of critical parameters of the transmission system or of other data. Contractors to include such a system in their offer, shall document their compliance with IEC-62446 Standard "Cyber security Railway Signaling and Processing Systems".

The Contractor shall monitor the progress made in the data protection technology (Cyber security) and, upon AM's request or at his own initiative, shall update the protection methods

up to the provisional acceptance of the Signalling system, following a relevant submission and approval by AM.

4.12.8 Any relay or component used in vehicle / train detection equipment shall be approved as a component to be fail-safe. The Contractor shall show how fail-safe principles are met. All contacts used in track circuit equipment shall be sufficient in size for the duty each is to perform.

4.12.9 The vehicle / train detection equipment shall withstand any effects produced during short circuit of the traction power system, without suffering any damages. Under no circumstances shall a voltage change due to a short circuit in the traction power system lead to an increase in potential on cables between connection boxes and technical rooms. The insulation level and the installation in track connection boxes shall be able to maintain separation between track side and 'technical room side' during short circuit of traction power systems.

4.12.10 The requirements for track maintenance using mechanised equipment shall be taken into account so that the use of such equipment in track maintenance will not impair or damage the vehicle / train detection system, and will cause no failures.

4.12.11 Vehicle / train detection equipment for vehicle or train detection, such as track conductors or track beacons, if installed shall allow track maintenance vehicles to perform track work with minimal interference.

4.12.12 Particular Requirements for Track Circuits on Mainlines and the Depot Stabling Shed

4.12.12.1 The track circuit equipment proposed for use in areas where Automatic Train Protection is used shall not require insulated rail joints in straight tracks. In areas with points a minimum number of insulated joints shall be used. The insulated joints within turnouts shall always be installed on the less frequently used side. The Contractor shall state his estimated quantity, location and insulation requirements for all insulated rail joints.

4.12.12.2 Both rails of a track shall be available for traction return current. This requirement is not compulsory in the Depot, provided that more than 2 parallel rails are available for return current.

4.12.12.3 The Contractor shall clearly identify his requirements for safe and reliable function of track circuits regarding permitted noise current for balanced and unbalanced traction return current and the principles of traction return connections and equipotential bonds.

4.12.12.4 The cables used for S-Bonds, Terminal Bonds and Equipotential Bonds shall be adequate in size and number for carrying the traction return current under normal or faulty conditions. Isolation of one rail of return current (fully broken rail) shall be considered as a faulty condition. The Contractor shall submit drawings showing the location of connection to rectifier stations, and the place where equipotential bonds are permitted.

4.12.12.5 Track circuit equipment shall function correctly in ballast conditions as well as on tracks on concrete slabs likely to be experienced in Thessaloniki, in tunnels, in Depots and in open land. Ballast resistance will vary between 1.5 ohm/km and up to 10 ohm/km. The track circuit equipment shall be capable of operating with nominal axle shunt resistance equal or less than 0.5 Ohm. The Contractor is reminded that high temperatures in open land, especially in sealed boxes exposed to strong sunshine will occur. Furthermore the Contractor is reminded that heavy rainfall in periods of the year takes place.

4.12.12.6 Track circuit equipment shall detect occupancy of a track section for the following:

- With the passage of one axle and wheel of a train.
- With non-revenue trains and service trains of the system.
- The detection shall be registered no later than 0.35 seconds after the physical occupation has occurred.

4.12.12.7 The safety case of the track circuit system shall not require a special periodical traversing by trains of non-frequently used track sections. If such conditions exist in the safety case of the track circuit system, then the surface of the rails of such short track sections in crossovers shall be covered by material, which ensures a sufficient low resistance between wheels and rails in order to ensure a safe operation of track circuits that have not been traversed by trains for two weeks.

4.12.12.8 Track circuit equipment shall be equipped with an embedded delay function, keeping any circuit occupied until the physical condition for release in the tracks has persisted -

without any interruption - for 1.0 Second. The delay function shall be implemented as a fail-safe function.

4.12.12.9 Any significant part of a track circuit that requires maintenance in order to prevent errors or periodic adjustment shall be located inside the technical signalling equipment room. Test connection points for preventive maintenance and periodic measurements necessary to determine the state of the track circuit shall also be located inside the technical room.

4.12.12.10 All Track Circuits shall be arranged to provide an acceptable level of broken rail detection. At point and crossing areas, the bonding shall be such as to eliminate any significant length of undetected parallel rails.

4.12.12.11 For Track Circuits the Contractor shall state in his technical offer and guarantee the following:

- Maximum vehicle shunt in order to ensure occupation of the track circuit at the feeding end of the track circuit.
- Minimum vehicle shunt in order to ensure release of the track circuit at the receiving end of the track circuit.
- The guaranteed range of ballast resistance (ohm/km) in which the track circuit is designed to operate.
    - The maximum and minimum length of track circuits over which the circuit will operate without violating the specified conditions for the track circuit.
    - The type(s) and maximum length of cable necessary for connections to the track, for correct operation.

The cabling shall connect the different track sections with feed and receive equipment, located in the technical room for Signalling equipment.

4.12.13 Particular Requirements for Axle Counters on Mainlines and the Depot Stabling Shed

4.12.13.1 Axle counters shall be designed for a train speed of > 160 km/h and the shortest axle distance of service cars and revenue vehicles.

4.12.13.2 The axle counter circuit shall be of fail-safe design (SIL 4) and successfully used in railway and metro applications for a period of at least 5 years.

4.12.13.3 The status of the axle counter section (clear / occupied / failure) shall be clearly indicated by LED's on each axle counter unit in the technical room. Each axle counter circuit shall be able to manage at least 4 counting points.

4.12.13.4 The electronic counting points shall be compatible with the applied rail profiles and the full worn wheel diameters and shall be immune against electro magnetic interferences.

4.12.13.5 The axle counter system shall be redundant and error tolerant. Counting errors of one axle shall not lead to an occupation status of the track section. The Contractor may propose, and the Service might approve an Axle Counter system without counting error acceptance, provided that the Contractor can prove and demonstrate that a maximum of not more than one counting error per month of Metro operation will occur.

4.12.13.6 In case of an erroneous occupation status it shall be possible to clear the track section via a vital command (emergency release) via the ATS system and from the local operator workstation. Emergency clearance of the track section on lines shall become effective after correct passing of one train through the disturbed track section.

4.12.13.7 The axle counter system shall be able to identify the direction of a train movement over a counting point. A train that stopped with a wheel set on a counting point for reversing shall not lead to a counting error.

4.13 Train detection equipment in Depot areas without ATP/ATO Operation

4.13.1 The Depot consists of the "Automatically Operated Part" including the stabling tracks, and the "Manually Controlled Part" including the maintenance tracks, the test track and the connection tracks between. The "Automatically Operated Part", the test track and the connection track to the mainline shall be protected and operated in the same manner as the main line, using the same systems and equipment. It is permitted to use for the remaining part of the Depot monorail insulated AC track circuits. The maintenance tracks inside the building shall not be insulated. In case the Contractor will apply monorail insulated AC track circuits instead of joint less track circuits, the following shall apply.

4.13.2 Track circuit equipment for Depot areas shall be able to operate, under all possible environmental conditions encountered, in tunnels and in open land in Thessaloniki.

4.13.3 Track circuit equipment to be used in Depots shall be approved for fail-safe applications.

4.13.4 The selected frequency for the track circuit equipment for Depots shall not permit EMI from any sources that create harmonic frequencies, such as the rectification process producing DC traction power or adjacent transformation process producing AC traction power or Rolling Stock Choppers and Inverters, which can violate safe operation.

4.13.5 AC track circuits installed in Depots shall be frequency and phase selective in order to ensure sufficient immunity against noise from Rolling Stock traction equipment and 50 Hz adjacent Traction Systems.

4.13.6 In areas where AC Track Circuits are installed, one rail shall always be available for traction current in such a way that the current can flow in at least two different paths to the rectifier station.

4.13.7 Equipotential bonds and Traction Power return cables shall be adequate in number and size, as required for carrying traction return current under normal conditions as well as fault

conditions. The signalling system shall permit Traction Power return cables and shall identify the places where equipotential bonds can be installed.

4.13.8 The Contractor shall submit together with his offer the type of vehicle detection equipment proposed together with the following information:

- Complete explanation of the operation of the proposed track circuit equipment, including a block diagram and information showing how fail-safe operation is achieved and maintained under the conditions encountered in the operation of the Depot.
- Shunting sensitivity.
- Methods to detect insulated joint failures.
- The immunity against EMI.
- Reliability figures and environmental conditions.

4.13.9 For track circuit equipment of the AC track circuit type, the Contractor shall state and guarantee the following:

- Maximum vehicle shunt resistance in order to ensure occupation of the track circuit at the feeding end of the track circuit.
- Minimum vehicle shunt resistance in order to ensure release of the track circuit at the receiving end of the track circuit.
- The guaranteed range of ballast resistance (ohm/km) in which the track circuit is designed to operate.
- The maximum amount of conducted noise current and transient peak currents that can be allowed to flow in the rail under worst-case conditions without picking up an AC track circuit where the track is physically occupied by train.
- The maximum and minimum length of track circuits over which the circuit will operate without violating the specified conditions for the track circuit.
- The type(s) and maximum length of cables connected to the track necessary for correct operation. The cabling shall connect the different track sections with feed and receive equipment, located in the technical room for Signalling equipment.

4.14 Points and Point Machines

4.14.1 Point Machines including control and detection rods shall be suitable for use with the rail section, third rail and type of track formation. Point mechanisms shall be tolerant with the minimum of adjustment and with rail movement caused by temperature variation or rail drive caused by vehicle and train movement.

4.14.2 It shall be the Contractors responsibility to ensure that point-machines and derail equipment are compatible with the track form adopted by Thessaloniki Metro Base Project.

4.14.3 Point Machines shall be small, compact units, readily accessible and interchangeable. They shall present a minimum hazard to staff or passengers walking along the track. Point Machines shall be simple in operation and shall require the minimum of maintenance. Points shall be operated by electric power. Any point mechanism and control equipment shall comply with a stated National Railway Standard or used by an established Metro authority.

4.14.4 Power operated point equipment shall include a locking mechanism to prevent switch and stock rail opening except by deliberate operation of the mechanism. Locking mechanisms that clamp switch and stock rails in an integral unit are preferred. Maintenance intensive external clamp locks are not permitted.

4.14.5 The driving time needed to perform a full movement of the point mechanism from one side to the other shall not exceed 5 seconds. The throwing time shall be reviewed together with reversing time calculations to be provided by the Contractor. The design of point operating circuit shall relate the driving time of the switch and the train detection length under worst case conditions to ensure that any switch does not move in front of a moving vehicle / train.

4.14.6 The point equipment shall be capable of manual operation locally by use of a crank-handle or bar. A Key shall be necessary to disconnect the power source whilst a suitably authorized member of the staff is carrying out manual operation. The key shall be locked in a key-release instrument close to the turnout. Release of the key shall be made by an interlocking command.

4.14.7 An electrical circuit shall detect all closed switches. The accuracy of the detection shall be such as to prevent detection being obtained if an opening exists between stock and switch rail, which could be entered by a wheel flange or a worn wheel flange. The detection shall be continuous and shall also check that the open switch has a sufficient clearance for a wheel flange to pass. Detection devices shall be located close to the rails, minimizing the length of any interconnecting rod.

4.14.8 The Contractor shall provide a safety assessment of the permitted tolerances of "closed position detection" between stock rail and switch rail with respect to the wheel flanges and worn wheel flanges of the passenger and maintenance train wheels.

4.14.9 The Contractor shall provide all equipment necessary to secure a set of points in either "normal" or "reverse" position to permit vehicle movement over the points in emergency if the locking and detection of the points is not possible under failure conditions. If such equipment is independent and not an integral part of the point design the contractor shall arrange for a suitable location and housing in the nearest Station Master Room. The Contractor shall furnish one such device for each point machine on the mainline. Details of this equipment and its location shall be proposed by the Contractor and agreed to by the Service.

4.14.10 The Contractor shall be responsible for ensuring that equipment will fit efficiently under all conditions and to ensure the provision of adequate rail drillings, stretcher bars, auxiliary drives and a gauge plate. All equipment shall be provided with insulated coverings to provide a safe walkway to staff and detrained passengers. Protection shall also be provided against damage to point equipment by hanging equipment from passing trains.

4.14.11 All point operating equipment and operation and detection circuits shall be totally immune from traction current effects or other interference sources. The case of the point machines shall be grounded to the 'grounding' rail.

4.14.12 A permanent label shall be fixed to the fixed part of the point machine to depict the point number and the normal position of the point. Where two or more points are operated together from a common control circuit each end of the point shall be clearly identified by labels both locally on the equipment and on circuit diagrams and plans by an agreed system such as a suffix letter A, B, C, etc where the "A" end is nearest the signal equipment room.

4.14.13 The control circuitry for the points shall include a circuit to disconnect the power supply to the points after a predetermined period of time if detection is not confirmed.

4.14.14 It is the Contractor's responsibility to ensure that all point equipment and connections thereto form an integrated design and that points operate efficiently under service conditions.

4.14.15 The Contractor shall fully describe his proposed point operating, locking and detection mechanisms, together with any requirements for auxiliary drives or other special features.

4.14.16 Point Machine wires shall be protected to prevent short-circuiting and monitored continuously for earth leakage. Housing shall be insulated from the mounting devices and grounded.

4.14.17 Point machines, located in open land and in tunnels closer than 1000 metres from any entrance or connection track from open land, shall be equipped with lightning arrestors in order to protect interlocking equipment against surges from lightning. All wires form the aforementioned point machines, except for wires related to detection, shall by their entering to a Signalling Technical room be equipped with lightning arrestors able to stop any surges that may find its way into the technical room from Point Machine motors.

4.14.18 The preceding provisions also apply for derails. Additionally derails shall be automatically restored to the derailing position upon releasing of electric route or time locking.

4.15 Signs, Signals and Point Indicators

4.15.1 All wayside signs required for train movement purposes shall be located such as to be readily visible to train attendants or service train drivers. Signs shall be reflectorized and visible from a vehicle cab from a minimum unbroken distance of 40 meters. Signs, which may need to be viewed from a greater distance, shall be illuminated.

4.15.2 Signs installed inside tunnels and Depot shall not obstruct the walkways or create danger for staff and/or evacuation of passengers. Signs shall be printed/manufactured in a quality that can withstand washing and cleaning without losing printing and degradation due to weather and daylight.

4.15.3 Signs shall be installed in the following locations:

- On signals and point indicators with a unique number of the signal/point Indicator.
- At train stops of operational reversing and berthing positions
- At train stop position at platforms for facilitating accurate train stops for manually driven trains and rescue movements for both, single train and coupled train movements
- At track ends.

The Service shall approve installation of signs. A unique number forming part of the signal-numbering scheme shall be included for reporting purposes.

4.15.4 All equipment in tunnels and Depot shall be labelled by a unique unmistakable numbering system. The labels shall be on engraved material and clearly visible for operation and maintenance staff. Labels shall be placed on the following equipment:

- On point machine boxes with a unique number of the point.
- On track connection boxes for track circuits with a unique number of the track circuits together with identification of the track circuit end.
- On cable distributors
- On beacons and loops,
- On key-instruments and connection boxes.

The Service shall approve material of labels, sizes and fastening.

4.15.5 In areas where tracks end, in terminal stations and ends of tunnels, a signal or sign shall be provided for each track. Signs shall be used in ordinary cases. Signals shall be provided in case of difficulties with visibility or other difficult conditions. If signals are used, 2 permanent red aspects shall be provided. If signs are used, the sign shall display a reflectorized S. The

sign or signal shall be installed 1 meter before the end of the track. If signals are used the Interlocking shall monitor them.

4.15.6 Mainline Signals in areas where Automatic Train Protection is used are named Point Indicators. Point Indicators shall be located at the approaches to all track switches or group of track switches. Point Indicators shall show green aspect when all of the following conditions are fulfilled:

- Points to be traversed behind the Point Indicator have detection and are locked.
- Points that provide flank protection for the route behind the Point Indicator have detection and are locked.
- Absence of automatic origin release. (Emergency release not in progress).

Otherwise red aspect shall be shown.

Signals in Depots shall show yellow aspect for the tracks without ATP when all of the following conditions are fulfilled:

- Points to be traversed behind the signal have detection and are locked in interlocking.
- Flank protection is provided for the route behind the signal either from points with detection that have been locked in interlocking or from signals showing red aspect and locked by the Interlocking.
- A route from a signal to the next signal or point indicator is set.
- All track circuits located in the route and tracks that provide flank protection are unoccupied.
- Absence of automatic origin release (emergency release not in progress).

Otherwise red aspect shall be shown.

4.15.7 Signals in Depots shall be visible from a vehicle cab at a distance of 40 metres and continue to be visible at a distance of 2 meters from the signal. Signals shall be equipped with light-spreading devices.

4.15.8 Point Indicators shall be provided for driving in both directions on both tracks. Under normal (non-failure) conditions the point indicator status shall be consistent with cab signalling.

4.15.9 Point Indicators shall be used primarily under failure conditions to permit operation of trains in Permissive and Manual modes, in case of failure of the ATP/ATO mode.

4.15.10 When a point indicator is red or cannot show red aspect, information shall be sent to ATP line side equipment in order to establish a stopping point in front of the destination signal.

4.15.11 Point Indicators shall be visible from a vehicle cab at a distance adequate for the train Driver to stop in front of the point indicator by applying normal service brake, from a speed of 15

km/h. The distance in any case shall not be less than 40 meters. In cases where 40 meters cannot be achieved, a repeater Point Indicator shall be provided, in such a way that the Driver has unbroken view for 40 meters. Repeater point indicators shall show yellow aspect or green aspect, both purely repeated from the preceding main point indicator.

4.15.12 Point indicators and Depot signals shall be equipped with Light Emitting Diodes. A lifetime of 10 years shall be guaranteed.

4.15.13 For signals and point Indicators the loss of energy in each lamp circuits shall be limited not to exceed more than 50%, of the energy transferred from a feeding point inside a technical room. If the feeding equipment is common to a group of lamp circuits the loss shall not exceed 50% for each of the lamp circuits.

4.15.14 Signals installed outside the tunnel shall be equipped with a day/night function. The function shall be performed by automatic detection of daylight and automatically controlled. A manual control from the ATS and the LWS shall be possible.

4.15.15 Signals and point indicators shall be continuously monitored for physical cable cuts. In addition, the Contractor shall identify how he intends to deal with short circuit of lamps, cable & wire short circuits and earth leakage. Housings shall be insulated from the mounting devices and grounded.

4.15.16 Signals and point indicators, located in open land and in tunnels shall be equipped with lightning arrestors in order to protect Interlocking equipment against surges from lightning and over voltages. All wires from the above-mentioned signals and point indicators, entering the Signalling Technical room shall be equipped with lightning arrestors able to prevent equipment damage from lightning.

5 TECHNICAL REQUIREMENTS

5.1 General

5.1.1 Equipment, materials and designs supplied for signalling and train control shall be designed and installed in accordance with the most stringent of the relevant European or National Railway standards. The Contractor shall provide a brief design including the differences between the updated editions of the relevant Standards and the Standards utilized in Base Project, laying emphasis on the safety and operation-related differentiations and shall submit same for approval by AM. Equipment to be used shall be listed and the relevant standard or specification indicated. Equipment in this context shall be taken to include both hardware and software.

5.1.2 The following equipment shall comply with the most stringent of the European Railway or National Railway Standards and shall have been previously successfully employed by a Metro Railway Administration for use in metro lines.

- Track circuits, axle counters and other vehicle/train detection equipment.
- Safety Relays.
- Electronic Interlocking Equipment.
- Point operating and detection equipment.
- Line side Signals (Point Indicators)
- Line side ATP/ATO equipment.
- Continuous and intermittent communication equipment.
- Train borne ATP/ATO equipment.
- Cabling and wiring.

The Contractor shall comply with all accepted National standards for design and installation of electrical equipment covering earthing, bonding, corrosion protection and stray currents and shall comply with any requirements in force in Greece. The Contractor shall refer to the General Specifications concerning Earthing, Bonding & Corrosion Protection.

5.1.3 The Contractor shall propose a consistent numbering scheme, which shall clearly identify all equipment and enable controls and Interlocking to be readily discerned. The numbering scheme shall be subject to the approval of the Service. The numbering scheme shall be offered for agreement in principle within 6 weeks after award of Contract.

5.1.4 All drawings, schedules and plans shall be produced to a format agreed with the Service. All symbols, nomenclature and abbreviations shall be described on the drawings. All symbols, nomenclature and abbreviations shall comply with an accepted specification or standard, e.g. I.E.C 1991 - Railway signalling symbols, wiring diagrams and nomenclature.

5.1.5 All drawings, wiring diagrams, schedules and plans etc, shall be supported by clearly presented control tables, flow charts and written descriptions explaining the operation of the proposed systems.

5.1.6 All designs, materials and equipment shall, where applicable, comply with an accepted fire safety standard especially with the updated edition of Standard NFPA-130. The entire signalling system including its power supply shall be considered as a life safety critical system in the understanding of NFPA -130. All designs, materials and equipment shall continue to function correctly and safely in the presence of the traction system.

5.1.7 All designs, materials and equipment shall continue to work correctly and safely in the presence of Electro-magnetic fields (EMI) created by other equipment, whether part of the Thessaloniki Metro or not. The Contractor shall be responsible for identifying such (EMI) sources and providing adequate screening or other remedial measures.

5.1.8 All designs, material and equipment shall be of proven technology and used in Metro transit applications.

5.1.9 All designs, material, equipment and accessories supplied under this Contract shall be to the approval of the Service.

5.2 Security/Safety

5.2.1 The Contractor shall ensure the safety of the installation, demonstrate the safety of the installation to the Service and furnish all necessary items to maintain the safety level for the life of the system.

5.2.2 The Contractor shall comply for the execution of the project with the requirements of the following standards:

- EN 50126: Railway applications- The specification and demonstration of RAMS
- EN 50128: Railway applications - Software for railway control and protection systems
- EN 50129: Railway applications- Safety related electronic systems for signalling
- EN 50159: Railway applications- Communication, signalling and processing systems. Part 2: Safety related communication in open communication systems
- EN ISO 9000-3: Quality management and quality assurance standards- Part 3: Guidelines for the application of ISO 9001 to the development, supply, installation and maintenance of computer software)
- ISO 10007: Quality management –Guidelines for configuration management.

5.2.3 All designs, material and equipment (including the software) associated directly with the control of train movement shall be fail-safe whereby one fault, breakage or disconnection

shall result in a more restrictive condition being applied or otherwise shall not result in controls allowing train movement to be made under unsafe conditions.

5.2.4 The safety integrity level shall comply with SIL 4 with corresponding application criteria in accordance with EN 50129 standard. It is clarified that SIL 4 is required for the Operator Workstations with signal control. In case of systems with central control architecture, SIL 4 safety rating is required for central workstations.

5.3 ORGANISATION OF THE CONTRACTOR

5.3.1 The Contractor's organisation shall be in accordance with the § 5.3.3 of the standard CENELEC EN 50129. The safety assessor shall be independent from the Contractors organisation and shall be approved by the Service.

5.3.2 The Contractor shall mandate a qualified and certified authority (third party) to provide a valid safety approval of the system. The choice of this third party shall be submitted to the Service for approval.

5.4 SAFETY ACTIVITIES

5.4.1 It is the responsibility of the Contractor to prepare the generic and specific safety cases for the entire system and to obtain all required safety approvals for operation.

5.4.2 In accordance with the above standards the Contractor shall submit for approval, a plan describing the safety assurance program relating to the systems and equipment proposed for the project. This plan shall describe how safety is managed and achieved throughout the life cycle of the system including all the activities affecting safety, from requirements analysis and material/equipment selection to design, system verification testing, maintenance and performance demonstration. The objectives of the safety assurance program shall:

- Ensure that the system achieves proper level of safety in all phases of the project. The safety life-cycle plan shall address all activities, which affect the safe implementation of the Signalling system; e.g. material conformance, design and implementation, installation, overall validation and maintenance procedures.
- Minimise the probability of a hazardous condition (reliability analysis).
- Minimise the effects of hazardous condition.

The Contractor shall complete a hazard and risk analysis report prior to submitting the safety assurance plan for approval.

The technical overall safety report shall include all facts that are relevant to the safety of the design, including all supporting evidence; for example, design calculations, test results and safety analyses. The document shall be arranged under the following chapters:

- Assurance of correct operation.

- Operation under fault conditions.
- Operation with external influences.
- Safety related application conditions.
- Test specification and results.
- Quantitative safety analysis.
- Safety regarding operating rules and procedures.
- As an additional and subsidiary benefit, the ease of fault finding and maintenance of the system shall also be addressed.

5.4.3 In the event when safety modifications are performed in any safety system or when new equipment is added, the Contractor shall document such modifications and shall submit the necessary safety certificates for approval.

5.4.4 The Contractor shall provide all safety approvals and closing out of corrective action requests – if any - two month prior to start of trial run – for the release of the trial run and two month prior to start of revenue operation – for the certification of the system for revenue operation. The safety approval shall cover the Extension to Kalamarai and the impact on the generic system, the generic application and the specific application of the entire signalling and train control system of Thessaloniki Metro. All costs related with the safety approval and certification of the systems by a accredited certification body shall be borne by the Contractor.

5.5 SPECIAL REQUIREMENTS

5.5.1 The Contractor shall furnish authenticated evidence of safe and reliable implementation of a full automatic driverless Metro signalling and train control system together with references to in-service installation obtained from other public metro authorities. This evidence shall be supported by a technical explanation of the equipment principles, including failure modes and experienced availability data. This document of evidence shall be submitted to the Service together with his technical offer.

5.5.2 The Contractor shall furnish details of his proposed Quality Assurance programme for all materials, equipment (including software) and accessories within his supply.

5.5.3 The Contractor shall identify those features, which reduce the susceptibility of his equipment to unauthorised interference, theft and vandalism. This is to include both design and installation features.

5.6 General Requirements for Interlocking

An electronic interlocking is a computerized safety system and is the interface between the central ATS control, train control system and the trackside signalling equipment. It contains

a record of the state of the railway and a set of rules, which must be obeyed when changing the state of equipment.

Risks shall be identified and controlled to maintain the safety integrity of the EIXL interlocking associated with:

- Remote control and data communication system
- Power supply system
- Control and display system
- Other interlocking system
- Trackside signalling equipment.

All systems must include the following requirements;

a) Demonstration of an acceptable level of safety, with assurance of system safety under all failure conditions, including power failure;
b) An acceptable level of dependability;
c) Compatible interfaces between hardware, software and other systems, including electro-magnetic compatibility;
d) Testability, including the ability to validate individual sub-systems separately, e.g. by disconnecting output comparators; and
e) The occupational safety of personnel working on the system.

5.6.1 A balance of diversity and redundancy should be used in developing the system architecture, so as to achieve the required safety and availability. If necessary, gradual degradation – in terms of operation - should be used to maintain availability with reduced functionality in the event of system failure. In a design of his, the Contractor shall present the aforesaid gradual degradation of the operability in a different manner than downgraded operation, as valid in the case of the Base Project (train movement with reset - ATP) underlining that network availability with downgraded operation is maintained to the maximum possible extent. This design shall be submitted to AM for approval. Based on the results of the designs, the implementation of the foreseen downgraded operation mode of the Extension to Kalamaria may be replaced by the operation mode foreseen in the aforementioned design. Whole life-cycle management, including verification and validation, should be provided for each phase of design, in accordance with EN 50129. Software requirements are given in EN 50128 and dependability requirements in EN 50126.

5.6.2 Any power supply failure such as interruption of power supply shall be handled by the electronic interlocking system in a way that shall allow the system to start again without intervention by signalling maintenance staff. The electronic interlocking system shall also be able to withstand power interruptions/fluctuations. Power interruptions/fluctuations shall not cause the electronic interlocking system to become non-responsive.

5.6.3 After any interruption of power supply, circuits shall revert to the appropriate state, and operation of the Metro shall continue without manual intervention by the signalling maintenance staff.

5.6.4 A high standard of safety and operational reliability shall be achieved by consistent use of safety-tested and approved equipment. The hardware employed shall ensure a high level of availability and reliability. Comprehensive error detection measures shall be implemented in order to achieve the maximum level of security during data communication. Correct functioning of the software specific to the interlocking shall be ensured by means of verification and validation.

5.6.5 Test programs shall check the hardware of each channel during normal operation to ensure that the safety process of the interlocking is guaranteed. Test programmes shall be executed cyclically and continuously by the Interlocking system. When a test program discovers a safety-related fault, the program shall terminate ordinary program execution and shall be able to bring the system into a safe state. Ordinary program execution shall take place according to well-known fail-safe principles.

5.6.6 The system shall be of advanced modular design, fail-safe, with high availability, utilising safe digital bus communication to reduce the total number of interconnections and shall be easy to expand. Therefore, the system can be extended in both data volumes and functions according to the needs of an expanding metro system.

5.6.7 The Contractor shall furnish authenticated evidence of reliable, fail-safe service and performance on an established railway or metro system. This shall be supported by a detailed technical explanation of the system principles, including operating modes, failure modes and assurance that a single fault will not affect operation at more than one interlocking. Clarification on the impact of such a fault on the operation of the corresponding interlocking shall be provided. The interlocking shall ensure that no hazardous operating conditions shall develop in the event of a single equipment failure. If an interlocking component or part of the outdoor equipment fails or malfunctions, the interlocking shall switch to a safe status ("fail-safe"). The interlocking shall be connected with each other using standard communication bus configured for fail-safe operation. Communication between interlocking shall be via a fully redundant optical fibre link. The same methodology shall be used for transfer of information to and from the Operational Control Centre (OCC).

5.6.8 Linking the interlocking equipment with local operating workstations or remote equipment shall be fully redundant and have a highly reliable design.

5.6.9 All circuits external to a signalling equipment room, which are of fail-safe design, shall be protected against cable faults and immune to any malfunction by external interference. The Contractor shall explain how his design meets these requirements. Separate cables shall be used for vital circuits such as train detection, point detection and point indicators.

5.6.10 All circuits shall be protected (e.g. by fuses) such that a fault on one circuit cannot cause the failure on another unrelated circuit. All connections of the electronic interlocking system with other equipment shall be protected against over voltage and over current. All outputs of the interlocking system shall be equipped with electronic circuits for current limiting. Any short circuit or over current of an output load shall be indicated by the electronic interlocking system (audible and visual indications). Circuits shall be segregated such that they can be isolated by withdrawal of fuses or isolation links for testing, fault-finding etc., on an individual basis and shall not affect any other circuits. All circuits entering or leaving a signalling equipment room shall be able to be isolated by withdraw able fuses or links of an approved design. All used terminal blocks shall provide means for connecting test instruments.

5.6.11 The Contractor shall explain clearly how all these requirements will be met, using typical circuit plans and diagrams where possible. He shall fully describe the equipment he proposes. The Contractor shall also furnish calculations of response times for each input/output operation.

5.6.12 With regard to systems with local architecture, the electronic interlocking system shall be controllable locally by a Local Operating Workstation and remotely by operation from the ATS system. This requirement is applicable to centralized systems architecture.

5.7 Hardware Requirements for Interlocking

5.7.1 The microprocessor-based interlocking shall comprise fully configured cabinets with the appropriate number of interface circuit boards corresponding to the outdoor equipment.

5.7.2 The electronic interlocking system shall consist of multiple microprocessors, using 2-out-of-3 fault-tolerant systems or other equivalent well-proven technology. Electronic interlocking shall use fault-tolerant microprocessors to handle information and the fail-safe processes. The E-IXL shall be of modern design using preferably PC compatible processors of latest technology. Redundant power supplies, sized with adequate reserve capacity, shall be provided for each microprocessor system.

5.7.3 The interface modules shall be the links between the interlocking system and the outdoor equipment. It shall contain the fail-safe logic for control and monitoring. The same shall apply for the interface modules for power adaptation to the elements of the outdoor equipment.

5.7.4 The interface modules of an interlocking shall allow sufficient capacity in operations in order to permit control of the entire line from a few local interlocking centres without need to install programmable interlocking equipment in tunnels.

5.8 Software requirements

The software shall be divided in two parts, basic software and application software.

5.8.1 Basic Software

The basic software shall carry out the system start and it shall enable online operation. During the system start, memories shall be checked and initialised, test programs shall be executed and the processes shall be started in the stipulated sequence. Reliable and redundant data communication channels shall be established and verified.

5.8.2 Application Software

The application software shall form a safe gateway to the signalling logic. All information transmitted from the operations control level to the interlocking shall be checked for syntactic and format errors.
The application software shall be approved by the Service and shall comply with the following:

- It shall be well structured, documented in detail and analysed by means of flowcharts, state diagrams that shall be subject to approval by the Service.
- The graphical environment E-IXL logic shall provide real time symbol animation of all elements, which shall offer the user the opportunity to define the exact structure of the system and the source of any malfunction.
- All necessary manuals in order for the Service to understand the application software.

- The Application software shall monitor correct response from all connections to the computer system. In case a line does not responds, the application software shall detect the missing response in less than 1 sec. An error message shall be generated and sent to the Local Workstation and the ATS system, if communication to these is not corrupted.

The acceptable recording time to the local operating and diagnostic network shall be maximum 1 sec.

5.9 Cables for Signalling

5.9.1 All cables run in any part of a tunnel or enclosed building or station shall be constructed according to National or International standards issued by an authorised organisation. The construction of cables shall be fire resistant as specified in EN 61373. Low smoke and halogen free material shall be used for both insulation and sheath. Especially for low smoke and halogen free properties testing to IEC 60754-1 and 60754-2 flame tests according to IEC 50265-2-1, shall be used. All cables and their construction or testing shall be subject to approval by the Service. The design shall comply with NFPA -130.

5.9.2 All outdoor cables shall be armoured and in case that screening is foreseen the braid coverage shall not be less than 80%.

5.9.3 All accessories and other materials shall comply with an accepted National or National Railway Standard and shall be to the approval of the Service.

5.9.4 The Contractor shall supply detailed information and appropriate data sheet for the cables he proposes to use for approval by the Service.

5.9.5 All cables forming a part of a fail-safe circuit or system shall be conventional copper conductor cables designed to international standards for railway signalling purposes and mechanically constructed to suit the method and route selected.

5.9.6 No manufacturer's joints shall be permitted in cables or wires carrying safety information. Any installation joints shall be by means of a termination box.

5.9.7 All cables shall be resistant to corrosion, rodent and insect attack. They shall be suitable in all respects for continuous operation in a Metro system under the environmental conditions prevailing in Thessaloniki in tunnels and in open land and shall meet the standard DIN VDE 0816 part 2.

5.9.8 Where cables cross the track or other ballasted area they shall be protected in a cable pipe against the environment and all manner of track maintenance.

5.9.9 Multi-core cables shall have an unmistakable system of identifying individual cores and shall (except for power cables) allow 20% or 4 cores, whichever is the greater, as spares. Identification of cores depends on cable construction (layers, quads, twisted pairs) and shall

be colour coded or marked with guide wire. The Contractor shall provide detailed information for the unique core and quad identification.

5.9.10 An approved method of identifying manufacturer and cable type (material, construction method and geometric characteristics) shall be provided throughout the length of all cables and wires. All cables shall be special ink printed on the sheathing with the word "Signalling" or "Remote Control", as applicable, at intervals of not more than 5m in Greek and/or English language in a size and style to be approved by the Service.

5.9.11 If not directly terminated in multi connectors all cables shall be terminated in the order of their core numbers on combined terminal links, equipped with screw terminals, according to a commonly agreed arrangement of cable routes agreed to by the Service. These links shall be easily accessible for test purposes with standard equipment. Each link or terminal shall be identified (numbered) and shall be labelled with the name of the circuit it carries.

5.9.12 All cables entering boxes, locations or equipment rooms shall be suitably clamped and the entries sealed against vermin, moisture, etc.

5.9.13 In track connection boxes, point machines, signals, point indicators and cable frames holding cables from trackside, all unused cores shall be terminated as all other cores.

5.9.14 All cables, after installation, shall undergo as a minimum continuity and insulation test. Audio frequency cables shall be tested for attenuation and characteristic impedance. The Contractor shall conduct all cable tests. The Contractor shall replace any cables failing to meet its requirements.

5.9.15 All cable ratings shall be such that adequate voltage, current and power ratings are used in compliance with stated national standards. Additionally, cables shall be selected such that a voltage drop in excess of 10% of applied voltage does not occur between bus bar and final equipment terminals. This requirement does not apply to remote control cables and other audio frequency circuits, which may use amplifiers to ensure an adequate signal level. The maximum attenuation before amplification shall be identified in each case.

5.9.16 Cables in tunnels and buildings shall be installed in cable ducts or cable trays clear of any possibility of damage. Trunking of an agreed design with removable lids shall be used on open sections. Cables and cable routes shall be clear of the system structure gauge and allow for walkways for staff or detrained passengers use in defined areas of the railway.

5.9.17 Low power cables (230 V AC) for signalling and signal cables, which are laid on the same tray or in the same compartment shall be mechanically forced segregated.

5.9.18 All cables shall, where necessary, include screens to protect circuits from the effect of induced electromagnetic radiation. Cables in tunnels and the Depot shall be armoured. Any shielding and armouring shall be properly insulated. In other areas where metallic screens are incorporated into the cable design, adequate insulation shall be provided to ensure that

the sheath cannot form a path for traction current return. The Contractor shall propose his method of connection to screens and conductors to achieve this. The Contractor shall also provide details of the construction and effectiveness of any cable screens for approval of the Service. It is not permitted to use shielding or armouring of cables as an earth connection.

5.9.19 Where cable routes are made common for more than one kind of equipment, e.g. telecommunications, then the Signalling Designer shall liaise with the Telecommunications and Power supply designer for determining mutually satisfactory arrangements for the use of routes and the running of cables, which shall be approved by the Service. Special consideration shall be given in determining routes to ensure lack of possible interference from cables running in parallel.

5.9.20 High voltage power supply cables and traction cables shall be segregated from signalling and telecommunications cables as far as possible. Minimum distance between LV cables and 750 V DC traction cables, 230/400 V AC power cables or 20 kV AC cables shall be 1 m. For cable routings in stations and buildings for routings through openings the distance may be reduced on short length.

5.9.21 Any trunking or similar devices for carrying cables shall not allow the accumulation of water nor shall they form drains for water.

5.9.22 All cable routes shall allow the easy identification and removal of any cable. The cables shall be clean and printing and labelling shall be easy to read. Cables shall be labelled each 20 meters approximately and at each connection and deviation point.

5.9.23 All indoor cabling shall be neatly run and installed in cable trays, ducts or conduits as are appropriate to the layout and equipment. All materials necessary for the routing of cabling and wiring, equipment rooms, apparatus boxes, kiosks, etc, shall be provided under this Contract. This shall include all fittings, brackets, clamps etc, which may be necessary.

5.9.24 Wiring within technical rooms shall use wires of a standard conforming to a National standard or National Railway or International Specification for use in fail-safe circuits. All wires in technical rooms shall be fire retardant and halogen-free. The Contractor shall supply details of the wiring he proposes

5.10 Power Supplies

5.10.1 Power supplies for Signalling purposes shall be from a highly reliable source based on a parallel redundant Uninterruptible Power Supply (UPS) located in a separate room consisting of two UPS units sharing the load current. The UPS shall be galvanic isolated from mains supply via isolation transformers.

5.10.2 The total capacity of the parallel redundant UPS shall be in excess of the load requirements by at least the capacity of one UPS unit so that one of these can be disconnected with the remainder maintaining the continuity of load power.

5.10.3 If one UPS unit fails, it shall be automatically isolated to prevent it from interfering with the other so that the remainder can continue to supply the full load. In addition, synchronising and load sharing circuits are required.

5.10.4 The system shall be equipped with one bypass switch and one battery set. The Input side of the UPS shall be protected against over voltage and surges from lightning.

5.10.5 The UPS configuration shall be such that a failure of a single component (one rectifier or inverter) permits the UPS system to function with the rest of the components.

5.10.6 An isolation switch shall be installed beside the UPS for disconnection of the mains for maintenance. Batteries shall be installed in a separate room for batteries.

5.10.7 Cables between the UPS and the Batteries shall be single conductor cables sufficient in size to carry full load and protected against short circuit at the connection to the batteries. A gas proof DC cable disconnection switch shall be installed in the battery room for disconnection of the battery.

5.10.8 The design and the performance of the redundant UPS shall be consistent with standard IEC 146-4 edition 1986 and with the following additional requirements:

Main input:

Voltage	3 phase 400V -15% + 10%.
Frequency	50 Hz ± 3 %.

Inverter output:

Rated voltage	3 phase 400V/230V AC.
Voltage variation	± 2 %.
Rated frequency	50 Hz.
Frequency	± 0.5 % (Free running)
Type	3 phases + neutral + ground.
Ambient temperature:	$+10^{O}$ C to 48^{O} C.

During operation with one phase at nominal load and two phases without load or two phases with nominal load and one phase without load:

Load regulation	± 1 %.

5.10.9 In order to reduce losses in the UPS and to limit distortion, the Inverters shall be equipped with transistors in the main output stage.

5.10.10 The distortion produced by the Inverters output stage shall be less than 3%.

5.10.11 The noise produced by the UPS and its fans shall be limited to 50 dB for frequencies 500 Hz, 1000 Hz and 2000 Hz. Noise produced by internal transformers shall be limited to 40 dB for frequencies 50 Hz, 100 Hz and 300 Hz.

5.10.12 The UPS shall be provided with output current limiters, which will protect the module against short-circuit. The overload capacity of the Inverters shall be 150% of the rated power for 1 minute and 125 % for the next 10 minutes.

5.10.13 Supply of signalling equipment, shall be maintained for at least six hours after interruption of Power.

5.10.14 The operational status of the UPS shall be visible at the front of the cabinet. As a minimum the following shall be shown:

- Input voltage selectable 3 times Phase to Neutral and 3 times Phase-to-Phase.
- Input current selectable Phase by Phase and Neutral.
- Battery voltage.
- Rectifier current.
- Output voltage selectable 3 times Phase to Neutral and 3 times Phase-to-Phase.
- Output current selectable Phase by Phase and Neutral.
- Various operation information that shall be shown on a display.

Voltage shall be shown on analogue instruments, current on digital instruments equipped with LED display.

5.10.15 The UPS shall be able to give information to the ATS system via potential free contacts or a maintenance bus. Typically rectifier failures, low battery level, Inverter failure, high temperature, overload, etc. Power supply failures shall be indicated on the workstations for signal control as well as on the security management workstation.

5.10.16 The UPS mechanical construction shall allow for service from the front door. The mechanical construction and installation shall take into account the probability of earthquake in the region of Thessaloniki.

5.10.17 The UPS mechanical construction shall be installed on the floor independent from the false floor construction.

5.10.18 From the UPS, power shall be fed to a distribution frame from which power shall be distributed to different systems. Each system or part of system that is fed from the power

distribution panel shall have its own circuit breaker, equipped with contact for indication of release.

5.10.19 A common indication of circuit breaker release shall be provided to ATS.

5.10.20 All outputs shall have independent insulation transformers and insulation failure detection. Insulation failure shall be indicated on the front panel for each group. A common indication of insulation failure shall be provided to the remote control system.

5.10.21 Single-phase supply of 230 V shall be created by transformation from 2 phase 400V in a single-phase transformer.

5.10.22 The UPS and all other power supply equipment shall be designed with a spare capacity of 25% of the nominal load.

5.10.23 Transformers used in the power supply equipment shall be sufficient in size and shall be of low loss type.

5.10.24 The Contractor shall propose a complete power supply system, based on the above-mentioned paragraphs that shall interface with the electrical supply system (see Performance Specification for Power Supply).

5.10.25 The signalling power supply system shall ensure that in the event of any fault, trains are able to proceed, coasting in the event of loss of traction power supply, as far as the next station or as near to a station as possible to facilitate de-trainment of passengers.

5.10.26 No power supply, transformer, rectifier set, battery or other power source that is used directly to supply fail-safe circuits shall be used to feed non-signalling circuits.

5.10.27 Any equipment using voltages exceeding 59 V and any terminals carrying a voltage above 59 V, shall be enclosed, labelled and with suitable precautions taken to prevent accidental contact by any person.

5.10.28 All power supplies, which are not connected to a recognised earth, shall be equipped with earth fault detection. Indications of earth status shall be displayed on maintenance panels and sent to the Operational Control Centre as an equipment alarm.

5.10.29 Power supply equipment circuits shall be provided with automatic circuit breakers, to protect power supply equipment and cables from faults. Automatic circuit breakers shall remain closed on loss of power and after restoration of power. In case Automatic Circuit Breakers are used in DC circuits carrying more than 1A, the Circuit Breakers shall be designed to break DC current.

5.10.30 All power supply transformers shall have sufficient tappings available to enable power supply voltage adjustments to be made to an optimum level.

5.10.31 All equipment supplied shall be able to withstand over-voltage and other power supply surges, as may be caused by lightning, switching effects, machinery starting currents, etc.

5.10.32 Power supply frames shall be constructed to a National or International standard; details to be provided by the Contractor. Front panels of power supply cubicles shall include, as a minimum, indications and instruments to show the status of the power supply. A diagram of the power supply arrangement shall be provided on the front panel with instruments and indications correctly located within that diagram.

5.10.33 Operation of automatic circuit breakers and loss of power supplies, status of the static switch, operation of batteries among other shall be indicated to the OCC and shall be subject for approval by the Service.

5.10.34 The Contractor shall propose a power supply arrangement for a typical station equipped with Interlocking and shall provide a list of his estimated power supply loads at each station together with his offer. With regard to systems of centralized architecture, the Contractor shall propose a power supply arrangement in the OCC/ECR for the interlocking unit or units controlling the Extension to Kalamaria.

5.10.35 The Contractor shall provide a safety analysis demonstrating that with the proposed power supply design, any equipment fault cannot lead to a non fail-safe system condition.

5.11 Equipment and Finishes

5.11.1 As far as possible, equipment shall be located in signalling equipment rooms in stations with interlocking. In stations without interlocking the signalling and interface equipment shall be installed in a technical room together with the necessary signalling power supply. The design of the system shall be made in a manner that the minimum of equipment will be located in tunnels and close to tracks. The structure gauge must be kept free from any equipment. Equipment cases and their location on the trackside shall also ensure that doors, lids etc, cannot foul the structure gauge when in the open position and that staff can also have access without fouling the structure gauge.

5.11.2 Equipment cabinets in signalling equipment rooms shall be of sufficient volume to allow the removal of heat from the boards and racks by internal convection. Removal of heat from cabinets shall take place by radiation and external convection. Fans shall be avoided in the process of removal of heat.

5.11.3 Equipment mounting shall not obstruct the movement of staff or passengers in emergency de-trainment from vehicles to station platform on walkways and track bed. All track mounted equipment and cables shall, therefore, be fitted with such ramps and covers as may be necessary for this purpose as well as for protection.

5.11.4 Equipment shall be accessible for work to be carried out on it with fixed or movable ladders provided by the Contractor. Equipment cases shall be designed and located so as to be safely accessible to maintenance personnel at all times, whether a service is running or not.

5.11.5 Details of all fixings to tunnel linings and their proposed positions shall be submitted to the Service for approval. No work on site in respect of such fixings shall commence until agreement has been given.

5.11.6 Equipment boxes, signals, signs, indicators, etc. and cable termination boxes mounted track-side shall be of a heavy duty, corrosion resistant construction with gasketted watertight doors. Wherever possible the material of cable termination boxes shall be of stainless steel. Clamped glands shall be provided for all cable entries. All equipment cases shall be capable of being secured with an approved series of padlocks or similar security devices, which shall also be provided. All equipment and apparatus cases, signs, signals, indicators, other trackside units, shall be constructed to exclude the ingress of water and dust and to prevent the accumulation of moisture by condensation. Equipment cases shall comply with IEC 529 schedule IP65, point machines IP 45 or an equivalent standard, details of which shall be supplied by the Contractor for approval by the Service.

5.11.7 The Contractor shall provide any brackets, frames or other mountings and fixings, including drilled holes required for complete installation of the supplied equipment.

5.11.8 In the tunnels and for the maintenance of the field equipment, the communication among the personnel shall be made via TETRA terminals and mobile phones, on condition that their operation is supported in tunnels and stations..

5.11.9 All equipment shall be designed and installed for a service life of at least 25 years, subject to the maintenance laid down by the Contractors maintenance plan. Where any equipment is not expected to conform to this requirement and where it is not a consumable spare item, then the Contractor shall list that equipment, its expected service life and any further support that he will provide to ensure that the system will be fully operative for a minimum of 25 years.

5.11.10 All equipment supplied under this Contract shall at a minimum, carry the manufacture's name or identification mark and at least the year of manufacture.

5.11.11 All equipment supplied under this Contract shall be finished to the highest standards for continuous usage for its full service life. All finishes shall be selected and applied to reduce the maintenance requirements to a minimum during the service life.

5.11.12 All corrosive metal parts shall be protected, as appropriate, against corrosion by dipping, plating, painting or similar process to a standard that shall be subject to approval by the Service.

5.11.13 All equipment and apparatus cases, signals, signs, indicators and point machines shall carry a permanent identification label in a form approved by the Service. Where cases have removable lids or doors then labels shall be fixed to the case, with duplicates on the lid or door, for identification from the trackside.

5.11.14 All portable or removable items of equipment shall carry a permanent identification label in a form approved by the Service. This will identify uniquely the type of equipment and carry a serial number.

5.11.15 All terminals in equipment rooms, trackside apparatus cases, and termination boxes shall bear labels identifying the circuit they carry, and shall be subject to approval by the Service.

5.11.16 In order to ensure a prolonged reliable life under arduous conditions, all electronic components shall be de-rated. The Contractor shall specify the de-rating he has used, e.g. percentage of manufacturer's normal voltage, current or power rating used in his design and the anticipated effect of this de-rating on the component's life.

5.11.17 All electrical and electronic equipment shall be constructed on a modular basis with high quality connections for easy and reliable replacement of faulty modules. Plug-in units shall be designed with restraining devices to hold them in place and shall include a system to allow modules to be interchanged only with another of the same type. All modules shall be clearly and unmistakably identified.

5.11.18 In order that the maximum service life may be achieved with the minimum amount of resources and personnel, the numbers and types of units and components shall be minimised. Every effort shall be made to select components, which are readily available from more than one manufacturer.

5.11.19 Equipment shall be capable of operating to full specification with an a/c main power supply fluctuating at least +/-10% of the nominal declared voltage and within a frequency range between 47Hz and 53Hz (50Hz nominal).

5.11.20 Systems (groups of equipment) shall be capable of operating to full specification with a total maximum variance in power supply voltage and frequency as detailed in this specification and simultaneous maximum cable voltage drop.

5.11.21 All bolts, studs, nuts and threads used for mechanical fixings shall be to an approved standard, to metric dimensions and shall generally be of stainless steel material.

5.11.22 Bolts, studs, nuts and washers used for electrical connections in all locations shall be manufactured from manganese bronze or plated brass to an approved standard to ensure corrosion resistance.

5.11.23 Washers shall be provided under all nuts and also bolt heads where appropriate. Torque tightening of fasteners shall not be permitted on painted surfaces.

5.11.24 Nuts, bolts, set pins and any other item subject to vibration shall be secured with approved locking devices.

5.11.25 All surfaces shall be protected; they shall be cleaned and primed with corrosion inhibiting paint and adequate coats of finishing paint. The type of paints being selected to suit the material and location shall be designed as a weather resistant finish requiring no further treatment during the service life of the surface. The Contractor shall supply details of the treatment he proposes for the protection of surfaces. Self finish materials, e.g. stainless steel or anodised aluminium may be used. The Contractor shall supply full details if he proposes the use of such materials.

5.11.26 The galvanizing to be used on any surface or component shall be applied by the hot dip process to an approved specification and depth of covering consistent with its use. It shall consist of a smooth, clean zinc coating, free from defects and of uniform thickness. Any drilling, punching, tapping, welding and bonding of parts shall be completed and all burrs removed before galvanizing is carried out. The Contractor shall ensure that galvanized surfaces are protected during transit and installation and there is no impairment of the galvanized surface.

5.11.27 Cable and wiring termination shall be appropriate to the function, current and voltage. The method of terminating cables and wire shall be by screw terminal, crimp, wire wrap or soldering. Pinch type screw terminals, where the screw is in direct contact with the conductor, shall not be used. Plain washers, spring washers, lugs, nuts and lock nuts, shall be used on cable terminations as appropriate. Where the wires are connected to the same terminal, each wire shall be identified and on the circuit diagram, wiring schedule etc, this wire shall also be denoted. This is to enable individual wires to be identified without ambiguity. Only two connections per terminal shall be allowed

5.11.28 Printed circuit boards shall be used to mount electronic components. The boards shall be of sufficient thickness to ensure mechanical rigidity but shall not be the sole support for connectors, handles etc. Printed edge connectors shall not be used. Printed circuit boards shall be made of fibreglass epoxy material or an equivalent material and shall be designed and manufactured to an approved standard. Boards shall be covered, where appropriate, with solder resist material and lacquered or varnished after manufacture. All components shall be identified on the surface of the board with an identification designation consistent with the manual and diagrams. Component identification shall be fully visible with the component in place. All printed circuit boards shall be unmistakably identified for equipment, function, modification status, manufacturer's name and date of manufacture.

5.11.29 All relays used in signalling equipment (in printed circuit boards, or in equipment racks) shall be suited for their purpose. The Contractor shall guarantee a minimum of one million operations for the relays without failure.

5.11.30 The anchoring system shall comply with the following requirements:

- Chemical type, stainless steel: In tunnels, station track level and station platform level.
- Expansion type, hot dipped galvanised: In concrete walls of all areas of the concourse level.
- Chemical type, hot dipped galvanised: In brick walls of all areas of the concourse level.

5.11.31 The Contractor shall provide furniture in each signalling room for use by maintenance staff. The furniture shall comprise of a worktable, chair, table mounted bookshelf and lockable cabinet of minimum dimensions 100 cm x 50 cm x 100 cm (H x D x W).

5.12 Electromagnetic Compatibility

5.12.1 It is expected that equipment supplied for use on the Thessaloniki Metro will use frequencies over a wide range from power to radio frequencies. Some of this equipment will be covered by this Specification whilst some will be covered by others. In the vicinity of the Thessaloniki Metro with there may be or planned to be various equipment, which produce other electromagnetic radiation. The signalling system intended for the Extension to Kalamaria shall use the same frequency zone as the Base Project for the data wireless communication system, since it is its extension. In cooperation with the Regulatory National Authority (RNA), the Contractor shall make all pertinent arrangements so as to ensure that radio coverage of the entire Kalamaria Extension is lawful and shall assume the entire cost for all permits that may required.

5.12.2 It is the Contractor's responsibility to ensure that the frequencies proposed for use by his equipment and electromagnetic energy limits of that equipment, even under fault conditions, shall not create interference or unwanted signals for this or any other systems. Similarly, it is the Contractor's responsibility to ensure that the frequencies and modulations of other AC signals (including all potential variations) shall not cause interference with or affects the operation of his equipment.

5.12.3 Adequate shielding of both equipment and cables shall also be provided to ensure that no interference or unwanted signals can be produced. Equipment designs shall ensure that any unwanted frequencies are eliminated or reduced below the level of susceptibility of other equipment, domestic or industrial appliances operating in the vicinity of the Thessaloniki Metro, which have been designed, manufactured and operated in accordance with current recognized standards.

5.12.4 The Contractor shall prepare for the approval of AM, a scheme to ensure electromagnetic compatibility for all equipment, materials and designs within his supply for use on the Thessaloniki Metro and its extensions. The Contractor shall indicate the scope of such a scheme and his experience in this matter.

5.12.5 The Electromagnetic Compatibility of the equipment shall be in accordance with EN 50121-4.

5.13 Environmental Conditions.

5.13.1 All equipment shall be capable of continuous operation at or between the limits of environmental conditions as given in the General Specifications without the use of heating or air-conditioning equipment. Heating and air-conditioning equipment is required in all signalling rooms to achieve a full service life and shall be supplied and installed under this

Contract. The Air conditioning of signalling technical rooms shall be considered as a life safety critical system.

5.13.2 The minimum of equipment must be mounted trackside. This shall be limited to essential rail-connected equipment, e.g. point equipment, signs, indicators etc. All other equipment shall be housed in signalling equipment rooms at each station, or at the OCC/EDR. Any electronic equipment proposed to be installed trackside shall be fully justified and approved by AM before designs using such equipment are advanced.

5.13.3 All equipment shall be designed to operate fully within the stated conditions. The Contractor shall provide a programme for testing (type tests and routine tests) for all equipment types to be supplied under environmental and operational limits according to this specification and the General Specifications.

5.13.4 Equipment cases installed outside of technical rooms shall comply with IP 65 and shall be fully proofed against the ingress of dust, sand, water, rain and the accumulation of moisture due to condensation. All equipment for the system shall be designed to withstand the effects likely to be encountered in the area of Thessaloniki including industrial and other pollution. Thessaloniki is on the Thermaikos Gulf of the Mediterranean Sea, the air is sufficiently modified by the saltwater to provide a mildly corrosive atmosphere. Suitable protection shall be applied to those items of equipment, which are exposed to the atmosphere, and also protection shall be given to those parts of the equipment, which might be affected by any adverse long-term conditions prevailing in the area.

5.13.5 The Contractor shall be responsible for ensuring that his equipment and systems are not adversely affected by the modified environmental conditions caused by the localized heat emissions of other equipment.

5.13.6 All equipment supplied shall be able to withstand power supply surges, interference and spikes caused by lightning currents and equipment, mains and traction supply surges and switching effects.

5.13.7 Apparatus rooms shall be provided in selected stations and in the depot where interlocking are located, to accommodate signalling and interface equipment. Interface equipment required in stations without interlocking shall be installed in the control equipment and PSD monitoring room.

5.14 Management Plans

The Contractor shall supply Management Plans based on the overall project Management Plans such as Design Management, Configuration Management, Software and EMC/EMI.

6 Technical Requirements of The Train borne Systems

6.1 General

6.1.1 Each train shall be provided with redundant ATC equipment. The ATC equipment shall comprise a fail-safe Automatic Train Protection system (ATP) and an Automatic Train Operation system (ATO) and the required communication systems.

6.1.2 Train operation shall be fully automatic without any train attendant action for normal operation (UTO, GOA4 per EN 62290). In case of emergency the train can be operated via an Emergency Driving Position situated at each end of the train.

6.1.3 The ATC system shall receive the time reference from the stationary system wide time distribution system. All train borne systems shall have the same time reference.

6.1.4 The environmental conditions for ATC and transmission system equipment shall meet the following:

Temperature:	EN 60068-2-1/2
Humidity:	EN 60068-2-30
Vibrations:	EN 60068-2-6
Shocks:	EN 60068-2-27

6.2 Definition of Safety

The ATP onboard equipment shall meet the EN 50126, 50128 and 50129 Standards and fulfil the following safety criteria:

- Design shall be fail safe (SIL 4), fully redundant and of well-proven technology to perform the ATP functions
- Error detection and handling shall be used system wide.
- Testing shall be performed during development in order to ensure failsafe code.
- ATP equipment shall ensure that trains will safely come to a stand still ahead of any danger point.
- ATP system shall safely ensure that safety distances between two trains are always guaranteed, taking into account all possible tolerances, wrong driver reactions (in case of manual operation) and system failures.
- Emergency Brake shall be only applied if required for safety.
- Command of emergency brake shall be irrevocable until the train comes to a stand still

- Change of driving modes from ATO to other modes and vice versa shall be only permitted when the train is stationary.
- Errors of ATO or other non-safety related system should not lead to application of emergency brake or to a shut down of the ATP system.
- The command of the safety loop shall comply with safety integrity level SIL 4
- In case of emergency the ATP system of each individual train on each position on the line shall receive emergency stop commands from the OCC/ECR via the vital continuous transmission system or the digital radio data communication system (DCS).

An independent third party (safety assessor) shall assess the ATP system and certify to AM that the above mentioned points are all fulfilled in order to get AM's acceptance and approval of the system. The third party shall be authorized by a national railway or safety administration to perform such assessments and is subject to approval by AM.

6.3 Modes of Operation

The train shall operate in different modes, which are delimited here-below: in driverless operation by the signalling system, while in manual operation by the train itself. More specifically:

Signalling Modes

- Full Automatic Operation under ATO including automatic turn back,
- Washing mode with a maximum speed of 5 km/h for automatic running through the washing plant
- Supervised manual mode under ATP with continuous speed supervision and over speed control – maximum line speed 80 km/h.
- Permissive mode under ATP with supervised limited speed driving of max.15 km/h and over speed control of 15 km/h
- ATC –off – which shall result to Train Mode of operation.

Train Mode

- Manual mode forward (Yard mode) with speed control performed by the train propulsion system only at a maximum speed of 15 km/h
- Manual mode back ward (Yard mode) with speed control performed by the train propulsion system at a maximum speed of 15 km/h

6.4 Design Requirements for the Automatic Mode (ATO)

6.4.1 The function of the ATO system shall be as follows:

- To receive wake up commands from the OCC/ECR via the data communication system and to wake up the train for service

- To receive setting to sleep commands from the OCC/ECR via the data communication system and to set trains to sleep,
  - To manage the vehicle self built in test and to transmit the "vehicle readiness status to the OCC/ECR via the data communication system,
  - To receive actual line information, routing information and train traffic information from OCC/ECR via the data communication system,
  - To check that all information, which is necessary to perform a mission is stored.
  - To optimise brake control and traction control in order to regulate train speed and running times to comply with received traffic information.
  - To perform optimised energy driving
  - To automatically stop the train with the required stopping accuracy at the platform stopping point, reversing and stabling positions,
  - To open the passenger train doors in stations in conformance with information received from the ATP system
  - To announce Platform Screen Doors (PSD) closing to the stationary Public Address System prior to the command for closing of Platform Screen Doors (PSD)
  - To close passenger train doors and to synchronise the command for closing of platform screen doors according to information received from OCC/ECR,
  - To provide continuous self-test to prove that the equipment is free of failures.

6.4.2 Principle of Operation

The ATO system shall permit train operation without need for interaction of the train attendant except in the case of emergency. Movements from the stabling position in stations and the Depot to the next station shall be performed without any staff on board of the train. Train reversing in terminals and temporary terminals shall be performed without any staff on the train.

6.4.3 Awakening of Trains

Trains – if not in "Off" - Mode shall be awakened automatically via the OCC/ECR commands. After awakening of the train with its correct intended driving direction a built-in self-test shall be performed in order to check and confirm fitness for operation. The train shall be able to perform such an awakening even after a period of 1 week of stabling. The awakening shall be possible at all stabling positions on the line and the Depot

6.4.4 After awakening and ATP/ATO built-in self-test the ATO shall transmit all necessary train status data to the OCC/ECR, including the number of the rolling stock and the train attendant, on condition that the latter has undertaken the train's operation. In any other case, the system shall indicate "no attendant" or something similar.

6.4.5 If required, the train attendant number shall be keyed-in by the train attendant via a key-in device independent from the EDP.

6.4.6 A cyclic train door opening and closing test and a static brake test shall be a part of the test prior to automatic start of the service.

6.4.7 After awakening of a train and proving fit for operation the heating respectively cooling of the train shall be switched on automatically as specified in the "Performance Specifications for Rolling Stock".

6.4.8 ATO shall receive all data of its train mission including train operating number from OCC/ECR. The train ATO logic shall control the indication panel above the windscreen.

6.4.9 The stopping accuracy in station platforms shall be maximum ± 0.3 m. If the stopping accuracy on platforms cannot be achieved with the normal train borne distance measurement system, then the additional equipment shall be installed on tracks, in compliance with the standards of the EUROBALISE of the European ERTMS system. Other systems for final distance measurement adjustment such as loops or radar are permitted, provided that such systems have been successfully used for the same application on other Metro systems. The Contractor shall deliver a description of his distance measurement system and the achieved tolerances to AM for approval together with his offer.

6.4.10 Automatic Speed Regulation

The speed on all tracks, connection tracks and crossings shall be regulated automatically by the ATO system. The standard running profile shall be energy optimised running with time reserve applying coasting and cruising. In case of deviation to the train borne stored time table the train shall adjust its running profile automatically. Adjustment of the running time between two stations shall be made by:

- Coasting and cruising,
- Increase and reducing of maximum speeds
- Change of train performance such as acceleration and service brake values.

ATO shall depend on time table information received from the OCC/ECR and shall not depend on transmitted speed information.
The Contractor may propose various standard train run scenarios for train regulation based on combinations of above mentioned parameters. In that case at least 20 different scenarios shall be provided between each station – station trip, subject of approval by AM.
The Contractor shall provide a description of his proposed ATO regulation system together with his offer.

6.4.11 Skipped Station

The ATO system shall support skipped station function. After receiving skipped station command from the OCC/ECR the train shall pass through a station without stopping. Release of the forced station stop shall be a function of ATP. The skipped station command

could be either a scheduled function or an unscheduled function. In the latter case the timetable information of the train is not updated. The train shall regulate in the best possible manner the shorter running time without station stop. The skipped station function shall function in normal and reverse direction of traffic

6.4.12 Door Control

The ATO shall control opening and closing of train doors. Door release of train and platform screen doors shall be made from the vital ATP system. The immobilization information of the train is a requirement for release of the platform screen doors. The ATO shall send PSD open/close commands to the platform screen door control logic. ATO shall receive information from the train door logic about isolated doors and transmit this information to the line side PSD system in order to avoid opening of the corresponding isolated PSD. Vice versa the PSD control logic shall send door isolation information to the ATO of each train in order to avoid opening of the corresponding train door.

6.4.13 Control of Front and Tail Doors of Trains (if any)

Front and end doors of trains for emergency passenger evacuation – if any - shall be released via a vital remote command from OCC/ECR. Opening of doors shall become effective only at zero speed and parking brakes shall be applied. Prior to the opening of the doors the traction power must be switched off and the train borne short circuiting device shall be remote controlled for protection.

6.4.14 Re-positioning of Trains

If a train fails to stop accurately on the platform track and the clearance between train door and PSD would be less than 1m then the opening of the train doors shall be inhibited by the ATP system In case of over shooting the stopping position the train shall move back automatically at a low speed until the train doors be in line with the PSD. This function shall be active for a maximum distance, which is programmed by the central ATP/ATO system; in case this limit is exceeded, then the train shall be directed to the next station, and, an updated pre-recorded announcement shall be made inside the train via the PA system to inform the passengers. The re-positioning movement shall be indicated at the OCC/ECR to regulate the dwell time and an alarm shall be indicated on the Station and Train Supervisor workstation. In case of an earlier train stop the train berthing position shall not be issued to door control logic and the train shall proceed automatically to its stopping position.

6.4.15 Passenger Information system

The ATO system shall be interfaced with the on-board passenger information system to provide sufficient accurate train position information for announcement and display of station platforms and train destinations.

6.4.16 Train Diagnostic Information

The train diagnostic information shall be transmitted to the OCC via the data radio communication system (DCS) and, at the same time, via the non-vital data communication system (TETRA). Due to the amount of information a communication channel separate fromor of a lower priority than the signalling channels shall be used.

6.4.17 Setting a train to sleep

At the end of the service or for stabling and unstabling movement between changes of headways the train shall be parked automatically on the scheduled parking position. The correct application of the mechanical brakes and the train status shall be transmitted to the OCC/ECR prior to setting to sleep. The staff number - if registered and if not already cancelled by the train attendant when he left the train – shall be automatically cancelled with setting the train to sleep. Prior to setting a train to sleep all related systems shall be automatically checked that the next awakening is possible. When trains have been set to sleep some functions will have to remain active in order to permit next awakening.

6.4.18 During all automatic movements of trains, safety shall be ensured by the ATP system and no indicators shall be visible to public and no acoustic alarms shall be on the EDP

6.5 Supervised manual mode under ATP (SMM)

6.5.1 General

The description made under this chapter specifies the function of the train borne ATP system operated by the train attendant in an emergency.
Generally the ATP system shall always permit a train to enter a station, if no safety restriction exists. A train shall not be permitted to leave a station, if the station stop has not been safely released for this train.
The main ATP Functions shall be as follows

- To receive and decode line related information generated by the wayside signalling system and transmitted to the train via the vital communication system
- Process and calculate safely and continuously the speed profiles and overlaps
- To display target speed and distance to go on the EDP when in use.
- Apply permanent and temporary speed restrictions.
- To communicate speed information to the ATO system.
- To determine the actual train speed and passed distances using signals from dedicated speed sensors, which should be mounted at not driven axles and radar systems.
- To determine the existence of an over speed condition and to annunciate such on the EDP when in use.
- To enforce speed limits by activating the braking system when an over speed condition exists. The Emergency brake should be only applied if required for safety.
- To supervise ATP stopping points and driving direction.

- To provide safely a door release signal to the door interface circuit in order to unlock doors on right side or left side or both sides, prior to stopping of the train in stations.
- To provide safely a door release signal to the door interface circuit in order to unlock doors for passenger evacuation– if any.
- To supervise door close function by monitoring signals from the Rolling Stock equipment.
  - To receive "all doors closed" information from the PSD system and permit train departure only when all PSD are closed
  - To allow the train to enter the Automatic Reversing Mode at designated terminal stations.
  - To provide continuous, self-test to prove that the ATP system is free of any dangerous failures in order to prevent - as fare as possible- applying of the Emergency Brake.

6.5.2 The ATP equipment shall continuously compare the computed target speed with the actual train speed. Actual train speed shall be derived from speed sensors on at least two different axles monitoring wheel rotation. Compensation for wheel wear shall be provided to correct for variations in wheel diameter on axles monitored by the ATP sensors. Such wheel wear compensation shall work automatically and shall not require manual adjustments.

6.5.3 The speed sensors shall be capable of continuously monitoring wheel rotation at all train speeds. All equipment related with speed measurements and speed indications such as odometers, speedometers and wheel adjustment shall be highly accurate instruments of less than 1 % tolerance. The self-checking feature of the ATP equipment shall ensure that the speed sensors are both electrically and mechanically intact.

6.5.4 In case of differences between the measurements from the sensors up to a certain limit, which is tolerated by the safety assessment, the ATP equipment must act by assuming the worst-case measurement to be the correct measurement and allow the train to proceed. An alarm shall be sent to the OC/ECR "request for maintenance".

6.5.5 Emergency brake application shall be irrevocable until stand still of the train. However, the application of emergency brake shall be activated only when safety is no longer guaranteed. Whenever a service brake application is sufficient for safety reasons, then service brake shall be applied instead of the emergency brake.

6.5.6 The application of an emergency brake via an OCC/ECR command or by operating a signalling emergency plunger shall not require a manual reset on board of the train. The command of an emergency stop shall be indicated in the OCC/ECR and/or the LWS, if any. The OCC/ECR shall have the possibility of remote release of the emergency stop.

6.5.7 When the EDP is activated, and for over speed less than 5 km/h the train attendant shall be warned visually by light indication on the EDP as well as by an acoustic alarm. These warnings shall continue until the train attendant places the master controller handle into the braking position and the target speed has been attained.

6.5.8 Should the over speed reach or exceeded 5 km/h, Service brake or Emergency Brake – if required, shall be initiated. At lower train speeds the tolerances of the speed band may be reduced from 5 km/h to 3 km/h in order to limit the length of interlocking overlap.

6.5.9 Only the ATC equipment associated with the active EDP shall be able to open the train's safety loop. Other ATC equipment in the train shall be used for back-up purposes or for safety validation of the active ATC equipment. The safety loop shall be opened only if absolutely required for safety.

6.5.10 Systems shall be designed in a fault tolerable manner. Monitoring systems shall trigger alarms and automatically request train maintenance.

6.5.11 Roll back Supervision
ATP shall permanently supervise the train stop position at platforms and stabling position. In case a train rolls back then the emergency brake shall be applied immediately, so that the overall distance of the rolling back (including detection, activation up to the immobilization of the train) cannot exceed 8 meters. This action shall be of safety level SIL 4.

6.5.12 Basic function of the train borne ATO such as an automatic train run and train stop along a train route and from platform to platform shall be maintained as far as possible during SMM mode. The train attendant shall trigger the train start by button operation.

6.6 Permissive mode under ATP with supervised limited speed

6.6.1 General
If the line side ATP system fails on a line section then the train shall be able to proceed in controlled supervised permissive mode with a restricted maximum speed of 15 km/h. Under permissive mode it is not permitted to transport passengers further to the next station. The basic function of the permissive mode shall be

- Detection of a speed above 20 km/h and triggering emergency brakes,
- Applying emergency brakes when the train rolls back, so that the overall distance of the rolling back (including detection, activation up to the immobilization of the train) cannot exceed 12 meters,
- Detection of a fault in the train borne ATP even during permissive run,
- Upgrade the running mode automatically to ATP mode when the train is on a section with an intact line side ATP.

6.6.2 The ATP Permissive mode will persist until a valid signal has been received with permission to proceed in ordinary ATP mode and a new target speed has been shown to the train attendant.

6.6.3 The change from Permissive mode to ATP mode shall happen without any attendant intervention during train movement.

6.7 Washing mode

6.7.1 The washing process of a train shall not require a train attendant on board of the train. The washing mode is a full automatic ATO mode with a pre-defined speed of maximum 5 km/h and specific ATP interfaces.

6.7.2 At the end of the service, trains shall be stabled within the automatic area of the Depot. The mission of a train to the stabling position at the Depot might be directly to the stabling track or passing through the washing plant to the stabling track. The washing mode shall be automatically set for a specific train from the OCCECR.

6.7.3 Prior to activating the washing mode, the train shall be automatically berthed in front of the washing plant. After confirming the stand still and berthing information to the OCC/ECR the running mode shall be changed automatically to the washing mode. The washing procedure shall be as follows:

- Set the train to washing mode
- Limit the speed to 5km/h maximum
- Run the entire length of the train through the washing plant
- Permit running through the washing plant as long as "GO' information is received from the washing plant
- An independent "STOP / GO" button shall be installed beside the control device of the washing plant. The train movement can be controlled (stop/go) by operating this button.
- Stop the train immediately when the emergency stop button of the washing plant is operated
- Prevent a second train from being routed through the washing plant as long as the first train has not cleared the washing plant and a safety section behind.
- Stop the train after passing through the washing plant and a safety section behind.
- Cancel the washing mode, after entire length of the train has passed through the washing plant; ATO mode is still active
- Guide the train to its stabling position
- Set the train to sleep.

The washing mode might be also considered as a sub-function of the ATO mode.

6.6 ATC –off (disconnection of the Automatic Train Control System)

While ATC-off is set the train is completely disconnected from the Automatic Train Control System. The train cannot be awakened. If the OCC/ECR identifies a train on line or in the

automatic part of the Depot, then an alarm is set and the train will be identified as a "Non-identified train".

7 Design Requirements

7.1 Advanced Concept Design (ACD)

Within the time delay defined in the Contract Document, the Contractor shall complement his technical proposal and draw up the Advanced Concept Design. In particular he shall:

- Establish a Document Submittal Program, which shall identify each document, required to complete the project, including a unique document number, title, purpose of the document and scheduled submittal date.
- Establish a coding concept for all systems, sub-systems and components of his offered systems
- Provide an interface management plan for identification and managing of interfaces of his systems and interfaces with other systems and civil works
- Complement and submit all his offer designs with respect to the results of contract negotiation and the clarifications made in the "Clarification document" – if any.
- Complement all his designs regarding
  - Room layout,
  - Line layout,
  - Equipment lists,
  - Arrangement of equipment on trains at an advanced concept design level,
  - Power needs and heat dissipation,
  - Typical arrangement of equipment in tunnels, including the data communication equipment,
  - Typical arrangement of equipment on platforms,
  - Typical cable routing,
  - Principle earthing principles
  - Layout and arrangement of work stations
  - Cable layout including fibre optic cables
  - Arrangement of the telecommunication equipment in the tunnel, in stations and at the OCC/ECR for Signalling purposes.

The ACD design is subject to approval by AM.

7.2 General Final Design (GFD)

Based on the approved ACD design the Contractor shall produce his General Final Design. The target of the GFD design is that each technical discipline may proceed with its design

based on approved GFD designs having all operational, spatial and functional interfaces defined. In particular the following documents shall be supplied during GFD:

- Schematic Signalling Layout drawings length scale 1:1000
- Route tables
- Tunnel installation drawings showing all equipment installed in tunnels and cables in a scale 1:500
- Insulation drawings showing all track circuits and insulated joints in a scale 1: 200
- Cable routing drawings within stations including cable lists in a scale of 1: 100
- Room layout drawings in a scale of 1: 50, details in 1:10
- Train installation drawings

The following System designs and GFD Reports shall be supplied within GFD:

- System Report Signalling – covering all aspects of signalling except ATC
- System Report Automatic Train Control (ATC)
- Hazard Analysis
- System Safety and RAMS overall Requirement definition
- System Report Depot Signalling including test track operation
- Operation Concept
- Interface Report – Defining all interfaces between components and subsystems of signalling and interfaces of signalling with other systems and building.
- Any other document, which is required for a full understanding of the system and which is needed for clarification of interfaces.

7.3 Detailed Final Design (DFD)

The DFD shall complement all designs required for design, installation, operation, commissioning, maintenance, certification, validation and training of the system, sub-systems and components as specified in the contract. Test procedures, bill of quantities, Material Submittal Sheets (MSSs), Operation and Maintenance Manuals and materials, spare parts and special tools lists shall be submitted at this phase.

7.4 Handling of Commissioning Documentation and As-Built for Signalling

Beside the requirements for as-built document as defined in the Contract the following shall be applied for signalling.

For testing and commissioning the Contractor shall supply 3 sets of approved documents at least 10 days prior to each test, where all field changes – if any – have been incorporated by the Contractor. The documents shall be marked as "Test Document Set 1", Set 2" and Set 3".

The Contractor shall incorporate all findings during testing and commissioning into the three test sets during the test phase. All three test sets shall be signed by the Contractor's authorized test and commissioning engineer and counter signed by AM Test Supervisor. AM responsible design engineer must approve all changes made on site during testing. The responsibility for all designs and changes made on site is with the Contactor.

Set 1 of the test document shall stay with the installation until final As-built drawings have been delivered.
Set 2 shall stay with the Contractor for producing final As- built drawings and shall be delivered together with the as-built drawings to AM for verification of correctness of the as-built drawings.
Set 3 shall be kept safe by AM together with the originals of the test reports as "Original Test Document".

8 TESTING FOR THE SIGNALLING SYSTEM

8.1 Test and commissioning shall be in accordance with the General Specifications, 'Test and commissioning' of the Extension to Kalamaria, as well as of the Base Project, as required. For the Signalling system, the Contractor shall perform the necessary testing in order to verify proper function and safety of each part of the system as well as the entire system.

8.2 The first test the Contractor shall perform is the Factory Acceptance Test (FAT). Prior to this test all internal testing and all quality control tests shall have been successfully performed. Internal test reports from these tests shall be present during the Factory Acceptance Test. The factory acceptance test shall test complete systems, however when this is not possible, separate parts of the system shall be tested with simulation of the missing parts. The Factory Acceptance Test shall verify, but not be limited to, the following:

- Test – by samples – that wiring is correct in cabinets and frames that handle fail-safe information.
- Test that interlocking, ATP, ATO logic produces correct results internally and externally for interfacing with other systems.
- Test that commands to the system are acknowledged by the system and that the correct response is received.
- Test that commands from the remote control and transmission system are acknowledged by the system and that the correct response is received.
- Test that the system responds within acceptable time on inputs from local work-station / remote control as well as inputs from track circuits or response from points.

The result of the FAT test shall be successful in order to install the system on site. Any unsolved or open items shall be written into the FAT test report and shall be resolved prior to shipment of equipment on site. Equipment with unsolved or open items shall not be shipped to the site without prior approval from AM.

8.3 After the system has been installed and the Installation Testing completed, the Site Acceptance Test (SAT) shall be performed. The SAT test shall verify, but not be limited to, the following:

- Track circuits, shunt tests and bonding, Axle counter tests.
- Interlocking relations between track circuits, ATP/ATO, IXL and local or central Workstations are correct.
- Testing of power supply systems
- Communication of data from track to train and from train to track is correct and prompt
- Connections between Points, Signals and IXL are correct.
- Correct installation of equipment in technical rooms, tunnels, stations, in the depot at the OCC/ECR and on-board the trains.
- Correct program versions are used, which must have been fully developed prior to their installation.
- Testing of train borne systems
- EMC tests
- Validation tests of all systems including trains and train parameters in order to validate safety of the systems.

8.4 After SAT the entire signalling system shall be fully tested ready for integration tests with other systems. Interfaces of signalling with other systems such as time distribution, train control, platform screen doors (PSD), Automatic Train Supervision System (ATS) etc., shall be included.

8.5 All costs related with testing at factory site including travel costs of the Service shall be borne by the Contractor

9 QUALITY ASSURANCE

The process of manufacturing and installation of equipment on site shall be certified in accordance with ISO 9001. The Contractor shall perform the following:

9.1 All hardware modules and software programs, which are to be delivered under this Contract, shall be factory tested as a complete system in accordance with factory test procedures (FAT), which have been furnished by the Contractor and approved by the Service. The Contractor shall generate FAT procedures in accordance with the guidelines set forth in the contract documents. Factory testing shall not commence until the Service has approved these procedures.

9.2 AM shall be informed 2 week prior to every Quality test that takes place in the Factory and reserves the right to witness any and all such tests.

9.3 The Contractor shall record the results of these Quality tests on the appropriate Factory Test Report forms. For each subsystem, cabinet or piece of equipment such updated test reports shall be organized, grouped and shall be accessible either On-line or Off-line.

9.4 All the hardware modules and software programs, which have been installed under this Contract, shall be field tested after installation in accordance with a field test procedure. The Contractor, in accordance with the guidelines set forth in the contract documents shall generate this procedure. Field-testing shall not commence until the Service has approved this procedure.

9.5 The Contractor shall provide and maintain up-to-date, a diary or log (either in electronic format or as a print-out) containing a detailed write-up of any and all changes made to the system hardware and software from the time of their approval by AM until final acceptance, at which time the log shall be delivered to AM. This record shall conform to typical international requirements and/or standards for documentation.

9.6 The Contractor shall provide "Type Acceptance Testing" for all modules. This Type Acceptance Testing shall be performed at the manufacturer's factory. The testing may be under the surveillance of the Engineer of AM and shall be thoroughly documented.

9.7 The Type Acceptance Testing for Electronic Interlocking complete with I/O modules, shall be in accordance with the acceptable updated versions of CENELEC standards or similar EN 50121-4 EN 50081-2, EN 60068-2-1 EN 60068-2-2, EN 60068-2-6, EN 60068-2-14, EN 60068-2-27, EN 60068-2-30 and shall include, but not be limited to, the following tests:

- Full Temperature Sequence
- Full Humidity Sequence
- Full Vibration/Shock Sequence
- Full Power Voltage Variation
- Electrical Transient Withstand (All External Connections)
- Proof of Validity and Accuracy of the Executive or Control Software and Proof of the Vitality of Its Execution
- Artificial Fault Simulation of all Hardware and Software (Glitch) Failures
- Intentional Clock Frequency Variation (Plus And Minus)
- Broadband Radio Frequency Interference-Output And Withstand
- Proof of Diagnostic Operation.

10 MTBF VALUES AND DEFECTS LIABILITY PERIOD

10.1 Determination and Verification of the MTBF

The Contractor shall furnish the following information, at first, at the design phase and, then, further to commissioning through measurements:

- Mean time between failures for one installation as a whole system.
- Mean time between failure of all individual parts of the installation, such as loss of central control or local control belonging to one interlocking computer.
- Availability of a whole system as installed.
- Availability of all individual parts of a system installed.

Availability analysis shall be conducted for each E-IXL/ATP/ATO in the system. These analyses shall be fully supported by the models used for the analyses and all related calculations. The analyses shall be submitted to AM for approval.

10.2 Defect liability period

10.2.1 The Contractor shall supply sufficient staff, spare parts and test facilities on site to enable him to repair all system, equipment or cable and wiring faults reported to him for a period of 12 calendar months from the commissioning into traffic service of that system or equipment for the line. The Contractor shall provide a full fault analysis report of each system or equipment fault, which shall include, the type of faults found and the remedial action taken to rectify each fault.

10.2.2 In addition, the Contractor shall supply sufficient staff, spare parts and test facilities on site to enable him to modify any parts of, or entire systems, or any ranges of equipment found in the opinion of AM, to require modification to comply with this Specification. This service shall be provided for a period of 12 calendar months from the date of final commissioning into traffic service of that system or the entire equipment for the line or 12 calendar months from the date of any modification to any system or range of equipment on the line, whichever is the later.

10.2.3 "Systems" in the above context shall be taken to include both hardware and software.

11 INSTALLATION REQUIREMENTS

11.1 Installation of cables

11.1.1 The high availability of signalling shall be ensured using redundant optical rings, with the backup fibres located in a separate cable from the main fibres. One cable loop shall be installed in each single tunnel. Within stations the cable route shall be in installed in different cable ducts, trenches, conduits and trays. Signalling cables may be routed together with telecommunications cables but separated from power cables

11.1.2 All cables shall be installed by competent staff, suitably trained and supplied with all necessary plant, equipment and tools. The installation of cables shall be such as to provide an orderly formation, free from unnecessary bends and crossings that will permit the removal of any one cable without undue disturbance to adjacent cables. Precautions shall be taken to ensure that cables are not installed in a manner, or under conditions likely to cause corrosive action or damage to cables or be detrimental to the performance of cables during operation.

11.1.3 Openings to walls, ceilings and floors required for running cables shall be sealed in order to reduce the risk of spreading fire.

11.1.4 Cables shall be cleaned and clean after installation has finished. Cables installed in cables ducts shall be free from debris such as residue of cement, painting and other material. In case of any work is being performed above open cable ducts with cables, these opening shall be covered to prevent ingress of debris.

11.1.5 As concerns the installation in stations and tunnels of cable trays, trunking and conduits, these items – in their majority – will have been installed by the main Contractor of the Extension to Kalamaria further to his coordination – at design level – with this Contractor. As concerns the additional items that are required, mainly locally at track level or elsewhere needed, these shall be designed and installed by this Contractor with reference to the Specifications for cable trays, trunking and conduits of the weak current systems (LV) of the main project of the Extension.

11.2 Installation of Equipment in Tunnels

11.2.1 Equipment installed in the track bed or at the tunnel wall shall not form any obstacle for passengers and / or Metro staff walking in the tunnel track bed or on the duct walkway. Such need for access may arise due to maintenance work, passenger evacuation or access for rescue teams.

11.2.2 The equipment installed in tunnels shall be minimised. Whenever possible, equipment shall be installed in station technical rooms.

12 PARTS LIST, SPARES, SPECIAL TOOLS, TEST EQUIPMENT, MANUALS AND MAINTENANCE

12.1 Parts list and Spare parts list

12.1.1 In accordance with the General Specifications, the Contractor shall provide parts lists and spare parts lists. The list of Spare parts shall be divided into two lists; one describing non-capital consumable spare parts and one describing capital spare parts. Every attempt shall be made to provide at least two sources for spare parts or components and both sources shall be quoted. AM shall be the owner of all delivered spare parts. The Contractor has the obligation to replace with new spares every spare part used during the warranty period.

12.1.2 The Contractor shall include in his list of spare parts the re-ordering time and shall undertake the obligation to continue the supply of spare parts or acceptable replacements for the minimum service life of the system, 25 years. In case the Contractor fails to do so he shall offer substitute solutions at a lower price than the original spare parts.

12.1.3 The Contractor shall submit to AM a parts list, containing a list of all major parts of the system that he shall install. The parts list shall be submitted together with the list of spare parts.

12.1.4 The delivery of capital spare parts shall include, but not be limited, to the following:

- ATP, ATO, E-IXL, Track circuits, Axle Counters, Data communication systems
  1. Five percent (5 %) of all installed I/O boards. Boards with EPROM's shall be provided with programmed EPROM's, one for each different type of motherboards.
  2. If the module and/or the chassis of the E-IXL have different motherboard wiring arrangements and the modules are not interchangeable from one location to another, the Contractor shall provide the different types of modules.
- Track Circuits (track side equipment)

Spare parts equal in value to the cost of 5 track circuits of each type. AM will determine composition of the actual spare parts upon receipt of the parts list from the Contractor.

- Point Indicators
  Spare parts equal in value to the cost of five point indicators. AM will determine composition of the actual spare parts upon receipt of the parts list from the Contractor.
- Point Machines
  Spare parts equal in value to the cost of three point machines. The Service will determine composition of the actual spare parts upon receipt of the parts list from the Contractor.
- Balises
  Spare parts equal in value to the cost of 10 balises.
- One complete set of train borne equipment
- One complete set of operator workstation equipment
- One complete set of Data Communication System (DCS) items of equipment corresponding to one track, for two intermediate tunnel sections – lengthwise – as well as the equipment of the DCS system of two stations. In addition, one central router of the OCC/ECR.

12.2 Special Tools and Test Equipment

12.2.1 In accordance with the General Specifications, the Contractor shall provide a list of all special tools, gauges and test equipment necessary for preventative maintenance and basic fault repair of all equipment. The type and quantity of special tools and test equipment to be supplied shall be sufficient to ensure the efficient operation of the system. Where equipment is not considered to be economically maintainable by the Service, e.g. computer processors, then the Contractor shall specify those available maintenance facilities that exist in the Thessaloniki area for that equipment. If no facilities exist in the Thessaloniki area then the Contractor shall propose how such equipment shall be maintained. The list of special tools and test equipment shall contain the following:

- A serial number for the purpose of identification.
- A description of the tool/test equipment.
- The recommended quantity.

Special attention shall be paid to the provision of portable test equipment to determine for example, vehicle detection system parameters, ATP modulations and noise due to traction return current. This equipment shall be capable of being used during service without affecting the fail-safe nature of circuits or equipment.
In this context, portable shall be taken to mean that the equipment can be carried, connected and operated by one man carrying all associated leads, tools, etc.

12.2.2 For the new electronic interlocking and ATO/ATP system, the Contractor shall identify all special tools, hardware as well as software that shall be used during commissioning. A full set of these tools shall be delivered to the Service after commissioning of the system.

12.3 Manuals

The Contractor shall supply copies of all manuals as shown below, in an approved format, before the commissioning of that equipment.
The Contractor shall revise any or all manuals as required to incorporate any modifications found necessary during commissioning. Copies of the revised manuals shall be submitted to AM to replace manuals submitted originally.
In general, manuals shall include sufficient information and details to enable the full understanding, operation and maintenance for the service life of the supplied signalling equipment or system.
Manuals shall be supplied in Greek and English languages.

Manuals shall include, but not be limited to, the following:

- Systems Manuals - comprehensive description of all system principles to block diagram format.
- Operating Manuals - divided into as many sub-sections as may be necessary and providing sufficient information to enable non-technical staff to operate each system.
- Workshop Manuals - shall contain full schematics, circuits, wiring diagrams, mechanical construction drawings and itemised parts lists to enable all maintenance, rectification and setting up to be carried out.
- Software Manuals - shall be provided for each piece of equipment or system, which contains software programmable devices. These manuals should contain all software principles, source listings adequately supplied with comments, communication protocols, flow charts and operating instructions. Source codes and their development tools should be given also in electronic form.
- Equipment Room Manuals - shall contain all wiring diagrams, equipment layout, terminal and schematic circuits and cable listings for equipment contained within the room and for such external equipment as may be necessary for completeness.
- Maintenance Manuals - shall convey sufficient information on equipment diagnostic principles and maintenance practices to enable first line fault diagnosis and rectification by technician staff.
- Final Drawings Manual - all as-built circuits and working drawings as necessary per the General Specification in reproducible and electronic form.

The number of copies and the electronic format requirements shall be in accordance with the General Specifications.

12.4 Maintenance

The Contractor shall indicate the amount of necessary maintenance that is necessary to be carried out on his equipment in order to keep it operating efficiently for the full service life of the equipment, in accordance with the General Specifications.
Maintenance shall be divided into periods, the following being proposed as typical:

- Every 6-12 weeks - preventative maintenance, gauging, lubrication and inspection.
- Every 12 months - annual overhaul on site, checking of connections, wear and effectiveness of track shunt.
- Every 5 years - main overhaul, replacement of worn parts, rechecking of equipment to performance specification.

Other such maintenance as may be required to achieve fault-free operation and a minimum service life of 25 years.

13 TRAINING

Training shall be carried out in accordance with the content of the Specification for ATS System and in line with the following, namely:

- Training activities shall be of sufficient size, content and scope to enable the training of engineers, technicians and specialist artisans to ensure the opening of the Line and continuous efficient operation of the Thessaloniki metro. The Contractor shall submit a detailed description of all courses for approval by the Service.
- The Contractor shall provide an economic solution for a training model consisting of a basic interlocking system, an interlocking workstation, a telecommunications workstation for the signalling data from/to the train with simulated train and communication interfaces. At least one point machine, one signal, one track circuit of each applied type, one axle counter – if applied, one beacon shall be connected to the interlocking model. Other devices shall be simulated. The training model shall be used for training of operators and maintenance staff. The Service will accept that the Contractor might use this installation also for testing and validation of his software during implementation and warranty phase. The Contractor shall provide together with his offer a description of his proposed training model. The training model shall be installed in a training room of the Depot.

- The Contractor shall provide training facilities for operational and maintenance staff at his facilities and in Thessaloniki. The Contractor shall propose details of the courses and reach agreement on the numbers of classes for each course with the Service. The Contractor shall also supply operational instructions and documentation. Training documentation shall be based on use of the Operating and Maintenance Manuals.
- The Contractor shall submit to AM for approval all information related to training syllabus, training equipment, training rooms, training personnel, training methods, training practice, the selection of the trainees and the duration of the training courses.