ΕΛΛΗΝΙΚΟ ΜΕΤΡΟ Α.Ε.

TITLE: **"DESIGN, PROCUREMENT, INSTALLATION AND COMMISSIONING OF THE AUTOMATIC FARE COLLECTION SYSTEM FOR THE EXTENSION OF THESSALONIKI METRO TO KALAMARIA"**

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TECHNICAL DESCRIPTION AND SPECIFICATIONS

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1 INTRODUCTION

1.1 This Technical Description and Specifications shall be read and apply in combination with the Conditions of Contract and the remainingContract documents.

1.2 In the event of discrepancy between the requirements included in thisTechnical Description and Specifications and in other contractual documents, their order of prevalence shall be set in the Conditions of Contract. In the event of discrepancy between the requirements of this document, the strictest requirements shall prevail, provided that any official system or equipment certification is not revoked.

2 PURPOSE

2.1 The purpose of this Technical Description andSpecifications documentis to provide the scope of the contract and the requirements for the design, manufacturing, procurement, installation, testing, commissioning and start-up of the Automatic Fare Collection system for the extension of Thessaloniki Metro towards Kalamaria.

2.2 The Kalamaria AFC system shall be designedand implemented to provide all fare collection passenger functionalities such as in AFC system of Thessaloniki Metro Base Project (TMP).

2.3 The technical specifications, as presented in this document,describe and define the functional requirements, the hardwarecomponents, the software and the interoperabilityof the AFC system for the Kalamaria MetroProject (KMP) in conjunction with the one of the Base Project and indirectly with the central AFC system of the city of Thessaloniki,which shall be implemented by an independent contract.

3 ACRONYMS AND DEFINITIONS

ACC	Access Control
ACELP	Algebraic Code-Excited Linear Prediction
AFC	Automatic Fare Control System
AFNOR	Association Française de Normalisation (code widely used in Europe)
EM	EllinikoMetro S.A.
ATC	Automatic Train Control
ATIM	Automatic Ticket Issuing Machines
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
BACS	Building Automation Control System
BRI	Basic Rate Interference

CCIR	ComitéConsultatif International pour la Radio
CCITT	Comité Consultatif International Télégraphique et Téléphonique
CCTV	Closed Circuit Television
CELENEC	European Committee for Electrotechnical Standardization
CIF	Common Intermediate Format
CIT	Card Issuing Terminal
CSC	Contactless Smart Card
CPU	Central Processing Unit
DCF	German long-wave transmitter for time synchronization / 77,5kHz
DHCP	Dynamic Host Configuration Protocol
DLT	Direct Line Telephone
DLP	Digital Line Protection
DMO	Direct Mode Operation
DMT	Degraded Mode Terminal
DSU	Diagnostic Services Unit
DTMF	Dual-tone Multi-frequency Signaling
DTS	Digital Transmission System
ECS	Environmental Control System
ECR	Emergency Control Room
EETT	National Telecommunications and Post Commission
EIA	Electronics Industries Association
EMC	Electromagnetic Compatibility
EMP	Electromagnetic Pulse
EN	European Norm
ETSI	European Telecommunications Standards Institute
FDDI	Fiber Distributed Data Interface
FIADS	Fault Identification and Diagnostics System
FO	Fiber Optic Cable
GMT	Greenwich Mean Time
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
IAPR	Independent Authority for Public Revenue (ΑΑΔΕ)
IC	Inspection Chamber
ICS	Intercommunication System
ID	Identification
IEC	International Electrotechnical Commission
IP	Protection Index
IP	Internet Protocol
IREG	International Range Instrumentation Group

IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IT	Installation Test
ITU-T	International Telecommunication Union – Telecommunication
KMP	Kalamaria Metro Project
KHz	Kilo Hertz
KMC	Kalamaria AFC Management Centre
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LCX	Leaky Feeder Cable (Leaky Coaxial Cable)
LTE	Long Term Evolution
MC	AFC Management Centre of Thessaloniki Base Metro Project
Mbps	Mega bit per sec
MDF	Main Distribution Frame
MIS	Management Information System
MMI	Man-Machine Interface
MTBF	Mean Time Between Failures
MPEG 4	Motion Picture Experts Group, Group of Methods for Image Coding
MV	Medium Voltage
NFC	Near Field Communication
NFPA	National Fire Protection Association
nm	Nanometer
NMS	Network Management System
OBMS	On Board Maintenance System
OCC	Operations Control Centre
ODF	Optical Distribution Frame
OEM	Original Equipment Manufacturer
OF	Optical Fiber
PA	Public Announcement System
PABX	Private Automatic Branch Exchange
PAMR	Public (Private) Access Mobile Radio
PCM	Pulse-code Modulation
PCI DSS	Payment-Card Industry Data Security Standards
PCI SSC	Payment-Card Industry Security StandardCouncil
PMR	Public (Private) Mobile Radio
PII	Personally Identifiable Information
PIS	Passenger Information System
POS	Point Of Sale
PRCS	Power Remote Control System

PSD	Platform Screen Doors
PSL	Platform Screen Local Control Panel
PSN	Persons with Special Needs
PSTN	Public Switched Telephone Network
PTZ	Pan–tilt–zoom Camera
QoS	Quality of Services
QR code	Quick Response code
RAM	Random Access Memory
RAID	Redundant Array of Independent Disks
RASTI	Rapid Speech Transmission Index (quality parameter for Announcement
RBS	Radio Base Station
RDT	Reliability Demonstration Test
RFID	Radio Frequency Identification
RPR	Resilient Packet Ring Technology
RS	Rectifier Substation
RTU	Remote Terminal Unit
SAM	Secure Access Module
SAP	Station Announcement Point
SAT	Stand Alone Test
SDTS	Short Data Transport Server
SEP	Signaling End Point
SIT	System Integration Test
STP	Shielded Twisted Pair
SCADA	Supervisory Control and Data Acquisition
SM	Station Master
SMR	Station Master Room
SMS	Security Management System
SNMP	Simple Network Management Protocol
Station Computer	Computer of the AFC system is Station Master Room
STM	Synchronous Transport Module
TCP	Transmission Control Protocol
TETRA	Terrestrial Trunked Radio
TFT	Thin-Film Transistor (Flat Screens)
TheTA	Thessaloniki Transportation Authority
TMP	Thessaloniki Metro Base Project
TVL	Ticket Validation Line
CU	Central Unit (Control Unit)
UIC	International Union of Railways
UMS	Unified Messaging System

UPS	Uninterruptible Power Supply
VDE	VerbandDeutscherElektroingenieure
VDU	Visual Display Unit
VLAN	Virtual Local Area Network
VoIP	Voice Over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network

4 CONTRACTOVERVIEW

4.1 Thessaloniki Metro Base Project includes one line from the New Railway Station up to NeaElvetia station (approximately 9.6km long, with 13 stations) and one depot at Pylea area connected via a double track single tunnel with NeaElvetia Station.

4.2 The Project of Thessaloniki Metro extension to Kalamariaconsists of one metro line approximately 4.78km long, starting right after the end of the trumpet shaft of 25thMartiou Station, and ending at the forestation of Mikra Station.It includes the tunnels, five (5) stations, five (5) shafts, three (3) crossovers and one recess.

The stations in the scope of works are the following:

- Nomarchia
- Kalamaria
- Aretsou
- NeaKrini
- Mikra

4.3 The entire extension to Kalamaria is constructed bymultiplecontracts that need to be coordinated.

The following contractors are involved in the subject project:

1. The main contractor assigned with the Civil Works, trackwork, E/M worksand systems for all building installations and certain railway systems ofthe Project
2. The contractor responsible for the Signaling system and the Automatic Train Control (ATC) system
3. The contractor responsible for the Building Automation and ControlSystem (BACS)
4. The contractor responsible for the Telecommunications,Low Voltage and Power RemoteControl System (PRCS)
5. The contractor of the new Rolling Stock (15 new trains)
6. The Base Project contractor (indirectly, on account of the existing Base Project systems that will need to be amended / upgraded / expanded, soas to function as an integrated entity).

4.4 All thestations of the extension are available for the installation of the AFC equipment.

4.5 The Thessaloniki Metro network shall operate as a driverless system, i.e. without any human intervention being necessary from the On Board Personnel (Train Attendants) during normal operation.

4.6 The Metro Base Project, the extension to Kalamaria, Pylea Depot and all possible futureextensions and Depots shall be supervised and controlled by the OCC in Pylea.

5 SCOPE OF WORKSOF THE CONTRACT

5.1 The Automatic Fare Collection System is included in the scope of this Contract.

5.2 In the framework of the scope included in this Contract, the Contractor shallbe responsible for the following:

- Preparation of the General Final Designs and the Detailed Final Designs.
- Coordination of designs in cooperation with the Main Contractor,Telecommunicationsand BACS contractors of theKalamaria extension, as required, as wellas coordination for the modifications to the Operation Control Center rooms in the Pylea Depot,related to matters such as designs, implementation, testing and commissioning.
- Preparation of the necessary designs targeting the fully compatible integration of this Project in the currently constructed Metro network, without causing any problems whatsoever or reducing the performance of the Base Project or disrupting its revenue service operation.
- Compilation of the Safety and Health Plan and File (SAY/FAY), as required by the local laws and regulations.
- Ensuring the unobstructed and safe access of the equipment during its installation phase, as well as during the operation and maintenance of theProject.
- Supply of the equipment.
- First Article Inspection (FAI) and Factory acceptance testing of the equipment (FAT).
- Delivery of the equipment.
- Installation of the equipment.
- The coordination and cooperation with other contractors involved for thesound and timely completion of the installations as a whole.
- Equipment installation tests (IT), stand-alone tests of the systems (SAT) and system integrationtests (SIT), incooperation with other involved contractors, wherever this required.
- The modifications and upgrading of equipment, systems, documentation, drawings and software to be commissioned in the Base Project,asrequired, for the functional integration of the Project in the existing Metronetwork.

- Three (3) years guarantee of the installed AFC system, as of the final acceptance of the overall scope of the contract (including the integration tests and the commissioning of the system).
- The training of the operation and maintenance personnel, enabling them to operate and maintain the AFCsystem in an effective and safe manner andto repair any potential failures.
- Periodic inspection and “corrective” maintenance of the AFC system,as included in this Contract, i.e. rectification/restoration of badworkmanship, failures, faults etc. throughout the guarantee period.
- Providing, in an intelligible form, every necessary justification, drawing, flow diagrams and software lists for every programmable equipment item (depending on each individual case), design information and information of electromechanical nature, as well as support manuals, in order to facilitate the Project Owner in operating, maintaining,troubleshooting relevant problems, and modifying and further developingthe Metro system.
- Providing the necessary spare parts for the guarantee period and the spare parts to be used after the expiring of this guarantee period, the special tools (e.g., programming devices), testing tools and equipment, application software and software official licenses for the systems to be installed by the Contractor. The lists with the above spare parts shall besubmitted by the Contractor for approval based on the specifications.
- Providing the necessary installation, operation and maintenancemanuals, as required.
- Conducting the tests to measure the system’sRAMS during the guarantee period (as required).
- Providing and securingallsafety certificates, as required, and disposing allequipment and documentation needed to conduct the above tests.

6 POINTS OF SPECIAL ATTENTION

6.1 The Contractor shall design and implement the Automatic Fare Collection system for the extension towards Kalamaria, taking into account the actual progress of other works and projects under execution.. The Contactor shall ensure that the connection of the extension shall cause the minimum possible impact to the systems of the TMP as well as to the other systems of the extension to Kalamaria during testing, commissioning, training and trial run at the new section of the metro network.

6.2 The present contract, based on specific specifications,shallgeographically extend the Automatic Fare Collection system installed by the Contractor of the TMP, to provide a fully operational Metro network, from New Railway station up to NeaElvetia and Mikra stations, ensuring state of the art fare issuance and control services and transaction security for passengers at stations.

6.3 The Contractor shall coordinate the AFC system design, installation, testingandcommissioning, taking under consideration all the functional and technical characteristics of the existing AFC system of the Thessaloniki Metro Project and the installation progress of the Kalamaria extension projects that are under execution.

6.4 In the event that any part of the design or the works to be executed by the main contractor of the extension to Kalamaria is still in progress, coordination will be required, through the coordination procedures applied under this contract. In all other cases, where the design and the installation of the contractor of the main Kalamaria extension project has been completed, all required actions/works to fulfill AFC requirements shallbe in Contractor's responsibility.

6.5 The Kalamaria AFC system design shall fully implement the fare policy currently adopted by the TMP and the business and operational rules set and applied in the city of Thessaloniki from TheTA. (see Appendix 2 showing the fare policy which is designed and planned to be implemented and if revised it will be given again to the Contractor)

6.6 The Contractor shall design, develop, and implement a fare media-based system, with the capability to workalso as a hybrid account-based fare collection system. The provided system shall fully support EMV and NFC payments at the gates of the stations for the extension to Kalamaria, functions that will applyupon the system's transition to the hybrid mode described above..

6.7 The Contractor shall ensure that the interconnection of the new extension will not affect the normal operation of the existing project and will cause the minimum impact on this, during commissioning, trial operation and trainingof the new part of the network. Similarly, the Contractor shall ensure the above for the case of interconnection of new future extensions, beyond the Kalamaria extension. For any future metro extensions the Contractor shall collaborate with and support any other future AFC Contractors in order to implement an integrated and fully operational AFC system for the entire Thessaloniki Metro.

7 AFC SYSTEM GENERAL DESCRIPTION

7.1 General Description

7.1.1 The Automatic Fare Collection system of Kalamaria extension shall be a system following the AFC design principles of the existing 13 stations of the TMP and functionally compatible with the existing Thessaloniki metro AFC system, as it is specified below.

7.1.2 Contactless fare media shall comply with the most recent versions of ISO 14443 and ISO/IEC 10373.

7.1.3 The AFC system of the extension will be a closedsystem,where the entry and exit of passengerswill be controlled (see Figure 1 below). Each passenger will own a personal fare media that can be a paper e-ticket, a personal or a non-personal smart card, or a "virtual

ticket" (NFC or QR code) on his mobile or a credit/cash card at a later stage. The passengers' fare media shall be checkedfor validity at the entrance and exit stations.

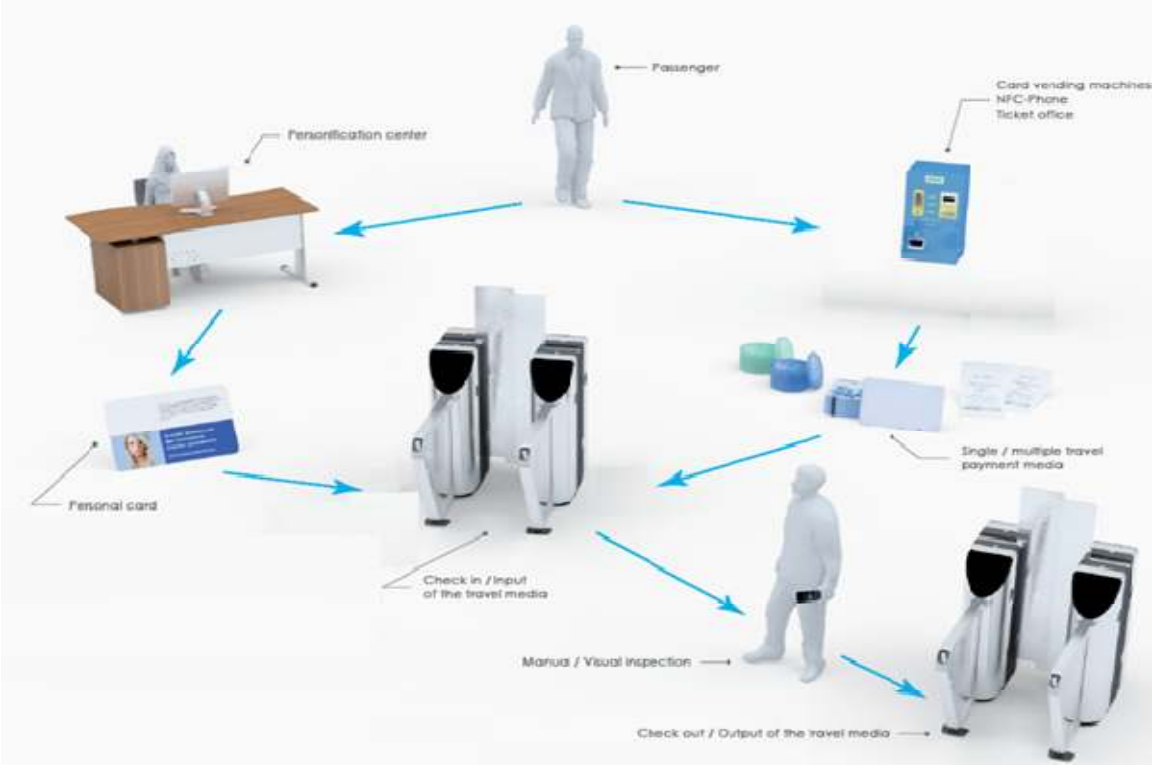

Figure 1: Operation of Automatic Fare Collection System

7.1.4 The main components of the AFC system shall bethe following:

- Fare Media
  - The Contactless Smart Card (CSC)
  - The Contactless e-Ticket (CST)
  - Mobile Ticket (NFC and QR)
  - Credit/cash card (future implementation)
- Field/Frond-End Equipment
  - Automatic Gates (mainly located atthe stations' concourse level)
  - Automatic Ticket Issuing Machines (mainly located atthe stations' concourse level)

- Portable Smart Card and E-ticket Reader (used for fare media validation by the operation personnel)
- Card Issuing Terminal (located in each Station Ticketing Room)

- Station AFC Management Equipment
  - Station Computer (located in Station Master Rooms)
- Central System (in OCC)
  - Kalamaria Management Centre (KMC)
  - Workstations

7.1.5 A new, dedicated AFC Management Center for the Kalamaria extension, shall be provided under the scope of the present Contract. The Kalamaria AFC Management Centre (KMC) will be installed in Pylea Depot and shall be interconnected with the existing Management Centre (MC) of theBase Project, as beingcarried outby the contractor of TMPby implementing an API server and the appropriateAPIs.

7.1.6 Concerning the use of bank cards (cash & credit) for paymentsatthe ATIMs and the CITs, the interconnection with Credit Institutes shall be implemented, via the existing central shelf-hosted payment gatewaylocated in Pylea Depot and via the relevant card acceptance service providers (Acquirer)(Any Bankor Dias) used in the Base Project and implemented by the Contractor of the Base Project. The details of the interface will be provided by ELLINIKO METROduring the design phase of the project. The equipment and the required communication paths used from ATIMs and CITs for all bank transactions shall be compliant to PCI-DSS.

7.1.7 Limited-use e-tickets (single or multi journey) and non-personalized smart cards shall be issued from ATIMs of the extension. E-tickets and smart cards (personalized or non-personalized) shall be able to be recharged via ATIMs or CIT.

7.1.8 The detail designof the e-tickets (structure, data, operation method, etc.) will be provided by ELLINIKO METRO S.A.basedon the ones currently issued by the existing AFC metro system of the TMP.

7.1.9 Extended-use smart cards shall also be used (smart cards, personalized or non-personalized with microprocessor). The personalized CSC will initially be issued by CITs in Ticket Offices of the stations. Non-personalized CSC will be also initially issued from ATIMs of Kalamaria extension. Smart cards, both personalized and non-personalized, shall be able to be recharged via ATIMs or CITs.

7.1.10 The use of mobile phones shall be also possible in order to have access to the Thessaloniki transportation network, including metro.

Initially, the customers shall be able to purchase an electronic virtualticket and download a related QR code or an NFC tag to their mobiles before they travel online (Pre-purchase

model). Customers then shall use their mobile as their ticket to travel. The QR codes or NFC tags will be issued and purchased by the web portal that will be developed by TheTA.

At a later stage, upon TheTA guidance and supervision, the system shallbe transformed to a hybridAccount/Fare Media Based system with full EMV capabilities, where real or emulating bank cards (e.g., through Apple Pay and Google Pay on mobile phones) will be used by passengers in simpleclose proximity to the readers of the gates/validators entrance/exitfor travelling on public transport (Pay as you go model).

7.2 Fare Media Specifications

7.2.1 The Kalamaria extension AFC system solution shall include the implementation of the new and existing(used in the TMP) fare media such as CSC and e-ticket mapping, lifecycle to secure full interoperability of sales,validation and after sales services for the overall Thessaloniki Metro AFC system.Transparent and integrated sales, validation and after sales activities and rules shall be ensured for the entire Thessaloniki Metro AFC system.

7.2.2 Contactless fare mediashall comply with the most recent versions of ISO 14443 and ISO/IEC 10373.The contactless fare media will support strong cryptography, such as Advanced Encryption Standard (AES/DES) to protect access to and modification of all data encoded withinthe media.

7.2.3 CSC shall be a PVC “Plastic Card” for ensuring optimum resistance during long use. CSC shall bear a photograph of their holder, the name of the holder and a unique identification number.

7.2.4 The Contactless Smart Card (CSC) type shall be MifareDESFireEV3.

7.2.5 The CSC shallbe in full compliance with the following most recent international,proven in use standards:

- ISO/IEC 7810:2019
- ISO/IEC7816-1:2011,
- ISO/IEC 14443-1: 2018,
- ISO/IEC 14443-2: 2020,
- ISO/IEC 14443-3: 2018,
- ISO/IEC 14443-4: 2018
- ISO/IEC 10373
- ENV 1545 (Storage of information regarding public transports)

7.2.6 The application related to the operation of the CSC shall be contactless.The following requirements for the CSCcard shall be at least strictly met from:

- Supporting other applications apart from the application of the electronic ticket.
- The card frequency operation willbe (according to the aforementioned standards) 13.56 MHz while the data transfer rate willbe higher than 100kbits/sec.

- It will be equipped with an EEPROM with a capacity of at least8Kbyte.
- Chip type: MF3Dx2

7.2.7 The CSC shall support authentication procedure per applicationand will ensure the security of all transactions.

7.2.8 The performance of CSC and the related hardware and software components installed in AFC equipment shall assure a proximity remote coupling distance up to 100mm.

7.2.9 The design of the system shall be such that when a card is being processed other cards may enter or leave the transmission fieldrange without disrupting the transaction in progress. The transmission integrity shall be assured by preventing write or read operations if several cards are within thetransmission fieldrange.

7.2.10 The smart card CSC shall conform to the norm ISO 7810, type ID-1.Dimensions of all e-tickets shall be ISO 53,98mm ±0,2mm x85,6mm +1mm -0.5mm.

7.2.11 The e-ticket that will be used shall be fromappropriatepaper type.

7.2.12 E-ticket shall have a chip type: ST25TB512-A-T, supportingEV3 emulated EV1, 128 bytes.

7.2.13 The e-ticket shall also conform to the norms:

- ISO/IEC 15457-1:2008
- ISO/IEC 14443-1:2018
- ISO/IEC 14443-2:2020

7.2.14 Dimensions of all e-tickets shall be ISO 53,98mm ±0,2mm x85,6mm +1mm -0.5mm.

7.2.15 The serial number of the integrated circuit board must be printed on theback of the ticket, in the horizontal position, with character of 2,5mm height.

7.2.16 The exact details for CSC and e-tickets will be provided be ELLINIKO METRO S.A.during the design phase of the Project.

7.2.17 The Kalamaria AFC system shall also support the mobile ticketing technology. Specifically, passengers shall be capable to pre-purchasefare products on their mobile phones and use it as a fare media through a mobile application. They shall receive verification, such as a QR code or a genuinetoken generated by an emulation software on the user's phone itself.

7.2.18 The system shall also, for future implementation,fully supportthe use of bank card (EMV)us a fare media. Bank credit/cash cards and mobile emulated cards shall be used as a fare media, upon proximity to the AFC gate readers.

8 AFC EQUIPMENT LOCATION

8.1 Fare collection and ticket validationwill take place at Station's Concourse Level. Access from/to each station area will be done via escalators and stairs and Passenger with Special Needs (PSN) lifts. At specified areas of the stations, automatic Gates shall be used for fare Control both at station entrances and exits. Gates shall be installed in each station such that access to platforms and station exits from every possible path shall be via the control gates.

8.2 At the points where the "paid-unpaid area" line is longer than the line of the installed gates, the Contractor will install fixed or movable barriers (opening glass doors), according to the indications of the architectural plans, which will be used in case of emergency.

8.3 The Automatic Ticket Issuing Machines (ATIM) shall be installed at the concourse level of each station,as they depicted on the contractual architectural drawings thatare included as informational elements of the contract.

8.4 Within Ticket Rooms(2.2), a Card Issuing Terminal (CIT) shall be installed, one per station, that will permit, issuing, dispensing and/or verifying of all types of CSCs and e-tickets.

8.5 ATIMs and CITsshall be in the "unpaid zone" area of the station concourse level.

8.6 In each Station Master Room(2.3) a Station Computershall be installed, to collect all sales and traffic information and supervise overall operation of all local AFC equipment units, at station level.

8.7 All required power supply and communication (power supply and control switchboard, network equipment-LAN) equipment required for the implementation of the AFC system will be installed within Ticket Room of each station.

8.8 One new management center, totally independent from the existing Management Center of the TMP, shall be provided and installed within the technical rooms of OCC at Pylea Depot. The new Kalamaria Management Centre shall comprise of one, fully redundant, computer system.

8.9 Voice Communication devices (telephone sets), on either side of each gate control line, shall be provided, in combination with the existing DLT set provided by the main contractor of the extension, for passenger communication in case of problems during the entrance or exit procedure at the AFC gate lines.

8.10 Portable Card / Ticket Readers shall be provided for checking the validity of Smart Cards,e-Tickets and mobile devices of passengers. All relevant checking data shall be recorder in the portable readers.

8.11 Workstations located at Pylea Depot connected with the KMC shall be foreseen for providing real time and historical AFC data for management issues.

8.12 Testing and training equipment for AFC system shall be provided.

8.13 All necessary SAM control and management modules required for the operation of the AFC system of the extension to Kalamaria shall be provided.

9 AFC SYSTEM ARCHITECTURE

9.1 The AFC system shall be designed and implemented using an open architecture approach to provide flexibility as operation agency needsand technologychange. The open architecture will apply to all fare media, system interfaces, and transaction formats used for the management, distribution, payment, and inspection of fares.

9.2 The Kalamaria extension fare collection system will beinitially a fare media-based system but with the provision to also support hybrid account-basedoperation. The Kalamaria extension fare collection system will be directly interconnected with the TMP MC. The interconnection of the new exclusive KMC for the Kalamaria extension shall take placeby using Application Programming Interfaces (APIs), which will be delivered to the Contractor by ELLINIKO METRO S.A., after being primarily developed by its Contractor of AFC of Base Project.The Contractor shall use the above APIs to implement its own partof the interface and interoperability that shall meet all the modern and proven in use standards.

9.3 For information, the general architecture of the Thessaloniki Metro fare collection system (Base Project and Kalamaria extension), including future connection with the Central Management Centre of the city of Thessaloniki is depictedin the following Figure 2:

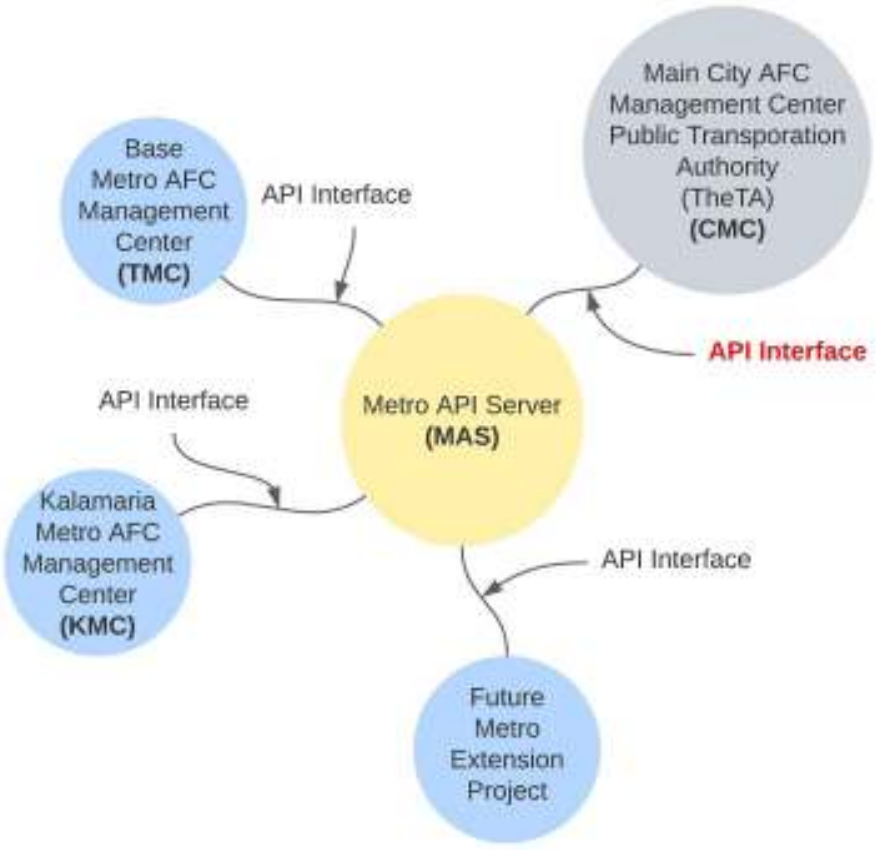

Figure 2: InterconnectionArchitecture of Management Centers of Fare Collection Systems of the city of Thessaloniki

10 AFC SYSTEM SPECIFICATIONS

10.1 System General Requirements

10.1.1 TheAFCsystemmanufacturer/suppliermusthavetherequiredexperienceand the main offered equipment must be of a proven in use and state of the art technology.The manufacturer/suppliermust have deployed a similar system, have met system acceptance requirements, and achieved a prominent level of reliability, accuracy, and availability in other railway or metro projects, the last five (5) years.

10.1.2 The core of the software, the mainequipment and all the works shall meet the corresponding ITU Specifications and/or European Standards. Here, the term “equipment” covers both the machinery, the devices, the facilities and the softwareand hardware.

10.1.3 The offered system shall fully implement the business rules and the Fare Collection Policy that ELLINIKO METRO S.A.and TheTA (see Appendix 2) applies using electronic tickets, smart cards and mobile ticketing to the public transportation means of the city of Thessaloniki.

10.1.4 The offered system shall allow modifications of itsoperating parameters and mode of operation that can be subject to a future change, allowing the Operation Agency to change their fare products, pricesand means in an easy and secure way.

10.1.5 Where applicable, all materials shall comply with the acceptable fire-safety standards, Greek and International.

10.1.6 The Automatic Fare Collection System and all its relevant equipment shall be suitable for a Metro Project and shall meet the following requirements:

- Easy maintenance
- User-friendly environment software for operation and configuration
- Flexibility (open interface)
- Possibility for further expansion to meet the future extensions of the Metro Line

10.1.7 The system shall have a modular design for all relevant components. These modules will support field replacement to return a device to service in minimal time in the event of a failure.

10.1.8 Software and hardware provided under this Contract shall be designed to provide a minimum useful life of fifteen (15) years, after the expiry of the warrantee period of the entire Contract Scope.

10.1.9 All main devices, components, parts, modules, assemblies, and subassemblies, excluding computer/server hardware and their peripherals, shall be available for purchase (as spare parts) for a minimum of fifteen (15) years, after the expiry of the warrantee period of the entire Contract Scope.

10.1.10 At the time of delivery, equipment and all associated components and software shall not contain non-standard, prototype, obsolete, known soon-to-be obsolete, or discontinued products.

10.1.11 The system shall be designed using modern, open and proven in use standards for software design, communications protocols, fare media, and other relevant design components.

10.1.12 All components of the system shall be constructed of the highest quality materials suitable use in the intended environment over the required useful life of the system. Only new components conforming to the requirements shall be used.

10.1.13 The Contractor shall supply all necessary software applications and shall design and configure all device and management center (back-office) software applications for optimal

system performance. The Contractor shall install all required software that is necessary for system operation.

10.1.14 All third-party software shall be at the latest commercial release, including all necessary updates, at the time the final commissioning.

10.1.15 System equipment shall provide reliable operation over its design life and shall be designed to require minimal scheduled and unscheduled maintenance.

10.1.16 Power supply,of all AFC equipment, at normal operation shall be providedby a 230 VAC of the UPS system for Telecommunication systems of each location. In case of power failure, all systems shall be suppliedby the batteries of the UPS System for Telecommunications, ensuring their continuous operation for 2 hours. The UPSs for the Telecommunication systems, supplying AFC systems of this Project, shall be provided by the main contractor of Kalamaria extension.

10.1.17 In the event of a loss of electrical power, all equipment shall complete any transaction in process, retain all data, and shutdown in an orderly manner. The equipment will return to full operational status after a power failure without manual intervention.

10.1.18 Adequate protection against transient power surges shall be incorporated to the extent necessary to prevent damage to the electronic components of the equipment.

10.1.19 The system equipment shall operate without being affected(stop or incorrect operation)by or causing electromagnetic interference (EMI).

10.1.20 All system components shall include protection against external EMI and Radio Frequency Interference (RFI) emissions, as well as internal conductive or inductive emissions.

10.1.21 All equipment enclosures, chassis, equipment, panels, switch boxes, and terminal boxes will be grounded. Protective grounding will be provided to ensure that exposed metal on all system components is connected to a common ground point.

10.1.22 The software proposed by the Contractor that shall be installed centrally and/or in workstations, mustbe developed according to the related modern and proven in useindustry standards and shall provide safe data processing. Hierarchical staff access to software user rights will be followed, with capabilities to manage these rights. The initial definitionof the rights shall be proposed by the Contractor and shall be subject to approval from ELLINIKO METRO S.A..

10.1.23 The entire hardware equipment (active and passive)and software, involved in the Payment-Card Industry, including the procedures for equipment upgrading and maintenance, shall be certified as per the latest edition of the •Payment Card Industry Security Standards issued by the PCI SSC (Payment-Card Industry Security Standards Council).

10.1.24 Physical and logical access to system components that contain Personally Identifiable Information (PII) and/or financial data will be restricted from unauthorized access. Physical

and logical security will be sufficient for compliance with the PCI-Security Standards in effect at the time of startup of the system.

10.1.25 The Contractor shall provide a PCI compliance plan during design review and obtain certification for the entire system. The Contractor shall employ a certified Qualified Security Assessor (QSA) and shall conduct all testing required to achieve certification prior to system startup.

10.1.26 All the necessary software tools and know-how to be able to modify this application in terms of functions or display in the future shall be provided.

10.1.27 The entire main equipment shall bear an identification project number, in accordance with the Drawing Office Manual and the Project Breakdown Structure.

10.1.28 All important parts of equipment shall bear labels with serial numbers, as well as equipment marking and symbols that indicate safety warnings, servicing steps, and wiring connections.

10.1.29 The Contactor shall prepare, as required, the Designs (Detailed Final Design) shall take all necessary measures and shall ensure all necessary interfaces at local and central level (OCC level) so that all AFC equipment of Kalamaria extension, as described in the present specification, to consist a complete, reliable and fully operational system, similar with the existing, in operation, AFC system of the Base Project.

10.1.30 The designs, materials, equipment and spare parts to be provided in accordance with this Contract shall be subject to ELLINIKO METRO S.A.approval.

10.2 Automatic Ticket Issuing Machine (ATIM)RequirementsSpecifications

10.2.1 Functional Requirements

10.2.1.1 ATIM functionalityto be supported shall include, but isnot limited to:

- Load stored value or fare product(s) to an existing CSC or e-ticket
- Review CSC and e-ticket balance and history
- Purchase one (1) or more e-tickets
- Purchase a non-personalized CSC
- Accept euro coins and notes of different values
- Accept authorized magnetic strip, contact, and contactless bank cards
- Return deposited cash(coins and notesof different values) if a transaction is canceled
- Provide change (coins and notes of different values)
- Print and issue legal receipts
- Print coding for e-tickets
- Display instructions and notices

- Provide audio andvoice messages and instructions
- Contain required security and alarm system
- Communicate over a network to send and receive transaction data in real-time.

10.2.1.2 The ATIMsmust issue non-personalized smart cards. Reloading of personalized or non-personalized cards will be done using notes, coins, credit and debit cards and mobile payment with NFC.

10.2.1.3 The reloading process requires the placing of the smart card(CSC) or the e-ticket on a specific holding location of the ATIMfor certifying the validity of the cart/e-ticket and proceeding with reloading actions. The card reading distance rangeshall be between 0-70mm and no more than 100mm. The following reloading actions will depend on the passenger's selection from an option list shown on the screen. Passengers will then insert the appropriate coins and banknotes, payment cards or mobile phones (NFC). If required, the machine will display instructions to passengers on how to incrementally add up to the ticket value and to complete the process. Changes will be saved in a reliable manner ensuring data protection during recording (anti-tear property). Problemsoccurring during the reloading process shall result in returning to the passenger the money that has been inserted.Instructions shall be provided at all times

10.2.1.4 Through the ATIM operating options, passengers shall be able to be informed on the status of their CSC and e-tickets (validity, expiry data, balance and other information, such as client loyalty scheme), without proceeding to any other transaction.

10.2.1.5 Each ATIM shall indicate clearly to passengers whether it is in service, able to dispense tickets and give change.

10.2.1.6 All passenger functional procedures of ATIM shall be clearly and unambiguously displayed, on its display, followed by the appropriate operating instructions. The display shall be a touch screen with graphic environment (GUI) and shall guide the passenger's actions using the equipment for any action taken. The display software application (menus and instructions) shall be subject to approval.

10.2.1.7 All passenger instructions shall also be announced via ATIM speakers. Each voice annunciation message will occur as close as possible to the event or change in transaction status as possible and be as brief as possible to convey the necessary information.

10.2.1.8 ATIM shall include as option to change the display language and the voice annunciation language between Greek, English, French, German, Hebrew,Bulgarian and Arabic.

10.2.1.9 In addition to the operating instructions (Greek, English, French, German, Hebrew,Bulgarianand Arabic), the display provided on the front of the deviceshall, as a minimum, show:

a) The price of the selected transaction, as well as the type of the coins, banknotes and/or Payment Cards, acceptable for the specific transaction.

b) The reduced remaining balance payment, as each coin or banknote is validated and accepted by the machine while the value inserted is less than the selected fare. When the value is equal to or exceeds the selected fare, coin or note insertion slots are to be closed.

c) The remaining number of coins or banknotes allowed to complete the transaction, decreasing each time a coin or note is verified and accepted by the machine, and if the value of the inserted coins or notes is less than the selected fare.

10.2.1.10 Transactions shall not be cancelled oncethe required value of the fare product is inserted and the coin and note slots have been closed.

10.2.1.11 Three typesof payment shall be provided by ATIM. For each action selected by a passenger, payments through money (coins, banknotes), bank cards (and mobile phone) payments shall be available. According to the selected action and its related fare media price, acceptance of notes or coins is restricted to those that assure the optimum management for change giving.

10.2.1.12 The Contractor shall follow a solution for management of coin and banknote stock (for change giving) that will assure the maximum ATIM autonomy, implementing fare values at the time of installation, compatible with the solution used in the existing metro network. All parameter settings of this solution shall be configurable, set by the Operator. Capability of configuring coins or notes acceptance criteria shall be set both centrally and locally, only by authorized personnel.

10.2.1.13 When the reserve of a coin hopper reaches a low level (programmable) or when the coin hopper is empty, the device shall display the relevant indication on the screen and a signal shall be transmitted to the Station Computer and to the Management Centre. Station authorized staff shall be permitted access to and will be able to refill empty coin hoppers with the appropriate coins.

10.2.1.14 Each machine shall check regularly and frequently the integrity of the fare table information it contains and shall request a re-load from the Station Computer if an error is detected. Records of the nature of such errors shall be transferred to the KMC for the preparation of maintenance reports.

10.2.1.15 Data transfer between the ATIM and the Station Computer shall include but not be limited to:

a) Fare table.

b) Status monitoring.

c) Vault access authorization.

d) Transaction Data.

e) Clock synchronization function.

10.2.1.16 Fare tables shall be initially sentfrom the MC to KMC. From KMCfare tablesshall be downloadedto ATIMs, though the Station Computer.

10.2.1.17 In case of Station Computer's fault, the required management actions shall be performed by the KMCdirectly.

10.2.1.18 In the event of a communication fault between the KMC and Station Computer it shall be possible to download fare tables directly from the Station Computer.

10.2.1.19 Fare tables shall be stored within ATIM in non-volatile memory or in battery powered memory. Modification of fare tables shall not require the changing of hardware.

10.2.1.20 Accounting and transaction details of the local station shall be transmitted and stored to the Station Computer and eventually to the KMC. Data shall be displayed on the screen of the Station Computer and KMC and printed out on demand. ATIM shall be able to store all transactions completed during any seven (7) consecutive days.

10.2.1.21 All transactions, events and alarms shall be time tagged (dd/mm/yy/hh/mm) and recorded separately (by category) in non-volatile memory in the ATIM. Detailed sales data per product, as well as the total from the machine shall be recorded on counters which cannot be reset and which shall be capable of being read. This data shall be transmitted automatically to the Station Computer and KMC.

10.2.1.22 Currency (coin and notes) verifiers shall monitor the proportion of coins and notes rejected and shall raise an alarm when the rejection rate exceeds a pre-set but adjustable threshold.

10.2.1.23 In the event of power supply failure, the machine shall complete any transaction in progress in the proper manner, save any unsaved information and then shut down. No information shall be lost under any circumstances.

10.2.2 Technical Requirements

10.2.2.1 ATIM's shall be designed to be vandal resistant. Displays, panels, buttons, etc. shall be resistant ofbeing damaged and slots/apertures shall be made resistant to the insertion of inappropriate (foreign) bodies and objects. Inappropriate objectsor fluids introduced into equipment through apertures shall have no effect on the equipment's normal operation.

10.2.2.2 Protection index shall be according to IP 54 standards for the machine internal equipment with particular attention to vermin-proofing and ventilation considerations of all slots/apertures. Protection– impact resistance rating shall be IK 10. Protection index for slots (for coins and banknotes) shall be according to the IP 34 standard. When not in use, apertures for coins and banknotes shall be blanked off with retracting flaps.

10.2.2.3 The casing material shall be brushed stainless steel, at least 2mm thick. The door and the base shall be constructed by steel at least 3mm thick.

10.2.2.4 The ATIM door shall have the appropriate number of locking points (indicatively 5), asafety mechanical lock, and an electronic access control system, specifically used for the ATIMs, for identification and secure access validationand deblock the locking system. The list of

personnel authorized to intervene on the ATIM shall be configured at a central level by specifying the levels of authorization. In case of not respecting the ATIM opening procedure, an online message to the central system, as well as a siren alarm at the machine will be activated.Upon unlocking of the safety mechanical lock and the authorization of the access control system, the ATIM door must open with a crank key.

10.2.2.5 ATIM shall be securely fastened (but adjustable) to the floor and shall be resistant to knocking over.

10.2.2.6 Special consideration shall be given to the ergonomic design and dimensions of the display, buttons, money and card inlets/slots as well of the output tray in order to accommodate passengers with special needs. The Contractor must specify the relevant standards that he complies with.

10.2.2.7 The ATIMs to be installed shall be suitable for use in a metro environment and shall have brushed stainless steel housing without any visible fasteners. They shall possess all pertinent certificates to this end, such as CE marking, and shall comply with the international standards on electromagnetic compatibility.

10.2.2.8 All ATIM's shall be clearly and uniquely identified on the front, rear and inside all doors and internal access points.

10.2.2.9 All passenger's interfaces on ATIM (banking card reader, banknote acceptor, coin slot, CSC/e-ticket holder, receiptoutput, CSC/E-ticket receipt tray, e.g.) shall be clearly, properly, labeled/marked for helping passengers during their operations on ATIMs. The type, the signs and the wording of the marking shall be approved by ELLINIKO METRO S.A..

10.2.2.10 The ATIMs shall comply with the following operational parameters:

- Operating voltage: 230V AC
- Operating temperature range: 0 ^{0}C to 50^{0}C
- Relative humidity: up to 95%

10.2.2.11 The ATIM shall be installed assuring an acceptable architecturally aesthetic line up. The Contractor shall co-ordinate to determine access arrangements for maintenance, restocking and cash collection.

10.2.2.12 All ATIM positions in all stations, regardless of whether they are equipped with ATIM or not, shall be provided with power and data cables of the LAN network, properly terminated. The positions that are not equipped with ATIMs shall be covered with removable stainless-steel panels.

10.2.2.13 ATIM shall be equipped with contactless readers, which shall process electronic tickets - MifareUltralight Ev1 paper tickets and smartcards – MifareDesfireEV3 PVC tickets. The reader shall be equipped with at least 4 SAM (Secure Access Module) positions.

10.2.2.14 Access of the personnel to SAM shall be controlled and the system musthave the capacity to identify intruders.

10.2.2.15 ATIM shall be equipped with two contactless e-ticket modules, each one being capable of handling at a minimum of 2000 e-tickets. Events/alarms like ticket stock low and end of a stock shall be transmitted to Station Computer and/or to Management Centre.

10.2.2.16 The maximum time for the issuance of an e-ticket or a smart card, once passengers complete the payment procedure, shall not exceed 10 sec.

10.2.2.17 All ATIMs shall be equipped with the appropriate number of printers or encoding printers. They shall be used for encoding data on e-tickets and smart cards andprinting e-tickets and legal payment receipts for any payment transaction. It is noted that the data and the location of the printing on e-tickets shall be configurable. The accounting data of the machine (contents of recyclers and coin and banknote receivers) shall also be automatically printed on blank paper every time the door opens.

10.2.2.18 The coin validator shall be capable of validating and accepting all types of euro coins, with validation parameters (coin geometrical and alloy characteristics) being software programmable. The validator shall have a high percentage of accepting valid coins, higher than 98%, and shall reject damaged or invalid coins to the coin tray. When the transaction has been completed, access to the coin insertion slot shall be blocked to prevent the insertion of foreign bodies that could create a blockage.

10.2.2.19 Coin processing equipment shall include indicatively:

- A coin validator detecting and accepting all eurocoins, eight (8) in total
- A minimum of two (2) recharge coin hoppers for bulk coin storage with a minimum storage capacity of thousand (1000) coins of one (1)euro each
- One coin vault for coin repository with 4 litter capacity
- A “smart” coin recycling unit for driving coins to coin vault or to collecting tray and recycling at least six (6) different types of coins with a minimum total storage capacity of fifty (50) coins of one euro each.
- A collecting tray.

10.2.2.20 All the above represent the minimum accepted requirements for coin capacity and management. Equivalent or better configurations of ATIM can be accepted upon design documentation and approval.

10.2.2.21 The maximum weight of a single full coin vault/boxshall not exceed the weight of 25 Kg.

10.2.2.22 Coins introduced by the passenger shall be stored into the recycling device and once the device is full, additional coins shall be deposited to the secure coin vault.

10.2.2.23 The used coin recharge boxesshall be able to store all types of coins, even coins of the same type.

10.2.2.24 When the inserted coins exceed the displayed fare, then the optimum combination of stored coin types shall be determined for the change to be returned.

10.2.2.25 When the recycling device has not enough coins for change, the machine shall use coins from the coin recharge boxes. In case appropriate changecannot be provided to the passenger, the transaction shall be cancelledand the inserted coins shall be returned to the passenger.

10.2.2.26 Coin storage in the ATIM shall be within a secure coin vault. No access to the vault contents shall be possible regardless of whether it is placed within the ATIM or not. The vault design shall prevent any potential fraud action by closing automatically and securely when being removed.The Contractor should submit for approval to ELLINIKO METRO S.A. the secure access design of the coin vaults, inside and outside the ATIM.

10.2.2.27 Banknote processing equipment shall have the feasibility to give changes in banknotes and shall indicatively include:

- A banknote acceptor/validator
- A recycling device capable of recycling at least four different types of notes and intermediate escrow boxes for temporary storage and reuse of eighty (80) in total banknotes.
- One cash box for permanent repository of a thousand (1000) at least banknotes.

10.2.2.28 The bank note acceptor shall be compatible with all security measures available in Euro Banknotes. For example:

- Banknote layout
- Magnetic elements,
- Ultraviolet (UV)
- Infrared

10.2.2.29 The acceptor/validator shall recognize and process at least sixty (60) different types of notes, inserted at any manner. The Operator shall be capable through a simple procedure to disable or enable the acceptance of a note type. The validation parameters of banknotes shall be software configured.

10.2.2.30 The bank note acceptor/validator shall be able to recognize and process the new euro banknotes expected to be redesigned in year 2024.

10.2.2.31 The note acceptor/validator will accept one (1) bill at a time and will determine the denomination and validity of the currency.

10.2.2.32 It is required that the successful validation and acceptance/non-acceptance rate to be constantly greater than 98%, and bank note processing time less than 2 sec.

10.2.2.33 Notes shall be retained in escrow until the transaction is completed or is cancelled.

10.2.2.34 In case of a cancelled transaction, the same used notes shall be returned to the passenger.

10.2.2.35 When a transaction is completed, all used notes will be in the intermediate escrow of the recycler.When the intermediate escrow is full then the notes shall be transported to the cash boxfor permanent repository.

10.2.2.36 The cash box for permanent repository shall have a capacity of no less than a thousand (1000) stacked banknotes.

10.2.2.37 A “Banknotes vault almost full” alarm signal shall be transmitted to the Station Computer when the number of notes held within the cash box exceeds a pre-set, but adjustable threshold. When cash box reaches its maximum capacity of stacked banknotes, a “vault full” alarm signal shall be transmitted to the Station Master. At this point the ATIM shall not accept any more banknotes until the full vault is replaced unless the recycling facility can support the transaction. An illuminated sign on the display of the ATIM shall notify passengers accordingly.

10.2.2.38 Banknote cashboxes shall remain secure when removed from ATIM. No access to the cash box contents shall be possible regardless of whether it is placed within the ATIM or not. The cash box design shall prevent any potential fraud action by closing automatically and securely when being removed. The Contractor should submit for approval to ELLINIKO METRO S.A.the secure access design of the coin vaults, inside and outside the ATIM.

10.2.2.39 The design of the coin vault and banknote box shall permit easy and safe lifting and handling by station staff.

10.2.2.40 Each coin vault or banknote cash box shall include a printed and electronically uniquely encoded serial number. The serial number will be read by the ATIM for reporting upon bill vault insertion and removal.

10.2.2.41 As any coin vaults or banknote cash box is removed by the ATIM, a printer within the ATIM shall print a receipt containing at least the following information:

a) Station Number

b) ATIM Number

c) Date and Time

d) Vault theoretical contents, based on performed transactions

e) The name of the maintainer removing the cashbox

10.2.2.42 The same information, as an event, shall be also transmitted to Station and Management Centre Computers.

10.2.2.43 Under this contract, two (2) additional sets of coin recharge boxes, coin vaults, banknote cash boxes and boxes for temporary banknote storage and reuse shall be provided per each ATIM. Each set shall contain all types of boxes used in the ATIM. It is clarified that the quantities are additional to the ones foreseen in the initial configuration of the ATIM.

10.2.2.44 The coin and banknote management terminals shall be equipped with hardware and software that verifies the electronic identity of each vault. ATIMs shall store in a memory, protected against power failure, the identity of the vault, as entered for its operation. In case of electric voltage interruption caused either by handling or by a fault occurring during ATIM startup, the terminal shall read the vault identity and shall compare it with the one stored before voltage interruption. If the two values differ, then the machine shall not start and an alarm shall be sent to the Management Centre, while the relevant actions shall be carried out by a Maintenance Technician to bring the ATIM back to service. All necessary items for tracing such incident (station, machine, maintenance technician code, time stamp, etc.) shall be included in a special report of the Management Centre.

10.2.2.45 ATIM shall be equipped with an EMV bank card reader (contactless and magnetic strip) and a pin-pad to support bank card payments.

10.2.2.46 EMV card readers shall support the NFC technology for allowing smartphones, tablets, and other devices to share data when in proximity for contactless payments via mobile wallet applications, like Apple Pay, Google Pay, as well as contactless cards.

10.2.2.47 The EMV bank card equipment that will be installedin the ATIMs shall communicate usingan independentaddressing, through the LAN-WAN, with existing Bank Payment Gateway located in Pylea Depot. This configuration shall be used to validate the authenticity of the card, to verify the card holder and to ensure the authorization of the Credit Institution for the current transaction. Depending on the results of the aforementioned checks, the ATIM shall either proceed with the issuance of the selected product or shall reject the transaction informing the passenger accordingly.

10.2.2.48 The ATIM involved equipment and network connectionshall be PCI and EMV certified for the acceptance of bank-issued credit and debit cards using all common formats based on the latest version of the standard at the time of Final Acceptance of the system.

10.2.2.49 The ATIM software shall process the result of the checks and the alarms (in service, out of service alarm) of the EMV equipment. No data related to the communication between LAN – WAN – GATEWAY – Credit Institution shall be processed by or stored in the terminal. The data and the transmission method (One-way hashes, truncation, tokenization Encryption) shall be set in the Detailed Final Design in cooperation with the Credit Institution, while the solution in its entirety shall be certified as per PCI DSS.

10.2.2.50 For ensuring the completeness of the accounting logs recorded in the ATIM and in the KMC, only the Transaction Number returned by the Credit Institution shall be stored.

10.2.2.51 The ATIM shall be equipped with a button for cancelling the transaction. The operation of this button shall be clearly described.

10.2.2.52 All transactions shall be registered in accounting files stored in a non-volatile memory. The contents of recyclers, coin and bank note vaults (by coin/bank note type and quantity) per machine shall also be kept in a similar type of memory. An ATIMprinter shall print this

information every time the front door (maintenance door) is opened. Accounting files shall be protected against destruction, modification, or alteration.

10.2.2.53 For each passenger transaction, a legal receiptwill be printed. The printed information on the payment receipts must comply with the requirements of current legislation (article 12 of Greek Law 4308/2014). So as a minimum the following information must be printed on the tickets:

a) The date of issue.

b) The serial number for one or more sets of retail items, which uniquely identifies this item.

c) The Tax Registry Number (TIN/VAT/ΑΦΜ) based on which the seller delivered the goods or provided the services.

d) The full name and full address of the seller of the goods or services.

e) The VAT rate which allows and the gross sales value concerned.

10.2.2.54 If required, the Tax Electronic Mechanism (ΤΕΜ/ΦΗΜ) (software application issuing the receipts) must be interconnected with the Tax Electronic Mechanism information system of the Independent Authority of Public Revenue (IAPR-ΑΑΔΕ) on the myDATA digital platform (a platform created by the authority, to digitize business tax and accounting information declaration). The Tax Electronic Mechanism (ΤΕΜ/ΦΗΜ) shall produce receipts with an integrated QR Code identifying the tax mechanism and the receipt, and shall transmit to IAPR its transactions, one by one, in real time. (based on the decision Α.1171/2021 of IAPR-ΑΑΔΕ)

10.2.2.55 The receipt will be collected from the appropriate collecting trayor dropbox/pickup box in the ATIM, where returned coins, e-tickets and smart cards are also collected, or from another collection point.

10.2.2.56 ATIM shall be protected against theft by sensors detecting door opening, and when the required procedures have not been applied. Related alarm shall be transmitted to the Station Computer and to the KMC. Each ATIM shall be equipped within a special keyboard for maintenance personnel or vault collecting personnel for entering a code. The alarm should operate with a relevant time delay. A different code shall be required for each operator and type of work.

10.2.2.57 ATIMs shall also have a mechanical locking mechanism for the unlatching of the vaults and the recyclers. In case the contents of the recycler are altered, or the hopper is removed, an automatic alarm shall be produced and transmitted to the Station Computer and the KMC. In general, the ATIM shall be designed to exclude fraud either from personnel or from others.

10.2.2.58 ATIM shall be self-monitoring, they shall detect and report immediately all fault conditions and maintenance requirements to the Station Computer, which shall transmit them to KMC and shall raise an alarm. The Contractor shall propose the (critical) set off alarms and

events which need to be transmitted online to the KMC. The content of this set shall be subject to approval from ELLINIKO METRO S.A.. All fault records and history of service shall be transmitted to KMC where they will be processed into management and maintenance reports daily.

10.2.2.59 Key functions shall be monitored internally, and signals shall be made available for monitoring at the Station Computer and the KMC. Conditions to be monitored internally shall include, as a minimum:

1. Machine status (in service/out of service, defective service)
2. Cash vaults (Coin/Bank note): nearly full
3. Cash vaults (Coin/Bank note): full
4. Coin jam
5. Note jam
6. E-ticket/smart card stock jams
7. E-ticket/smart card stock low/empty
8. Access to (Coin/Bank note) vault
9. Access by service personnel
10. Non-fatal fault leaves machine in service
11. Unauthorized access
12. Rechargebox(coins/banknotes) of recycling units empty
13. Recycling unit fault (coin, banknote)
14. Bank card reader failure
15. Software Failures

10.2.2.60 All possible faults of machine modules shall generate alarms to the KMC. The use of common/general alarms shall be minimized as much as possible. Each machine shall have a maintenance keyboard, display and internal (built-in) diagnostics to facilitate fault finding and maintenance. The internal diagnostics shall permit determination (hierarchically) of module failure in features, boards and removable board units.

10.2.2.61 All machines shall be equipped with a built-in clock, which is synchronized and updated regularly by the Station Computer. All Station Computer clocks shall be synchronized by the KMC computer but in the event of communication failure, all equipment shall be capable of operating safely with the built-in clock.Alternatively, the AFC equipment can be synchronized via the NTP protocol produced by the Time Distribution System and distributed within backbone communication network DTSof Kalamaria extension.

10.3 Card Issuing Terminals (CIT) Requirements Specifications

10.3.1 Functional Requirements

10.3.1.1 The CIT shall be installed in the Ticket Office of each station. This terminal shall issue and reload cards for all the following cases for which provision has been made:

- First issue of personalized or non-personalized CSC
- Issue of a CSC following a declaration of loss or theft
- Issue of a CSC to replace a defective card
- Issue of an e-ticket
- Reload of CSC and e-ticket

10.3.1.2 The CIT unit is a device to support the following functions:

- Supervision (operating messages, alarms)
- Accounting
- Downloading of parameters or files
- Card Blacklist management
- Card stock management

10.3.1.3 Additionally, CIT shall support and transmit to KMC information such as:

- Day/time synchronizationwith the Station Computer
- Controlling the operator's code based on the list of authorized operators personnel at the start of shift.
- Registration of operator's code
- Alteration of the list of authorized operators (function running at a Management Centre level, safe procedure)
- Printing the sales data (per type of card and as a total) by the end of shift.
- Intermediate printing of sales data upon request
- Selection of type of product for sale
- Combination of individual sales selections in one transaction
- Cancellation of last transaction in agreement with the overall sales cancellation procedures
- Automatic recognition of the mean to be reloaded
- Control of natural means and data to be codified
- Payment with cash with automatic calculation of the change to be returned
- Payment with bank cards with a POS device
- Printing of a legalreceipt, as described in par. 10.2.2.53and 10.2.2.54

- The functions to be provided to the terminal shall be configurable (addition/removal of operation or peripheral)

10.3.1.4 All types of payments for the issuance of a CSC or e-ticket shall be available by the CIT, in a manned Ticket Office, while all accounting data shall be safely stored both locally and centrally at the KMC. In addition to cash, payments with Payment Cards and NFC card emulators shall also be supported.

10.3.1.5 ThroughCIT terminals it shall also be possible that passengers can consult and solve conflicts or errors. These terminals also shall be used to deal with customer's complaints. The following functions shall be supported:

- Read CSC or/and of e-ticket and display of result
- Card or/and e-ticket related detailed information to be requested from KMC.

10.3.1.6 CIT equipment within ticket offices shall be online connected with the Management Centre of the extension.

10.3.1.7 For the issuance of personalized cards, passengers will present the necessary supporting documents specified by the Operator and/or OSETH. After checking these documents, the card will be issued and passengers will receive it immediately. Processing of all supporting documents will be feasible, adhering to all requirements regarding the protection of Personal Data.

10.3.1.8 Accounting logs shall be protected against interventions for modifications until they are transferred to the KMC.

10.3.2 Technical Requirements

10.3.2.1 The CIT shall consist of the following equipment and peripherals:

- Personal computer with typical industrial hardware and software of the latest edition, which shall include keyboard and high-resolution, flat colortouch screen display TFT
- All the required hardware and software equipment for the connection with the LAN, the IT infrastructure, the DTS, the Station Computer and the KMC.
- The software to be installed shall use a graphic environment and shall be self-controlled in order to facilitate maintenance
- Terminal POS equipment for bank card transactions(contactless and magnetic strip and /or chip)
- Accounting receipts printer as described in paragraphs 10.2.2.53 and 10.2.2.54.
- Reader/writer of CSC DesfireEV3, e-tickets, NFC tags, QR codes, having at least four (4) SAM (Secure Access Module) positions.
- Display for the information topassengers, which shall show the executed function and the transaction amount in two languages (Greek and English). The display shall be able to be moved and relocated in the best direction, in relation to the visibility by the passenger.

This display shall also be used for the information of the passengers regarding the status of the card (expiry date, remaining value)

- Complete keyboard with at least 101 keys
- Document flatbed scanner for digitalizing the passenger' s supportive documents
- High resolution digital camera for passenger photographs
- Smart card colorprinter for printing photographs on personalized card.
- Cash drawer

10.3.2.2 The POS terminal shall be equipped with a card reader, a keyboard and a display screen. The card reader shall ensure card authentication and verification through the Chip & Pin technology or contactless card or NFC card emulators authentication and verification. The POS terminal in its entirety shall be certified as per the latest edition of PCI DSS before installation.

10.3.2.3 The POS terminal shall communicate with the portal connection point (Gateway) for Bank Transactionswhich is installed at the Management Centre of the TMP, through the LAN-WAN in order to validate the authenticity of the card, to verify the card holder and to obtain the authorization of the Credit Institution to carry out the current transaction. Depending on the results of the aforementioned checks, the CIT shall either proceed with the issuance of the selected product or shall reject the transaction informing the passenger accordingly.

10.3.2.4 The CIT software shall interacts with the POS for exchanging thebasic payment transaction information (price, date, ID etc.) and the functional alarms (in service, out of service alarm) of the POS terminal.

10.3.2.5 No data related with the communication and security details of the payment transactions between LAN – WAN – GATEWAY – Credit Institution must be processed by or stored in the CIT. The abovementioned data and the transmission method (One-way hashes, truncation, tokenization Encryption) shall be defined in cooperation with the Credit Institution, while the solution in its entirety shall be certified as per PCI DSS.

10.3.2.6 For ensuring the completeness of the accounting logs recorded in the CIT accounting logs and in the KMC, only the Transaction Number returned by the Credit Institution shall be stored. No data which could be characterized as Personal Data shall be stored locally or centrally.

10.3.2.7 Sales data shall be safely stored for preventing data destruction and for protecting data integrity. Power cut-offs or voltage drops shall in no way entail loss of data. Thus, the Contractor shall develop the relevant safety data backup systems, at local (station) and central level (OCC).

10.4 AFC Gate RequirementsSpecifications

10.4.1 Functional Requirements

10.4.1.1 Gates shall be provided at the entry and exit of all stations to validate and to check passengers' tickets and to prevent passengers entering the system without a valid ticket.

10.4.1.2 Gates shall be suitable for heavy use in a metro environment and shall have brushed stainless steel housing. They shall possess all pertinent certificates to this end, such as CE marking, and shall comply with the international standards on electromagnetic compatibility.

10.4.1.3 The gate components and its software shall enable:

- Reading of contactless CSC ande-tickets, QR codes and NFC tags and EMV bank cards
- Transmission of the command to release the mechanism.
- Fare media Validation.
- Management of the indication pictograms situated on the casing.
- Activation of alarms.
- Data Transmission to the Station Computer.
- Display of the various alarms, to indicate the status of the reader to the operations or maintenance personnel.
- Management of station commands and alarms.
- Transmission of alarms to the Station Computer and to KMC.
- Safekeeping and filing of operational data and parameters such as:
    i. Time-related information (time, date, etc.).
    ii. Station geographical information

10.4.1.4 Gates shall be installed mainly in the concourse area for processing exit and entry passenger flows.

10.4.1.5 At the locations wherethe "free – paid" line is longer than the installed gates, the excess open line will be blocked by placing barriers made of materials harmonized with the architectural finishes (uprights and other metallic elements of polished stainless steel and 12mm thick tempered safety glass). These obstacles will be placed by the Contractor in coordination, as perthe design and the installation of the obstacles, with the main Contractor of the extension and ELLINIKO METRO S.A..

10.4.1.6 In case that moving barriers are foreseen, according to the architecture design and the contractual station drawings, they shall be designed, supplied and installed by the Contractor of AFC. They will be remotely controlled by AFC system, like being normal AFC gates, from AFC station computer or the emergency button within the Station Master Room.Moving barriers shall be perfectly harmonizedwith the architectural finishes of the

station and the fixed barriers supplied by the main contractor who is in charge for the Civil Works.They will be made of glass panels with similar characteristics (tempered safety glass) and thickness and height same as those of the gates (thickness 12mm, height 1,2m), uprights made of polished stainless steel and with a conventional, electric retaining mechanism (lock) that will release them.

10.4.1.7 To optimize the gate array efficiency, the gate mechanism and operating software shall permit selection for use in either single direction (entry or exit) or bidirectional.

10.4.1.8 According to the peak hour flow, reversible gates may be operated in either direction at different periods of the day. Direction of operation of the reversible gates shall be controlled through the Station Computer and the KMC.

10.4.1.9 Detection and safe passenger passage, shall be assured along the entire length and height of the gate by an adequate number of sensors, minimum eight, to:

- Prevent injury of adult passengers, passengers carrying a suitcase or small kids
- Prevent fraudulent use of the gate

10.4.1.10 The obstacles shall close when the passenger hascompletely gone throughthe obstacles and shall not be struck by them closing while closing. In case that a valid ticket or card follows within a pre-set period the obstacles shall remain open. This function though shall not allow passage of two persons with one valid ticket/card in which case an alarm shall be triggered and obstacles shall close.

10.4.1.11 Gates shall be designed to operate continuously with the obstacles operating in the normally closed mode. In the normally closed mode operation, the obstacles shall remain closed until the ticket is confirmed as valid, when they shall open.

10.4.1.12 A system for the simultaneous opening of all gate obstacles and emergency doors of the station, upon the activation of a button at the Station Master Roomin case of emergency, shall be provided.

10.4.1.13 The design of the gates opening system shall comply with the fail-safe design principle. The opening of the obstacles mustbe done with a mechanismwith a set offail-safe springs.

10.4.1.14 When the reader in an entry gate detects a fare media the following, as a minimum, card encoded data shall be read:

a) Fare media Identification Number

b) Passenger rights

c) Validity end date

d) Time, Date, number of trip restrictions, value balance

10.4.1.15 These data are compared with the fare media blacklist, and if not found, then further processing is allowed. In case that the fare media arelisted in the blacklist, the gateremains closed, fare media is invalidated, and an alarm notifies the Station Master. In case the fare

media is not included in the Blacklist and the rest of the preconditions for access permit are fulfilled the gate opens.

10.4.1.16 When a fare media is detected by an exit gate, it is checked whether the preconditions, in relation to the applicable business/commercial rules are fulfilled. The subtractive stored value/product shall be calculated in the exiting gates automatically. Upon successful fulfillment of condition/restrictions, the gate opens.

10.4.1.17 Fare media readers/writers shall communicate with the Station Computer and KMC via an AFC data transmission network:

a) To receive the fare media processing program (for maintenance or modification purposes), as well as the parameters required for this processing.

b) To return information relative to operation of the reader (operating mode), technical or operational alarms, or information relative to passenger flow.

10.4.1.18 In case of Station Computer's fault, the communications shall be directly established with KMC for supporting the above functions.

10.4.1.19 The fare media reader/writer shall be capable of executing their primary task of control even in the absence of communication with the Station Computer or the KMC (e.g. transmission inoperative). In this case, overall operation of the reader is degraded in as much as the reader cannot acquire all the parameters required for full processing of the tickets/cards. The reader then operates with the last parameters received. Reader's software installed shall permit storage of all executed transaction information locally and upon restoration of communication these shall be sent to Station Computer and KMC for further processing.

10.4.1.20 The reader shall execute the following functions in normal operation:

a) Transmission of gate status to the Station Computer and KMC.

b) Reception of messages from the Station Computer and KMC.

c) Processing of messages and management of the gate without disturbance of fare media checking.

10.4.1.21 At each transmission of information, the receiving device transmits an acknowledgement message that indicates that data transfer was performed properly or the need for data retransmission.

10.4.1.22 When the Station Computer or the KMC must update the readers as regards the processing program, time or geographical parameters, or must inform itself of the status of the station, sends a message to inform the readers accordingly.

10.4.1.23 Fare media reader/writer shall have increased data storage capacity and shall communicate through Ethernet/IP protocol with the upper-level systems.Therefore the following characteristics shall be able to apply:

- To store operational data (validations, alarms, incidents, etc.) of the last seven days as a minimum

- To store the Blacklist data
- To have an integrated software mechanism ensuring data safety and integrity, preventing their processing and loss
- Hardware and software components shall allow for manual data extraction.

10.4.1.24 Messages exchanged between the readers and the Station Computer, or the KMC/MC can be of different types:

a) Service message (acknowledgement, “alive” message, etc.).

b) Centralization of Passenger Counting and transaction information.

c) Reader alarms and status.

d) Request for resources (time parameters, operations data).

e) Request for downloading (ticket processing program).

f) Alive Messages

g) Start-up and Shutdown messages

10.4.1.25 The gate shall not be shut down without uploading remaining transaction records, except in the case as emergency shutdown. Typically, when the gate is set out of order, the gate shall change its state to “Not in operation” and the relative sign shall be illuminated on both sides. Then the gate shall wait the request of uploading transaction records from the Station Computer and uploads all records. After uploading is finished, real suspension of operation process of the gate starts.

10.4.1.26 The gate shall connect to the Station Computer and KMC automatically at its starting-up time and shall send start-up message to download full entries of blacklist. The downloaded blacklist shall be stored in non-volatile memory of the gate, and it shall be used for stand-alone operation of the gate when communication fault with the Station Computer occurs.

10.4.1.27 The gate will accept new blacklist data during its runtime at intervals to be specified in the DetailedDesign. The new entry of blacklist shall be merged to original blacklist.

10.4.1.28 The Contractor shall define all reader-operating alarms, status messages, data requests notably as regards operating supervision of hardware and installed software during the design phase and considering the corresponding implementation of the TMP.

10.4.1.29 Status monitoring and control of AFC gates shall be carried out locally by the Station Computer and centrally by the KMC. A data link shall enable the KMCto request and obtain a complete status history of all AFC equipment. The Contractor shall propose the (critical) alarm and event set which needs to be transmitted online to KMC. The content of this set is subject to ELLINIKO METRO S.A.’s approval.

10.4.1.30 Conditions that shall be monitored shall include at least:

a) Machine status: in service/out of service.

b) Access by service personnel.

c) Fault.

d) Unauthorized entry.

e) Check-in, Check-out direction of reversible gates.

f) Gates in emergency mode.

10.4.1.31 In emergency situations, fire alarm and on power failure, the gate shall open automatically.

10.4.1.32 PSN gates shall differ from the standard gates only regarding the opening aisle width and their width dimensions. All other technical and functional specifications ofPSNgateswill beidentical to the ones of the normal gates.

10.4.1.33 “HELP” buttons,providing telephone communicationfor passengers entering the station, shall be provided by the Contractor. Thetelephone devices shall be installed at one end of each gate line, on the unpaid area of the station, coordinated with the intercom/DLT provisions of the DLT system of the main contractor. Each communication device shall be installed on a wall or on a brushed stainless-steel stanchion, clearly identifiable, with non-visible cable installation. When operated, it shall establish a DLT phone call to theDLT telephone console in the Station Master Room. If no answer from the Station Master is given, the call shall be forwarded to the Operation Control Room. DLT equipment supply and installation, cable supply, installation and termination, DLT devices programming, commissioning and testing are on AFC Contractor’s responsibility.The telephone devices that will be used should be as similar or equivalent as possible to the devices used by the main contractor of Kalamaria. Detailed information of the existing devices will be made available during the design phase of the Project.

It is mentioned that a corresponding DLT telephone will be installed by the main contractor of the extension, at each station and at each gate line, in the paid area.

10.4.1.34 An Emergency Button located in the SMR area, easily accessed by Station Master, shall put immediately all station AFC gates and emergency doors, in emergency mode and in fully open position.

10.4.1.35 When passengers pass through the gates, to be granted legal passage, anopening command must be delivered to the gate management unit. This command, can originate either:

- From the reader software: passage authorization is issued if the fare media has been acknowledged as valid; the command is cancelled once the gate has been passed; or
- From the Station Computer: (this opening function refers to all gates but operationally is applied only to PSN ones) this control, used by the Station Master, provides “free” passage to a PSN passenger or to a special category passenger (e.g. mother with baby carriage) or toauthorizedtechnical personnelhaving to operate inside the station

- From the Management Center of the Kalamaria Extension and its Workstations, if there is no possibility of local handling and remote action is required.

10.4.1.36 The fare mediachecking unit shall be placed in an “inoperative” status when one of the following conditions is met:

a) The door has been set in the “inoperative” position by the Station Master.

b) The software of the reader has detected a fault or other reason, which could involve its operating integrity.

10.4.1.37 In the inoperative status, the gate mechanism shall be closed, and the relative sign shall be illuminated on both sides.

10.4.1.38 Changeover to “maintenance” status shall be carried out via the Station Computer. Maintenance agents after gate is set to maintenance status shall proceed with their work using Portable Diagnostic Terminals (PDT), which can be connected to the AFC gate during intervention phases. Restoration to operating status shall follow inversely the same secure procedure.The supply of the necessary number of Portable Diagnostic Terminals (PDT) is on the Contractor’s responsibility.

10.4.1.39 Each gate must be shelf-checked for identifying any problem. All logic systems installed in the gates shall carry out cyclic checking of proper operation of the main constitutive elements. Indicatively, without however being limited to it, the integrity of the RAM area containing the fare media processing program, the main operational parameters, blacklist integrity etc. shall be checked.

10.4.2 Technical Requirements

10.4.2.1 Gates shall be compatible with the following operational conditions/parameters:

- Operating voltage: 230V AC
- Operating temperature range: 0^0C to 50^0C
- Relative humidity: up to 95%.
- Impact resistance rating: IK10

10.4.2.2 The obstacles ofthe gates shall be safety tempered glass of 12mm thickness, sliding in and out of the cabinet, at a height of 1,2m.

10.4.2.3 The gates must be able to perform at a rate of 60 cycles (mechanical obstacle open –close) per minute.

10.4.2.4 Gates shall include the fare mediareading and controlling device, the cabinet, and the above-mentioned sliding panels (obstacles). Within the cabinet the safety spring and the electromechanical drive for each obstacle, the electronic control units for motors, electronic boards/ communication units, the sensors, the power distribution, and protection shall be accommodated.

10.4.2.5 The materials and the electronic boards forming these units shall be of industrial type.

10.4.2.6 The motors shall ensure a smooth movement during open and close of the obstaclesand will at least have high energy efficiency, according to IEC/EN 60034-30-1: 2014.

10.4.2.7 The communication unit shall accommodate all the communications effected between the gate and the systems of the aforementioned level.

10.4.2.8 All communications shall be ensured through standardized Ethernet protocols. All data necessary for the operation of the gate (operation rules, blacklist etc.) shall be stored in the reader/writer.

10.4.2.9 Detection of an invalid ticket or card shall trigger an audible warning.

10.4.2.10 The minimum aisle width when the obstacles are open shall be not less than 550 mm for standard gates and 900 mm for the PSN gates.

10.4.2.11 Obstacles shall be positioned so that a passenger walking towards the gate is given ample opportunity to see that the obstacles are shut and to stop. Theobstacles shall be positioned transverse,at the middle of the gate.

10.4.2.12 An adjustable safety torque limiter ensures user's safety by immediately stopping the obstacle in case of accidental contact.

10.4.2.13 All AFC gates shall be interfaced with the station Fire Detection and BACS systems. In case that a station fire alarm is appeared, all AFC gates and opening doorsmustopen automatically, providing free exit passage to passengers. In case of fire in the tunnel and activation of the corresponding smoke extraction scenario from BACS system, the gates and the opening doors of the two adjacent stations shall open automatically. Station staff shall do the restoration to normal operation. Anti-panic operation and fire alarm gate opening shall be reported online to KMC.

10.4.2.14 The interface of the AFC gate control system with the Fire Detection and BACS systems shall ensure a total SIL 2 safety level at gates opening function and shall include:

- Opening Command from Fire Alarm Panel to the AFC gate control system
- Opening Command from BACS to the AFC gate control system
- Power off command from BACS to the AFC gate power supply panel of the station, in the event of gates opening failure through the above-mentioned opening commands. As a result, the AFC gates must open through the safety springs to their fail-safe position.

10.4.2.15 Any AFC gate emergency opening mechanism activation shall return a relevant confirmation sign to the BACS system.

10.4.2.16 Presence detection and user's passage safety sensors of each gate (at least 8 pairs of Tx-Rx per gate)will be alsoused to provide passenger counting information, which are transmitted via the Station Computer to the KMC. E-Ticket and CSCtransaction records are also uploaded to KMC.

10.4.2.17 The gate willbe equipped with areader and afare media control device, on the right side of passing direction, at a convenient height (conforming to ergonomic standards).

10.4.2.18 An appropriate illuminated sign, (preferably a green arrow) clearly visible, shall direct the passenger to the correct aisle, or shall indicate that the gate is closed (preferably with a redprohibition sign).Signage will be subject to approval by ELLINIKO METRO S.A..

10.4.2.19 Detection of the presence and direction of motion of a passenger shall be implemented through precision photocells all along the length of the gate as close as possible to the ends and the obstacles, but without causing false operation due to the passenger being detected before the ticket is controlled or CSC detected.

10.4.2.20 Close to the reader, a high analysis (e.g., LED) screen shall be provided displaying visual indications on the following information that is addressed to the passengers. Namely:

a) An arrow pointing in the direction of travel if the passenger is permitted to pass.

b) “Seek Assistance” or similar in Greek and English, in colored letters, if the passenger is not permitted to pass.

c) Validation result

d) Remaining stored value, or trips, if stored value cards are used

10.4.2.21 In addition to the above, sound signals shall be also provided emitting different sounds for all possible validation results.

10.4.2.22 The validation device shall consist of a fare media reader / writer compatible with the fare collection means used, namely the DesfireEV3 PVC tickets, the Smartcards Ultralight C paper tickets, NFC technology and QR codes (from mobiles). The reader / writer shall also be equipped with 4 SAM positions and the appropriate number of SAMs for the secure system operation.

10.4.2.23 If the control of one fare media, leading to a gate opening, is followed by a second fare media that is invalid, the audible alarm shall sound, and obstacles shall close. In any case, the gate design and operation shall ensure that the risk of injuries by the obstacles is eliminated.

10.4.2.24 Each line of AFC gates, at each station,mustinclude at least two gates, one at least of them for allowing the passage of wheelchairs (900 mm free passage). Exception to the rule is the case when the line is placed at such a location which practically renders wheelchair passage impossible, e.g., access ensured only through the fixed staircase.

10.4.2.25 A brushed stainless-steel casing of a minimum 2 mm thickness, used as support and cladding for the gates.

10.4.2.26 The case will have a removable cover that will allow full access to all its internal parts for easy removal. Special attention will be paid to the smooth and efficient removal and installation of the removable cover from/to the enclosure, as well as the adjustment of access barriers.

10.4.2.27 The aisle width shall be a minimum of 550mm for normal width gates and 900mm for the PSN gates. Obstacles shall be made of 12mm thick tempered safety glass, the height of which, from the floor finish, shall be 1,20m. Obstacles in closed position shall provide full width/height screen blocking of the passage whereas in open position shall be retracted within the gate's casing providing clear passage. The glass material and its mounting mechanism shall be designed for such applications and shall not cause injuries under any circumstances to the users.

10.4.2.28 The housing width for the normal gates shall be around 300mm and around 450mm for the PSN, the housing height shall be around 1.000mm and the housing length shall be a maximum of 2200mm.

10.5 Station Computer Requirement Specifications

10.5.1 Functional Requirements

10.5.1.1 Each station AFC system shall include a local computer installed at the Station Master Room 2.3.

10.5.1.2 Operating hours of Station Computer shall consider the need for 24 hours per day, 7days every week. The computer system and software packages shall process the maximum foreseeable daily amount of data from each station and sized to handle 125% of the installed AFC equipment.

10.5.1.3 The following operations shall be performed through the Station Computer:

a) Station Configuration using software menus.

   Several pre-set configurations (changeover between the operation mode of the entry/exit gates at the control line ATIM's in/out of service) per station shall be stored. Application of each configuration shall be done either automatically depending on the time of the day or manually by the Station Master.

b) Display the current operational status of all equipment in the station.

c) Remote control of each equipment for putting into/out of service or in Maintenance Status as well as changing of entry/exit operation direction per gate.

d) Receive, perform and monitor specific tasks (e.g., gate control line configuration) prepared and scheduled by Management Centre. The Contractor shall propose his own specific task list that will be subject to review and approval from ELLINIKO METRO S.A.. Structure of this list shall allow additional tasks to be added/deleted, as necessary, by the Operator.

e) Operating (Automatic/manually) the anti-panic function.

f) Manual control of PSN gates.

g) Display, record and announce all alarms, events and fault conditions in station AFC equipment and relay specific alarms conditions immediately to Management Centre.

10.5.1.4 All recorded alarms, events, and Fault conditions are transmitted on specific time intervals to KMC automatically.

10.5.1.5 The Station Computer shall store all collected data in the main storage means, as well as in back-up memory.

10.5.1.6 Record all authorized entry access to AFC equipment. Any unauthorized access to AFC equipment shall trigger an alarm and shall also be recorded.

10.5.1.7 Store and download current fare table data and fare media blacklists for all machine types several times in a day.

10.5.1.8 Retrieve, store and transmit to KMC all transaction-recorded data (Accounting) from all equipment (ATIM's, CIT).

10.5.1.9 Retrieve, store and transmit to KMC all recorded data concerning e-tickets, CSC, recycling modules for coin/banknotes, money vault operations etc.

10.5.1.10 Print out data of alarms, events and fault conditions.

10.5.1.11 Receive updated fare table data, fare mediablacklist, and task list from KMC. This information is merged with previous day dataor replacing them as appropriate.

10.5.1.12 Station Computer receives from the KMC date and time information and distributes them to all AFC equipment of the station.

10.5.1.13 Passenger traffic and accounting data shall bestored in two (2) redundant and separatehard disks on the Station Computer, to prevent data destruction and protect data integrity, on, with export capabilities to removable media, to software tools, data storage unit and to the KMC. Power or communication failures shall not result under any circumstances in data loss. Backup data shall cover operating day and at least the past three consecutive days.

10.5.1.14 The following operations shall have to be performed in real time:

- Servicing of AFC equipment and KMC requests
- Fare Table download from KMC
- Task list download from KMC
- Blacklists download from KMC
- Date and Time synchronization
- Critical alarms processing
- Provision of validations information to the OCC Supervisor

10.5.1.15 Accounting files shall be additionally protected against modification, until they are transmitted to the Management Centre and the correct receipt has been confirmed.

10.5.1.16 The Station Computer must enable ticket gates to operatein a degraded mode of the metro network by removing time constraints, e.g., in the event of train delays or, in the event of a station having to operate in an emergency exit mode.

10.5.2 Technical Requirements

10.5.2.1 The computer shall comprise industry standard hardware and software of the latest generation at the time of installation, serving as gateway between AFC station equipment and the KMC/MC and shall include:

a) Function keyboard and display (high resolution color type)

b) Local UPS

c) All necessary interfaces (hardware and software) for Station Computer connection to KMC/MC

d) Software using a graphic environment for all its screens and shall contain a self-diagnostic to facilitate maintenance

e) Heavy-duty printer laser printer

10.5.2.2 The minimum technical specifications that must be fulfilled are the following ones:

- Processor: 10thGEN INTEL® CORE i9, or equivalent
- RAM Memory:16GB
- Hard Drive: 1TB SSD
- Monitor:>=22”, 4K
- Double Power Supply Unit – redundant in case of fault
- Double Network card – redundant in case of fault

10.6 Portable Ticket / Card Readers Requirements Specifications

10.6.1 Functional Requirements

10.6.1.1 The Contractor shall supply six (6) portable control devices under the terms of this Contract. The inspectors of all agencies will use the portable control devices to check the validity of Cards and Tickets of the passengers and record all relevant checking data. The portable devices should be able to identify the validity of the card/ticket through the reading/use of all data required for this purpose, such as, e.g., monthly card validity, card cancellation in the specific route, blacklist etc.

10.6.1.2 Portable devices shall record the following data, as a minimum requirement:

- Code of Inspector
- Line/Vehicle
- Number of checked cards/e-tickets
- Date/Time of checking

- Outcome of the checking
- Data concerning the imposed fine

10.6.1.3 Data Transfer Terminal shall be provided through the portable devices to KMC. The location of this data transfer terminal shall result from the Contractor's DFD.

10.6.1.4 The portable control devices must work properly and reliably at any point of the Base Project and the Kalamaria extension.

10.6.2 Technical Requirements

10.6.2.1 The portable devices will have the following capabilities, as a minimum requirement:

- Storage in non-volatile memory of all system parameters (ticket list, blacklist etc.) required for the checking of fare media.
- The device memory will be sufficient for the storage of a blacklist including at least 2000 entries (Serial Number of Cards or Range Number of Cards)
- Maintenance of sufficient control data which can cover all checks that may be performed by every group of inspectors (indicatively, 1000 checks/shift)
- During the battery charge of these devices there will be communication with a proper terminal where all stored data concerning transactions/checks will be automatically transmitted for further processing by the KMC
- These devices shall be equipped with a built-in real time clock.
- These devices will be easily and safely transported, having a suitable transportation holster and shoulder strap, and may operate independently to cover –as a minimum requirement- the needs in two consecutive shifts.
- They will have the capacity to record the fines certified by the inspectors (Number of Fine Note, as initial action), irrespective of whether these fines are paid in cash or based on a deadline.
- They will have the capability of retrieving more recent data concerning the operation of cards throughout the day, either following a visit to the system, or through communication with the central system under the responsibility of which falls the crew of inspectors.

10.6.2.2 The portable ticket reader shall be powered by dry rechargeable batteries, capable of being fully recharged up to 70% of their full capacity from their minimum operating charge within five hours.Two batteries per machine shall be provided together with facilities for simultaneously charging the batteries of 150% of the machines supplied.

10.6.2.3 Each battery package shall provide an autonomy at least for 10 hours of continuous operation

10.6.2.4 The portable control devices shall bear an indication concerning the capacity of storing data from inspections, battery charge indication and operation diagnostics.

10.6.2.5 The weight of the portable ticket reader in its fully configured state shall not exceed 1kg. A clip-on shoulder strap shall be provided with each machine suitable for continuous wearing for a full day. The portable control devices shall be shock resistant in case they fall from 1m height.

10.7 Kalamaria Management Centre Requirements Specifications

10.7.1 Functional Requirements

10.7.1.1 The new Kalamaria Management Centre shall be installed at the Pylea Depot Control Centre. The exact installation room will be defined during the Detailed Design phase.

10.7.1.2 Thenew Kalamaria Management Centre will be the responsible AFC Management Centre for the Kalamaria extension stations. It shall be capable to handle the passenger ridership of Kalamaria metro network. It will be in operation 24-hour a day, 7 days per week.

10.7.1.3 The Kalamaria Management Centre will enable the following operations, as a minimum requirement:

- Interface with the existing metro AFC Management Centre to meet the needs of interoperability of the fare media along the whole Thessaloniki Metro network.
- Interconnection with the existing AFC Management Center of the Metro to achieve the management, i.e., the functional parameterization, the control and the monitoring of the AFC system of the extension from the existing AFC Management Center.
- Management of the basic parameters, such as product determination, dairy, clock, etc., of the field equipment (Gates, ATIMs, CIT, Station Computers) of the AFC system of Kalamaria extension
- Information/Preparation of Reports for the extension
- Insurance of safety of the communication networks of the extension
- Confirmation of the completeness and reliability of data transmitted and accepted to the KMC.
- Management of the requests resulting from Card Issuance Terminals concerning the issuance of cards. Card Issuance Terminals shall transmit, codified messages relating to the issuance or the replacement of “cards” and which should be responded in real time. Such messages shall have higher priority against all others.
- Monitoring and checking of the overall operation of AFC system, including back-office, in real time through various procedures and issuance of orders to the various devices either scheduled, per request or following the recording of various events. The AFC equipment status reported mustinclude operational status (e.g., in service, degraded mode, out of service, or no communications), maintenance alarms associated with individual device modules, and revenue alerts (e.g., vault near-full/full).
- Graphics and detailed description of the existing condition of every piece of AFC equipment of KMP.

- Management of all devices and terminal equipment installed at the network.
- Presentation of overall operation of the system and statistic processing of the average availability of the individual equipment.
- Preparation of the list of works and its transmittal to the Station computers.
- Analysis of system operation data.
- Collection and processing of data concerning ridership and validations from the station computers.
- Collection and processing of data concerning sales (tickets, cards, mobile ticketing) from the station computers.
- Management of all data bases to be used by the system (Smart Cards, sales, ticket validations, equipment etc.).
- Creation of back-up documents in real time.
- Management of access rights.
- Management of system safety.
- Connection with banks for the service of transactions through bank cards.
- Card management
- Management of keys
- Management of the blacklist
- Management of the pricing policy tables
- Management of System operation parameters, such as definition of products, calendar, clock
- Transmission of system parameters to the entire equipment.
- Collection of documents concerning checks – fines

10.7.1.4 The Management Centre shall cover the following indicative specific needs:

- Data introduction and extraction to/from the existing AFCmanagement center of TMP. The exact content and the structure of the information to be exchangedwill be defined byELLINIKO METRO S.A.during the design phase of the Project. This detailed designshall be considered as the communication model between the Management Center of the Base Projectand any future metro extension, while the Contractor undertakes unreservedly the obligation to implement it in full.
- Data collection/transmission from/to the station equipment will be donein real time, online from the stations, through the Station Computers.

- Data collection/transmission from/to the station equipment will be concurrently done with the use of external storage units in case the communication with the individual equipment or Station Computers is interrupted.
- All collected data to be determined with accuracy during the DFD level will enable the checking of the condition of the entire system (e.g., condition of the device, alarms and events collection…) and the executed transactions (e.g., acknowledgement of devices, time stamp, message number etc.).
- Processing of actions and transactions will be automatic and shall include all necessary operations for the acknowledgement of the equipment to be used for the execution of works, such as transactions, data ratification, recording of extraordinary events, alarms etc.

10.7.1.5 The following shall also be applicable for the Kalamaria Management Centre:

- It shall be possible to prepare reports using processed or primary data to provide information on financial issues, as well as issues related to ridership/operation/system performance.
- A list of already prepared reports will be provided per category (reports related to operational issues, financial issues, issues related to ridership, system reliability, traffic agencies etc.).
- It shall be possible to create new reports using a commercial tool of the last generation (Report Generator).
- It shall be possible to retrieve data from the reports in original file forms (e.g. Microsoft Excel, ASCII).
- The preparation of selected reports will be scheduled and automated.
- The Contractor should describe procedures that ensure the continuous and unobstructed operation of the Management Centre systems (copies for safety reasons, re-starting procedures etc.).

10.7.1.6 A special set ofAPI interfaces shall be provided by ELLINIKO METRO S.A.(developed by the contractor of the Base Project), for ensuring the communication and the interconnection of the Kalamaria AFC management center with the existing TMP Management Centre. This set of API interfaces must ensure the full functional integration of the Kalamaria AFC system to the existing AFC system of the Base Project. The Contractor shall support, if need be, the contractor of the Base metro project to develop the following, indicatively given, API interfaces:

- Fare Distribution
- Fare Payment
- Fare Inspection
- Customer Account Management (future provision)

- Device Management
- Data exchange and statistical processing
- Security Management

The set of API interfaces shall be fully applied by the Contractor and the Kalamaria extension AFC management center shall by properly structured and programmed.

10.7.1.7 The Contractor shall demonstrate use of the APIs as part of system implementation and testing. The Contractor shall perform API-specific testing, which will be witnessed and validated by ELLINIKO METRO S.A.representatives. Any changes to the APIs because of testing will result in the API specifications being updated by the Contractor.

10.7.1.8 During the preparation of the design, the Contractor shall work in coordination with ELLINIKO METRO S.A.to ensure the full interoperability between the system to be provided and the AFC system of the TMP.

10.7.1.9 All KMC software applications shall be preferably web-based. Data received from the Kalamaria metro station computers shall be collected ensuring the following:

- Safe data transmission
- Data authentication
- Integrity of transmitted data

10.7.1.10 When critical fault or critical incident alarms occur on AFC equipment, relevant, high priority messages must be transmitted to the KMC,which will inform the system operators for their immediate action.

10.7.1.11 The KMC software must support and process multiple types of fare. It shall be also feasible to support account-based operation.

10.7.1.12 The KMC hardware and software installed, as well as all relative peripherals and network elements, shall be sized to support the anticipated transactions per day for the entire transportation network of Kalamaria extension, including a future transaction increase of 50% which will result from the extension of metro line towards Airport.

10.7.1.13 The KMC software, as well as the software installed on workstations and station computers, shall be upgradeable and parameterized in such a way that addition of new stations or any other AFC equipment at station level shall be easily accomplished by the Operator without installing any additional software.

10.7.1.14 The KMC software, as well as the software installed on workstations, shall support on-line real-time processing, as far as the Station Computer functions are concerned.

10.7.1.15 The KMC Computers shall be equipped with all necessary relational databases (Oracle or SQL type) and shall comprise industry standard hardware and software of the latest generation at the time of installation.

10.7.1.16 The Operating System shall provide protection against data alteration by non-authorized staff and shall be multitasking, using high-level software. Only the System Manager shall be entitled to have access to all types of files and database tools. Other users shall be authorized to have access only to the files considered necessary in the department and the work they execute. Database routine shall provide data integrity and consistency at all steps of the process. Data shall be stored in removable storage means for backing-up all operational and user configurable software and for historical storage of equipment status records.

10.7.1.17 Backups shall be created without interrupting the operation of the system. The Contractor will propose the procedure to be followed and the frequency of creating backups and copies of original data (data related to transactions) to be approved during the DFD phase.

10.7.1.18 The historical data storage system shall index the storage media to enable rapid location of data and time and be able to do event searches based on selected criteria.

10.7.1.19 Database routines shall enable authorized staff to have access to the said data by using standard relational database queries. It will be also possible to identify/process data from the back-up documents without modifying/causing any damage to the current condition of databases.

10.7.1.20 It will be also possible to “compress” the DB to check the space it occupies by using parameters defined by the system Administrator. This DB will keep detailed row data for a period of 7 days. Upon elapse of the seven (7)-day period, the system will “compress” data per equipment group, type of transaction and period (e.g., 15-minute period), as defined by the Administrator, and shall keep them available for forty (40) days. Upon elapse of the forty-day period, data shall be compressed based on a daily basis using previously described criteria and shall be kept available for 24 months. Subsequently, data will be compressed on monthly basis and shall remain available for 4 years. The above mentioneddata compression process must be initiated automatically, after the confirmation of the user of the system andprovided that the creation of the copies of the detailed transactions (per level) has been successfully completed.

10.7.1.21 In the Management Centre to be installed, the accounting logs incorporating the analytical data of every sales transaction carried out using a Bank Payment Card shall also include the transaction number returned by the Credit Institution. The transaction number shall be the only item to be stored in the System out of the data and items exchanged with the Credit Institution.

10.7.1.22 In addition, using a special field in the Data Base it shall be possible to separate from all the sales the ones effected using a Payment Card, so that the pertinent report can be prepared. This report shall include all analytical data identifying each transaction.

10.7.2 Technical Requirements

10.7.2.1 The Computer System of the Kalamaria Extension Management Center must be fully redundant, through the use of redundant servers.

10.7.2.2 For both servers, backups shall be deployed to ensure quickly restore data in the event of a disaster.

10.7.2.3 Hot spares should be available for hard disks so that if a hard drive in a server fails, another one (disk) can immediately replace it. Using a RAID array should ensure that a server can keep running when there is a single disk failure.

10.7.2.4 Redundant power supplies should be deployed so that if the main power supply fails, the second power supply unit can continue operating.

10.7.2.5 In case of equipment or software failure in the Kalamaria extension Management Center server, the redundant server shall assume control of the whole network without any time delay (transparent to the user) and without any data loss. Operation by the redundant equipment shall not cause any delays in information processing speed compared to normal operation. The software installed shall support automatic recovery to normal operation after server or network fault restoration.

10.7.2.6 Each server, primary or redundant, shall be equipped, as a minimum, with the following items:

- Rack or modular mounted Server
- Rack or modular redundant Server
- Redundant Power Supply and UPS modules, of rack-mounted type
- Redundant WAN Network Interface Cards
- SAN modular memory configuration with Raid 5 Hot Swap Hard Disks of the appropriate capacity, common for all servers, of rack-mounted type
- Unit for back-up, of rack-mounted type
- Multiprocessor Platform
- Intel XEON 4thGenor AMD EPYC 4thGen or equivalent
- Unix or Windows Server operating system
- Master clock Unit

10.7.2.7 The Kalamaria extension Management Centercomputers shall be supplied by a local UPS for two (2) hours minimum. Should the main power supply fail for a period greater than the specified one, the computers shall start up the termination procedure upon receipt of the relevant alarm signal by the UPS.

10.7.2.8 The server computer system, all active and passive network components, UPS and all interfaces (server's heartbeat, Controllers, F/O Copper) shall be such so as to ensure that all the needs are met in the event of failure (fully redundant system). Servers shall be properly sized, in terms of hardware and software, so that both the main and the auxiliary server are able to control individually the entire network on its own. If the main server fails,

the corresponding auxiliary server shall take control of the entire network without delay (this should not be understood by the user) and without loss of data. Auxiliary equipment Operation shall entail no delay whatsoever to the information processing speed as compared to normal operation. The software installed shall support automatic resetting to normal operation upon removal of a fault to a main server or to any other active Rack component.

10.8 Workstation Requirements Specifications

10.8.1 Functional Requirements

10.8.1.1 Four (4) workstations shall be provided. These workstations shall be connected with the Management Centre and shall recover data from the DB in view of providing information on management issues.

10.8.1.2 The Contractor shall furnish and install the Workstations in the places to be indicated during the Detailed Final Design and the installation. Four (4) Workstations concern various sections (such as accounting office, Finance Division, Cash Counting Section, Operations and Technical Works Section) of the Operations Company.

10.8.1.3 Authorized staff from all Sections shall be able to recover data from the databases, namely only those that have been set in the profile featuring the rights of each group of users (e.g. financial, maintenance data, etc.).

10.8.1.4 The following primary facilities shall be as a minimum provided at each workstation to enable:

- Menu-driven displays for software configuration and parameterization.
- Files extraction from the databases using standard relational database queries. These files shall refer to statistical analysis, accounting reports, alarm management, equipment status and so on. The Contractor shall provide his own typicalreports. Additionally, the Contractor shall provide all the necessary tools (report generator) for the Operation Agency to create itsown reports.
- Retrieve data according to file specifications.
- Data sorting requests by relational database queries.
- Updating of databases.
- File editing and generation of graphical presentation.

10.8.2 Technical Requirements

10.8.2.1 Workstations shall consist of a central unit (PC), high-resolution color display with keyboard and mouse. Operating system shall be based on a standard Graphical User Interface according to industry software standard of the latest generation at the time of installation.

10.8.2.2 The minimum technical specifications that must be fulfilled are the following ones:

- Processor: 10thGEN INTEL® COREi9, or equivalent

- RAM Memory:16GB
- Hard Drive: 1TB SSD
- Monitor: >=22", 4K
- Double Power Supply Unit – redundant in case of fault
- DoubleNetwork card – redundant in case of fault

10.9 Data Processing Requirements Specifications

10.9.1 The Sales, Passenger Traffic and Operational statistics shall be presented in report form and, where appropriate, in graphical form. The operator shall be able to extract relevant data and issue all types of statistics by use of a report generator module. Processing of all data concerning validation and sales will be carried out at least once a day.

10.9.2 Sales statistics shall enable the following functions:

- To subdivide sales according to the fare media types (number of selling operations and products) per equipment and station.
- Accounting of collected revenue daily, weekly, monthly, quarterly, and annually per station and station equipment.
- Coin and Note Vaults accounting report for each vault exchange per ATIM on each station, line and total
- Bank transaction reports
- To assess revenue inputs thatshall be processed for revenue apportionment.
- Number of daily, weekly, monthly, quarterly, and annual transactions per each station by fare media and sales terminal.

10.9.3 Detailed validation statistics, are required to be provided such as:

- Entry flows for each reader, for each checking line, for all checking lines per stationand for the entire system. These flows are subdivided according to fare media type.
- Exit flows for each reader, for each checking line, for all checking lines per stationand for the entire system. These flows are subdivided according to fare media type.
- Origin – destination matrix (fare media of all types) for the entire system.

10.9.4 The system shall be able to provide on-line the number of validations in stations and in the extension in total, cumulatively for a repetitive time period (e.g., every 15 minutes), which shall be parameterizable between specific limits (e.g., from 10 minutes to 1 hour).

10.9.5 The traffic statistics reporting shall be based on fare media validations per station and as total.

10.9.6 Time intervals for which traffic statistics are required (minimum every 5 minutes) and the number of time intervals (minimum 288,which correspond to 24 hours of operation per day) shall be programmed dynamically by the Operations Company.

10.9.7 Operational statistics for each terminal equipment and per station, including hours in service, soft faults, hard faults, cumulative transactions, etc. shall also be produced by the system.

10.9.8 Collection of statistics at stations may be made by intervals to be defined by the Operations Company. The maximum number of time intervals for the collection of statistics shall be sized to cover one operating day.

10.9.9 Statistics shall be collected per equipment -apart from stations- at time intervals to be defined in the Contractor's DFD.

10.9.10 At least once a day all fare media transactions shall be analyzed to detect fraudulent fare media use. A complete historical transaction record for each fare media shall be retained by Management Centre for comparison with the current transaction record. Cards detected, as being fraudulently altered shall be blacklisted and the revised blacklists downloaded to the Station Computers for transfer to the fare control gates.

10.9.11 At the fare control gates or any validation equipment, checks on Cards/Tickets/Tickets via mobiles (mobiletickets-when they will be activated) shall be made for:

a) Either entering or exiting more than once at the same station within a set period or without exiting or entering respectively at another station.

b) Detection of one or several persons without passage authorization following an authorized user.

c) Parameters of the applied Fare Policy (zone, time, etc.).

10.9.12 Data processing specifications shall fully comply with the AFC specifications of the TMP. All additional data processing specification of the AFC system of the TMP will be provided during the design phase of the Project.

10.9.13 All available data and processing reports of KMC will be also available to the MC via the appropriate API interface.Through this interface, all the statistical processing of the data of the Kalamaria extension will be able to be carried out through the Workstations of the AFC system of the Basic Project.

10.10 System Interfaces and API Requirements Specifications

10.10.1 All critical AFC system functions and interfaces between TMP and KMP AFC system components will be supported by the API interfaces that will include all API calls, data formats, and communication and security protocols used to support the system interfaces. TheseAPI specifications will be the property of ELLINIKO METRO S.A.and will be provided for use to the Contractor.

10.10.2 The APIs will be HTTPS based functional APIs (e.g., not device- or system-specific), using modern architecture and formatsthat support core system functions and enable access to those functions for any device or system that requires use of them. Devices and systems may make use of more than one API to support required functionality.

10.10.3 Strong security features and industry-accepted best practiceswill be used by APIs to prevent fraudulent.Relevant information will be given to the Contractor by ELLINIKO METRO S.A.during the design phase of the Project.

10.10.4 The following indicative API applications will be delivered by ELLINIKO METRO S.A.to the Contractor (as developed by the Base Project contractor), and he will review and confirm their completeness to achieve the full functionality of the system to be provided:

- Fare Distribution API: supports the sale of fare media and fare products offered through all fare distribution channels
- Fare Payment API: supports the processing fare payments by all fare payment devices
- Fare Inspection API: supports the querying and management of fare media related data (real time and historical)
- Passenger Account Management API: supports the querying and management of fare-related data maintained within closed-loop passenger accounts that will be used by all devices and systems like ATIMs, CITs, Customer Relationship Management, third party systems etc.)
- Customer Account Management API: supports the querying and management of individual and intuitional customer data maintained within the customer database and will be utilized by all devices and systems like CITs, Customer Relationship Management, third party systems etc.)
- Device Management API: support the monitoring and management of all devices deployed within the system, including the back-office equipment.

10.10.5 As the above APIs are not currently received by ELLINIKO METRO S.A., they may have a partially alternative categorization, to that mentioned in par 10.10.4 above, while maintaining the requested functionality and interoperability requirements.

10.10.6 The full scope and programming details of the APIs that will support all the Base Project and extension AFC interface points may require additional APIs than those listed above. These can be identified either by the Contractor or by the contractor of the Base Project, but in any case, the parties involved will cooperate as required through ELLINIKO METRO S.A.to develop the new required API applications and ensure the reliable interoperability of the two systems.

10.11 Security Requirements Specifications

10.11.1 The Contractor shall be responsible for ensuring that the system as delivered is compliant with all applicable PCI standards at the time of Final Acceptance, and with all international, European, and national policies for the handling of Personally Identifiable Information (PII).

10.11.2 All equipment provided by the Contractor that will capture, store, transmit, or process bank card data will be certified as compliant with all applicable PCI standards at the time of Final Acceptance.

10.11.3 Physical and logical access to system components that contain PII and/or financial data will be restricted. Physical and logical security will be sufficient for compliance with the PCI DSS (Payment Card Industry Data Security) standards in effect at the time of Final Acceptance.The application of the Standard creates a safe environment for the processing, storage or transmission of card data, while card transactions are carried out with all security measures, as determined by the banks. The basic requirements of the aforementioned security standards are:

- Installation and maintenance of firewalls
- Non-use of default access and settings
- Credit cards data protection
- Encryption of credit card data during public transfer
- Use and upgrading of antivirus
- Development and maintenance of safe applications
- Restriction in data access
- Use of unique access codes per user for the interconnection implementation systems
- Restricted physical access
- Recording and access control at network level
- Periodic control of the security of the systems
- Adherence to safety and security policy.

10.11.4 The approach to system security will include avoiding the storage of bank card data and PII on field devices and only storing and transmitting such data in an encrypted form.

10.11.5 The connection between all fare collection devices and systems will be over an IP network. Where required, the connections will be secured using Transport Layer Security (TLS 1.3) and strong encryption, such as AES/DES or similar. All data sent via the internet will be TLS-encrypted using the HTTPS protocol.

10.11.6 All payment data will be secured from the point when it is captured to when it is received by the processor. When communications are over public networks, Leased Line or Virtual Private Networks (VPNs) and VLANs shall be used to increase security.

10.11.7 Firewalls will be established around all servers, in addition to the use of other traffic filtering security measures where required.

10.11.8 The Contractor shall be responsible for providing a PCI compliance plan during design review, and for obtaining certification for the entire system. The Contractor shall employ a Qualified Security Assessor (QSA) who has been certified by the PCI Security Standards Council as being qualified to assess compliance to the PCI DSS Standard and shall be responsible for conducting all testing required toachieve certification prior to Final Acceptance.

10.11.9 Through the software of the workstations, the System Administrator shall be able to modify the user rights of the operation personnel. These modifications shall concern:

- Geographical restrictions in accessing the equipment
- Access rights restrictions per type of operation and type of equipment (User, Maintenance staff, etc.)
- Restrictions in the access rights to the DB per type of operation (Financial Data, Maintenance Data).

10.11.10 In addition, the System Administration shall be able to modify the number of the users by adding or removing users and their corresponding codes.

10.11.11 All the user data (user profile, user ID, access codes, etc.) shall be entered in the DB of the Kalamaria Management Centre and only the System Administrators shall be able to modify them.

10.12 Privacy Requirements Specifications

10.12.1 Regarding the protection of passengers' personal data, the international and national regulatory provisions and the provisions of the EU GDPR must be observed.

10.12.2 The Automatic Fee Collection System shall comply with:

- the institutional and regulatory framework applicable to the privacy of communications (Law 4411/2016, Law 4070/2012, Law 3917/2011, Law 3674/2008)
- the institutional and regulatory framework applicable to the protection of personal data (L.2472/1997, L.4070/2012, L.3471/2006, General Data Protection Regulation (EU) 2016/679)

10.12.3 Technical security measures system security and privacy protection should be ensured.

10.12.4 The Contractor will ensure that, to the extent it is responsible for:

- prove his compliance with the above
- to respond to the requests of the authorities/bodies for the personal data that may arise before the start of the commercial operation of the system.

10.13 Communication Requirements Specifications

10.13.1 The Contractor shall be responsible for the complete design, supply, installation and commissioning of the AFC equipment Data Network at station or depot level. The

interconnection of each AFC equipment up to the DTS of the station is on Contractor' s scope.

10.13.2 The Contractor shall use the Digital Transmission System, provided by the contractor for the Telecommunication systems and any additional passive or active equipment at a station/depot level to implement the AFC Data Network. All new station AFC equipment shall be interconnected with the new AFC Management Centre at Pylea depot via AFC Data Network by using the TCP/IP protocol. The Contractor will cooperate with the Telecommunications contractor, the main contractor of the Kalamaria extension as well as the contractor of the Basic Project, as required to ensure the reliability of the AFC data transmission.

10.13.3 Any network traffic related to the communication between the local AFC equipment of all stations shall remain at the local network of the specific station and shall not burden the AFC Data Network in general. Moreover, data transmitted from a station to the Management Centre and vice versa shall not burden the traffic of the local network of other stations.

10.13.4 All physical and logical relevant parameters (Port, IP address, subnet, gateway, VLAN) required for the integration of AFC system in DTS system and implementing the AFC Data Network shall be coordinated with the Contractor of Telecommunication systems.

10.13.5 The Contractor, as an alternative implementation, may use the existing IT infrastructure of the stations or the Pylea depot, provided by other contractors. Any update, upgrade or extension of the existing IT infrastructure required for the AFC Data Network is on Contractor' scope of work.

10.13.6 All data communication networks required for the interconnection of the fare media issuing equipment (ATIM and CIT) with the banking institutions shall use an independent network that will be designed, supplied and implemented by the Contractor. This bank data network shall comply with and be certified according to the latest PCI DDS standards.

10.14 Power Supply Requirements Specifications

10.14.1 The electric power of AFC system at each new station shall be provided by the Telecommunication UPS system, following the design principles of the Kalamaria extension.

10.14.2 The entire station AFC equipment shall be connected through power distributionswitchboards, which the Contractor will install for the AFC system at each station, with provision for a 25% of additional positions for circuit breakers. Each individual distribution network shall have protection against ground fault in accordance with appropriate standards.

10.14.3 If the power and autonomy of the Uninterruptible Power Supply System (UPS) of the Telecommunications systems of the stations of the extension is not sufficient to support the

needs of the AFCsystem, the reserve of 25% of the Telecommunications UPS system will be used. The AFC should be supported by the UPS system for a period of two (2) hours.

10.14.4 The electric power of the new Management Centre of Kalamaria extension at Pylea Depot shall be supplied by a new independent AFC UPS System. As a minimum the following specifications shall be fulfilled from the UPS:

- Modular/Rack mounted type with N+1 redundancy
- On-Line technology for zero switching time and protection for critical loads.
- High output power factor 0,9 or better
- With 25% spare capacity
- With batteries for two (2) hours.

10.15 System Cables Specifications

10.15.1 All cables of the Automatic Fare Collection System must be low smoke emission, halogen free and must have reduced fire spread characteristics.

10.15.2 They shall have enhanced electromagnetic interference protection features.

10.15.3 They will be suitable for installation in underground projects, with very low smoke emissions during their combustion.

10.15.4 The cables must be B2ca-s1a-d0-a1 certified according to the CPR regulation.

10.15.5 They shall be marked with the name of their manufacturer, their type, their length, and their year of manufacture, per meter.

10.15.6 Communication and data cables shall be of the latest technology, at least Category 6A.

10.15.7 They shall be physically separated from the power cables, using different supports or dividers. Their installation will take place within the low voltage cable trays.

10.15.8 The design of cable routing shall take into account deformation and bending radius restrictions. The mechanical properties will be strictly observed. In any case, the cable manufacturer's instructions (regarding bending and forming with or without tensile forces) shall be followed.

10.15.9 The Contractor is responsible for the installation of metal gratings, steel supports, clamps and other elements, where required, for the placement and fixing of the cables. All the above metal parts will be hot dip galvanized.

10.15.10 All cables shall bear clear and legible marking labels for the Project at:

- Each end of the cable
- Every approximately 20 meters
- At every change of direction and space

11 RELIABILITY, AVAILABILITY, MAINAINABILITY & SAFETY (RAMS)REQUIREMENTS

11.1 The Contractor, under the scope of this contract, shall make all the necessary analyses and shall undertake all the necessary tests to prove to ELLINIKO METRO S.A.that the AFC system delivered meet the RAMS requirements of ELLINIKO METRO S.A..

11.2 The Contractor shall document instances where evaluations or analyses indicate an unresolved problem area. The Contractor shall formulate appropriate recommendations as well as maintain records, which show that follow-up action has been taken to resolve the problem.

11.3 The Contractor shall ensure participation of his System Assurance and System Safety Organization in design and implementationphases.

11.4 The Contractor shall develop predictions to judge the adequacy of the proposed design to meet quantitative maintainability requirements and shall identify design features requiring corrective action during early stages of design and development.

11.5 The Contractor may submit existing analyses that are properly documented and verifiable for plant and applications, which are identical or obviously similar.

11.6 The Contractor's safety organization shall comply with the requirements of paragraph 5.3.3 of standard EN 50129.

11.7 The required Technical Availability for the AFC equipment/system shall be at least 98,50%.

$$(Equipment\ or\ System)Technical\ Availability = 1 - \frac{\sum Downtive\ over\ reference\ period}{Total\ reference\ period}$$

11.8 The AFC equipment / system shall achieve as a minimum Reliability R(t) the 99,90%.

$$R(t) = e^{-\frac{t}{MTBF}}$$

- e is the mathematical constant approximately equal to 2.71828
- t is the end time, in hours, that you are interested in
- MTBF is expressed in hours

11.9 If availability or reliability cannot be achieved, the Contractor must notify ELLINIKO METRO S.A..

11.10 The maintainability requirements for each AFC equipment/system shall be as follows:

- No routine inspection work shall be required on any component at more frequent intervals than monthly and no maintenance more frequently than bimonthly, except for maintenance/replacement of filters

- All units or sub-systems requiring inspection, routine replacement or adjustment shall be arranged for easy access in less than 10 minutes without having to remove any unrelated equipment.
- No item of equipment shall require general overhaul at intervals less than five years.
- The system shall be designed, installed and constructed to enhance the ease of maintenance of the system.

11.11 The Contractor shall implement maintainability criteria which shall include the following features:

- The AFC system shall be designed to minimize the amount of maintenance tasks required to ensure that any maintenance work can be easily and quickly carried out.
- The design of electronic circuits and sub-systems shall be Line Replaceable Units (LRU).
- Equipment that has to be disassembled must not weight more than 25 kg if to be handled by one person or more than 50kg if to be handled by two persons.
- Equipment will allow for easy access for maintenance and cleaning purposes but will also not allow for easy access to unauthorized personnel and passengers.
- Self-test facilities by means of built-in-test equipment or circuits shall be provided for start-up and normal operation where applicable.

11.12 The Contractor shall undertake the Reliability and Availability Analyses using verifiable field failure data for identical or similar equipment or calculations to demonstrate achievement of the reliability and availability targets specified in the Contract.

11.13 The Contractor shall produce a FMECA to analyze the high-level failure modes of the AFC system to assess the criticality of the failure consequences

11.14 The Contractor shall submit to ELLINIKO METRO S.A.a complete list of Preventive Maintenance Tasks and periodicities and spares requirements for all equipment supplied under the Contract.

11.15 The Contractor shall define maintainability targets, based on maintainability analysis and indexes like the MTTR and MDT, to demonstrate compliance during the normal operation of the system

11.16 Technical Availability, Reliability and Maintainability targets shall be successfully demonstrated for the following periods:

- 1 week during system trial run (prerequisite for Revenue Service Operation)
- 2 years during the Revenue Service Operation of the system, starting six (6) months after the start of this period

11.17 The Contractor shall demonstrate during the design stages achievement of the portion of risk criteria allocated to each E/M System. These Risk Criteria shall be agreed with ELLINIKO METRO S.A..

11.18 The Contractor shall conduct risk identification exercises, in order to ensure that all relevant risks have been systematically identified. The risks shall be ranked using the risk matrix. All risks shall be classified on the basis of EN 50126 principles at risk index R1 (intolerable) and R2 (undesirable) must be dealt with by the Contractor by design measures and, if necessary, operating or maintenance procedures to reduce the risk index R3 (tolerable) or R4 (negligible) level.

11.19 The Contractor shall propose the risk evaluation and acceptance criteria, which shall be approved by ELLINIKO METRO S.A..

11.20 No general SIL requirements are applicable to AFC system. The emergency AFC gate opening function (in case of fire or emergency), and the involved interfaces with Fire Detection and BACS systems,shall comply in total with the SIL 2 requirement.

11.21 The Safety Integrity Level (SIL) shall be confirmed before the design is finalized, in cooperation with the main contractor of the extension and the contractor of the BACS system.

11.22 The reliable operation of the AFC system will be confirmed during a 2-year trial period(RDT), starting after the first 6 months of operation, through a reliability demonstration program which will be submitted by the Contractor to ELLINIKO METRO S.A.for approval and will be implemented accordingly.

12 DESIGN REQUIREMENTS

12.1 The level of the designs to be prepared by theContractor upon the contract signing shall be the Detailed Final Design – DFD

12.2 The Contractor, as a minimum, shall issue and submit for approval to ELLINIKO METRO S.A. thefollowing technical documentation:

(A) Drawings

- Detailed schematic diagrams for each location (station or OCC), including communication, power supply and grounding information
- Final coordinated drawing showing the layout per level for each station, indicating the locations of the equipment (scales 1:200 or 1:100)
- Final coordinated drawing showing the routing of cables, ensuring the cable compatibility
- Detailed connection diagrams showing the equipment cable connections
- Detailed Data Base schedule for the AFC system along with their interfacing diagrams.
- Detailed equipment construction drawings for all basic AFC equipment
- Typical installation details for gates and ATIMs

(B) Technical Reports/Descriptions/Procedures

- Engineering Documents Register – Document Submission Plan
- Evidence reports for Compliance with Contractual Requirements (Requirements Matrix)
- Hazard Analysis and Mitigation measures
- System Safety Case
- RAM targets and predictions
- Operation description of the AFC system
- Definitionof functional and technical specifications for all equipment
- Power supply, control and communication requirements.
- List of interfaces with other systems
- Finalization of all design parameters, final dimensioning and selection of equipment
- Detailed description of equipment and of the operation of the system, including the entire equipment and software
- Detailed analysis of interfaces with other systems
- Detailed description of functions and interfaces with Thessaloniki Base central system and the Credit Institutes
- Description of system redundancy
- Construction (installation) Methodologies
- Detailed inspection and test plan
- Factory acceptance test procedure and reports
- Test and commissioning procedures and reports
- Detailed API description and specifications
- Detailed manuals of operation for the complete AFC system and each individual equipment
- Detailed manuals of operation and maintenance
- Training plan and manuals
- Spare Parts List with the required calculations

12.3 The design submission and review procedures are as follows:

- Each design shall be submitted in five (5) copies.
- All copies (with the eventual exception of the original – for the Contractor'sconvenience) of the Design Documents, Calculation Notes, Technical Reportsetc. shall be submitted in double-side printouts.

- Each design (drawings and documents) shall be submitted in electronicformat as well (CD or DVD) in two (2) copies in a form to be notified by EM. Theelectronic format of the files shall include both the Word, Excel, Autocad (dwg) and the pdfversions.
- The Field Changes shall be submitted in five (5) copies
- Construction (Installation) Methodologies and Testing Procedures shall be submittedin four (4) copies plus two (2) more additional first pages for stampingapproval.
- The Material Submission Sheets (MSSs) shall be submitted in five (5)copies. The monthly and weekly reports and the Health and Safetyreports, as well as the factory tests results shall be submitted in three(3) copies.

12.4 The designs shall be submitted in due time so that their contractually scheduled final approval may be affected prior to the foreseen -in accordance with the Contractor's approved time schedule of works- commencement of works.

12.5 The review on each submitted design shall be completed within thirty (30) calendar days and shall be transmitted to the Contractor with a Review Code, as they are defined below.

12.6 Within thirty (30) calendar days as of the receipt of a design coded 2 "APPROVED WITH COMMENTS" or 3 "REVISION AND RESUBMISSION", theContractor shall submit the revision of the design to EM.

12.7 The design review codes shall be as follows:

- Code 1 "APPROVED" or "APPROVED AS NOTED":

  The design is approved. The works may be executed if the comments (if any) are incorporated in the "As Built" documents. In case of resubmission is required, the revised design shall be resubmitted.

- Code 2 "APPROVED WITH COMMENTS":

  The design is approved with comments. The design shall be re-submitted for approval in order to be upgraded to code 1. The works can be executed, on condition that the Contractor takes into account the comments and incorporates them into the construction as well as the "As Built" documents.

- Code 3 "REVISION and RESUBMISSION":

  It is not allowed for the works to be executed. The design must be revised and resubmitted, taking into account EM's comments, corrections and notes.

- Code 4 "NO CHECK IS REQUIRED":

  There is no reason for any design review.

12.8 The Contractor shall submit for approval the Design Submittal Plan (DSP) ofthe project within two (2) months upon contract signing. This shall include allDesign Reports, Methodologies, Drawings and all items contained inparagraph 12.2, which shall be prepared during the execution of the Project.

13 INSTALLATION

13.1 The Contractor shall supply all labor, supervision, and materials required for installation of all new equipment and systems delivered in accordance with these specifications.

13.2 AFC equipment shall be installed following the instructions of its manufacturer and shall be fixed so as not to fall over or move due to earthquake, mischief etc., securing operation space and maintenance space.

13.3 The Contractor shall install the power, control, telecommunication cables and earth/grounding conductors required for the operation of the AFC system.

13.4 Cables shall be installed by using the existing cable trays and cable routing infrastructure of the stations. Any additional cable routing infrastructure required for the installation of AFC system will be on Contractor's scope.

13.5 All cables shall be installed so that the influence of noise from the power cable is minimized as much as possible.

13.6 Existing communication infrastructure (DTS, IT infrastructure etc.) may be used by the Contractor in order to support the communication needs of the AFC system, upon ELLINIKO METRO S.A.approval. Any additional communication infrastructure required for the installation of AFC system will be on Contractor's scope.

13.7 Existing power supply infrastructure (Telecom UPS) shall be used by the Contractor for the AFC system, according to the present specifications. Any additional power supply requirements for the AFC system will be on Contractor's scope.

13.8 All space allocation and coordination for the installation of AFC equipment in stations and in OCC will be done with the cooperation of ELLINIKO METRO S.A.andKMP Contractor.

13.9 Any modification works in existing constructions, required for the installation of AFC equipment, will be on Contractor's responsibility. Prerequisite for any such work execution is the approval of ELLINIKO METRO S.A..

14 TESTING AND COMMISSIONING

14.1 The testing and commissioning for the AFC System shall be performed by the Contractor in order to verify the correct function and safety of each part of the specific system as well as for the entire AFC system, emphasizing the integration with the existing AFC system of the Base Project of Thessaloniki Metro and indirectly through the Base Project AFC system, with the central AFC system of the Thessaloniki Public Transport.

14.2 The Contractor shall not offer any individual equipment, module, component, system or sub-system for inspection or factory tests (witnessed by ELLINIKO METRO S.A.), which has not previously been inspected or pre-tested and is known to be operated properly and satisfactory.

14.3 All tests shall demonstrate that the equipment and systems meet with the specified requirements and functionalities. The Contractor shall provide fully detailed inspection and test plan and the test procedures themselves for the AFC system, which shall be submitted to ELLINIKO METRO S.A.for review and approval, prior to the commencement of the subject testing phase.

14.4 The following types of tests shall be executed by the Contractor:

- First Article Inspection Tests (FAI)

  A First Article Inspection (FAI) assesses the quality of the main AFC equipment, including ATIM and gates, before their massive production. The equipment under inspection is examined exhaustively to factors such as measurements and dimensions, equipment, design, and materials, and compare these against the Customer's requirements and Contractor's specifications. Special attention shall be paid to the testing of the securitymeasures of the ATIM and the gate's safety design. If a part fails the FAI, the product will go back to pre-production so that the problems can be addressed. After a successful FAI, the mass production run can commence. The Contractor shall conduct FAI test procedures that shall be reviewed and approved by ELLINIKO METRO S.A.before the testing phase commences.

- Factory Acceptance Tests (FAT)

  The FAT of the AFC System shall be carried out in the manufacturer's premises before the delivery on-site of all AFC equipment. The tests shall demonstrate that AFC system (hardware and software) meet the requirements of the required specifications.

- Stand Alone Tests (SAT)

  After the onsite installation and connections of the AFC equipment, the SAT tests in each location shall be performed. These tests shall verify that all equipment and systems are supplied and installed according to the specifications, the design and the contractual requirements and are ready for SIT testing.

- System Integration Tests (SIT)

  The SIT shall be conducted after the successful execution of the SAT in all locations of integrated systems, including not only the extension to Kalamaria, but also the interfaces with the existing Metro network.

  The SIT tests shall demonstrate that all AFC equipment is correctly interfaced with all related other Metro systems such as BACS, Fire Detection, Power Supply, DLT.

Additionally, it shall be confirmed that the interface with the AFC system of the Base Project and the Bank Institutes works correctly, reliably and securely.

14.5 The Contractor shall demonstrate the correctnessof any API that uses, as part of system implementation and testing. The Contractor shall perform API-specific testing, which will be witnessed by ELLINIKO METRO S.A.and be validated prior to Final Acceptance. Any changes to the APIs because of testing will result in the API specifications update.

14.6 The FAI, FAT, SAT and SIT procedures and test schedules shall be produced and conductedby the Contractor, in close co-operation and co-ordination with any thirdELLINIKO METRO S.A.contractor working on the Project and shall be submitted to ELLINIKO METRO S.A.for review and approval.

14.7 During the execution of the tests, the Contractor shall prepare the relevant reports and shall keep the required records of design, installation and testing, as these may be required, in order to demonstrate that the respective Specifications have been met, that the statutory requirements have been achieved, and that approvalhas been given for the operation of all parts of the system.

14.8 The Contractor shall prepare and forward to ELLINIKO METRO S.A.an original and three (3) copiesof a Test Report within fifteen (15) days upon completion of each test.

14.9 If ELLINIKO METRO S.A.accepts that the tests have been carried out in accordance with the Contract and the approved test procedure, ELLINIKO METRO S.A.'s representative will sign for this part of the test on the appropriate test sheet. Once the relevant signatures of ELLINIKO METRO S.A.are obtained for all parts of the test, then the test is considered successful andthe Contractor shall issue and submit to ELLINIKO METRO S.A.the appropriate test report.

14.10 All Smart Cards, Electronic Paper Tickets and paper for printers required for the testing and commissioning purposes of the system are included in the Contractor' s scope of work. These shall be as specified by TheTA.

15 SPARE PARTS AND CONSUMABLES

15.1 The scope of the Contract includes the following:

a. The supply of warranty period spare parts for corrective maintenance for three (3)years, as of the final acceptance of the overall scope of the contract (including the integration tests and the commissioning of the system).

b. The supply of the Capital spare parts as defined and quantified further down, necessary for the corrective maintenance for a period of three (3)years, starting after the three (3)-year warranty period. These need to be available one month prior tothe completion of the contracting period for delivery.

c. Spare parts forpreventive maintenance for one (1) year from the operation startup, which includes any consumable spare parts. Smart cards, electronic tickets, printers' paper and receipts' paper are not considered as consumables.

15.2 Warranty period spare parts are the spare parts required for repair of defects, faults, poor workmanship and other deficiencies falling under the Contractor's contractual obligations throughout the three-year warranty period of the Project. The Contractor shall be responsible for their availability. Storage facilities at the Pylea depot will be available for their storage.

15.3 Spare parts for preventive maintenance (for one (1) year) are the equipment parts and materials undergoing wear during the normal use of the Project and, therefore, requiring replacement at predetermined time intervals for normal operation of the systems installed and set into operation. These are defined in the Maintenance Manuals of each system and they will be submitted by the Contractor and approved by EM. Electronic Paper Tickets, Smart Cards andATIM and CIT printers' papers are not included in the scope of the Contractor.

15.4 The Contractor shall provide the capital spare parts lists analysisfor each individual equipment. The part list shall contain the hardware analysis of each equipment up to the Lowest Replaceable Units (LRU), the individual block components composing the equipment. The LRU shall be separated in Spare and Consumable parts.

15.5 The Lowest Replaceable Units shall be available for a service lifetime of, at least, fifteen (15) years, after the expiry of the warrantee period of the entire Contract Scope.

15.6 The quantities of the capital spare parts shall be calculated based on the MTBF and MTTR figures, and the specified Reliability, Availability and Maintainability targets for the system and each individual equipment, for a period of three (3) years. All Spare Parts methodology and calculations shall be subject for review and approval from ELLINIKO METRO S.A..

15.7 As a minimum, one (1) piece of each LRU shall be provided as a spare part.

15.8 For all software supplied as part of the works, the Contractor shall supply sufficient maintenance and upgrade services for three (3) years of Revenue service period.

15.9 The Contractor has the obligation to replace with new spares every spare part used during the three (3) years warranty period.

15.10 The Contractor shall include in his list of spare parts, for each material, the manufacturer, the order number and the estimated delivery time.

16 SPECIAL TOOLS AND TEST EQUIPMENT

16.1 The Contractor shall provide a list of all special tools and test equipment necessary for preventive maintenance and fault repair of all equipment of the AFC system.

16.2 The type and quantity of the special tools and test equipment to be supplied shall be sufficient to support the RAM targets and to ensure the efficient operation of the AFC system; moreover, they shall be available one month prior to the completion of the contractual time period for delivery.

16.3 Special equipment for the training of the personnel shall also be provided. An independent systemsimulating the KMC, Station Computer and CIT shall be provided. A set of an ATIM, a gate and a separate CSC/e-ticket wireless reader for test purposes shall also be provided.

16.4 Portable diagnostic devices for testing all ATIM functionalities and equipment, on site, will be provided. The required quantity of the portable devices (laptop or tablet or equivalent) is three (3) pieces.

16.5 The list of special tools and test equipment shall contain the following:

- A serial number for the purpose of identification.
- A detailed description of the special tools / test equipment and related documentation.
- The recommended quantity.

16.6 The list of special tools and test equipment shall be subject to review and approval by ELLINIKO METRO S.A., which shall be the consignee of all delivered spare parts.

17 TRAINING

17.1 The 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 extension to Kalamaria and the continuous efficient operation of the Metro network.

17.2 The scope of the training shall include, not restrictively, the training of the ELLINIKO METRO S.A.Engineers and maintenance and operations staff of the Thessaloniki Metro Operation entity / company to ensure full familiarity with the design, maintenance, operation and the methods / principles to develop skills for future modifications / upgrading and extensions of the systems (in OCC, ECR and peripheral stations).

17.3 The Contractor will provide the training both at the available training facilities at the Pylea Depot, and on site, upon agreement with EM and the Operation Authority/Company.

17.4 The Contractor shall submit a detailed description of the courses that will be reviewed and approved by ELLINIKO METRO S.A.. The number of the training teemsfor each series of educational lessons shall be agreed with ELLINIKO METRO S.A..

17.5 The Contractor shall also supply operational and maintenance manualsthatshall be approved by ELLINIKO METRO S.A.. The training documentation shall be based on use of

the approved by EM Operation and Maintenance Manuals and other required information of the AFC system ofthe extension.

17.6 Prior to the courses the Contractor shall submit a training schedule for EM's review and approval. The training courses shall include classroom lectures with site visits and instructions to demonstrate and explain the equipment and systems as well as training with the software packages. All the training schedules and manuals, for each separate course, shall be reviewed and approved by ELLINIKO METRO S.A.at least one(1) month before the training commences.Upon completion of the training, the trainers shall assess each trainee's understanding and competence to perform the operations and maintenance activities for which the training has been provided.

18 WARRANTY PERIOD

18.1 The warranty period in which the Contractor is contractually liable for the proper operation of the AFC system is set to three (3) years as of the final acceptance of the overall scope of the contract (including the integration tests and the commissioning of the system).

18.2 During the warranty period, the Contractor's obligations are as follows:

- Repair, reconstruction, rectification of defects, poor workmanship, faults, constructional deficiencies or other deficiencies that may occur in the Project.
- Supply of the spare parts, materials, equipment and the works that are required for the correction of the defects and poor workmanship ensuring sound operation of the system during the warranty period.
- Six-month extension of the Good Operation Guarantee, starting from the date when the warranty period is expired,for the spare parts, materials and equipment of the systems or parts of the Project that have either been replaced or repaired during the warranty period.
- Ensuring the immediate availability of the spare parts and materials required for the project's maintenance during the warranty period. In case where the Contract's spare parts stock during the warranty period in used, all used spares shall be replace with brand new ones.
- During the first year of the warrantee period, the Contractor is obliged to provide preventive maintenance activitiesto the AFC system.
- ELLINIKO METRO S.A.and the Contractor shall inspect the Project during the warranty period at regular time intervals that would not exceed three (3) months. ELLINIKO METRO S.A.may call the Contractor to perform an extraordinary inspection at any other time.

18.3 The procedure of defects rectification and fault repairs, as well as the other cases mentioned before, occurring during the entire warranty period is as follows:

- ELLINIKO METRO S.A.shall be issuing a failure report, accompanied by a work order concerning the repair of the involved fault/defect, where the details of the fault-defect shall be stated along with a detailed description of the problem, the place, the time, the Operation Agency assessment as to the cause of the fault/defect and the corrective actions required. ELLINIKO METRO S.A.and the Operation Agency shall sign the failure report.
- The Contractor, upon receipt of the work order, which in extraordinary cases can be also given via telephone by ELLINIKO METRO S.A.or the Operation Agency, shall proceed immediately to the necessary actions and works for the repair of the fault, the provision of the required spare parts-materials and maintenance personnel etc.

19 INTERFACES

19.1 The Contractor shall define, detailed describe and efficiently handle all AFC system interfaces with the Base Project(TMP)and the extension to Kalamaria (KMP).

19.2 Interface between the TMP AFC Management Center and the new Kalamaria extension Management Centre shall be foreseen and implemented. Via the appropriate APIs, (currently under development for the Base Project AFC system) a fully functional integration of KMC to the TMP AFC Management centersshall be achieved. Interface API requirements shall meet modern and proven in use interoperability international standards.

19.3 Interface for the connection of the EMV modules responsible for the bank payments of ATIMs, the POS payment devices of the CIT and the entrance/exit gates with the existing portal bank payment GATEWAY of the TMP to ensure secure bank transactions shall be foreseen and implemented. This connection shall be fully compatible and certified as per the latest edition of the PCI DSS in force during installation.

19.4 Interface with BACS system (of the BACS system contractor) to control and monitor the emergency opening of the AFC gates. The BACS system shall be able to:

- Control the AFC gates of a station to open in a case of emergency
- Switch off the AFC power of AFC gates of a station in a case of emergency
- Monitor the open/close status of AFC gates

19.5 Interface with Fire Detection system (of the KMP main contractor) to control the emergency opening of the AFC gates of a station.

19.6 All interface details and technical solutions shall be coordinated, via ELLINIKO METRO S.A., with any third involved Contractor providing BACS, Fire Detection System, AFC or any other metro system.

20 USED STANDARDS

20.1 The AFC system shall be designed to use open architecture and shall adhere to proven in use and modern standard protocols so as to allow third party interoperability. This requirement is essential for allowing future expansion of the AFC system as required to serve new metro stations.

20.2 The AFC system shall conform to all applicable national and international codes and regulations. In the framework of the AFC system's design, supply and installation, the Contractor/Supplier shall take into account,but not limited to (all modern and proven in use standards shall be considered), at least the following standards and all their most recent editions:

- ISO 9001:2015-Quality Management System
- ISO 8583 (all parts), Financial transaction card originated messages — Interchange message specifications
- ISO/IEC 14443 (all parts), Cards and security devices for personal identification — Contactless proximity objects
- ISO/IEC 18092, Information technology — Telecommunications and information exchange between systems
- ISO/IEC 18092 / ECMA-340, Near Field Communication Interface and Protocol-1
- ISO/IEC 21481 / ECMA-352, Near Field Communication Interface and Protocol-2
- ISO 27001:2022, Information security, cybersecurity and privacy protection — Information security management systems — Requirements
- ISO/IEC 27002:2022 Information security, cybersecurity and privacy protection — Information security controls
- ISO/TR 19639, Electronic fee collection — Investigation of EFC standards for common payment schemes for multi-modal transport services
- ISO 24014-1, Public transport — Interoperable fare management system — Part 1: Architecture
- ISO/IEC 7810, Identification Cards – Physical Characteristics
- ISO/IEC 10373-2, Identification cards-Test Methods—Part 2: Cards with Magnetic stripes
- ISO/IEC 8583 – Financial transaction card originated messages
- IEC 61000-4-6 (EN61000-4-6) pertaining to conducted susceptibility
- IEC 61000-4-3 (EN61000-4-3) pertaining to radiated susceptibility
- IEC 61000-4-2 (EN 61000-4-2) pertaining to electrostatic discharge

- Payment Card Industry Security Standardsby Security Standards Council (PCI-SSC) including:
    - PCI Card Production – Physical
    - PCI Card Production – Logical
    - PCI Token Service Provider (TSP)
    - PCI Data Security Standard
    - PCI PIN Transaction Security Point of Interaction (PTS POI)
    - PCI Payment Application Data Security Standard (PA DSS)
    - PCI Hardware Security Module (HSM)
    - PCI Point-to-Point Encryption (P2PE)
    - PCI 3D Secure Software Development Kit (3DS SDK)
    - PCI Software-based PIN Entry on COTS (SpoC)
    - PCI Secure Software Standard (SSS)
    - PCI Secure Software Lifecycle (Secure SLC)
    - PCI Contactless Payments on COTS (CpoC)
    - PCI 3-D Secure (3DS) Core
- EN55024, Immunity standards for CE marking
- EN 300 330 V2.1.1: Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz.
- EN 50561-1:2013: Power line communication apparatus used in low-voltage installations - Radio disturbance characteristics - Limits and methods of measurement - Part 1: Apparatus for in-home use.
- FCC Part 15 Class B – Radio Frequency Devices
- FIPS 140-3- Security Requirements for Cryptographic Modules
- IEEE 802.11 b/g/n standard for wireless data communications
- IEEE 802.11i standard for wireless data network security
- International Electro-technical Commission Standard 529 (IEC529)
- EN 50159 (Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems)
- EN 50173 Information technology – Generic cabling systems – General requirements)
- Standards Series IEEE 802.3xx for Ethernet networks (interface cards compatibility)

- IEEE 802.1w Rapid Reconfiguration of Spanning Tree
- IEEE 802.1Q VLAN trunking and Tagging
- IEEE 802.1x Port Based Access Control
- IEEE 802.3ad Link aggregation
- RIP Routing Information Protocol
- RFC 791 Internet Protocol(IP)
- IEC 60331 Tests for electric cables under fire conditions – Circuit integrity
- IEC 60332 Flame Propagation Tests on electric and optical fiber cables under fire conditions
- IEC 60754 Test on gases evolved during combustion of materials from cables

20.3 Additionally, to the above, the offered system should comply with:

- The statutory and regulatory framework applicable to the privacy of communications: Greek Laws N.4411/2016, N.4070/2012, N.3917/2011, N.3674/2008
- The statutory and regulatory framework applicable to the protection of personal data: Greek Laws N.2472/1997, N.3471/2006, The General Data Protection Regulation (GDPR) (EU) 2016/679
- The best practices in the field of Information Security Management Systems

21 EQUIPMENT QUANTITIES

21.1 The number of the ATIMs to be installed per station in view of serving the ridership demands is calculated on the basis of the foreseen ridership, the specified performance characteristics of the ATIMs and their foreseen use based on the technologies they support and the available installation space, as this has been foreseen by the civil works contractor. The number of ATIMs that will be installed per station shall allow for the 50% of the peak minute flow of the maximum number of passengers entering the station to purchase tickets. Peak minute flow has been taken as the 2.5% of peak hour flow. Each ATIM is assumed to serve up to 3 passengers per minute, but available space provisions and other factors have also been considered in order to estimate the number of ATIMs per station. There shall be a minimum of two ATIMs per station. Gate dimensioning and layouts are shown in the architectural drawings of stations.The Contractor shall ensurethat the offered ATIMs are compliant with the above.

21.2 Depending on the architecture design of each station, more than one ticket validation lines, separating “unpaid” and “paid” areas may exist. At each ticket validation line entry/exit gates shall be installed. The gate processing speed in conjunction with the number of gates

accommodated and line layout shall eliminate or minimize queuing of passengers. At least one PSN gate shall be installed in each ticket validation line.

21.3 The number of the gates to be installed per station meets the needs of the number of passenger based on the foreseen ridership, the performance requirements of the gates, the geometry of each station, the train headways, the anticipated queuing and the queues safe distance from the escalators as well as the safe passenger evacuation in case of emergency and the provisions for the future passenger ridership. Peak minute flow has been taken as the 2.5% of peak hour flow, the safe queuing distance between gates and escalators is taken as 12 m assuming 0.5 m per person along the queue, the rate of flow of passengers through the operating gates is considered 25persons/minute during normal operation, while gates open fully during emergency operation allowing 50 persons per minute for normal gates and 80 persons per minute for the wider PSN gates, to pass through. The resulting contractual dimensioning is shown on the contractual, architectural drawings of the stations.The Contractor shall ensure that the offered gates are compliant with the above.

21.4 The used term “gate” is used to describe the complete equipment required to form each passenger passage and includes both side devices required for its implementation.

21.5 The quantities of the main AFC equipment including ATIMs, Gates and the auxiliary equipment, as per the above, are given in APPENDIX 1.

APPENDIX 1

TABLE 1

ΑΝΑΜΕΝΟΜΕΝΗΕΠΙΒΑΤΙΚΗΚΙΝΗΣΗ, ΕΚΔΟΤΙΚΑΜΗΧΑΝΗΜΑΤΑ&ΠΥΛΕΣΑΥΤΟΜΑΤΟΥΣΥΣΤΗΜΑΤΟΣΣΥΛΛΟΓΗΣΚΟΜΙΣΤΡΟΥ
EXPECTEDRIDERSHIP, ATIMs&GATESOFAUTOMATICFARECOLLECTIONSYSTEM

A/A Num.	Τοποθεσία Location	*Επιβιβαζόμενοι* *Embarked passengers (1)*			*Αποβιβαζόμενοι* *Disembarked passengers (1)*			*Επιβιβαζόμενοι& Αποβιβαζόμενοι* *Embarked & Disembarked*	ΑριθμόςΕισόδωνΕξόδων No of Entrances Exits	AMEE ATIM	Πύλες AFC AFC Gates		
		Τροχιά 1 Track 1	Τροχιά 2 Track 2	Σύνολα Totals	Τροχιά 1 Track 1	Τροχιά 2 Track 2	Σύνολα Totals	Σύνολο Total			Κανονικές Normal	AMEA PSN	Έκτακτης Ανάγκης Emergency
1	Νομαρχία Nomarchia	0	1417	1429	487	42	529	1958	2	6	4	2	2
2	Καλαμαριά Kalamaria	8	1280	1288	465	17	482	1770	2	6	4	2	2
3	Αρετσού Aretsou	4	1523	1527	426	9	435	1962	2	6	4	2	2
4	Νέα ΚρήνηNeaKrini	0	715	715	78	0	78	793	2	5	4	2	2
5	Μίκρας Mikras	0	368	368	167	0	167	535	3	5	7	6	0
								ΣυνολικέςΠοσότητες: Total Quantities:		28	23	14	8

TABLE 2

ΕΞΟΠΛΙΣΜΟΣ ΑΥΤΟΜΑΤΟΥ ΣΥΣΤΗΜΑΤΟΣ ΣΥΛΛΟΓΗΣ ΚΟΜΙΣΤΡΟΥ AUTOMATICFARECOLLECTIONSYSTEMEQUIPMENT

A/A Num.	Τοποθεσία Location	Τερματικά Έκδοσης Καρτών Card Issuing Terminals	Η/Υ AFC Σταθμού Station AFC PC	Τηλεφωνικές Συσκευές Επιβατών Passenger Telephone Devices	Ηλεκτρικός Πίνακας Διανομής AFC AFC Electrical Distribution Panel	Ερμάριο Επικοινωνιών AFC Σταθμού Station Communication Equipment Cabinet	Εξοπλισμός Κέντρου Διαχείρισης Συστήματος AFC (περιλαμβανομένου UPS) AFC System's Management Center Equipment (UPS included)	Σταθμός Εργασίας AFC Κτιρίου Διοίκησης Πυλαίας AFC Workstation Administratio Building Pylaia	Εξοπλισμός Εκπαίδευσης (Τμήματα Πύλών& ATIM περιλαμβάνονται) Training Equipment (Gates & ATIM parts are included)	Φορητές Συσκευές Ανάγνωσης Εισιτηρίων/ Καρτών Portable Ticket / Card Readers	AFC Κομβία Ανάγκης στο SMR AFC Emergency Buttons in SMR	ΛογισμικόΚέντρουΔιαχείρισης &Σταθμών Management Center & Station Software	Καλώδια (Ισχύος. Δικτύου, Ελέγχου) Σετ Cables (Power, Network, Control) Set
1	Νομαρχία Nomarchia	1	1	2	1	1	0	0	0	0	1	1	1
2	Καλαμαριά Kalamaria	1	1	2	1	1	0	0	0	0	1	1	1
3	Αρετσού Aretsou	1	1	2	1	1	0	0	0	0	1	1	1
4	Νέα ΚρήνηNea Krini	1	1	2	1	1	0	0	0	0	1	1	1
5	Μίκρας Mikras	1	1	4	1	1	0	0	0	0	1	1	1
6	Αμαξ/σιο Πυλαίας Pylaia Depot	0	0	0	1	0	1	4	1	6	0	1	1

Συνολικές Ποσότητες: Total Quantities:	5	5	12	6	5	1	4	1	6	5	6	6

APPENDIX 2: Fare Policy / Products

There will be a Single Urban Area except the Suburban Area. Ticket prices are indicative.

A. Electronic tickets

Num.	Product	Type	Fare Media	Category		Zone		Basic Product Fare *(Cummulative price)*		
			E-ticket	Normal	Reduced	Urban	Urban+Rural	Urban	+Zone I	+Zones I+II
1	**70-minutes ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	1,00 €	1,00 €	1,00 €
2	**5 tickets pack** *(Airport not included)*	Count-Based	X	X	X	X	X	TBD	TBD	TBD
3	**10 tickets pack + 1 Bonus** *(Airport not included)*	Count-Based	X	X	X	X	X	TBD	TBD	TBD
4	**Airport ticket (Bus-Metro)**	Single Fare	X	X	X	NA	NA	2,00 €	NA	NA
5	**24 hour ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	3,00 €	3,00 €	3,00 €
6	**24 hours ticket** *(Airport included)*	Single Fare	X	X	X	X	X	5,00 €	5,00 €	5,00 €
7	**3 Days Tourist ticket** *(1 trip to and 1 trip from Airport are included)*	Single Fare	X	X		NA	NA	12,00 €	NA	NA
8	**5 Days ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	TBD	TBD	TBD

A) Smart Cards – Non Personalized

Num.	Product	Type	Fare Media	Category		Zone		Basic Product Fare *(Cummulative price)*		
			Smart Card Non-Personalized	Normal	Reduced	Urban	Urban+Rural	Urban	+Zone I	+Zones I+II
1	**70-minutes ticket** *(Airport not included)*	Single Fare	X	X		X	X	1,00 €	1,00 €	1,00 €
2	**5 tickets pack** *(Airport not included)*	Count-Based	X	X		X	X	TBD	TBD	TBD
3	**10 tickets pack + 1 Bonus** *(Airport not included)*	Count-Based	X	X		X	X	TBD	TBD	TBD
4	**Airport ticket (Bus-Metro)**	Single Fare	X	X		NA	NA	2,00 €	NA	NA
5	**24 hour ticket** *(Airport not included)*	Single Fare	X	X		X	X	3,00 €	3,00 €	3,00 €
6	**24 hours ticket** *(Airport included)*	Single Fare	X	X		X	X	5,00 €	5,00 €	5,00 €
7	**3 Days Tourist ticket** *(1 trip to and 1 trip from Airport are included)*	Single Fare	X	X		NA	NA	12,00 €	NA	NA
8	**5 Days ticket** *(Airport not included)*	Single Fare	X	X		X	X	TBD	TBD	TBD

B. Smart Cards – Personalized

Num.	Product	Type	Fare Media	Category		Zone		Basic Product Fare *(Cummulative price)*		
			Smart Card Personalized	Normal	Reduced	Urban	Urban+Rural	Urban	+Zone I	+Zones I+II
1	**70-minutes ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	1,00 €	1,00 €	1,00 €
2	**5 tickets pack** *(Airport not included)*	Count-Based	X	X	X	X	X	TBD	TBD	TBD
3	**10 tickets pack + 1 Bonus** *(Airport not included)*	Count-Based	X	X	X	X	X	TBD	TBD	TBD
4	**Airport ticket (Bus-Metro)**	Single Fare	X	X	X	NA	NA	2,00 €	NA	NA
5	**24 hour ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	3,00 €	3,00 €	3,00 €
6	**24 hours ticket** *(Airport included)*	Single Fare	X	X	X	X	X	5,00 €	5,00 €	5,00 €
7	**3 Days Tourist ticket** *(1 trip to and 1 trip from Airport are included)*	Single Fare	X	X		NA	NA	12,00 €	NA	NA
8	**5 Days ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	TBD	TBD	TBD
9	**Monthly ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	30,00 €	30,00 €	30,00 €
10	**3-Months ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	80,00 €	80,00 €	80,00 €
11	**6-Months ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	150,00 €	150,00 €	150,00 €
12	**Annual ticket** *(Airport not included)*	Single Fare	X	X	X	X	X	280,00 €	280,00 €	280,00 €

D) Passenger Categories and Discounts

Price of Ticket = Basic Ticket Price x (1 – Discount)

Num.	Passenger Category	Discount
1	MEMBERS OF THE NATIONAL OR EUROPEAN PARLIAMENT	100%
2	POLICEMEN & MEMBERS OF THE POLICE ACADEMY, SPECIAL GUARDS, BORDER POLICE, PERSONNEL OF THE MINISTRY OF PUBLIC ORDER AND CITIZEN PROTECTION	100%
3	FIREMEN & MEMBERS OF THE FIRE BRIGADE ACADEMY	100%
4	HELLENIC COAST GUARD PERSONNEL & TRAINEES	100%
5	MILITARY	100%
6	DISABLED	100%
7	CHILDREN AGED UNDER 6	100%
8	CUSTODIANS OF FOUR OR MORE CHILDREN	50%
9	PUPILS	50%
10	PASSENGERS AGED UNDER 12	50%
11	PASSENGERS AGED UNDER 18	50%
12	PASSENGERS AGED ABOVE 65	50%
13	STUDENTS	50%
14	NORMAL PASSENGERS	0%

Remark: Apart from the above types of tickets, during the Detailed Final Design phase there may be changes to the fare products that must also be taken into consideration by the Contractor for the design, development and implementation of the AFC system.