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1. GENERAL FRAMEWORK OF THE PROJECT

1.1 New AFCS - OASA

The Athens Urban Transport Organization (OASA) is currently running a PPP Contract for a project that embodies the design, funding, installation, testing, operation, operation support, maintenance and technical management of a Unified Automatic Fare Collection System (AFCS) which will cover all transport modes of Athens (buses, trolley buses, tramway, Metro Lines 1, 2 and 3 and suburban railway). The system's key feature is the electronic ticket, which will give a decisive push to the public transport system, shall minimize ticket evasion and shall offer a substantial assistance to all transport studies and activities by providing a detailed record of passenger trips.

In particular, OASA's Contractor – Private Sector Partner (PSP), has undertaken the following tasks:

- Design, installation, ensuring the full / uninterrupted operation and technical management of the system
- Preparation of the necessary designs for the installation of the new equipment needed for the smooth operation of the system and the integration of the existing infrastructure into the new complete AFC System.
- Ensuring the correct and reliable operation of the new equipment, at specific availability rates
- Maintenance of the system and its components
- System and equipment customization in view of implementing the applicable fare types and the policies related to fare pricing, control and distribution, as decided by OASA.
- Technical support of the system, which shall address the periodical system upgrades, as well as the staffing of the system control centers throughout the contract duration
- Personnel training on system operation
- Procurement / printing of the initial quantity of the electronic "card", as well as initial procurement of the "Multiple" ticket, either pre-loaded or not
- Insurance coverage for the equipment and other installations and systems comprising the AFC System and forming the PPP Contract scope, covering the project both during its design and construction stage, as well as during its operation maintenance period.

More specifically, for each station on the Metro Lines 2 and 3 the Contractor – Private Sector Partner (PSP) shall install:

- Access control Gates
- Station Management Center (SMC)

- In parallel, the existing ticket issuing machines shall be upgraded so as to accept smart cards – electronic tickets.

1.2 E/M Metro Systems interoperability with OASA's AFCS

In this framework and in order to ensure interoperability among:

- the new systems of the AFCS (mainly the access control gates)
- the local (in stations) and central (in the OCC) gate control systems
- the already installed (earlier contracts) in the stations E/M systems for fire detection, Building Control & Automation Systems (BACS), direct telephones (DLT), data transmission (OTN), cameras (CCTV), clocks and power supply system

the aforementioned existing and operating E/M systems in the stations along Lines 2 and 3 must be amended and upgraded, with the view of finally achieving the smooth and safe operation of OASA's AFCS, ensuring primarily the safety of the passengers both during normal operating conditions, as well as in emergency conditions which will likely call for passenger evacuation.

The above interfaces shall me implemented as follow:

Specifically :

- The fire detection systems must be interfaced with the new AFCS, so that - in case a fire is detected – the gates will open automatically in order to facilitate passenger evacuation procedures. It is stressed that the Metro network is served by five distinct providers / installers of fire detection systems, each one being responsible for a distinct geographical area of the Lines 2 & 3 network; even though the general architecture and operational requirements are similar, a different technical approach is generally required in terms of DFD, required new equipment and implementation, as well as different software for each case. Certainly, any amendments to existing E/M systems shall be carried out in a manner not affecting their current functions and capabilities. Among the amendments to the fire detection system will be the interfacing between the fire detection systems with the stations BACS. The scope of the amendment to the fire detection systems also includes the relevant preliminary safety assessment on a design level, so as to ensure that the combined AFCS, Fire Detection and BACS systems achieve the required SIL levels.

- The BACS systems must be interfaced with the new AFCS, so that in case of an emergency (e.g. activation of fire scenarios) the gates will open automatically in order to facilitate passenger evacuation procedures. It is stressed that the Metro network is served by two distinct providers / installers of the BACS systems, each one being responsible for a distinct geographical area of the Lines 2 & 3 network, namely one for the Base Project (Sepolia – Dafni on Line 2 and Ethniki Amyna on Line 3) and one for all other extensions. Even though the general architecture and operational requirements are similar, a different technical approach is generally required in terms of DFD for the required new equipment and implementation, as well as different software for each case. Certainly, any amendments to existing E/M systems shall be carried out in a manner not affecting their current functions and capabilities. Among the amendments will be the interfacing between the BACS and the respective fire detection systems in the stations. The scope of the amendments to the BACS systems also includes the relevant preliminary safety assessment on a design level, so as to ensure that the combined AFCS, Fire Detection and BACS systems achieve the required Safety Integrity Levels (SIL)

- The direct telephone system is mainly required for the normal operation of the stations and is related to the option that must be provided to the passengers to directly communicate with the personnel of each station at the gate control line area, whenever the passengers are unable to pass through the gates to either enter or exit the station (faulty electronic tickets or cards, inability to exit from the gates etc.). One DLT shall also be installed near the Fireman Box in each station.

- The data transmission system (OTN) is required in order to serve the great number of new telephones to be installed in the stations and their connection to the OCC, but also for data transmission purposes as required by the amended BACS system in the 19 Base Project Stations.

  This system shall be amended – upgraded by means of this contract and shall require new equipment in all stations and the OCC, as well as upgrading of the existing software.

- The cameras – CCTV system is mainly required in order to provide the capability for automatic activation of the surveillance cameras at the control line area of the new access gates in each station and, thus, to provide the capability to the Station Master and the OCC for immediate surveillance on the line, in case one or more gates fail.

- The Clock system must be connected to the AFCS system so as the new AFCS system is synchronized with the existing E/M systems in each station, in order to provide a more precise recording of the time of all events and functions, especially in case of failures or incidents that require special addressing and/or subsequent investigation.

- The power supply system must be expanded/amended so as to feed the new AFCS system without affecting the operation of the existing E/M systems. These amendments shall be carried out by the PSP – OASA's existing Contractor.

Before any works are executed, the required interfaces, the methodology for their implementation, the new software and all relevant tasks must be designed at a DFD level, in cooperation with the original suppliers of the operating E/M systems.

All the above works shall require the cooperation with the PSP Contractor of OASA (TERNA – LG), at a technical and operation level, as well as with STASY S.A., because the systems to be amended must not loose their functionality at any given time period other than the night time engineering hours, after a detailed planning in terms of time and technical matters.

The amendments to the above E/M systems and to their connections with the AFCS system will be followed by individual and combined tests, which will demonstrate that the original function of each E/M system has not been altered, but also that the new operational requirements are met after each system is connected with the AFCS.

Finally, in parallel to the above activities and until their completion, an overall and independent safety assessment shall be required (by a specialized independent safety assessor) for the entire combined AFC system – E/M systems for:

- The layout of the gates in the stations and their operation both during normal and emergency conditions;
- The safety and compliance with the required SIL levels as regards the connections and the combined operation of the AFCS with the E/M systems of the stations.

2. SCOPE OF THE PROJECT

2.1 Purpose

The scope of this Project is the amendment – expansion and upgrading of the data transmission (OTN) system in 36 underground Metro stations currently in service, so as:

- to cover the requirements for data transmission among the stations and the OCC related to the installation of 122 additional DLT telephone sets on either side of the gate control line and at the Fireman's Box (FB) in each station.
- to provide a data transmission communication channel between the stations and the OCC for the BACS system in the 19 stations of the Base Project (Sepolia – Dafni on Line 2 and Ethniki Amyna – Monastiraki on Line 3).

The new DLT telephone sets as well as any eventual new equipment for the BACS system in the 19 stations of the Base Project shall be installed by independent Contractors.

More specifically, the scope of the Project shall incorporate the design, the supply of the new required interface and data transmission equipment (power supply units, PCBs, nodes, cabling etc.), the software and its required amendments and upgrading at a local and central (OCC) level, testing and commissioning of the amended and upgraded OTN system.

The new Direct Line Telephone sets near the gates shall be used by the passengers, enabling them to communicate with the Station Master or the OCC.

The 122 new required DLT sets are allocated as per the following tables.

LINE 2			
No.	**STATION**	**CONTROL LINES**	**TELEPHONE SETS**
1	ANTHOUPOLI	2	5
2	PERISTERI	1	3
3	AG. ANTONIOS	1	3
4	SEPOLIA	1	3

5	ATTIKI	1	3
6	LARISSA	1	3
7	METAXOURGIO	1	3
8	OMONIA	3	7
9	PANEPISTIMIO	2	5
10	SYNTAGMA	1	3
11	ACROPOLI	1	3
12	SYNGROU - FIX	1	3
13	NEOS KOSMOS	1	3
14	AG. IOANNIS	1	3
15	DAFNI	1	3
16	AG. DIMITRIOS	2	5
17	ILIOUPOLI	1	3
18	ALIMOS	1	3
19	ARGYROUPOLI	1	3
20	ELLINIKO	1	3
	TOTAL	**25**	**70**

L I N E 3			
No.	**STATION**	**CONTROL LINES**	**TELEPHONE SETS**
1	DOUK PLAKENTIAS	1	3
2	HALANDRI	1	3
3	AG. PARASKEVI	1	3
4	NOMISMATOKOPIO	1	3
5	HOLARGOS	2	5
6	ETHNIKI AMYNA	1	3
7	KATEHAKI	1	3
8	PANORMOU	1	3
9	AMBELOKIPI	1	3
10	MEGARO MOUSIKIS	1	3
11	EVAGGELISMOS	1	3
12	SYNTAGMA		
13	MONASTIRAKI	2	5

14	KERAMIKOS	1	3
15	ELEONAS	1	3
16	EGALEO	1	3
17	AG. MARINA	1	3
	TOTAL	**18**	**52**

The Contractor of OASA (TERNA-LG) shall supply and install the DLT sets and their wiring to the MDF panel in Telecommunications room (3.4 t) of each station for the sets to be installed on both sides of the control gates in each station. This concerns 86 out of 122 totally. The telephone sets to be installed near the FBs in each station (36 out of 122 sets), as well as the overall upgrading of the local and central DLT system by means of additional equipment or software for the entire number of the new DLT sets, shall be provided by an independent Contractor. The amendments and upgrading to the BACS system in the stations shall also be implemented by a separate Contractor. The OTN system shall be interfaced and shall serve all three of the above sub-systems (2 DLTs and one BACS) for data transmission purposes.

2.2 Designs

The Contractor shall be responsible for the Detailed Final Designs dealing with all necessary upgrades, amendments and additions to the equipment, new interfaces, software amendments or new software, as required, new materials, new cable routing, installation procedures, test and commissioning procedures. The requirements set forth in this specification must be viewed as the minimum requirements.

In order to prepare the above designs, the Contractor's immediate cooperation with the following agents must be ensured:

- OASA's Contractor (TERNA – LG) who installs the access gates and the AFC system;
- The Operations Company STASY S.A., because the existing operating OTN system may need to be amended in time windows to be specified by STASY S.A. without loosing the functionality of the original system during the Metro service hours;
- An independent Contractor who shall amend, supplement and upgrade both locally and centrally the BACS on the section of Lines 2 & 3 which concerns the 19 stations of the Base Project;

This cooperation shall be achieved through AM and OASA as required.

The designs shall incorporate the adopted standards, design reports, operational analysis of the amended system, calculations, single/multi line diagrams, connection diagrams, plan views of cable routing in each station (at a grid to be provided by AM),

MSSs for each piece of material and equipment to be incorporated in the Project, installation and testing procedures and methodologies, FAT, SAT and SIT testing procedures, as well as all other items required at a design level for the Project's implementation.

All the above items shall be submitted to AM for approval. All employed symbols, abbreviations and code names shall be described in the drawings. The designs shall be precise, concise, easily understood, with sufficient information to provide a full understanding of the functionalities and the characteristics of the new combined system.

After the construction and successful testing of this system, the "As Built" drawings shall be submitted.

The design approval codes are the following:

Code 1 : "APPROVED" or "APPROVED AS NOTED":
The design is approved, the works can be executed. In case the submittal receives comments of minor importance, AM can approve it with Code 1 – "Approved as noted" without the need for resubmission, but these comments shall be incorporated in the "As Built" drawings.

Code 2 : "REVISE AND RESUBMIT":
Works cannot be executed. The design shall be revised and resubmitted incorporating the comments, corrections and remarks of AM.

Code 3: "REVIEW NOT NECESSARY":
Review of the submittal is not necessary.

Each design shall be submitted in three (3) copies and in a digital form (CD or DVD) in two (2) copies.

Once the designs are approved, any design changes shall be submitted for approval and, after approval by AM, they shall be incorporated in the "As built" drawings.

3. EXISTING OTN SYSTEM INSTALLED IN THE METRO NETWORK

A Digital Data Transmission System OTN – Open Transmission Network has been installed on Lines 2 & 3 of the Metro network; the supplier was OTN Systems (former SIEMENS – ATEA); in other words, all stations, selected ventilation shafts, depots and the Operation Control Center (OCC) have been equipped with OTN nodes (racks 19'', mountable node chassis 38 HU).

The fiber optics transmission system of all Athens Metro stations and depots is available for voice, data, image transmission and LAN (local networks for p/c

connection), through the Fiber Optics Cables system; the central point of the system is the OCC at Syntagma Station.

The system is of modular type, fully redundant, highly available, easily maintainable, expandable, re-configurable, and flexible (all types of connections).

The OTN transmission system equipment is installed in the telecommunications room of each station, so as to serve the communication of the automatic telephones, the direct telephones, data, the public address system, the power remote control system, the fare collection system, etc. To this end, the necessary interfaces have been provided.

The system consists in two separate fiber optics transmission loops, one for Line 2 and the other one for Line 3. For redundancy reasons, the OTN nodes of each loop are interfaced via a fiber optics double ring, with the use of the "hopping" mechanism.

For controlling the OTN rings, the OTN system shall be equipped with an OTN Management System (OMS) that operates on a Microsoft Windows NT platform, which is located in the Syntagma OCC equipment room.

The current 589.824 Mbps (OTN600) bandwidth can be increased at 2.5 Gbps by changing the optics cards in the OTN nodes.

At this phase, the OTN system provides support to the following systems, namely:

PABX	Connection of the PABX remote terminals through 2.048 Mbps (E1) (ITU-T G703) links
Direct Line Telephones (DLT)	12LVOI-T & P PCB cards (two interface circuits (ITU-T G712) for the connection of the Traction Current Removal (TCR) analogue telephone sets with the PABX at Syntagma
CCTV	Connection of the OTN with the CCTV system via high quality video cards (cards VID4-IN-X and VID4-OUT-X). Communication ports RS485 (multidrop, outband) are provided for the transmission of the PTZ operation control signal of the cameras. In addition, for signalling reasons, ports RS422 (point to point and/or multidrop) are also provided.
Public Address System (PA)	Connection of the PA System with the OTN through high quality sound cards (HQ-AUD-M and S cards) up to 15 kHz. In addition, for signaling purposes, the ports are equipped with RS 422 communication ports (point to point and/or multidrop), (to control the local amplifiers of the PA system).
Power Romote	RS485 (PROFIBUS) interface cards are provided for the

Control System (PRCS)	PRCS system
Environmental Control System (ECS)	Fast Ethernet ET-100 (IEEE 802.3) interface cards are provided for the ECS system
Automatic Fare Collection System (AFC)	Fast Ethernet ET-100 (IEEE 802.3) interface cards are provided for the AFC system
Information Management System	Fast Ethernet ET-100 (IEEE 802.3) interface cards are provided for the Information Management System

4. TECHNICAL AND FUNCTIONAL REQUIREMENTS AND SPECIFICATIONS

The main technical and functional requirements and specifications for the expansion, upgrading and functional interface of the OTN system are the following:

1. The Contractor shall design, supply, install, test and commission the appropriate equipment and software in all stations and in the OCC, so as to ensure functional interface of the new DLTs in all stations. The DLT cabling shall terminate at the MDF panel (in the telecommunications equipment room 3.4t) accommodating the local OTN (data transmission) system (PCB ITU-TG.712 of the OTN). In addition, he shall also ensure that the OTN transmission system shall connect the DLT sets in all stations with the central DLT automated telephone system (ALCATEL OMNIPCX 440) by means of OTN ITU-TG.712 central interface card in the OCC in Syntagma Station, room 2.14.3. This new equipment may include special OTN PCBs, OTN nodes, power supply units – UPSs, racks, cabling and all other required items.

2. The upgrading and expansion of the OTN equipment in all Metro Stations and in the OCC/Syntagma shall be based on a design and inventory of all existing free cards/ports and, in general, of all available resources. Upon completion of the upgrades, the free OTN ports for DLT telephones shall not be less than 10% of the total ports per area.

3. The Contractor shall provide the possibility for data transmission between the BACS system in the 19 stations of the Base project and the central BACS System in the OCC, via the existing or new cards, connections, cabling, software and anything else required locally in stations and centrally in the OCC.

4. All new cables shall be fire resistant, low smoke emission halogen free cables.

5. The Contractor shall use the existing cable trays in the stations and the OCC for cable routing as required. It is clarified that in all stations, the new cabling running from new DLT sets to the MDF panel in telecommunications room 3.4t shall be installed by TERNA-LG, OASA's Contractor (sets on either side of the gates),

while the DLT sets near the Fireman Box shall installed by the DLT Contractor. These two cable runs shall terminate in existing MDF panels in the stations.

Wiring from each MDF panel to the OTN system shall be supplied by the DLT's Contractor, but all required connections on the OTN side shall be implemented on the basis of this contract by providing locally and centrally equipment/software, and any other items, as required, in order to accommodate the new telephone sets.

Visible cable routing or cable trays / conduits in station public areas are not allowed. Wherever new cable routing must run through fire rated walls, any drilled holes must be sealed with special fire rated mortar.

6. All interventions/ expansions/ modifications to equipment and/or software shall not affect at all the functionality and capabilities of the data transmission system (OTN), in its current form.

7. The addition of telephone sets in all stations shall generate the need for additional PCB(s) to the local data transmission system and/or PCB(s) to the central OTN equipment in the OCC. When the DLT design is finalized, the relevant information shall be passed to the independent Contractor for the upgrade of the OTN system, who, in cooperation with AM, shall take all steps to supply the PCBs or other equipment necessary for the operation of the DLTs.

8. The interface works shall be followed by the SAT and SIT tests which shall demonstrate the proper operation of the new telephone sets (as well as shall reconfirm the proper operation of the existing telephone sets).

9. Works for the implementation of the Project on the operating Metro network are permitted to be executed as follows:
   - Works on equipment and software of the operating OTN system shall be executed during the night engineering hours (00.30 – 04.30);
   - Works in technical rooms of the stations can be executed any day and time;
   - Works in public areas (e.g. cable routing/pulling) shall be executed during the night engineering hours (00.30 – 04.30);
   - The possibility to close down the stations for short periods of time (few days) for the safe and swift execution of the works for gates installation is open to examination.

   The working hours of the Joint Venture to install the access gates has not yet been defined, but the option will be examined to execute works in phases during the station operation hours (obviously during night hours, too), while a short-lasting closure of the stations (successively) is not excluded for the time being in view of the rapid and safe installation of the gates. Therefore, on the basis of the above assumptions, the parallel execution of works is not ruled out.

10. Upon completion of the Project, the following items must be delivered to AM:

a) All functional information of the new upgraded and expanded OTN system;
b) Modifications/upgrades to the Operation and Maintenance Manuals of the OTN system, as required, possibly in the form of an Appendix to the original Manuals. The requirements of the above point (a) can be included in these Manuals;
c) "As Built" drawings of the new/additional routing cable layouts and new cable layouts, as well as single/multi-line drawings for each station;
d) A list with the required spare parts;
e) There will be a 3-year good performance guarantee and any failures during this period shall be at the Contractor's cost.

5. TESTS

5.1 Site Acceptance Test (SAT)

Upon completion of all required works of the Contractor for the modification and expansion of the data transmission (OTN) system in the framework of the installation of the AFCS gates by TERNA – LG / OASA, the Site Acceptance Test (SAT) of the system shall be carried out in each station.
The purpose of these tests is to verify the specified functions and interface requirements of the OTN system locally and centrally.

The time schedules of the SAT tests shall be developed by the Contractor and submitted to AM for approval.

5.2 System Integration Tests (SIT)

The System Integration Tests (SIT) shall be carried out after the successful completion of the SAT tests in all stations.

The time schedules of the SIT tests shall be developed by the Contractor in cooperation with the DLT Contractor, as well as with the Gates Contractor (TERNA – LG) and shall be submitted to AM for approval,

The purpose of these tests is to verify of the combined functions with the new DLTs, in all stations.

6. APPENDIX 1 – TECHNICAL DATA FOR THE DATA TRANSMISSION - OTN SYSTEM

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2. TECHNICAL DESIGN

2.1. Introduction

The technical requirements, as known today, for the backbone of a Fiber Optic Transmission System call for the OTN solution. The OTN transmission system provides along the Athens Metro Line 2 & 3 Extensions, voice, data, video and Local Area Network (LAN) facilities for the following systems:

- Automatic Telephone system
- Direct Line Telephone system (incl. TCR system)
- PA system
- CCTV system
- BAC system
- AFC system
- PRC system

The fiber optic transmission system, called **"*Open Transport Network*"**, which interfaces with all of the specified subsystems as described in detail in the next sections.

OTN or *"Open Transport Network"* is a transmission system based on the latest available technology on fiber optics. It is characterized by the dual ring approach, resulting in high network availability, and the integration of different types of services on one network. As such, it can fulfil almost all transmission requirements for voice, data, LAN, video and any special service required.

OTN is exactly what its name implies:

- **Open**: It can handle nearly all existing physical interface standards, but also very specific communication protocols in special environments, via its wide range of interface modules.

- **Transport**: It carries different types of information (such as voice, data, digital video and LAN) completely transparent throughout the network, and this with maximum availability. OTN operates at the physical level of the OSI-layer and is therefore independent of any application protocol.

- **Network**: It is based on fiber optic TDM technology in a future-proof network infrastructure, with virtually unlimited distance.

OTN is the ideal solution for a "mixed environment", as shown in Figure 2, which is found in many stretched networks in the world of transportation (railways, underground's, motorway systems), along oil, gas and water pipelines, in the world of electricity distribution and in petrochemical and chemical industries.

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2.2. OTN, the secure investment

In this so-called "Information Age", the communications infrastructure has to cope with fast changing requirements (e.g. increasing video applications). OTN grows with these new requirements and services.

Its easy migration capability from one environment to another by simply adding interface cards, makes it a system that can be used for years to come. The 7 members of the family, i.e. 150 Mbps, 155 Mbps, 600 Mbps, 622 Mbps, 2,5Gbps (2 versions) and 10Gbps versions satisfy different bandwidth requirements, with smooth upgrading capabilities between the versions.

For the Ag. Paraskeui Extension the extra needed bandwidth does not exceed 16MBps, adding 2,70% to the existing OTN capacity, reaching 37,00% for Line 3 including the Extension to Haidari. The study's results presented at the Table 1 below show that the add-drop capacity is not exceeded for any of the nodes.

The total required bandwidth has been calculated and shown below is :

New Services Added to the Ring	Bandwidth reserved(KBps)
60 additional Analogue Telephone Lines	4608
1 additional ISDN lines	1162
1additional Ethernet for PA	10000
Total	**15770**

Ring	Bandwidth reserved(KBps)
Line 3	186048
Line 3 extension to Nomismatokopio	15770
Line 3 extension to Haidari	14608
Total reserved	**216426**
Total Free	368566
Total	**584992**

Table 1: OTN Bandwidth Calculation

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Usage	Cards	Required ports	Holargos Station	Nomismatokopio	Ag. Paraskevi	Syntagma	
ISDN	SO-T	1	1			1	SO-P
	SO-T	1		1*		1*	SO-P
	SO-T	1			1*	1*	SO-P
Direct Telephone Lines	12LVOIT	36	3			3	12LVOI-P
	12LVOIT	48		4*		4*	12LVOI-P
	12LVOIT	12		1		1	12LVOI-P
	12LVOIT	48			4*	4*	12LVOI-P
PA	ET100	up to 6	1	1	1	1	ET100E
CCTV	VID4in	6	2	2	2	2*	VID4OUT
PRCS	RS485	port 1	1	1*	1*	1*	RS485
		port 3	1	1*	1*		
ECS/AFC/MIS	ET100	up to 6 per card	3	1 (2*)	1 (2*)	1 (2*)	ET100E

*Existing cards

Table 2: Cards to be installed

For the new Nomismatokopio Node a ring generator will be installed in order to support the new 12LVOI-T card.

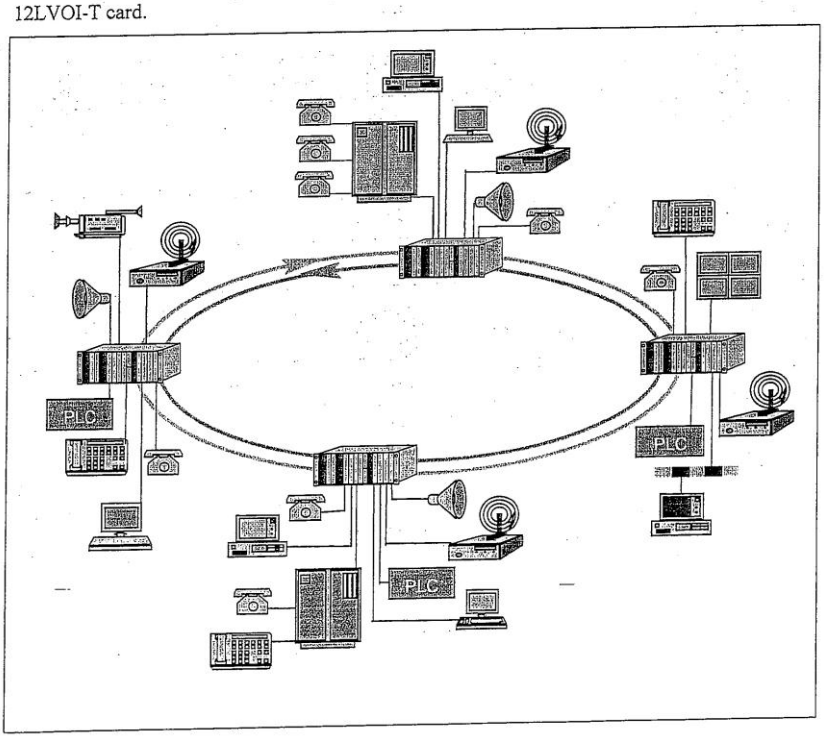

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Figure 2: OTN Environment

2.3. OTN advantages

The OTN system offers many advantages over specific networks for speech, data, compressed video and LANs, and over the traditional digital transmission systems in use today:

- the economies of different services sharing equipment and fiber;
- easy implementation in any environment, safeguarding the investments of the existing equipment;
- full bandwidth for LANs, unlike other wide area LAN interconnection solutions;
- transparent connections, making the network independent of changes in the higher layers of the various protocols;
- easier and simpler communications wiring, and hence easier management and maintenance;
- protection of investment, smooth and economic migration path from one bandwidth to a higher one;
- special features concerning availability and redundancy to protect your information transportation against failures or disruptions;

2.4. System adaptations

OTN comes with an extensive suite of interface cards. New industry standard and specific interfaces are developed as certain needs arise or standards gain momentum. OTN is the ideal platform for such developments. Choosing OTN is choosing for a guaranteed smooth upgrade from lower capacity versions to higher capacity versions, from OTN-36 to OTN150 or to OTN600, safeguarding your initial investment maximally.

2.5. OTN family

OTN comes in seven system bandwidth variants:

- 150 Mb/s (OTN-150)
- 155 Mb/s (OTN-155 (STM1, OC3c))
- 600 Mb/s (OTN-600)
- 622 Mb/s (OTN-X3M-622 (STM4c, OC12c))
- 2,5 Gb/s (OTN-2500 (STM16c, OC48c))
- 2,5 Gb/s (OTN-X3M-2500 (STM16c, OC48c))
- 10 Gb/s (OTN-X3M-10G (STM64c, OC192c))

Different types of nodes are available, and many user interface types (see the specification sheets). All interface types can be used in all three bandwidth versions.

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3. Philosophy

3.1. Topology

The preferred logical topology for OTN is the dual ring structure since it offers the optimum resilience against failures or cable breaks.

When set for dual ring, the fiber optic path is closed. As soon as the path is opened (cable break) the system will respond to this change by a loop back and it will indicate a faulty condition (full automatic).

The double optical ring is used specifically to guarantee a high degree of service, reliability and availability. The system will automatically correct different types of faults in the network.

3.2. Physical ring topology

This topology uses less cable than the star topology and creates automatically alternative cable routes in case of disasters. Examples are a vertical ring in a high rise building, a ring between various buildings in a campus, a ring along an electricity network, a ring along a motorway/metro/light rail, or a ring spanning an airport.

3.3. Types of connections

When reviewing today's networks, we can distinguish a number of typical connections. OTN can be used to support any of these types of connections by means of the appropriate interfaces:

- point-to-point
- multipoint
- multidrop
- broadcast

Point-to-point: In a point-to-point connection, devices are communicating in pairs, as is the case for a telephone set to PBX or terminal to host connection. In OTN these connections can be made completely at random between any pair of ports on identical interfaces, which are placed in any interface slot of a different node.

Multipoint: In a multipoint connection, many devices are connected to the same "line", in a bus (e.g. Ethernet) or ring (e.g. Token Ring) topology.

Access to the medium is controlled by an access protocol. LANs are typical examples of these multipoint connections. This type of connection can be made between any number of identical interfaces, which are placed in any interface slot in different nodes.

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Multidrop: In a multidrop (one source, many destinations) connection, data sent on the medium from the master station to several slave stations. The slave station can return data to the master station.

Broadcast: In a broadcast connection, data is sent on the medium from the master to several slave stations, e.g. audio broadcast or video broadcasting.

3.4. Basic design and operation

3.5. OTN architecture

As shown in Figure 3: OTN architecture, the OTN network architecture is based on 4 major system components:

- the fiber optic backbone
- the OTN nodes
- the interface cards which provide user access to the system
- the OTN Management System (OMS)

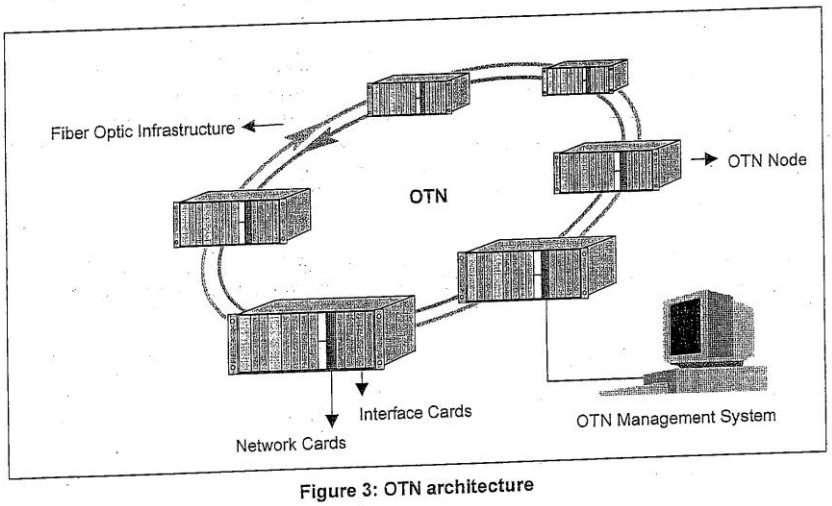

Figure 3: OTN architecture

3.6. Dual ring

The OTN nodes in the network are interconnected by means of double point-to-point optical fiber links. These fibers form 2 counter rotating rings.

In normal operation, all data of the connected equipment is transmitted over one ring, while the second ring is in standby.

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However, the latter is kept in synchronization to monitor its availability. The second ring serves as a back up and can, partly or completely, take over all data transport, if such is required in an emergency situation.

3.7. Node structure

Modular structure

An OTN node is based upon a 19" mountable chassis, equipped with a common logic module and has the capacity for 8 interface cards. All cards are plug-in units; their front panel forms the OTN front panel.

The common modules are the power supply or power supplies, two electro-optical modules and a common logic card. The nodes have interface card slots, in which different interface cards can be inserted in any mixture or position.

Common logic card

The common logic card implements the Time Division Multiplexing (TDM) scheme and sends the received information to appropriate interfaces and from the interfaces to the fiber optic module for transmission.

It also holds (in 1 or 2 ASICs) the algorithms for the various system functions such as reconfiguration and synchronization (redundant).

This module also contains the connection-RAM which stores the programmed connections and which is flash-PROM protected to overcome power failures (redundant).

Hence each of the nodes contains its own intelligence embedded in VLSI hardware.

As a result, correction of detected failures, such as cable breaks by means of loop back, is extremely fast (50 to 120 milliseconds), since this is executed without the intervention of the OTN Management System. Restarting the network, after a complete or partial power-down does not require any software boots: after a self-test the system is immediately available.

Power supply module

The power supply module generates the voltages required for all plug-in modules: +5V, +12V and -12V. Different types of power supply modules are available and can be mixed: 24 and -48V DC, 115 and 230V AC.

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Interface slots

The N22 node provides 8 interface slots. All user equipment is connected to the OTN system through these interface cards. The interface cards perform the conversion to digital signals to be injected in and retrieved from the TDM frame sent around the ring. They can be removed and inserted while the power is on (hot swappable).

OTN offers the user a wide range of interfaces, which can coexist on the same network. Any mixture, within the available bandwidth, of voice, data, LAN and compressed video interfaces, is possible. OTN is completely transparent for the higher layers of the protocols of these interfaces.

3.8. N22 node

The N22 node is used for OTN150/600/2500. The Common logic card is called BORA (Broadband Optical Ring Adapter).

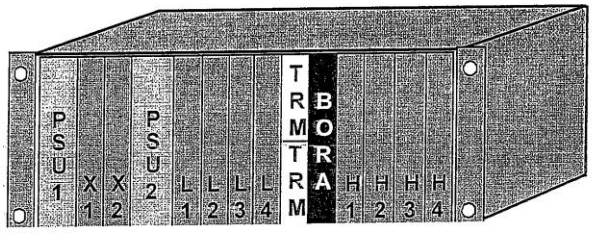

Figure 4: N22 node layout

Card position	*Card name*
PSU 1 - PSU 2 : "Power Supply cards" slots	Power supply
X1 – X2 : "Power Supply with Ringing Generator - 48 V/25 Hz" slots	Power supply and ringing generator 48 V DC/25 Hz
L1 – L2 : "Low Speed Interface cards" slots	Low speed interface card
BORA c/w TRM's : "Common Logic Card c/w Optical Transceiver Modules" slot	Common logic card complete with optical transceiver modules
H1 – H4 : "High Speed or Low speed Interface cards" slots	High or low speed interface card

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Fiber optic module

The OTR's are mounted on the BORA and perform optical transmitting and receiving, the electro/optical conversion, (de-) coding and clock recovery functions. Two fiber optic modules are required per node. There are various options of Fiber Optic Modules to adapt to the different fiber types and/or inter-node distance.

Interface slots

OTN N22 node supports both High Speed (4) and Low Speed (4) interfaces. The only HS interfaces available at the moment are the Fast Ethernet and the ATM interfaces; the video interface card is configurable as low speed or high speed interface card.

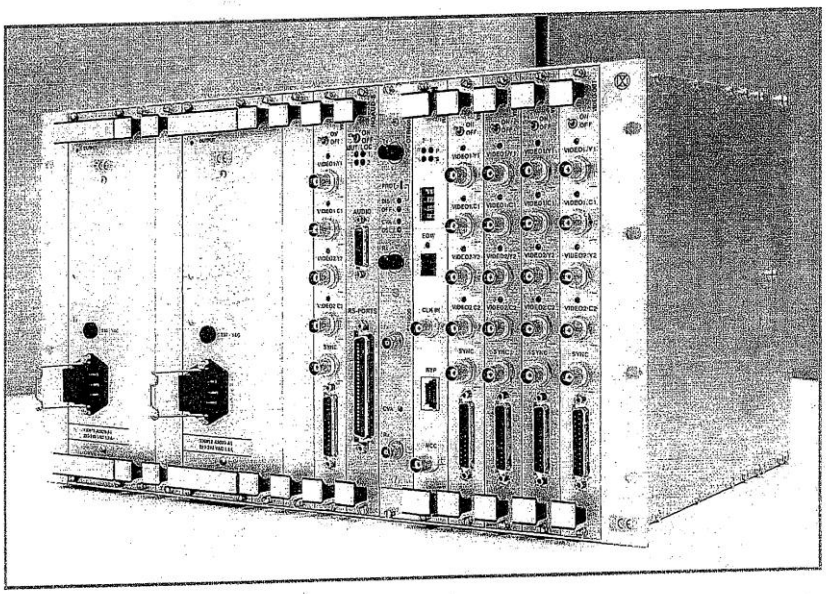

Figure 5: N22 node picture

3.9. Medium

An important element in the OTN Network Architecture is the fiber optic infrastructure. The final configuration of the OTN node is influenced by the following elements:

- transmission medium
- distance between nodes
- topology

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Influence of medium

Different types of fiber can be used for OTN:

- multimode fiber 50/125
- multimode fiber 62.5/125
- single-mode fiber 9/125

Influence of distance between nodes

This is certainly the case for short to medium inter-node distances with many connectors on the way.

Multimode fiber optic connectors used to be more economic (purchase and installation) than the single-mode but this is no longer true which means that installations often have a mixture of both types of cables. This is no problem for OTN since the lasers allow usage of both types within the limits of the specified distances.

For longer distances, the only option available is single-mode fiber. Here, dispersion characteristics and the overall attenuation of the fiber are the dictating parameters.

Topology

Beside the ring topology it is also to have different OTN topologies, like daisy chain, star and hopping. In this way the distance between two nodes and the overall length can be different depending on the possible cable tracks.

3.10. Interface cards

All interface cards of OTN operate at the physical level, this means that OTN is completely transparent for higher protocols as specified in the technical requirement.

OTN takes the application as it comes, so no need to put in intermediary equipment to change over to another type of interface and on top of that OTN does not interfere with the contents of the packets (100% transparent protocol).

Available interfaces:

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Data Interfaces

- RS232 (point-to-point connections and/or multidrop networks);
- RS422 (point-to-point connections and/or multidrop networks);
- RS485 (multidrop networks);
- 64 kbps digital stream (point-to-point connections);
- 2Mbps (E1) digital stream (point-to-point connections).

LAN Interfaces

- Token Ring (4 or Mbps);
- Ethernet (10/100 Mbps).

Voice Interfaces

- Analogue voice (2-wire; DP and DTMF signalling);
- Analogue voice (2/4-wire; E&M signalling);
- Digital voice (2-wire; 2B+D; Up0(e) signalling);
- Digital voice (4-wire; 2B+D; S0 signalling).

Multimedia interfaces

- Analog PAL or NTSC video signals are digitized and compressed on the VID4E-IN interface card. These signals are then transported to another node over OTN, where they are decompressed again and reconverted into an analog PAL or NTSC video signal.

3.11. OTN Management System (OMS)

The OMS fulfils the following basic requirements:

- runs under the Microsoft Windows 2000 operating system
- has a Graphical User Interface with mouse control
- supports the OTN150 and OTN600 and its variety of interface cards

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In addition it will support:

- all new interface card types, e.g. Ethernet 100 Mbps
- the central management of a network of multiple OTN-rings
- SNMP for alarm forwarding to an Umbrella Management System
- multiple operators, with access and authorization control
- comprehensive network database
- management system redundancy
- full alarm management with alarm correlation to end user services
- virtual private network management

The rationale behind the OMS development is to reduce the network operation's cost by maximally supporting the network operator with adequate and accurate status information and so avoiding the need for interventions by the manufacturer's field support engineers.

The OMS product is an entirely new developed management system, using state-of-the-art software technology, e.g. CORBA, for distributed communication between components, JAVA for the GUI. It is implemented on Intel-based PC's with Microsoft Windows 2000 as operating system. This should allow for cost-effective enhancement and extension with new features including future OTN-product components; it also allows for flexible management configurations.

The PC hosts are meant to be dedicated to OMS. Other commercial software applications are not excluded by design, but their proper operation, the configuration of the PC resources and the operation of OMS make it preferably to dedicate the system to OTN.

3.12. General vital non-stop networks

Redundancy in networks can be a major issue to protect data integrity or operational availability. Duplicated data centers or control centers are sometimes introduced in a network, for some applications optimally located at both ends of the network route. Interconnection of these control centers is important.

Access to the remote (standby) communication centre and sometimes automatic change-over from one to the other can be extremely important, especially when the loss of the control centre endangers the lives of e.g. passengers or employees.

The network connecting these control centers must ensure that effective changeover can take place. The built in redundancy of the network, even in the event of a major catastrophic failure, and the speed of the changeover are therefore important.

It is also possible to download pre-prepared alternative databases of connections, to match changed network configurations or communications requirements.

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3.13. Redundant fiber optic ring

The structure of OTN is originated on the base of maximum availability of the network. A cable break or an OTR failure will not cause problems on the network. The backup ring can be used to transport the information or to loop back to form a new ring.

The extremely short reconfiguration time to become again operational will take about 96 ms and therefore will have no loss of information as a consequence.

In the case of this project the fact that two different cable routes are used, the availability of the system will be maximum since a complete cable break will not bring the network down.

3.14. Redundant power supply

As mentioned in the description of the types of nodes, the N22 is equipped with one or two power supplies. One power supply feeds the entire chassis, but when a second is included they will both supply 50% of the power (load sharing) and a failure of one of the power supplies will not bring the node down (load balancing).

4. OTN SOLUTION FOR AG.PARASKEUI EXTENSION

4.1. OTN configuration

The 19" mountable node chassis is a N22 node chassis.

Each node chassis has been equipped with 2 redundant 230 V AC power supply modules a common logic card complete with 2 integrated optical transceivers. The distances to span between adjacent node locations determine the type of optical transceiver to be used.

The applied OTN system bandwidth is 589.824 Mbps (OTN600).

One OMS manages both rings. The OMS platform consists of a PC complete with a printer. An Ethernet or a PCMIA card, 2 cable connection kits, a manual and software CD-ROM are also included.

At each new location a 19" rack of 38 HU (H: 1800mm) is provided, except from Syntagma station where a 19" rack of 47 HU (H: 2200mm) will be provided. The dimensions of this 19" rack (RAL colour 7035) are 800 x 600 (mm, W x D).

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This rack comes complete with:

- glass door at the front
- glass door at the rear
- node assembling kit(s) and cable pass through panel
- cable guiders
- Main Distribution Frame (MDF)
- power distribution and circuit breakers
- adapters
- pigtails
- patch cords (= jumpers) to connect to the OTN
- Side panels, 600x2000mm

4.2.Hopping mechanism

As the stations are implemented along a "line", using the hopping mechanism ensures the OTN dual ring topology. This mechanism explains itself in

Figure 6: OTN hopping mechanism.

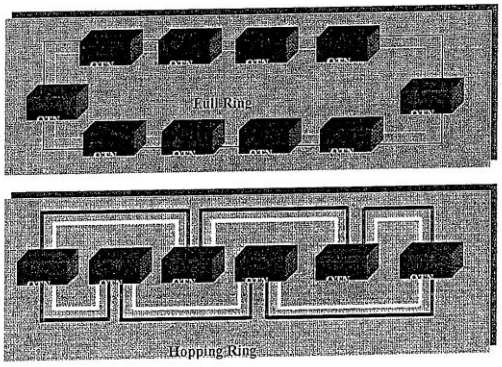

Figure 6: OTN hopping mechanism

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4.3.OTN Interfaces

4.3.1. Direct Line Telephone System

To connect the distributed direct line telephones of the new stations via the OTN with the Syntagma PABX 12LVOI-T and -P interface cards will be used. The DLT sets will be connected to 12LVOI-T interface cards. Each 12LVOI-T card has 12 circuits. The nodes with 12LVOI-T cards will be equipped with one or two "-48V / 25Hz power supply and ringing generator" cards.

The 12LVOI-P interface card interfaces with the PABX and has also 12 circuits.

4.3.2. Public Address System

To connect the Public Address system of the new stations with Syntagma via the OTN, ET-100E cards will be used. Through this interface card a bandwidth up to 10Mbps will be used for the PA system. The existing central / core equipment of Public Address in Syntagma shall be upgraded accordingly in order to handle both existing and new interfaces cards (High Quality Analogue Audio and Ethernet). All ET-100E cards will be properly configured in order to achieve compatibility with legacy Ethernet networks.

4.3.3. Closed Circuit Television System

To connect the closed circuit television (CCTV) system of the new stations with Syntagma via the OTN, high quality video interface cards (VID4-IN-X) will be provided.

The VID4-IN-X cards are used to transmit 4 PAL or NTSC video signals via the OTN. Analogue video signals are digitized and compressed (M-JPEG) on the VID4-IN-X card, transmitted to Syntagma existing node and decompressed and converted to an analogue PAL or NTSC signal by the VID4-OUT-X card. Furthermore, the PTZ and switching control will be managed by an RS-485 interface card.

These video cards provide switched connections (the video switching functionality is embedded in the OTN itself) between VID4-IN-X and VID4-OUT-X cards, both in point-to-point and multidrop configurations.

The bandwidth per video connection is depended on the monitor resolution and the field rate, already configured in the existing OTN, and no extra bandwidth is required. The actual switching system of the video channels remains intact.

The actual switching of the video channels is controlled by an external Video Management System (VMS). The VCC (Video Command Converter) is created as a separate protocol converter between this VMS and the OTN. It therefore interfaces with both the OTN and the VMS. The VCC runs on an existing PC in Syntagma. The VCC is connected to the OTN via an existing RS422 connection (RSXMM interface card).

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A video output on a remote local crossbar corresponds with a VID4-IN-X video input port, while a video input on the central crossbar corresponds with a VID4-OUT-X video output port.

4.3.4. Building Automation and Control System

We assume that the BAC System will need a 10Mbps LAN between all relevant locations. The fast Ethernet ET-100 interface card allows the creation of fully transparent Ethernet networks through the OTN. It can be used in point-to-point and bus configurations and allows half / full duplex Ethernet operation.

The ET-100 card offers a bandwidth of 100 Mbps or 10 Mbps (selectable via the OMS or via auto negotiation) to the connected devices. However, the bandwidth used through the OTN network is allocated by the OMS, and is stepwise selectable. This allows the OTN network to save bandwidth for 100 Mbps (resp. 10 Mbps) Ethernet networks, which are not fully loaded.

The ET-100 card acts as a store and forward Ethernet switch and has 6 switched ports.

4.3.5. Automatic Fare Collection System

The automatic Fare Collection System requires an Ethernet LAN between OCC and new stations of line 2. We assume that a 10 Mbps Ethernet LAN will be adequate. For this purpose, an ET-100 interface card will be provided at each new station.

4.3.6. Power Remote Control System

A field bus on RS485 will be used for the communication between the Tele Control Interface (TCI) and a station / depot RTU. Therefore an RS485 interface card will be provided at all relevant locations.

5. OCC UPGRADE

The following sequence of works shall be performed in order to extend the OTN system for the new stations of Ag. Paraskeui extension:

1. Installation of a new OTN rack in OCC room with the new relevant nodes. The new OTN rack will be prefabricated with all internal cabling connection and with MDFs and MCBs installed. Please refer to drawing MET3.DRW.108.0007.01 for the exact proposed location.

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2. Laying the power cable from the nearest power panel to the new rack and terminating on the relevant MCBs.

3. Terminations of the interfaced systems on the relevant MDFs or directly on the interface cards.

4. Connecting the new OCC nodes in the fiber optic double ring with fiber optic patch panels.

5. Upgrading the OMS database in order to add the new nodes and activate the new relevant services. This phase shall be coordinated with the commissioning team of the interfaced systems.