13-SDMS-09

REV. 00

SPECIFICATIONS

FOR

DWDM EQUIPMENT

CONTENTS

1 Introduction

1.1 Objectives

The aim of this document is to give the specifications for the DWDM equipment for the deployment of an FTTx network in Kingdom of Saudi Arabia. The purpose is to provide the transport of defined tributary signals, while offering the required functionality and assuring sufficient system performance, at the lowest possible cost.

1.2 Scope

This document specifies the minimum requirements for SEC Distribution DWDM equipment. This equipment is required in the Aggregation network as capacity driven by requirements from the Access network grows. The scope of this specification includes describing the interfaces presented on the Access side of the network as well as the interfaces presented to the NG PE router, which forms the demarcation point between Distribution Aggregation network and the NG Core network (which is expected to migrate from SDH, to MPLS-TP, and ultimately to IP/MPLS). In time, these interfaces are likely to grow to Nx100G.

The scope of this specification also covers the following key industry standard requirements for a DWDM network, which are required to support SEC's requirements for traffic scaling and bandwidth efficiency:

- Efficient use of fibre
- High capacity transport interfaces
- Multiplexing and grooming capabilities
- Optical bypass opportunities (avoiding O-E-O)
- OTN based OAM capabilities
- End to end transparency

The scope also covers network management requirements (EMS and NMS) to monitor, control and configure traffic, integrating as efficiently as possible with existing management system.

The supplier is required to install, integrate and test all DWDM equipment and management systems.

2 Applicable codes and standards

This Distribution material standard specification shall be read in conjunction with the latest revision of Distribution General Specification titled "01-SDMS-01, Rev 01" which shall be considered as an integral part of this standard. This material standard specification shall also be read in conjunction with purchase order or contract schedules for the project, as applicable.

The latest revision/amendments of the following codes and standards shall be applicable for the equipment/material covered in this Distribution material standard specification. In case of conflict, the supplier/manufacturer may propose equipment/material conforming to one group of industry codes and standards quoted hereunder without jeopardizing the requirements of this standard specification.

Architecture and Functionality

- G 871/Y1301 Framework for Optical Transport Network Recommendations
- G 872 Architecture of optical transport networks
- G 798 Characteristics of optical transport network hierarchy equipment functional blocks
- G 805 Generic Functional Architecture of Transport Network
- G 806 Characteristics of transport equipment – Description methodology and generic functionality
- G 870 Terms and definitions for optical transport networks
- G 694.1 Spectral grids for WDM applications: DWDM frequency grid
- G 661 Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems
- G 662 Generic Characteristics of Optical Amplifier Devices and Subsystems
- G 663 Application-related aspects of optical amplifier devices and subsystems
- G 671 Transmission characteristics of optical components and subsystems
- RFC 3473 Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions
- G 8080 Architecture for the automatically switched optical network
- G 805 Generic Functional Architecture of Transport Networks
- G 7713 Distributed call and connection management (DCM)
- G 7713.2 Distributed Call and Connection Management: Signaling mechanism using GMPLS RSVP-TE SERIES
- G 7713.3 Distributed Call and Connection Management: Signaling Mechanism using GMPLS CR-LDP
- G 7715 Architecture and requirements for routing in the automatically switched optical networks
- G 7715.1 ASON routing architecture and requirements for link state protocols Series G: Transmission Systems and Media, Digital Systems and Networks Digital Terminal transmission Equipment – Operations, Administration and Maintenance features of equipment
- G 664 Optical safety procedures and requirements for optical transmission systems
- ETS300-417.1 Generic requirements of transport functionality of equipment

Error Correction

- M 2401 Error performance limits and procedures for bringing-into-service and maintenance of multi-operator international paths and sections within an optical transport network
- G 8201 Error performance parameters and objectives for multi-operator international paths within optical transport networks
- G 8251 The control of jitter and wander within the optical transport network (OTN) Amendment 3
- G 821 Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network
- G 826 Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network
- G 829 Error Performance Events for SDH Multiplex and Regenerator Sections

Interfaces

- G 709/Y1331 Interfaces for the optical transport network
- G 692 Optical Interfaces for Multichannel Systems with Optical Amplifiers
- G 959.1 Optical transport network physical layer interfaces
- G 693 Optical interfaces for intra-office systems
- G 698.1 Multichannel DWDM applications with single-channel optical interfaces
- G 698.2 Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces

Management

- G 874 Management aspects of optical transport network elements
- G 874.1 Optical transport network (OTN): Protocol-neutral management information model for the network element view

Protection

- G 808.1 Generic protection switching – Linear trail and sub network protection
- G 873.1 Optical Transport Network (OTN): Linear protection
- G 664 Optical safety procedures and requirements for optical transmission systems

Synchronization

- G 826.2 Timing characteristics of a synchronous Ethernet equipment slave clock Amendment 2

- IEEE 1588 A Precision Clock Synchronization Protocol for Networked Measurement and Control Systems Conflicts and deviations
- ETS 300 462 The control of jitter and wander within synchronization networks

Rack

- ETS 300-119 Part 3: Engineering requirements for miscellaneous racks and cabinets

3 Abbreviations

- 3R : Re-shaping, Re-timing, Re-amplification
- ADM : Add-drop multiplexed
- ALS : Automatic Laser Shutdown
- ASON : Automatically Switched Optical Networks
- BBE : Background Block Error
- BER : Bit Error Rate
- BFD : Bidirectional Forward Detection
- BIP : Bit Interleaved Parity
- CAS : Channel Associated Signaling
- CAP : Carrier-less Amplitude and Phase
- CD : Chromatic dispersion
- CRC : Cyclic Redundancy Check
- DCM : Distributed call and connection management
- DCN : Data Communication Network
- DGD : Differential Group Delay
- DM : Degraded minutes
- DRA : Distributed Raman Amplifier
- DSP : Digital Signal Processor
- DTMF : Dual Tone Multi-Frequency
- DWDM: Dense Wavelength Division-Multiplexing
- EN : European Norm
- ENNI : External Network to Network Interface
- EOW : Engineering Order Wire
- EPL : Ethernet Private Line
- ES : Errored seconds
- ETS : European Telecommunications Standards
- EVPL : Ethernet Virtual Private Line
- EVP-LAN: Ethernet Virtual Private LAN
- FEC : Forward Error Correction

- GMPLS: Generalized Multiprotocol Label Switching
- GPS : Global Positioning System
- HDSL : High Density Subscriber Line
- IEC : International Electrical Commission
- IETF : Internet Engineering Task Force
- INNI : Internal Network/Network Interface
- ITU : International Telecommunication Union.
- IP : Internet Protocol
- ISDN : Integrated Services Digital Network
- MCMI : Multi Coded Mark Inversion
- MPLS-TP: Multiprotocol Label Switching - Transport Profile
- MS : Multiplex Section
- NE : Network Element
- NG : Next-Generation
- NMS : Network Management System
- L2 : Layer 2
- LAN : Local Area Network
- LMP : Link Management Protocol
- LO : Optical Layer
- LSPs : Label Switched Paths
- OAM : Operation, Administration, And Maintenance
- O-E-O : Optical to Electrical to Optical
- OIF : Optical Internetworking Forum
- OLA : Optical Line Amplifier
- OS : Optical Section
- OSNR : Optical Signal-to-Noise Ratio
- OSPF : Open Shortest Path First
- OTN : Optical Transport Network
- PDH : Plesiochronuous Digital Hierarchy
- PDL : Polarization Dependent Loss
- PMD : Polarization Mode Dispersion
- PPP : Point-to-Point Protocol
- PW : Pseudo-Wire
- PWE3 : Pseudo Wire Emulation Edge to Edge
- QoS : Quality Of Service
- RDI : Remote Defect Indication
- RFC : Request for Comment

- ROADM: Reconfigurable Optical Add/Drop Multiplexer
- RS : Regenerator Section
- RSVP-TE : Resource Reservation Protocol-Traffic Engineering
- SDH : Synchronous Digital Hierarchy
- SES : Severely Errored Seconds
- SFPs : Small Form-factor Pluggables
- SLA : Service Level Agreement
- SNMP : Simple Network Management Protocol
- SOH : Section Overhead
- STM : Synchronous Transport Module
- TCP : Transmission Control Protocol
- TE : Traffic Engineering
- TTI : Trail Trace Identifier
- UAS : Unavailable Seconds
- UNI : User Network Interface
- VC : Virtual Container
- VF : Voice Frequency
- VLAN : Virtual Local Area Network
- WSON : Wavelength Switched Optical Networks
- WSS : Wavelength Selective Switch

4 General Requirements

4.1 The supplier shall deliver a fully functional DWDM network as a turnkey solution based on the Reference Architecture and BoQ.

4.2 The supplier shall study all SEC requirements and based on all facts propose a turnkey, cost effective solution, based on current international standards, including all necessary equipment (such as servers, power supply components, ancillaries, etc.)

4.3 Supplier shall be responsible to conduct a site survey to collect all relevant information that can have impact on project in terms of feasibility, BoQ items, cost, time plan and all aspects of realisation. Based on the site survey, the supplier shall propose all additional necessary equipment if any.

4.4 As per SEC requirements the supplier shall design the solution in such a way that it can provide efficient delivery of full range of services. This network shall be flexible and adjustable to future services, by proper dimensioning in design, hardware and software, to cope with services demands.

4.5 The Supplier shall produce a Solution Description (SD) document which will in detail explain functionality and design of each service, configuration of protocol and explanation of chosen options, benefits and drawback of solution as well as all possible limitations of that solution. SD shall extensively address resiliency and security threats, scenarios and protection solution. SEC will control and approve LLD through Technical Clarification list.

4.6 Shipment, custom clearance according to DDP (INCOTERMS2000) and delivery of all the equipment to the respective sites in KSA where the equipment will be installed.

4.7 The supplier's solution shall support all required retail, enterprise and wholesale product requirements specified in the SEC Product Offerings and Roadmap .

4.8 The supplier shall obtain all necessary certification from the KSA Telecoms Regulator for all equipment proposed in the solution prior to contract signing.

4.9 The supplier shall perform, or where performed by SEC, assist SEC in performing, and document user acceptance testing services for Applications developed implemented or modified by the supplier

4.10 The proposed solution will be according to the industry standards and based on supplier experience to provide the most effective and flexible network functioning. In exceptional cases, and with SEC's written agreement, proprietary standards may be used to achieve better capabilities.

4.11 The solution must be cost effective. It shall provide all necessary support for the services in chosen the design, and shall exclude unnecessary options that could increase the cost.

4.12 The solution must provide as best as possible performance of each proposed service.

4.13 All Hardware and software proposed to be deployed in SEC Network shall have at least 5 years roadmap guaranteed support. All relevant emerging technologies shall be clearly reflected in the roadmap.

4.14 The solution description document shall explain in detail the functionality and design of each service, the configuration of each protocol and full explanations of chosen options, the benefits and drawback of solution as well as all possible limitation of that solution

4.15 Services availability of 99.999% shall be assured by providing first class equipment with industry leading values for MTBF for the implemented HW and SW, and by providing redundancy features for hardware and proper configurations.

4.16 MTBF values shall be provided for all equipment

4.17 The solution shall offer enhanced security features and proper configuration of those options in the way that provide self-defending ability across whole network as well as per node basis.

4.18 Configurations of all network elements shall to be done in a way to provide a full set of features for all services mentioned in this RFP.

4.19 The proposed solution needs to incorporate effective and comprehensive tools for O&M through the deployment of appropriate EMS and NMS equipment to support Event and Fault Management, Inventory Management, Configuration Management, Performance Management, Security and System Administration Management.

4.20 Supplier shall completely integrate Fault Management and other tools as required into existing SEC OSS platforms. The supplier shall offer the list of all possible alarms with alarm correlation indicated recommended action. SEC shall choose what needs to be forwarded to OSS.

4.21 The Supplier shall provide complete list of counters and recommendation for KPIs. SEC will choose what will be implemented.

4.22 The Supplier shall provide tools for collecting all relevant statistics from nodes that can be used for analysis and accounting.

4.23 The suppliers shall explain all the capacity and capability of the system offered and the relation to the unit price of each component of the system. This shall include hardware, software (port license, software license, etc), services and support, with the BoQ clearly linked to the pricebook.

4.24 The suppliers shall explain the right of SEC in using the license offered and the limitation in using the license. The suppliers shall also explain the capability and limitation of the existing NMS & License in performing all NMS function.

4.25 The Supplier shall propose usage based software licences wherever feasible (such as Pay As You Use, Pay As You Grow)

4.26 The suppliers shall indicate the conformance of the equipment to relevant international standards.

4.27 The suppliers shall guarantee the interoperability with other vendor equipment (including SDH, DWDM, Ethernet, IP equipment), any limitation/restriction with other suppliers shall be clearly defined in the technical document.

4.28 All hardware shall have 2 years free warranty

4.29 The supplier shall conduct a Proof of Concept (PoC) to demonstrate the solution to the requirements specified in this document

4.30 SEC shall not be responsible or liable for any costs incurred by the supplier in the PoC.

5 Product Offerings and Roadmap

5.1 The solution shall support the following internal SEC product requirements:

i. Point to point services between hub substation and other substations on the ring. Every Metro Edge CE is connected point to point to 2 Metro Edge PE in the hub (to provide physical redundancy)
ii. 2 fibers per ring
iii. Layer 2 Fault Management
iv. Support for 1 Gigabit and 10 Gigabit Ethernet FO interfaces

5.2 The solution shall support the following external product requirements:

i. Dark fiber or DWDM capacity (wholesale)
ii. DWDM capacity: up to 80 lambda
iii. Capacity / lambda: 10, 100 Gbps
iv. Physical separation, on lambda, between external and internal traffic

5.3 The supplier's solution must be able to fulfil all SEC requirements for services at launch as well as future services.

6 Reference Architecture

6.1 The supplier's proposed solution shall follow the technological concept as per SEC requirements.

7 DWDM System Requirements

7.1 Overview

7.1.1 The supplier shall provide DWDM equipment which is fully compliant with ITU-T G.709 and ITU-T G.798 and provide details of their current roadmap

7.1.2 The equipment shall support ROADM/WSS architectures

7.1.3 The equipment shall support an integrated OTN grooming/switching architecture with electrical OTN switching capabilities for sub lambda grooming and lambda translation/regeneration

7.1.4 The equipment shall support GMPLS capabilities in the control plane for automatic topology and resource discovery and fast "point and click" Label Switching Path (LSP) provisioning

7.1.5 The equipment shall implement synchronous multiplexing at all ODUk/VC levels and synchronous Ethernet

7.1.6 The equipment shall support the implementation of GMPLS (RFC 3945) and ASON (ITU-T G.8080).

7.1.7 GMPLS/ASON control plane shall be adopted in ODUk, Och, and ODUk + Och.

7.1.8 The equipment shall support a centralized packet switching function to support migration to a packet optical transport system.

7.1.9 The supplier shall provide a Carrier Grade solution according to IEC 61850

7.1.10 The hardware shall be fully redundant with support for software redundancy

7.2 40ch/80ch System Architecture

7.2.1 The supplier shall provide a high level functional diagram for the supported equipment types with regards to OTM (Optical terminal multiplexer), Fixed optical add/drop multiplexer (FOADM), Reconfigurable optical add/ drop multiplexer (ROADM) and Optical line amplifier (OLA) with particular reference to:

7.2.2 Wavelength Grid and DWDM system capacity as defined in ITU-T recommendation G.694.1.

7.2.3 The supplier's solution shall be upgradeable to 80ch*100G@50GHz.

7.2.4 The supplier's solution shall support flexible grid to face up to 400G/1T system.

7.2.5 The equipment shall have modularity and scalability of the 40ch/80ch system architecture for Point-to-Point, ring and mesh network applications.

7.2.6 The supplier shall provide details about the 100G transmission as implemented at the 100G transponders as follows, but not limited to:

i. Polarization Mode Dispersion (PMD) tolerance of 100G transponders
ii. Methodology of Chromatic Dispersion Compensation (CDM) (Static CDM, DC per composite DWDM signal or per channel)
iii. Modulation Format (Keying) with comparison to other 100G

7.3 Power Management and Fibre Monitoring

7.3.1 The supplier shall state its support of automatic power reduction (APR) due to fibre breaks or equipment failures as well to automatic laser shutdown (ALS) for its offered 10G/100G Transponders/ Muxponders/ Optical Amplifiers.

7.3.2 The equipment shall support online OTDR measurement of length and loss of fibre, it must not affect the service while measuring.

7.3.3 On-line OTDR shall be capable of being managed from the NMS

7.3.4 The OTDR function shall be embedded, without the need for additional equipment or extra slots

7.3.5 The equipment shall support built-in precise fault position locating of broken fibre

7.3.6 The equipment shall support testing of connector and splice point of fibre, and the test must not affect service.

7.3.7 The equipment shall support in-built 10G/100G OSNR monitoring and reporting, with automatic in-service optimisation capability, without causing any service interruption.

7.3.8 The OSNR monitoring capability shall be accurate to within +/- 1dB.

7.3.9 The supplier shall support built-in automatic alarms for poor fibre quality, include connectors, splice points.

7.4 Optical Supervisory Channel

7.4.1 The equipment shall support for an optical supervisory channel (OSC) operating at 1510 nm for network management information purposes and the use of the generic communications channels (GCC0/1/2) of the G.709 frame for its offered 10G/100G Transponders/Muxponders.

7.4.2 The equipment shall support Auxiliary and EOW functionalities.

7.4.3 The OSC shall be capable of OMU Input Power Balancing.

7.5 Client Signal Encapsulation

7.5.1 The equipment shall comply with GFP mapping according to ITU-T G.7041 and shall support the following Ethernet encapsulation schemes: 10G/100G

7.5.2 The mapping of Ethernet to OTN shall be in according to G.709 and if both GFP-F and GFP-T mapping options are available, emphasising the benefits of the supported encapsulation scheme.

i. GbE into ODU0 (GFP-F)
ii. GbE into ODU0 (GMP)

iii. GbE into ODU0 (GFP-T)

7.5.3 The supplier shall describe their solution for mapping 10GE LAN PHY to ODU-2.

7.5.4 The supplier's solution shall support 4 x STM-64 / 10G POS /10GBE LAN PHY signals mapped into ODU3

7.5.5 The supplier's solution shall support GE / STM-16 / STM-64 / 10GE signals mapped into ODU3 without the cascade of Muxponders.

7.5.6 The supplier shall support the clock transparency to Synchronous Ethernet PHY (SyncE) GE interfaces.

7.5.7 The system shall also support the Ethernet service L2 aggregation of FE/GE/10GE, and then mapped into ODUk (k=0,1,2,flex) to save the bandwidth.

7.6 LLF (Link Loss Forwarding) Mechanism

7.6.1 The equipment shall support for LLF mechanism based on SSF (Server Signal Fail) propagation for transport network faults and local client input faults for triggering Remote Client Tx laser off. In particular the supplier, for the offered 10G/100G Transponders/ Muxponders, shall describe in detail (with diagrams) the following scenario:

7.6.2 SSF consequential actions in case of transport fault with particular reference to the type of defects in the OTN domain (OCh/OTU/ODU egress direction)

7.7 Equipment Monitoring

7.7.1 The equipment shall support analogue monitoring (for example, frequency/power/OSNR per channel) for 10G/100G system, error monitoring (i.e. Pre-FEC, Post FEC alarms, Degraded BER, Excessive BER, etc.), Loopbacks (client/WDM side) and alarms, generated after reaching different FEC correction thresholds.

7.8 Performance Monitoring

7.8.1 The supplier shall support performance monitoring (as applicable to its offered 10G/100G Transponder /Muxponders), with regards to the following layers:

i. OCh layer (ODUk/OTUk) support for post FEC error detection and Tandem connection monitoring (TCM) support.

ii. Data layer support for:

a) 8B/10B violation counters

b) Ethernet performance counts according to RFC 2819 (RMON) as snapshots

c) Historic performance log [Current and history counters (15m/24H)]

d) Ethernet performance alarms

e) Built-in Optical Spectrum Analyzer solution

7.9 Protection

7.9.1 The system shall support 1+1 optical line protection

7.9.2 The supplier shall detail the protection schemes and switching times for a ring or meshed structure considering data traffic as a client interface.

7.9.3 There shall be no modules which are single points of failures

7.9.4 The system shall support ODUk SNC/N and SNC/I protection.

7.9.5 For the ODUk SNC 1+1 protection, it shall be possible to configure a hold-off timer as specified in ITU-T Rec. G.798.

7.9.6 The equipment shall support ODUk network restoration

7.9.7 The equipment shall implement OCh protection switching mechanisms.

7.9.8 The equipment shall implement OCh network restoration mechanisms

7.9.9 The network shall be able to protect against two fibre failures if routing is available.

7.9.10 The system shall support the following Ethernet protection for L2 Ethernet features:

a) The system shall support LAG (Link Aggregation Group) which can protect port with LACP (Link Aggregation Control Protocol) applied for.
b) The system shall support DLAG (Distributed Link Aggregation Group) which can protect inter-board port with LACP (Link Aggregation Control Protocol) applied.
c) The system shall support multi-chassis link aggregation group (MC-LAG) feature which is inter-device link aggregation based on the link aggregation group (LAG) technology and provides dual-homing protection for Ethernet services.
d) The system shall support ITU-T G.8032 Ethernet Ring Protection Scheme (ERPS).

7.9.11 The transmission system shall give alarm or indication to router/switch to stop transmission/packet forwarding on FE/GE/10GE ports of transmission Ethernet card, if there is link down between transmission media due to fibre cut or some fault.

7.10 Supplier Portfolio / HW Architecture

7.10.1 The supplier shall provide full details of their solution with reference to:

i. Shelf layout
ii. Service slots distribution and backplane capacity per slot

7.10.2 The supplier shall provide full details of their 10G//100G Transponder/Muxponder hardware variants referencing the following specifications:

i. client side (technical specifications, service type and reference standard, Pluggable optics, maximum reach)
ii. DWDM side (technical specifications, Modulation format, Pluggable optics, tune ability, maximum reach)
iii. Port density (per hardware variant/shelf)

7.11 Capacity Upgrades

7.11.1 Capacity upgrades within one configuration and also from one configuration to another one (per card, per shelf, etc.) shall be non-traffic affecting

7.12 Availability

7.12.1 The solution shall be carrier grade, and achieve SEC's target availability for any circuit of 99.999% where the physical transport media makes it possible. Therefore it is necessary that the solution meets this target.

7.12.2 The supplier shall indicate the MTBF figures of the components of its solution as well as the MTTR.

7.13 HW Resiliency

7.13.1 All the common parts of the chassis shall be redundant: power supply redundancy, switch fabric redundancy (if any), shelf-controller redundancy and hitless switchover and hitless forwarding.

7.13.2 The equipment shall support insertion, replacement and removal of modules whilst the equipment is powered up without affecting traffic and / or damaging any module.

7.13.3 The equipment shall be a modular chassis architectures, there shall be no limitation as to where line cards can be installed.

7.13.4 The equipment shall offer power supply redundancy, switch fabric redundancy, controller redundancy, hitless switchover and hitless forwarding. However for compact platforms, some trade-off in redundancy could be admitted. The supplier shall provide details of the architecture for its compact solution and state clearly which parts are redundant and in different modules, and which one are not.

7.13.5 The supplier solution shall provide indications on each individual module to indicate a failure of the module. The equipment shall also have an alarm display showing at least major and minor summary alarms.

7.14 SW Resiliency

7.14.1 Control and forwarding parts shall be separate (autonomous) so that a control failure does affect the forwarding part.

7.14.2 SW upgrades and SW patches shall be capable of being performed without any service interruption and the solution shall supports the upgrade of all operating software without any traffic interruption.

7.14.3 In-service configuration backup and restore shall be supported, with the capability to batch download software and firmware and switch in bulk.

7.14.4 Autonomous operation shall be supported, without assistance from the Management System.

7.15 Tributary Interfaces

7.15.1 The equipment shall support the following TDM interfaces:

i. STM-1/OC-3 : ITU-T G.957 I-1.1 , L-1.1, L-1.2
ii. STM-4/OC-12: ITU-T G.957 I-4.1 , L-4.1, L-4.2
iii. STM-16/OC-48:ITU-T G.957 I-16 , S-16.1,L-16.1, L-16.2
iv. STM-64/OC-192:ITU-T G.691 I-64.1, S-64.2b
v. STM-256/OC-768:ITU-T G.693 VSR2000-3R2, ITU-T G.693 VSR2000-3R3,ITU-T G.693 VSR2000-3R5

7.15.2 The equipment shall support the following Gigabit Ethernet interfaces

i. IEEE802.3z 1000Base-SX, 1000Base-LX, 1000Base-ZX, 1000Base-T
ii. 10Gigabit Ethernet
iii. IEEE802.3ae 10GBase-SR , 10GBase-LR, 10GBase-ER, 10GBase-ZR
iv. 100Gigabit Ethernet LAN PHY (100GBASE-R) :
v. IEEE802.3ba 100GBase-LR4

7.15.3 The equipment shall support the following Fibre Channel interfaces:

i. 1/2/4/8/10 G Fiber Channel shall be supported.
ii. ESCON shall be supported.
iii. FICON/FICON Express shall be supported.

7.15.4 The equipment shall provide ODU0 granularity in the system side.

7.15.5 The GbE signal shall be mapped into ODU0.

7.15.6 The mapping of GbE signal into ODU0 shall guarantee timing transparency.

7.15.7 The mapping of GbE signal into ODU0 shall guarantee bit transparency.

7.15.8 Two ODU0 shall be able to multiplex into one ODU1.

7.15.9 The equipment shall provide ODU2+ granularity in the system side.

7.15.10 The equipment shall have a universal board which can support 8 clients interface for any service (GE/STM-1/STM-4/STM-16) converging to OTU2.

7.15.11 The 10GBE LAN PHY signal shall be mapped into ODU2+.

7.15.12 The mapping of 10GBE LAN PHY signal into ODU2+ shall guarantee timing transparency.

7.15.13 The mapping of 10GBE LAN PHY signal into ODU2+ shall guarantee bit transparency.

7.15.14 The equipment shall provide ODU3 granularity in the system side.

7.15.15 4*STM-64 / 10G POS /10GBE LAN PHY signals shall be able to mapped into ODU3.

7.15.16 FC400/FC800/3G-SDI signals shall be able to be mapped into ODUflex.

7.15.17 The equipment shall provide a tributary board of 100-2.5G with any service access, including STM-1, STM-4, STM-16, OC-3, OC-12, OC-48, ESCON, FE, DVB-ASI, GE, FC100, FC200, FICON Express. All of these services shall be configurable on the same board at the same time.

7.16 Line Interfaces

7.16.1 The following standards shall be supported:

i. ITU-T G.709 OTU2
ii. ITU-T OTU2/G.Sup43 OTU2e (Configurable)
iii. ITU-T G.709 OTU3
iv. ITU-T G.709 OTU4

7.16.2 The line interfaces shall support the tuning of the carrier frequency or pluggable optical module on all the working channels defined in ITU-T Recommendation G.694.1

7.16.3 The equipment shall have the ability to flexible converge FE/GE/STM-1/STM-4/STM-16/STM-64/10GE LAN/10GE WAN and FC100/200/400/800/1200/ESCON to 100G wavelengths directly without cascading transponders or equipment.

7.16.4 The DWDM equipment shall support built-in PRBS function for easy 100G self-test.

7.16.5 The proposed DWDM equipment shall support 100G Transponder loopback function for easy maintenance.

8 WSS/ROADM Architectures

8.1 Optical layer Grooming

8.1.1 The supplier's solution shall support WSS/ROADM architectures for wavelength grooming for both 100 GHz and 50 GHz operation. For every node shown, functional block diagrams shall be provided to show the traffic flow as per wavelength allocation plan.

8.1.2 The supplier's solution shall support both 1 x 9 or 9 x 1 and 1 x 4 or 4 x 1 WSS type ROADM for different node application scenarios.

8.1.3 The equipment shall provide fully flexible transponder access with reference to coloured (position–sensitive) and colourless add/drop (for 2-way and mesh architectures).

8.1.4 The solution shall provide colourless access in a coherent system and there shall be no limitations arising from wavelength access blocking, additional amplification requirements, wavelengths add/drop density per board and slots occupation.

8.1.5 The solution shall offer remote NMS reconfiguration, 40/80ch reconfiguration with access to all channels and switching between common port and switched ports.

8.1.6 The hitless operation of wavelength switching from pass-through to add/drop (i.e. no "scanning" of beam across intermediate ports) shall be supported.

8.1.7 The supplier's solution shall support flexible grid to face up to 400G/1T system.

8.1.8 The flexible grid DWDM shall comply with the definition in ITU-T. The flexible DWDM grid allowed frequency slots have a nominal central frequency as 193.1 + n × 0.00625, where n is a positive or negative integer including 0 and 0.00625. a slot width is defined as 12.5 × m, where m is a positive integer and 12.5 is the slot width granularity in GHz.

8.1.9 The supplier shall provide the evidence of at least 5 commercial deployments of WSS-based ROADM.

9 Integrated Grooming/Switching Architecture

9.1 Electrical layer grooming

9.1.1 The supplier shall have integrated OTN (G.709) switching functionality in the offered WSS/ROADM platform, for lambda translation/interchange. There shall be no wavelength blocking issues and flexible wavelength translation /interchange and regeneration in mesh structures shall be supported. The OTN switch matrix shall support directional flexibility.

9.1.2 The supplier shall detail the capacity of the integrated OTN switch, its granularity, and types of supported OTN tributary /lines cards (O-E-O) used for sub-lambda grooming and aggregation as well as their tuneability support.

9.1.3 The DWDM system shall support 6 level of TCM for transmission quality monitoring and fault locating.

9.1.4 The sub-wavelength cross connect fabric shall be based on ODUk (k=0,1,2,3,4,flex) .

9.1.5 A 4*10G line card that supports ODUk/VC/PKT universal switch shall be provided.

9.1.6 SDH/OTN/Packet traffic shall be aggregated into the same lambda after timeslot adaption to different ODUk channel and ODUk multiplexing

9.2 Switching fabric functional characteristics

9.2.1 The equipment will be equipped with one centralized fabric that performs connections at ODUk level, with k =0, 1, 2, 3, 4, flex, VC-n (n=12, 4) and packet

9.2.2 The switching fabric shall be strictly non-blocking for all the implemented cross connections.

9.2.3 The switching fabric shall support hot backup.

9.2.4 The system control and communication unit shall support hot backup.

9.2.5 The switching fabric shall be able to make cross connections driven by EMS/NMS, control plane and resilient mechanisms.

9.2.6 The switching capacity currently available shall not be less than 3.2T&6.4T in the backbone network and not less than 1.6T in the metro network.

9.2.7 The equipment shall provide an OCh switching fabric.

9.2.8 The OCh switching fabric shall be strictly non-blocking for all implemented types of cross-connections.

9.2.9 The OCh switching fabric shall be able to make cross connections driven by EMS/NMS, control plane and resilient mechanisms.

9.2.10 The Och switching shall support Directionless and Colourless configuration and the vender shall depict the configuration with schematic diagram

9.3 Interface and its characteristics

9.3.1 STM-1, STM-4, STM-16, STM-64 ports shall be structured in VC-4 based on ITU-T G.707 recommendation.

9.3.2 STM-64 interfaces shall comply with ITU-T G.691 recommendation.

9.3.3 There shall be STM-1 optical ports available with removable SFP modules based on ITU-T G.957 recommendation.

9.3.4 There shall be STM-1 electrical ports available based on ITU-T G.703 recommendation.

9.3.5 There shall be STM-4 optical ports available with removable SFP modules based on ITU-T G.957 recommendation.

9.3.6 There shall be STM-1/4 optical ports configurable with removable SFP modules based on ITU-T G.957 recommendation.

9.3.7 There shall be STM-16 optical ports available with SFP modules based on ITU-T G.957 recommendation.

9.3.8 There shall be Fast Ethernet ports available.

9.3.9 There shall be Gbit Ethernet ports available with removable SFP interfaces.

9.3.10 There shall be 10Gbit Ethernet LAN ports available.

9.3.11 Indicate the type of connectors for STM-1/4/16/64 optical interfaces

9.3.12 Indicate the type of connectors of the GE/10GE LAN interfaces.

9.4 Capacity of equipment

9.4.1 The supplier shall specify the maximum number of cards by equipment and the maximum number of ports by card as required in the following layer 1 table:

Tributary Boards:	STM-64	STM-16	STM-4	STM-1 op	STM-1 el.	GE	10GE	Other
Name of the Board								
Maximum nº of cards by equipment								
Maximum nº of ports offered by card								

9.4.2 If the equipment operates with coloured lasers, the supplier shall indicate the operation band in wavelength, or indicate if it operates with tuneable lasers.

9.5 Network Protection

9.5.1 The equipment shall support “Non preemptible unprotected traffic (NUT)”, as defined in G.841recommendation.

9.5.2 It shall be possible to use the SNC/N type protection mechanism at VC-4 level as defined also in G.841 recommendation.

9.5.3 It shall be possible to provide SNC/N protection also to the tributary-to-tributary connections (that is, when the operating and/or protection circuits are routed by STM-N tributaries instead of by STM-64 aggregates.

9.5.4 It shall be possible to protect all tributaries with the sole restriction of not limiting the aggregate capacity.

9.5.5 The "non-intrusive" type sub-network protection (SNC/N), as defined in G.841, shall be able to protect when dealing with the following faults:

i. Server signal fault (AU-AIS, AU-LOP).
ii. "non-equipped" path (AU-UNEQ).
iii. Path identifier incompatibility (HP-TIM).

9.5.6 Path error rate (HP-DEG). It shall be possible to program the error rate causing the protection switching intervention between 10-5 and 10-9 individually for each protected tributary. The definition of each degraded signal based on a consecutive number of degraded seconds (between 2 and 10), as defined in ETS 300-417.1, will also be accepted.

9.5.7 SNC/N protection shall be 1+1 unidirectional (single ended), and it shall be possible to select by software whether it is reversible or not. The protection channel switching criteria, as well as the switching time will be in conformity with G.841 recommendation. The supplier will indicate if there are other types of protection available (e.g. 1:1, bidirectional)

9.5.8 It shall be possible to apply the sub-network protection only to the tributaries desired, and at the time desired (that is, it shall be possible to provide protection to a tributary as well as to remove it at any time). It shall be possible to use the capacity used for protection (when the protection is not equipped) to course traffic. The operation of providing or removing the sub-network protection to a tributary will not cause any type of disturbance in the others (unless the channel that will be used as a tributary protection is occupied by another one, which would obviously be affected).

9.5.9 SNC protection will enable the operating circuit to go through a given interval of time of a VC-4 or an STM-N, and the reserve circuit through a different interval of time to the one used by the operating circuit.

9.5.10 The switching time (starting at the fault condition detection and excluding the hold-off time) shall not exceed 50 ms.

9.5.11 In case of selecting the option of reversible protection using SNC protection, or in case of using the shared protection, it shall be possible to establish a hold-off time for reestablishment (WTR) between 5 and 12 minutes in steps of 1 second, according to

G.841. In case there is a fault in the protection channel during this period, it will immediately return to the service channel without waiting for it to finish.

9.5.12 It shall be possible to use the Drop&continue functionality to provide protection to point-to-multipoint type connections outgoing from different nodes of a ring. In this last case it shall be possible to disable the alarms proceeding from unused inputs.

9.5.13 It shall be possible to use the SNC protection to protect unidirectional circuits, as well as to protect point-to-multipoint circuits. The supplier will indicate if the protection has any limitation for this last case.

9.5.14 It shall be possible that the STM-64 aggregated ports have the multiplexing section protection in conformity with G.841. It shall at least have option 1+1, with the possibility of defining it as unidirectional or bidirectional, and with the possibility of being reversible or not at the operator's choice.

9.6 Synchronisation

9.6.1 The system must support clock recovery from STM-1/4/16/64 interface

9.6.2 The system must support clock recovery from FE/GE/10GE interface.

9.6.3 The system shall support at least two 2MHz interface for external synchronization input and output in conformity with G.703 and G.704 recommendations.

9.6.4 The system shall support at least two 2Mbit/s interface for external synchronization input and output in conformity with G.703 and G.704 recommendations

9.6.5 The system shall support at least two inputs & outputs interface for IEEE 1588V2, please indicate the detail of time synchronization including electrical specification, networking, etc.

9.7 Frequency synchronization based on SDH

9.7.1 Equipment synchronization will be in conformity with ETS 300-417-6, G.781 and G.783.

9.7.2 The equipment shall process the timing markers (byte S1), as defined in G.707, G.781 and in ETS 300 417 recommendations. It shall be possible to enable or disable this mechanism (selecting then references based on their priorities).

9.7.3 When the synchronization reference taken by the equipment fails, they will be capable of switching to another available reference signal. In case of enabling the timing markers, this switching will be performed based on its reference selection algorithm selected among the available references of higher quality and of higher priority. In case of disabling, it shall be based on the priorities assigned. In this last case it shall be possible to select, by software commands, for the switching to be reversible or not.

9.7.4 It shall be possible to establish the reference priorities individually in the equipment and at any time of its useful life by software commands.

9.7.5 Once the synchronization reference 1 is lost, and therefore the equipment is synchronized over another reference or over the internal clock, it shall be possible to program the time (between 0 and 12 minutes in steps of one minute, with value by default of 5 minutes) to return to the same once it is restored.

9.7.6 In case of fault of all references, the equipment will operate with its internal clock, in conformity with ITU-T G.783 and G.813 option 1, and ETS 300 462/5 recommendations.

9.7.7 In the following cases it is considered that the reference signal is faulty, and therefore it shall switch to another one:

i. When synchronization is transmitted to the equipment through STM-N because of: Signal loss, frame loss, MS-AIS reception, J0 regeneration section identifier inequality, or timer marker reception under a determined level (programmable).

ii. When synchronization is transmitted to the equipment through 2 MHz because of: signal loss.

9.8 Synchronous Ethernet

9.8.1 The supplier shall comply to the Synchronous Ethernet standards ITU-T G.8261.

9.8.2 The supplier shall indicate if this function will be soft downloadable, or will require hardware change out.

9.9 IEEE 1588V2

9.9.1 The supplier shall state compliance to IEEE 1588v2 Timing Protocol

9.9.2 The system shall support phase synchronization and frequency synchronization.

9.9.3 The equipment shall support 2 input interface and 2 output interface of Clock signal and Time signal (1588v2) respectively.

9.9.4 The equipment shall support Syn.Eth and 1588V2 transport mode

9.9.5 The supplier shall support 1588V2 when using optical line protection.

9.10 Ethernet Features (Including Layer 2 function)

9.10.1 The system shall support L2 electrical layer switching based on VLAN and MAC Address. It shall support basic Ethernet management, including management of the EPL/EVPL and EPLAN/EVPLAN services.

9.10.2 A Port can be configured to support service multiplexing (VLAN based), using precise segregation fields (e.g. @C-VLAN, S-VLAN, PRI….).

9.10.3 EVPL service shall support C-VLAN ID preservation/translation.

9.10.4 The MTU of packet shall support 64 bytes up to 9600 bytes (Jumbo frame).

9.10.5 The system shall support another S-VLAN (Service VLAN) inserted to extend 4K VLAN IDs range to 4K*4K. It shall support flexible QinQ to resolve data isolation through S-VLAN tunnel for C-VLAN (Customer VLAN) service.

9.10.6 The supplier shall detail end to end QOS for L2 switching, including CAR, COS, 802.1q tag-based traffic classification (such as Port+VLAN, Port+VLAN+Priority etc), congestion scheduling, congestion avoiding, etc.

9.10.7 The system shall support the Ethernet service aggregation from FE/GE to GE, FE/GE to 10GE.

9.10.8 The system shall support IGMP（Internet Group Management Protocol）Snooping V1/V2, which complies with RFC 4541.

9.10.9 The system shall support ETH service OAM 802.1ag and ETH port OAM 802.3ah.

9.10.10 The system shall support OAM defined in ITU-T Y.1731.

9.10.11 The system shall support RMON.

9.10.12 The system shall support Ethernet mapping into ODUk /VC-n/Lambda/Packet.

9.10.13 The system shall support mapping packet frames, VCs and other data carried by OTN server layer from the universal matrix to different sub-wavelength which belongs to a same lambda.

9.10.14 The system shall support link aggregation group with at least 10 member links which member port are in same board, compliant with IEEE 802.1AX

9.10.15 The system shall support link aggregation group with at least 10 member links which can exist on different boards, compliant with IEEE 802.1AX

9.10.16 The multi-chassis link aggregation group (MC-LAG) feature, which enables inter-device link aggregation based on the link aggregation group (LAG) technology and provides dual-homing protection for Ethernet services, compliant with IEEE 802.3ad.

9.10.17 The system shall support replying to the ICMP PING request from other L3 devices (It is also called IP PING function).

9.10.18 The system shall support loopback testing for a specific service and VLAN.

9.10.19 The system shall support packet loss ratio, long time loss ratio, delay, throughput automatically testing base on port or service.

9.10.20 The system shall have the fault notification function in order to notify a fault which occurs between upstream system and external terminal equipment to downstream external terminal equipment when detected by fault notification functions as described in such item:

i. Performing link-down or optical signal shutdown at the port accommodating a UNI logical immediately.

9.10.21 (NMS)The system shall support end-to-end Ethernet service provisioning. The service types must include EPL, EVPL, EPLAN, EVPLAN, both end service type may be different.

9.10.22 (NMS)The system shall support end-to-end Ethernet service troubleshooting.

9.10.23 (NMS)The system shall support automatically configuration OAM along with service provisioning.

9.10.24 (NMS)The system shall support one-touch On-off and performance testing.

10 100G Solution

10.1 100G Modulation Formats Technical Overview

10.1.1 The 100G line interfaces shall support the tuning of the carrier frequency optical module on all the working channels defined in ITU-T Recommendation G.694.1

10.1.2 The equipment shall support single-carrier 100G coherent solution so as to provide minimum total bidirectional capacity of 8T over a pair of fibre.

10.1.3 The equipment 100G coherent shall support DSP arithmetic to compensate the CD and PMD. The supplier shall provide the mean DGD tolerance and the Chromatic Dispersion tolerance of the 100G line interface.

10.1.4 The equipment shall support co-transmission of 100G with 10G lambdas in existing DWDM network.

10.1.5 The service slot for 100G transponder/Muxponder/line board/tributary board shall be universal in the same subrack.

10.2 100G Span Budget

10.2.1 The system shall be able to support mixed operation of 10G/100G line rates sharing the same mux/de-mux hardware as well as be upgradeable in service (without traffic interruption) to carry 100 Gbit/s channels.

10.2.2 The supplier equipment shall support a high performance optical amplifier unit optimized for coherent system.

10.2.3 The supplier shall support 100G transmissions over G.652, G.653 and G.655 LEAF fiber.

10.2.4 The equipment 100G shall be support FOADM and ROADM cascade shall be 12 or more.

10.3 100G OTN Support

10.3.1 The offered system shall support 100G Transponder with 100GE/OTU4 clients and fully C band tune ability

10.3.2 The offered system shall support STM-256/OTU-3 clients mapped into OTU4 and fully C band tune ability.

10.3.3 The offered system shall support 100G TDM Muxponder (10 x 10G) with STM64/OTU-2/10GbE (LAN PHY)/10GbE (WAN)/FC800/FC1200 clients and fully C band tune ability.

10.3.4 The offered system shall support other service, such as STM-1/4/16, GE/FE, FC100/FC200/FC400, FICON, ESCON, FDDI, DVA accessed by one tributary card, multiplexed into OTU4.

10.3.5 The offered system shall support any-rate services such as STM64/OTU-2/10GbE/FC800/FC1200, STM-1/4/16, GE/FE, FC100/FC200/FC400, FICON, ESCON, FDDI, multiplexed into one OTU4 channel.

10.3.6 The 100G line card shall support any mixture of ODUk (K=0,1,2,2e,3,4) granulars multiplexing into ODU4.

10.3.7 The 100G Transponder /TDM Muxponder shall support OTN processing according to ITU-T G.872, G.798 and G.709.

10.3.8 The 100G Muxponder(10 x 10G) shall support a maximum clock tolerance of +/- 20ppm and the eye pattern mask will be compliant to G.691 respectively.

10.3.9 The 100G OTN Line card shall be available, and suppliers shall give the capacity in one Rack(300mm*600mm*2200mm).

10.3.10 The 100G OTN Tributary cards shall be provided to access 100GE/OTU4, which shall be multiplexed into 100G OTN Line card by ODU4.

10.3.11 The OTN tributary card for 10G any access shall be 10*10G any at least in order to be more efficient. And the integration in one Rack shall be offered.

10.3.12 The equipment shall support a mix of different signal rates and formats at the 100G aggregate module inputs/outputs.

10.3.13 The 100G line and tributary boards are integrated in standard subrack, the same as OA, Mux/DMux and other boards.

10.3.14 The 100G line and tributary boards shall be mix with 10G/100G transponder in the same subrack.

10.3.15 The offered system shall support built-in optical monitoring for 100G channel (frequency/power/OSNR per channel).

10.3.16 The supplier shall indicate the number of bidirectional 100G tributary boards that can be installed in a rack of 2.2m.

10.3.17 Loopback on client side shall be available.

10.3.18 The line board shall capable of being used in Regenerator mode.

10.4 100G Roadmap Evolution

10.4.1 The supplier shall describe their 100G strategy evolution up to 2018.

10.5 Metro 100G solution

10.5.1 The supplier shall describe their Metro solution.

10.5.2 The supplier shall support Metro 100G line card and transponder.

10.5.3 The supplier shall support 100G grey lights in line side interconnection and interworking.

11 Operating conditions and mechanical design

11.1 Mechanical Characteristics

11.1.1 The supplier shall detail the size (height-width-depth) of their solution

11.1.2 The supplier shall provide options for a 19 inch sub-rack solution or ETS 300-119 compliant solution.

11.1.3 The supplier shall detail the weight of their solution

11.1.4 The supplier shall describe the number of equipment in each rack as well as the expansion possibilities of the different equipment in the same or in other racks

11.1.5 The slots for DWDM board such as transponder, line board, tributary board, OADM, amplifier, coupler, protection board and etc shall universal in the same sub-rack.

11.1.6 The service slot shall be universal to SDH/OTN/WDM/Ethernet board.

11.1.7 The supplier shall indicate the standards met by their solution

11.1.8 The supplier shall indicate the average and maximum power consumption of their solution at normal working conditions

11.1.9 The supplier shall detail the power consumption per each element/card of their solution.

11.1.10 The supplier shall indicate the supply voltages characteristics of their solution

11.2 Electromagnetic Compatibility (EMC)

11.2.1 The supplier shall list the EMC standards met by their solution

11.3 Temperature and humidity range.

11.3.1 All equipment specified shall be capable of operating normally in the temperature range -5 to 40 °C

11.3.2 All equipment specified shall be capable of being stored without impact to performance in the temperature: -20 to 70 °C

11.3.3 All equipment specified shall be capable of an operating normally in the humidity range: 20 to 95% non-condensing

11.3.4 The supplier shall indicate the standards met by their solution

11.3.5 The supplier shall indicate the normal storage conditions of their equipment

11.4 Fan / Dust Filters.

11.4.1 The supplier shall describe the ventilation elements like fans, coolers, filters, fan alarms of their solution.

11.5 Related Standards

11.5.1 The Supplier shall state their compliance with regards to:

i. IEC 60825 (Optical Safety):
ii. ETSI 300-019-1-3 (Climatic):
iii. ETSI 300-019-1-2 (Transport):
iv. ETSI 300-019-1-1 (Storage):
v. IEC 60950 Safety of Information Technology equipment
vi. EN 300-386-2000 Electromagnetic compatibility and Radio spectrum Matters (ERM), telecommunication network equipment, EMC requirements
vii. ETS 300-753 Acoustic noise emitted by telecommunications equipment

12 Network Reference

12.1 Supplier shall submit at least TEN ASON based DWDM network references, which shall be installed and with live traffic with the Network restoration feature being implemented.

12.2 Supplier shall provide at least TEN coherent 100G commercial references and field trials with tier 1 operator.

13 Installation

13.1 The Supplier shall be responsible for a full installation of all equipment on site which includes mounting into the racks, cabling in MDF, power cabling etc and if required installation of rectifiers, DB, batteries, etc as a turnkey solution.

13.2 The supplier shall be responsible for full configuration of all protocols, features and options thereby providing optimal performance of system, preserve processing resources and implement all relevant security standards and protection mechanisms related to deployment scenario.

13.3 The supplier shall as part of the project fully integrate their solution into SEC existing systems, from network to applications level (supporting existing products and services)

13.4 The supplier shall be responsible for the installation and/or integration of a Network Management System, including configuration and integration of all network elements included in the solution into NMS. NMS shall provide full functionality for Fault Management, Topology Map, Configuration, Performance and Security Management. Performance and Fault management will be based on SEC recommendations and inputs from the supplier's experience. Supplier shall provide list of all counters and alarms that the equipment supports.

13.5 The supplier shall be responsible for the integration of FM (alarms and traps) into existing OSS for all proposed components through central management node.

13.6 The supplier shall be responsible for the configuration of all components in a legible manner thereby providing templates for plug and play of all services

13.7 The supplier shall be responsible for detailed as built documentation covering all aspects of the installation and detailed operational procedures.

14 Testing and inspection

14.1 The Supplier shall perform full functional tests, including verifying the establishment of stable and quality connections end to end

14.2 All tests shall perform all tests in the presence of SEC designated witnesses

14.3 Provisional Acceptance Test (PAT) and Final Acceptance Test (FAT) procedures must be documented and network acceptance will be performed based on the proposed tests and validated against the expected results.

14.4 Supplier shall assist with the development of user acceptance test plans and acceptance criteria for approval by SEC.

14.5 Supplier shall assist SEC to develop and document test cases for user acceptance testing.

14.6 Supplier shall assist SEC to coordinate user acceptance testing, including identification and support for all Authorized Users participating in the testing.

14.7 Supplier shall perform the Acceptance Testing operation, including project management, test planning, design and execution. All process are designed to fully address the business requirements and match SEC customer needs

14.8 Prior to SEC UAT, the Supplier will certify that it has completed internal testing on the entire solution and that all software delivered for UAT shall be free of defects and pass the same tests when administered by SEC staff.

14.9 The Supplier is required to perform the tests for the system to demonstrate the Acceptance Test Procedure KPIs.

14.10 The acceptance test scenarios shall aim to simulate the real live processes. A major part of this complexity will be derived from the data. Therefore, the AT shall be executed with production data, not synthetic data.

14.11 Supplier shall ensure all important aspects are ready for the UAT execution stage. This shall be done according to a checklist with pre-defined quality gates. This checklist will be finalized in consultation with SEC during the AT-Plan phase.

14.12 Manage and control the changes in the contents of the environments: The tested software, interfaces, reference data, and business data.

14.13 The Test Execution phase shall contain few rounds, depending on the system scope. Each round may have a different scope. Test Scenarios are to be executed in parallel on multiple UAT environments, in order to be efficient and monitor progress in several areas.

14.14 The entire Acceptance Test scope shall include new functionality, regression, defects, interfaces, business processes, and non-functional testing.

14.15 Prior to PAT, the Supplier shall handover all documentation as may be required by SEC, including as-built diagrams and O&M documentation