Template for submitting comments/inputs in respect of Draft Standard

(Draft standard No. TEC 86090:2026)

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Organization:

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Clause No.	Clause	Comments	Other Remarks, if any

Note: The comments/inputs on the draft Standard (Draft Standard No. TEC 86090:2026) may be provided in the above format vide email to **dirt2-tec-dot@gov.in** , **adet-tx-tec-dot@gov.in** and **ratx.tec-dot@nic.in**

सत्यमेव जयते

वर्गीय अपेक्षाओं के लिए मानक

टीईसी ८६००:२०२६(DRAFT)

(सं: टीईसी/जीआर/टीएक्स/ओटीएन-००१/०२/दिसम्बर-१७ को अधिक्रमित करता है)

STANDARD FOR GENERIC REQUIREMENTS

No.: TEC 86090:2026 (DRAFT)

(Supersede No. TEC/GR/TX/OTN-001/02/DEC-17)

मेट्रो और कोर नेटवर्क अनुप्रयोग के लिए डीडब्लूडीएम बेयरर ट्रांसपोर्ट सिस्टम के साथ बहु-सेवा ऑप्टिकल ट्रांसपोर्ट नेटवर्क (ओटीएन) प्लेटफार्म के लिए सामान्य आवश्यकताऐं

Multi-Service Optical Transport Network (OTN) Platform with DWDM Bearer Transport System for Metro and Core Network Application

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र

खुर्शीदलाल भवन, जनपथ, नई दिल्ली–११०००१, भारत

TELECOMMUNICATION ENGINEERING CENTRE

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FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of TEC Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements & Standard document of TEC for Telecom Products and Services
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE)
- Field evaluation of Telecom Products and Systems
- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centers (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

ABSTRACT

This document pertains to Standard for Generic Requirements for a Multi-Service Optical Transport Network (OTN) platform for applications in the metro as well as core domains of the Indian telecom networks. The equipment shall be able to converge all legacy as well as new client interfaces and map them to OTN based signals using ODU-k switching, grooming, consolidation and multiplexing. Finally, these OTN signals shall be transported through a pair of fibre using DWDM technique. The equipment shall, therefore, consist of two parts – OTN adaptation and switching and DWDM transport. The OTN part of the equipment shall interface various kinds of legacy & new client optical signals. These signals shall first be converted into electrical signals, map them to OTN

frame format standardized as per G.709, Cross-connected with ODU-k switching, groomed, consolidated, multiplexed and thereafter the colored OTN line signals shall be introduced to the DWDM Mux De-Mux for onward transmission. The OTN part of the equipment shall provide 40 / 80 or optionally 96 wavelengths carrying OTN signals. The Dense Wavelength Division Multiplexing (DWDM) Optical Line System (OLS) shall consist of DWDM Mux De-Mux, booster amplifier, pre-amplifier etc. which shall operate at discrete wavelengths in the C-band centered around 193.1 THz frequency as per ITU-T Rec. G.694.1 grid, at 100 /75/ 50 GHz/flexible grid channel spacing as the case may be. The DWDM system shall support transmission of 40/80 or optionally 96 wavelengths channels comprising of OTU-4/OTUCn per channel in the C-band.

CONTENTS

HISTORY SHEET

Sl. No.	*GR No.*	*Particulars*	*Remarks*
1.	TEC/GR/TX/OTN-001/01/MAR-13	Generic Requirements for Multi-service Optical Transport Network (OTN) platform with DWDM bearer transport system for Metro and Core Network Applications.	Release-1
2.	TEC/GR/TX/OTN-001/02/DEC-17	Generic Requirements for Multi-service Optical Transport Network (OTN) platform with DWDM bearer transport system for Metro and Core Network Applications.	Release-2 -Revised as per the latest template to incorporate latest standards and the upgradation of technology.

REFERENCES

S.No	*Document No.*	*Title/Document Name*
1.	ITU-T Rec.G.652	Characteristics of a single-mode optical fibre and cable
2.	ITU-T Rec.G.655	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
3.	ITU-T Rec.G.664	Optical safety procedures and requirements for optical transport systems
4.	ITU-T Rec.G.691	Optical Interfaces for single channel STM-64, STM- 256 systems and other SDH systems with optical amplifiers.
5.	ITU-T Rec.G.692	Optical interfaces for multichannel systems with optical amplifiers
6.	ITU-T Rec.G.694.1	Spectral grids for WDM applications: DWDM frequency grid
7.	ITU-T Rec.G.697	Optical monitoring for DWDM systems
8.	ITU-T Rec.G.707	Network node interface for the synchronous digital hierarchy (SDH).
9.	ITU-T Rec.G.709	Network node interface for the Optical Transport Network hierarchy (OTN).
10.	ITU-T Rec.G.783	Characteristics of SDH equipment functional blocks.
11.	ITU-T Rec.G.798	Characteristics of optical transport network hierarchy equipment functional blocks
12.	ITU-T Rec.G.806	Characteristics of transport equipment – Description methodology and generic functionality
13.	ITU-T Rec.G.825	The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)
14.	ITU-T Rec.G.828	Error performance parameters and objectives for international, constant bit rate synchronous digital paths
15.	ITU-T Rec.G.872	Architecture of optical transport networks
16.	ITU-T Rec.G.957	Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.
17.	ITU-T Rec.G.959.1	Optical transport network physical layer interfaces

18.	ITU-T Rec.G.975.1	Forward error correction for high bit-rate DWDM submarine systems
19.	ITU-T Rec.G.7713	Distributed call and connection management (DCM)
20.	ITU-T Rec.G.7714	Generalized automatic discovery techniques
21.	ITU-T Rec.G.7715	Architecture and requirements for routing in the automatically switched optical networks
22.	ITU-T Rec.G.7718	Framework of ASON Management
23.	ITU-T Rec.G.8201	Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)
24.	ITU-T Rec. G.8251	Control of jitter and wander within digital networks which are based on OTN hierarchy.
25.	ITU-T Rec. G.8080/Y.1304	Architecture for the automatically switched optical network (ASON)
26.	ITU-T Rec.M.3010	TMN conformance and TMN compliance.
27.	ITU-T Rec.M.3100	Generic network information model
28.	IEEE 802.3	IEEE Ethernet standards series
29.	IEEE 802.3ae	Media Access Control (MAC)Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation
30.	IEEE 802.3ah	Ethernet link aggregation standard
31.	IETF RFC 2544	Benchmarking for IP/Ethernet devices
32.	TMF-513	Multi-Technology Network Management Business Agreement
33.	TMF-608	Multi-Technology Network Management Information Agreement
34.	TMF-814	TM Forum MTNM Implementation Statement (IS) Template and Guidelines
35.	IS 8437 {1993}	Guide on the effects of current passing through the human body
36.	IS 13252 {1993}	Safety of information technology equipment including electrical business equipment
37.	CISPR 32 {2015}	Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment
38.	IEC-60825-1	Optical safety requirements

39.	IEC-62368-1:2023	Audio/video, information and communication technology Equipment- Part 1: Safety Requirements.
40.	IEC Publication 61000-4-2	Testing and measurement techniques of Electrostatic discharge immunity test
41.	IEC Publication 61000-4-3	Testing and measurement techniques-Radiated RF Electromagnetic Field Immunity test
42.	IEC Publication 61000-4-4	Testing and measurement techniques of electrical fast transients/burst immunity test
43.	IEC Publication 61000-4-5	Testing & Measurement techniques for Surge immunity test
44.	IEC Publication 61000-4-6	Immunity to conducted disturbances
45.	IEC Publication 61000-4-11	Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any)
New Standard	IEC Publication 61000-4-29	Immunity to voltage dips & short interruptions (applicable to only DC power input ports, if any)
50.	QM-333 or TEC 14016:2010	Specification for environmental testing of electronic equipment for transmission and switching use

Note: The ITU-T/CISPR/IEC/EN etc. standards and recommendations referred to in this document shall imply their latest versions.

CHAPTER-1

1.0 Introduction

This document describes the generic requirements for a Multi-Service Optical Transport Network (OTN) platform for applications in the metro as well as core domains of the Indian telecom networks. The equipment shall be able to converge all legacy as well as new client interfaces and map them to OTN based signals using ODU-k switching, grooming, consolidation and multiplexing. Finally, these OTN signals shall be transported through a pair of fibre using DWDM technique. The equipment shall, therefore, consist of two parts – OTN adaptation and switching and DWDM transport. The OTN part of the equipment shall interface various kinds of legacy & new client optical signals. These signals shall first be converted into electrical signals, map them to OTN frame format standardized as per G.709, Cross-connected with ODU-k switching, groomed, consolidated, multiplexed and thereafter the colored OTN line signals shall be introduced to the DWDM Mux De-Mux for onward transmission. The OTN part of the equipment shall provide 40 / 80/ 96 wavelengths carrying OTN signals. The Dense Wavelength Division Multiplexing (DWDM) Optical Line System (OLS) shall consist of DWDM Mux De-Mux, booster amplifier, pre-amplifier etc. which shall operate at discrete wavelengths in the C-band centered around 193.1 THz frequency as per ITU-T Rec. G.694.1 grid, at fixed grid of 100 /75/ 50 GHz channel spacing or in flexible grid design at nx6.25/12.5GHz(where “n” is the number of slices to define per channel spectral width) . The DWDM system shall support transmission of 40 / 80/ 96 wavelengths channels comprising OTU-4/OTUCn channel in the C-band.

Note: The requirement of 96 channels is optional and may be decided by the purchaser or user.

The Multi-Service OTN Platform shall enable service provisioning and re-provisioning using remote reconfigurability of WSS (Wavelength Selective

Switch) based ROADM (Reconfigurable Optical Add Drop Mux). This Platform shall also support for ASON/GMPLS based Control plane at different layers including OTN & Wavelengths to achieve intelligent functioning.

The system shall support a combination of client interfaces at different rates i.e. STM-1, STM-4, STM-16, STM-64, OTU1, OTU2, OTU2e, OTU3, , OTU4, ODUflex, Gigabit Ethernet (as per IEEE 802.3 and 802.3ah) and 10G Ethernet LAN and WAN PHY as per IEEE 803.3ae, 40GE, 100GE, SAN based Fibre Channel services, Video Services etc. The IO cards shall interface various combinations of the aforementioned interfaces which shall be mapped to ODU-k (k=0, 1, 2, 2e, 3, , 4, flex etc.) depending upon the bandwidth of the individual interfaces. These ODU-k shall be cross-connected and groomed for consolidation to the OTN line signals @ OTU-4/OTUCn. The line signals shall be colored OTN signals and shall be fed to the DWDM Mux De-Mux block without using the transponder or muxponder.

NOTE: STM-1 , STM-4 and STM-16 interfaces on client side are optional and may be decided by the purchaser.

2.0 Equipment architectural model

The equipment shall consist of two parts - OTN multi-service platform and DWDM bearer transport functions.

The OTN multi-service platform shall consist of:

a. Client signal interface modules,
b. OTN unified bearer layer, including the ODUk interface adapter processing,
c. OTN cross-connect switch module consisting ODUk cross-connect switch matrix,
d. OTUk line interface processing module which shall carry out functionalities like optical conversion, coloring the wave, FEC

codification, coherent detection etc.

The DWDM optical transport shall consist of:

a. Optical multiplex section (OMS) consisting of Mux and De-Mux blocks,

b. DWDM bandwidth transport layer consisting of Optical Transmission Section (OTS) processing module having booster and pre-amplifier.

A schematic diagram of OTN multi-service platform is given in Figure-1 below. It shall support Multi–service unified control plane, according to different services.

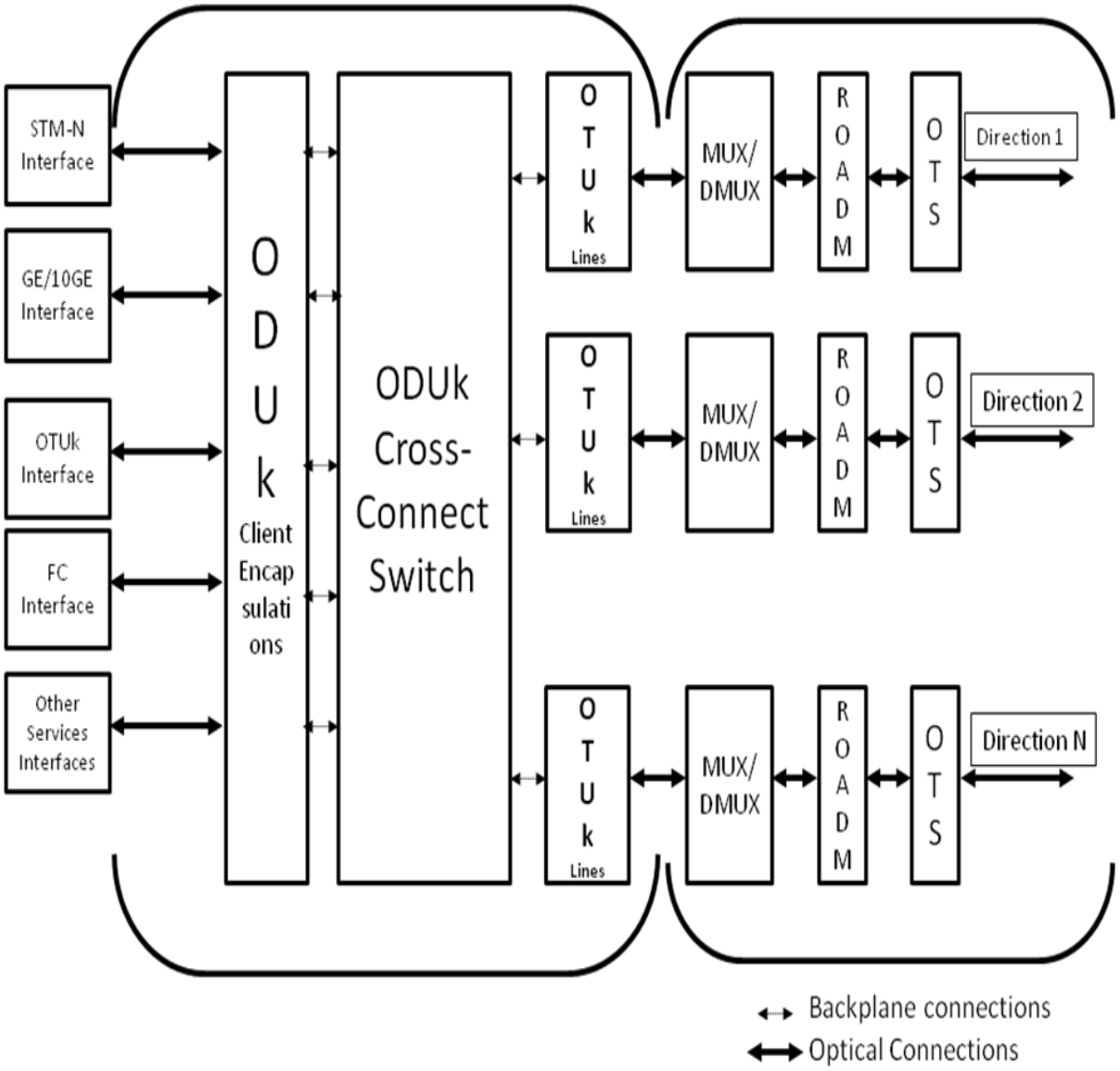

Fig 1: OTN Multi-Service bearer node based on a Single Platform Architecture Functional Model Diagram

2.1 Network topologies:

It shall be possible to configure the equipment to implement various Network Topologies as detailed below:

1)

2) Linear-chain,

3) Ring and

4) Mesh.

Two-fibre application i.e., one dedicated fibre for transmit-direction and one for receive-direction is envisaged for all network applications as mentioned above.

2.1.1

2.1.2 Linear add-drop topology

The reference model for linear add-drop topology is outlined in Figure-2 below:

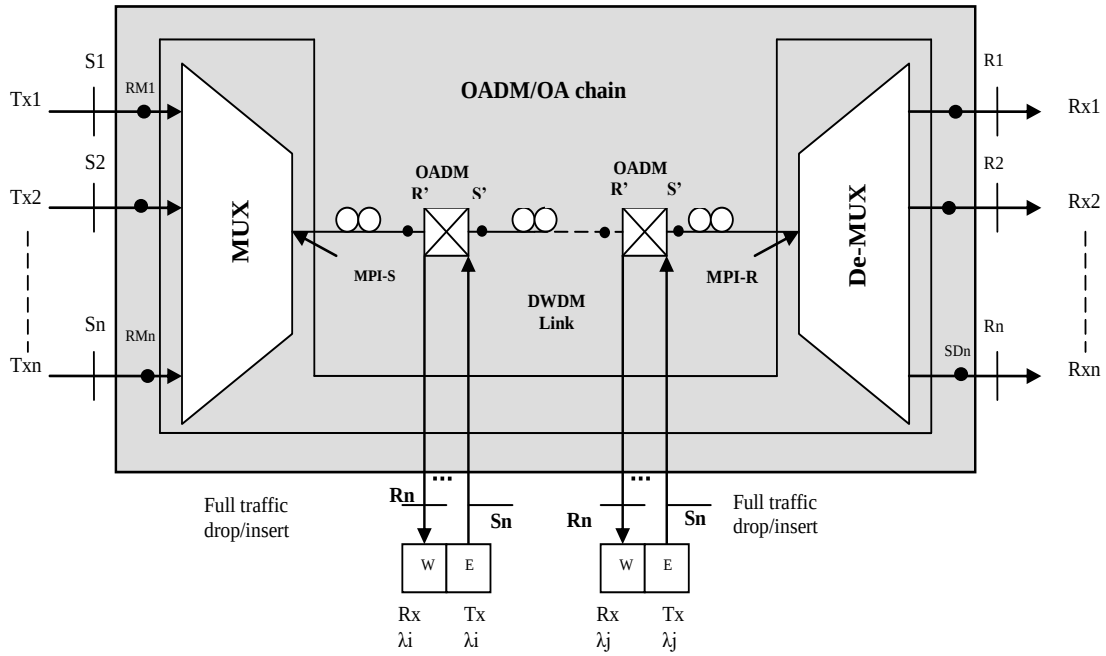

Fig. 2: Reference Diagram for DWDM Linear-chain link

The DWDM equipment in linear-chain shall be able to carry a maximum traffic of 40 channels, on a fibre-pair with one fibre each for 'East-Bound'

and ‘West-Bound’ direction. A pre-configured drop & insert facility, as defined later in the document, at any intermediate OADM node shall be possible. The DWDM system shall provide channel re-use in subsequent spans, after termination of a wavelength at an intermediate OADM node.

There shall be implementation of proper mechanism to combat OSNR penalties incurred due to continued channel add/drops of same wavelengths in subsequent spans at enroute ROADMs. The equipment shall provide a migration path from linear add/drop topology to two-fibre DWDM ring structure. Traffic shall be protected at client layer by using 1+1 Optical Sub-Network Connection protection (transponder protection envisaged). Separate fibre-pair shall be used for protection path.

2.1.3 Two-fibre DWDM ring:

The two-fibre ring network is closed two-fiber ring topology.

2.1.3.1 Closed two-fibre ring

The schematic of closed two-fibre DWDM ring architecture with distributed traffic patterns between nodes is given in Figure-4. Traffic shall be protected at client layer by using 1+1 Optical Sub-Network Connection protection (transponder protection envisaged). The network shall support termination of node to node traffic providing channel reuse feature.

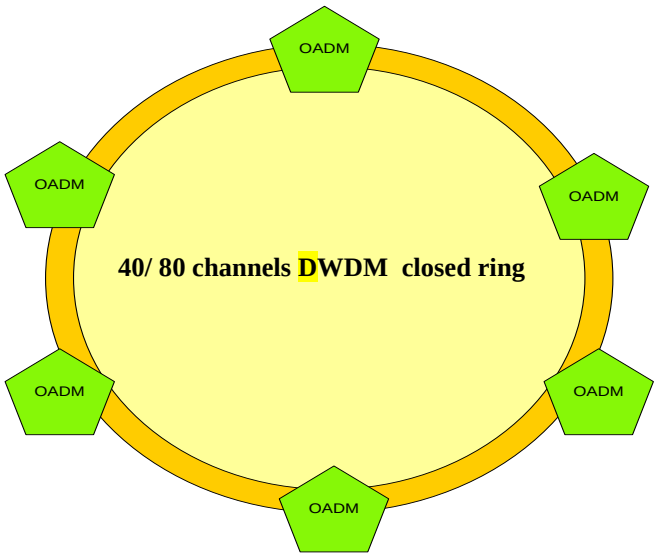

Figure-4: Reference diagram for an Internode DWDM ring.

2.1.4 Mesh topology

The schematic of a two-fibre DWDM mesh architecture is given in Figure-5. Traffic shall be protected at client layer by using 1+1 Optical Sub-Network Connection protection as well as by the implementation of Automatic Switched Optical Network (ASON). The network shall support termination of node to node traffic providing channel reuse feature. The architecture of ASON shall be as per Cl.12.0 and the ASON operation planning tool shall be as per Appendix-II of this document.

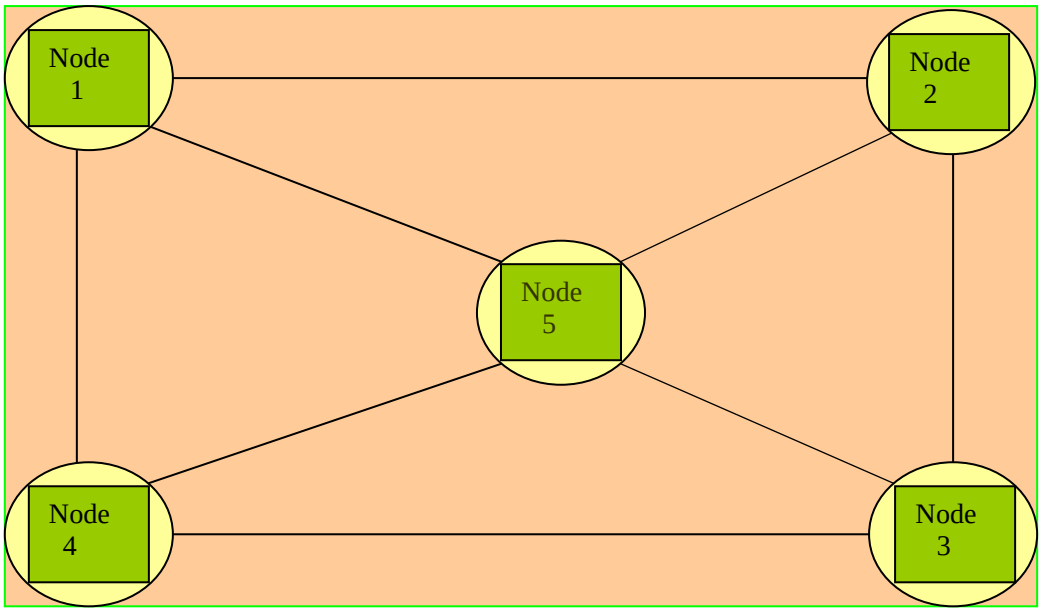

Figure-5: Reference diagram for a OTN mesh architecture

3.0 Functional requirements

3.1 Service interface module of the equipment shall provide SDH, Ethernet, FC, standard OTN interfaces, other various service interfaces, Packet services NNI interface to connect to other OTN equipment.

3.2 The ODUk interface adaptation processing module shall map the multi-service signals to the ODUk (k = 0,1,2,2e,, 4, flex frame format).

3.3 OTUk line interface processing module shall provide ODUk (k = 0,1,2,2e, ,

4 and flex) signal to OTUk (k = 4)/OTUCn colored line interfaces.

3.4 The ODUk cross-connect module shall be able to perform x-connections at ODUk (k = 0, 1, 2, 2e, 3, 4 and flex).

3.5 The Optical Channel Layer shall perform Optical Channel connection routing, processing of the Optical Channel overhead, Optical Channel supervisory functions & wavelength conversion.

3.6 In case of ROADM, OCh cross-connect functional modules shall support for multi-directional wavelength switching with remote configurability.

3.7 The Optical Multiplex section processing module or the DWDM multiplexer shall multiplex optical channels in the wavelength multiplexing / demultiplexing subsystem.

3.8 The equipment shall support multi-layer protection mechanism. It shall support SNCP protection at both ODUk and Och layers.

3.9 ASON/GMPLS control plane shall support automatic creation, discovery and recovery of the ODUk and Och channels.

3.10 The cross-connections within the switch matrix shall be done at ODUk level, irrespective of nature of payloads at the client interfaces. The control processor unit, cross connect switch matrix, timing circuitry and power supply shall be redundant. Expansion shelf, when required, shall house the IO cards and controller/power supply. The switching fabric shall support the redundancy of N:1.

3.11 The equipment shall support the state of art technologies such as ASON/G.8080 and GMPLS. The ASON, which is client independent, shall provide optical transport network with dynamic connection capability. It shall also provide added facilities such as Traffic engineering of optical channels, Mesh network topologies and restoration, Managed bandwidth to core IP connectivity and introduction of new optical services.

3.12 The hot-swapping of a card/unit shall not affect working of any other

tributaries / modules. Hot-swapping capability shall be provided for all cards/units except the power supply unit. No EMS notification or system setting shall be required for extraction or insertion of any unit/card.

3.13 It shall be possible to configure the network as fully protected, partially protected or un-protected as per details mentioned in clause 12.14.

3.14 The power-supply failure/EMS server break-down/ bugs in the software shall not affect the current cross-connection map. The removal/replacement of any unit shall also not affect the existing connection-map. No reconfiguration shall be called for against this action. The equipment shall restore back the existing connection-map, as configured in the pre-failure condition, upon clearance of the afore-mentioned faults.

3.15 The equipment shall include fully redundant non-volatile memory which shall facilitate cross-connection map configuration, as existent immediately prior to any system-failure, to be acquired back once the fault is cleared. Automatic switch-over to the redundant memory shall take place when detection of failure in the active memory occurs. It shall also be possible for the user to take-over the switching action manually.

3.16 The equipment shall support Automatic Switched Optical Network (ASON) and Generalized Multi-Protocol Label Switching (GMPLS) and shall be Optical Internetworking Forum (OIF) complaint. ASON/G.8080 is client independent transport network enriched with Control Plane. The purpose of control plane is to facilitate fast restoration and efficient configuration of connection in OTN (ITU-T G.872) environment. The ASON shall provide circuit switching capabilities, whereas the GMPLS with unified signaling and integrated routing approach shall provide for resource provisioning recovery and control-plane optimization.

3.17 The ASON/G.8080 control plane shall perform many functions such as neighbor (adjacency) discovery, resource discovery, service discovery, protocol control, link resource management, routing control, signaling,

connection control and call control. The GMPLS with ASON network architecture referred to as vertical networking, the nodes shall host multiple switching layers and shall be controlled by a single control plane.

3.18 The ASON shall support different connection type viz. permanent connection, soft permanent connections. Since interoperability between the equipment of different vendors is still a concern, switched connection may be optional to the purchaser.

3.19 Grooming & Consolidation:

The ODUk cross-connect in the equipment shall provide traffic grooming & consolidation. Grooming is the re-organization of incoming traffic from different links destined for a common destination, over links assigned for this traffic destination. Consolidation means re-organizing traffic from lightly-loaded links on to fewer, high-speed links for a better system-fill and efficient system capacity utilization.

3.20 The system shall support a set of optical cards that when equipped in a specific configuration shall allow the system to function as an Optical Terminal Multiplexer (OTM), Reconfigurable Optical Add/Drop Multiplexer (ROADM) or In-Line Amplifier (ILA).

3.21 The system shall support various topologies such as, linear add/drop, mesh and shall also support closed ring. The network protection shall be available as per the details given later in the document.

3.22 The DWDM system shall work in unidirectional mode of operation for all network topologies using dedicated separate fibres for ‘TX’ and ‘RX’ directions in terrestrial Longhaul and Very Longhaul networks with or without In-Line Amplifiers (ILA) as per network requirements. The DWDM link shall support spans for long haul and very long haul applications deploying In Line Amplifiers and FOADMs/ ROADMs or a combination thereof for various span-budget specifications as mentioned later in the GR.

Since the no. of spans varies depending upon the type of equipment used, the purchaser, if so desires, may also ask the vendors to carry out the complete network planning on the basis of the network information provided by the purchaser.

3.23 The Booster Amplifier and Pre-Amplifier (optical amplifiers) shall be an integral part of DWDM Terminals, as well as ILAs, FOADMs and ROADMs. The DWDM system design shall be such that it implements wavelength reuse after dropping a particular channel at a node. There shall be no restriction on the reuse of particular added/dropped channel, e.g. the same channel can be dropped and reinserted at all the ROADM nodes of a link. Any insertion-loss incurred in channel add/drop process and dispersion compensation shall be compensated by the system only.

3.24 The system shall comply with ITU-T Recs. G.709 and G.959.1 in relation to optical transport network (OTN) specifications including support for OTU-4/OTUCn frame format on the line side. In order to maintain transparency and supervision capability of client services in accordance with ITU-T Rec. G.709, all client services shall be supervised by processing out DU/OTU overhead bytes. At least path monitoring and section monitoring shall be supported. The equipment shall support Forward Error Correction (FEC) in accordance with ITU-T Rec. G.709 in the optical budget of the equipment and the same shall be a part of the network planning. It shall also support and implement HD-FEC (Hard Decision FEC) (Optional) as well as SD-FEC (Soft Decision FEC). The system shall be provided with the FEC enable/disable facility through LCT/EMS.

The equipment shall support super-FEC to provide higher performance. The equipment is expected to give 8 dB or better net coding gain at 10^{-12} output BER.

NOTE: HD-FEC compliance is optional and to be decided by the purchaser.

3.25 The fibre-media as stipulated in this document shall be compliant to ITU-T Rec. G.652D/ITU-T Rec. G.657A single-mode optical fibre and ITU-T Rec. G.655 NZ-DSF fibre.

3.26 The equipment shall support coherent detection to aid polarization separation and phase resolution and to clean up the effects of chromatic and polarization-mode dispersion. The electro-optics with coherent technology shall use DSP algorithms to facilitate polarization separation and phase resolution and clean up the effects of chromatic and polarization mode dispersion. This improves signal propagation and provides fast wavelength reconfiguration when restoration is required. Dispersion Compensation Modules (DCM), however, shall not be used in any of the Amplifiers. In case the purchaser requires the link engineering support/link engineering exercise, the manufacturer shall provide such support using link planning/design tools or any other method.

3.27 The manufacturer shall supply entire common hardware including ROADM Mux / Demux, Coherent Channel System and embedded control & management software etc. for 40 / 80/ 96 channels OTU-4/OTUCn DWDM system on day one. The system shall hitlessly upgrade in field to 40 / 80/ 96 channels @ OTU-4/OTUCn through insertion of IO cards followed by necessary cross connection and mapping functions.

Note: The requirement of 96 channels is optional and may be decided by the purchaser or user.

3.28 The Booster Amplifier and Pre-Amplifier (Optical Amplifier) shall be the integral part of OTMs, ILAs, FOADMs and ROADMs.

3.29 The equipment shall support the optical monitoring as specified in ITU-T Rec. G.697 through EMS of the equipment at all nodes (ILA, OTM, FOADM and ROADM).

3.30 The removal/insertion of any card including the redundant one shall not disturb the working of the system or deteriorate the BER of the other

working channels in the system.

3.31 To accurately simulate the performance of the offered equipment under end of life conditions (i.e. equipment with aged components operating at full capacity over aged fibre) and ensure successful transmission at OTU-4/OTUCn per channel over high loss optical fibre, a comprehensive network planning tool shall be supported. The tool may be standalone or may be integrated in to EMS. The tool shall, among others, perform the following analysis and recommend the most suitable hardware components as well as settings (i.e. optical power, gain) to mitigate the limiting effects:

a. Attenuation (including optical fibre loss, system component loss and margins),
b. Chromatic dispersion (including required residual dispersion),
c. Polarization mode dispersion (including contribution from both optical fiber and system components),
d. Optical signal to noise ratio (OSNR)
e. Non-linear effects(inc. XPM, SPM, FWM and SRS) (optional)

3.32 The terminations for the unused channels shall be provided by the manufacturer as a part of the system. It shall be possible to equip the unused channel at a later date without affecting the existing traffic.

3.33 The system shall support one Optical Supervisory Channel (OSC) as specified by ITU-T Rec. G.692 for the monitoring and configuration of OTM, ILA, F/ROADM on the route and shall be manageable from one location for the entire route via the EMS or LCT of the equipment. All OSC related functions including transmission, termination and processing shall be integrated within a single card; separate cards for OSC extraction, OSC insertion and OSC processing are not allowed to avoid slot wastage. The OSC channel shall be provided at 1510nm wavelength and shall have a capacity of at least 2 Mbps. The OSC transmitter and receiver behavior at the Inline Amplifier/Booster/Pre-Amp shall be monitored through EMS via suitable alarms.

The OSC shall be accessible at all the ILAs and OADM sites, in addition to the terminal sites.

It shall be required that OSC channel shall provide access to underlying DCC at Ethernet interface making possible to transport management information to other nodes through extended DCN. OSC is also used to transmit alarm information and consequently locating failures. If a card in a node fails, the alarm is written on the DCC of the OSC with the corresponding address of the “Smallest Replaceable Unit” failed. The information is propagated through the network carried by the DCC until it reaches the gateway to the EMS.

NOTE 1: The attenuation of the OSC hybrid possibly used to access the OSC is not part of the optical path power-budget.

NOTE 2: The OSC channel shall not consume any of the 40/80 traffic wavelengths.

3.33.1 Supervisory parameters:

The supervisory system of the equipment shall be capable of local & remote monitoring the following of the Local and Remote equipment:

1. Input power of the Booster Amplifier
2. Output power of the Booster Amplifier
3. Laser temperature of the Booster Amplifier(Optional)
4. Input power of the pre-amplifier
5. Output power of the pre-amplifier
6. Laser temperature of pre-amplifier(Optional)
7. Input power of the Optical Line Amplifier
8. Output power of the Optical Line Amplifier
9. Laser temperature of the Optical Line Amplifier(Optional)
10. Output power of the Dropped Channel
11. Input power of the individual optical channel
12. Input power of the Optical Supervisory Channel (optional)
13. Output power of the Optical Supervisory Channel (optional)
14. Laser temperature or Laser-Bias current of the Optical Supervisory Channel(Optional)

15. Bit error ratio (BER) before FEC at line interface
16. Fan failure at ROADM/ILA/OTM.
17. ODU/OPU alarms as per the list given below as per G.709.

    TCM Facility alarms

    • ODU AIS
    • ODU LCK
    • ODU OCI
    • ODU BDI
    • ODU Trace Identifier Mismatch
    • ODU Signal Degrade
    • TCM Loss of Tandem Connection
    - ODUCTP alarms
    • ODU Signal Fail (monitor or terminate modes)
    • ODU AIS
    • ODU LCK
    • ODU OCI
    • ODU BDI
    • ODU Loss of Frame and Multiframe
    • ODU Signal Degrade
    - ODUTTP alarms
    • ODU AIS
    • ODU LCK
    • ODU OCI
    • ODU BDI
    • ODU Trace Identifier Mismatch
    • OPU Payload Type Mismatch
    • ODU Loss of Frame and Multiframe
    • ODU Signal Degrade

The supervisory parameters shall be monitored and on crossing the specified limits an alarm shall be activated against each parameter listed as above. On the basis of nature of alarm, it shall be possible to mark it as Critical, Non-urgent and Deferred.

The measurement accuracy of input/output power of the Booster/In-Line Amplifier/ Pre-Amplifier from the EMS of the system shall be within ±1.0 dB from the actual measured value on a wide-band Optical Power Meter.

The supervisory system shall provide necessary audio/visual alarm on equipment for indicating the alarms. Also from the EMS of the system it shall be possible to locate the faulty-section in the case the fibre is cut.

To maintain transparency and supervision capability of client services in accordance with ITU-T Rec. G.709, all client services shall be supervised by processing the ODU/OTU overhead bytes. At least path monitoring (PM) and section monitoring (SM) shall be supported.

3.34 The system shall provide software controlled Optical Pre-emphasis via Variable Optical Attenuators (VOA) which provides for a capability to adjust the optical power per channel via the LCT/EMS. The optical power per channel must be adjusted automatically in case the DWDM equipment is equipped with a power monitoring unit.

3.35 The output jitter and input jitter tolerance at the optical channels shall be as per ITU-T Rec. G.825 & G.783 for SDH and as per IEEE 802.3 standards for Ethernet client signals. The jitter and wander within digital networks which are based on OTN hierarchy shall be as per ITU-T Rec.G.8251.

3.36 The optical amplifiers must implement the following mechanisms to maintain error free system operation under dynamic conditions:
Fast gain control loop: to protect against short term transient conditions such as sudden loss of channels.
Slow output power control loop: to protect against long term conditions such as fibre aging.

3.37 The equipment shall provide monitoring points for in-service monitoring the wavelength, power & OSNR of individual channel at the output points

of the Booster Amplifier, ILA and Pre-amplifier by using an external test instrument. These points shall be suitably connectorised and on connection of a measurement device, the main transmission path shall not be affected at all.

The equipment shall also facilitate monitoring the combined power at the output of Booster Amplifier, ILA and Pre-amplifier through the EMS / LCT.

3.38 NMS/EMS related requirements:

a. The equipment shall provide support for a comprehensive Element Management System (EMS). The managed-object database access protocol shall be either TL-1 or XML or Qx or SNMPver.2c (or later) or JSON or Web service interface with standard MIB Browser implemented therein based on UDP/IP stack shall be provided.
b. The EMS shall be provided with an open northbound interface towards Network Management Layer (NML) as per ITU-T standard Q3 or TMF-814 compliant CORBA or XML or JSON or Web service for future NMS/OSS integration objectives.
c. The manufacturer shall arrange testing for TL-1 or XML or Qx or SNMPv2c (or later) interface during the testing as per the PICS & MIBs (as applicable) and shall support the factory test results during testing of their products.
d. The functional as well as protocol compliance for the management system shall be tested. Complete information on the NMS/EMS Northbound, Southbound interfaces and the NMS/EMS implementation protocol stacks shall be disclosed in details, in writing during the testing process.
e. The manufacturer shall submit the soft as well as hard copy of his PICS & MIBs (as applicable) along with equipment for testing.
f. The model of the EMS shall be as per ITU-T Recs. M.3100 & M.3010 and software of the system shall reside in the Work Station/Server.
g. The power-supply failure (not applicable for ‘on-board’ power-supply), Work Station breakdown & bugs in the software etc., shall not affect

the healthy working of the system.

h. The Manufacturer shall provide a soft copy of his NMS/EMS on a CD/DVD as asked by the purchaser during the supply of the equipment. The setup/procedure to download the software shall be very clearly mentioned in the system manual of the equipment.

i. The NMS/EMS of the equipment shall have complete protection from the virus.

j. The EMS of the equipment shall support the management of minimum 500 NEs where NE shall mean a fully equipped DWDM terminal, ROADM and ILA nodes.

k. It shall be possible to manage complete DWDM link involving distant-end terminal, Optical Line Amplifiers and Reconfigurable Optical Add/Drop Multiplexers enroute. The Management System shall be provided for the ultimate capacity of the network.

3.39 The equipment shall have the provision of Automatic Laser Shut-Down (ALSD) in the case of fibre-plant breakdown and automatic re-start on restoration of fault in accordance with ITU-T Recs. G.664. The system shall restore within 0 – 10 sec (programmable) after restoration of fibre, plant breakdown or a faulty amplifier.

3.40 The equipment shall provide built-in ‘plug and play’ type of Optical Equalization/ Pre-emphasis, if any, to meet individual channel power difference (channel-power balancing) and individual channel OSNR requirements etc. No field adjustments such as use of external attenuators etc., at the output of Mux/Transponders shall be permitted for the purpose of equalization/gain adjustments etc.

3.41 The equipment shall provide guaranteed end to end performance at the BER of $1x10^{-12}$ (with FEC enable) at beginning of the life. To ensure end-of-life margins, the span lengths shall be tested for 3dB higher values than that values specified during testing

3.42 The removal/insertion of the Line Card shall not disturb the working of

other channels in the system.

3.43 There shall be sufficient sideways space for the running of the fibres/cables for inter- rack cabling etc. It shall be possible to handle the cabling from the front-side only.

3.44 There shall be provision of in-service monitoring points for the optical power, and channel wavelength measurement at output points of Optical Amplifiers (including ILAs), ROADMs, Mux & input point of Demux.

3.45 The termination of the unused channels shall be provided by the manufacturer as a part of the equipment. It shall be possible to equip an unused channel at a later date without affecting the existing traffic.

4.0 Mapping functions of the client signals

4.1 ODUk Interface Adaptation: Multi-service interface modules shall support STM-1/4/16/64, OTU1/2/2e/flex/3//4, GE/10GE/40GE/100GE Ethernet services as well as FC-100/200/400/800/1200 and other customer service access. The Interface adaptation modules shall be able to map the client signal into appropriate ODUk (k =0, 1, 2, 2e, flex, 3, , 4) size bandwidth. The ODUk interface adapter modules shall support packet services directly through the Ethernet interface modules to achieve ODUk through GFP-F functionality.

Note: STM-1, STM-4 and STM-16 interfaces are optional for client side and may be decided by the purchaser

4.2 Client signal mapping flow

The client signal mapping and multiplexing path shall be as shown in Figure 6 below.

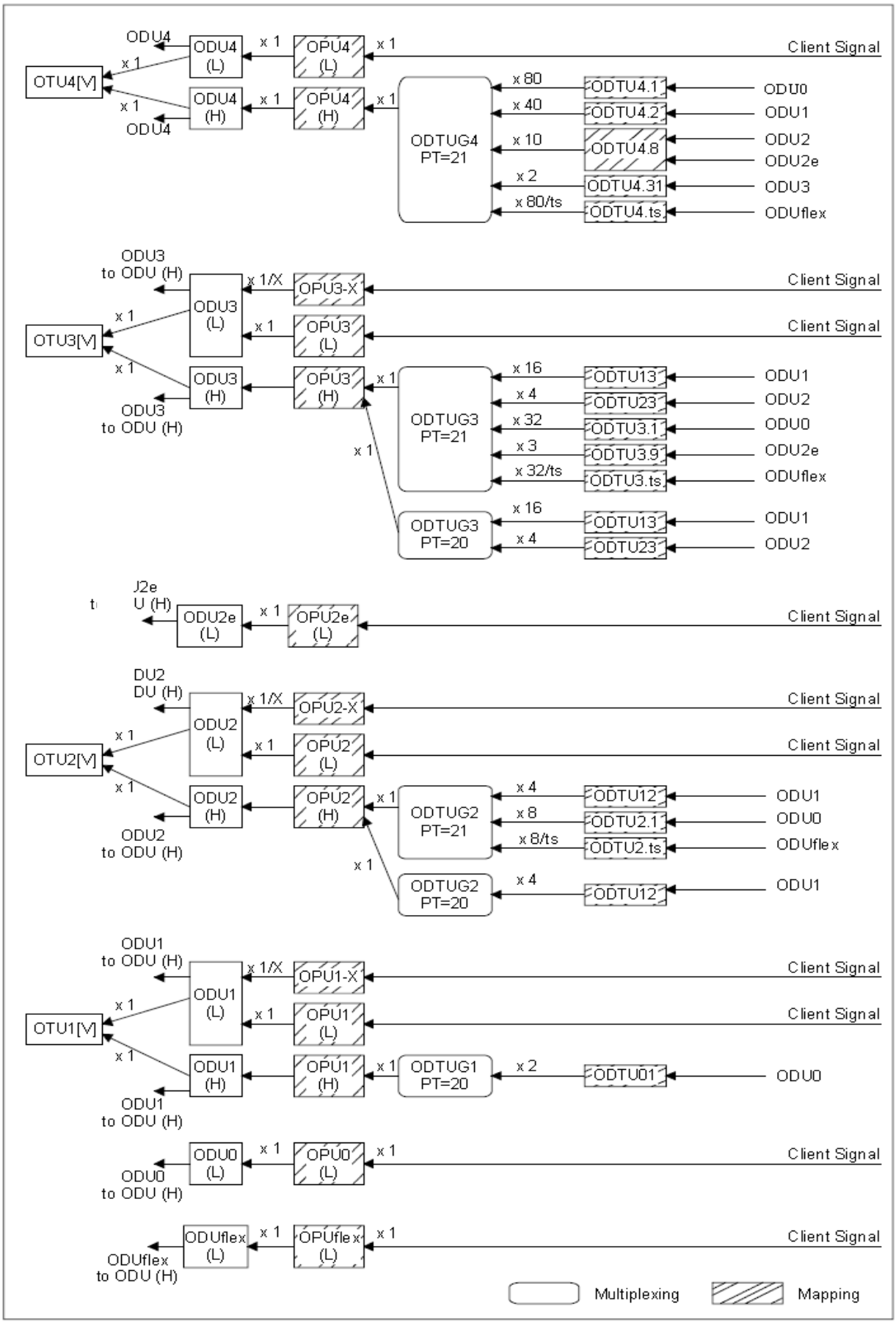

Figure-6 – OTM multiplexing and mapping structures

4.3 Mapping of Client signals to LO OPUk

Constant Bit (CBR), traditional SDH client signals as STM-16/64 are mapped to OPU1/2/3 using asynchronous mapping or bit synchronous mapping procedures (AMP / BMP).

Ethernet client signals GE/10GE/40GE are traditionally mapped on to OPU0/2e/3 by using GFP-F. In case of GE/40GE, the client signal is first compressed using the timing transparent encoded transformation (TTT) compression technique before mapping to OPU0 / 3 using Generic mapping procedure (GMP). 10GE is mapped using bit synchronous mapping (BMP) to OPU2e.

The client signals 1.238Gbit / s and below the CBR client signal, such as STM-1/4, FC-100 is mapped to OPU0 by using generic mapping procedure (GMP); the 2.488 Gbit / s and below CBR client signals such as FC-200 are mapped to OPU1; the rate near 9.995Gbit /s CBR client signals are mapped to OPU2; the rate closed to 40.149 Gbit/s CBR client signals are mapped to OPU3.

Other CBR client signals such as FC-400/800 are mapped to OPUflex using bit synchronous mapping (BMP), and FC-1200 signal with 50B/51B compression is mapped to OPU2e.

Table XII.1 of ITU-T Rec. G.709 below provides an overview of the mapping procedure of the CBR client signals into LO OPUk.

Table-1: Overview of CBR client into LO OPU mapping types

	OPU0	OPU1	OPU2	OPU2e	OPU3	OPU4	OPUflex
STM-1	GMP	-	-	-	-	-	-
STM-4	GMP	-	-	-	-	-	-
STM-16	-	AMP, BMP	-	-	-	-	-
STM-64	-	-	AMP, BMP	-	-	-	-
1000BASE-X	TTT+GMP	-	-	-	-	-	-
10GBASE-R	-	-	-	16FS + BMP	-	-	-

40GBASE-R	-	-	-	-	TTT+ GMP	-	-
100GBASE-R	-	-	-	-	-	GMP	-
FC-100	GMP	-	-	-	-	-	-
FC-200	-	GMP (C_{8D})	-	-	-	-	-
FC-400	-	-	-	-	-	-	BMP
FC-800	-	-	-	-	-	-	BMP
FC-1200	-	-	-	TTT+ 16FS+BMP	-	-	-
FC-1600							
FC-3200							

4.4 ODUk to ODTU signal mapping

ODUk to ODTU signal mapping can be supported using two mapping procedures - the asynchronous mapping procedures (AMP) and the generic mapping procedures (GMP):

a) ODUj to ODTUjk {(j, k) = {(0,1), (1,2) (1,3) (2,3); ODTU01 ODTU12, ODTU13 ODTU23} using the asynchronous mapping procedures (AMP).

b) ODUj to ODTUk.ts {(k, ts) = {(2,1... 8) (3,1... 32), (4, 1...80); j = 0,1,2,2e, 3, flex} using generic mapping procedure (GMP).

4.5 ODTU to HO OPUk mapping

ODTU signal multiplexing mapped to the HO OPUk in three ways,

a) ODTUjk {(j, k) = {(1,2) (1,3) (2,3); ODTU12, ODTU13, ODTU23} mapped to a 2.5G HO OPUk tributary slot (TS = 1, 4,16) any one of the combinations;

b) ODTUjk {(j, k) = (0, 1), (1, 2) (1, 3) (2, 3); the ODTU01, ODTU12

ODTU13, ODTU23}), wherein ODTU12, ODTU13, ODTU23 mapped to HO OPUk 1.25G tributary slot (TS = 2, 8, 32) any two combination; ODTU01 mapped to HO OPUk 1.25G tributary slot (TS = 2, 8, 32) any one of the combinations;

c) ODTUk.ts {(k, ts) = (2,1 ... 8), (3,1 ... 32), (4,1 ... 80)} is mapped to the HO OPUk 1.25G tributary slot (ts = 8,32,80) any of the ts combinations.

5.0 Cross Connect Capacity, Equipment Configurations and Network Topologies:

5.1 Cross Connect capacity:

The cross connect module of the equipment shall be universal packet / OTN switch matrix type. The equipment is divided in to thirteen distinct categories based on cross-connect matrix size and functionality, as equivalent OTU4/OTUCn.

Category-1: 600 Gbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category-2: 1Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

New Category: 1.6 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category-3: 2 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

New Category: 2.4 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category-4: 3 Tbit/s non-blocking matrix with each port configurable for

any direction of transmission.

New Category: 3.6 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category-5: 4 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

New Category: 4.8 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category6: 6 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category 7: 8 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

Category8: 9.6 Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

New Category: 12Tbit/s non-blocking matrix with each port configurable for any direction of transmission.

New Category:24Tbit/s non-blocking matrix with each port configurable for any direction of transmission

NOTE: User may order for an equipment of any of the above categories with reduced no. of line ports (eg. < 40 chl. in case of 40 chl. DWDM) as per the networking requirements.

5.2 Equipment configuration:

Reference point definitions

See the reference configuration for 40/80 × OTU4/OTUCn WDM system in the Figure-7, where -

OTUk Line unit is the optical transport unit which performs optical wavelength conversion, coloring the wave, FEC codification, coherent detection etc.

OMU is the Optical wavelength multiplexer unit, implements many wave length multiplexing functions;

OA is the Optical Amplifier unit and also includes chromatic dispersion compensatory function;

ODU is the Optical Wavelength De-multiplexer unit which implements many wave length de-multiplexing functions;

Tx/Rx is the client side trans and receive Optical interface.

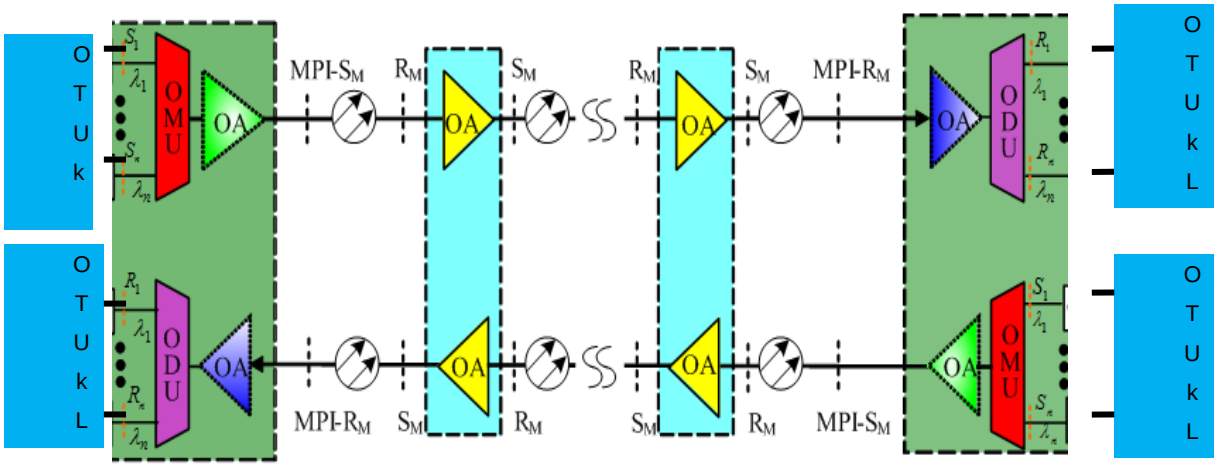

Figure-7: OUT-3/4 WDM system reference configuration

Figure above defines the network reference points as under –

- S is the output client reference point,
- $S_1 \ldots S_n$ are reference points between OTUk Line unit and OMU for channels 1…n respectively,
- MPI-S_M is a multi-channel reference point on the optical fiber just after the multi-channel OA output connector,
- S_M is a reference point just after the line multi-channel OA output optical connector,
- R is the input client reference point,

- R_1 ... R_n are reference points between the ODU and OTUk Line unit for channels 1…n respectively,
- MPI-R_M is a multi-channel reference point on the optical fiber just before the multi-channel OA input connector,
- R_M is a reference point just before the line multi-channel OA input optical connector.

6.0 Physical Interface Requirements:

The MS OTN platform equipment shall provide a combination of the following physical user interfaces and services. Purchaser / user shall explicitly indicate the interfaces as per requirements. The interfaces against the related international and TEC standards are as given below:

Table-2: Interfaces and relevant international and TEC standards

Service type and service rate				
Service Category	**Service Type**	**Service Rate**	**Reference Standard**	**TEC GR/IR**
SDH interfaces	STM-1(Optional)	155.52 Mbit/ s	ITU-T G.707 ITU-T G.691 ITU-T G.957 ITU-T G.693 ITU-T G.783 ITU-T G.825 ITU-T G.693 ITU-T G.783 ITU-T G.825	TEC/IR/TX/DMX/ 006/03.DEC 11
	STM-4 (Optional)	622.08 Mbit/s		
	STM-16	2.5 Gbit/s		
	STM-64	9.95 Gbit/s		
Ethernet interfaces	GE	1.25 Gbit/s	IEEE 802.3u IEEE 802.3z IEEE 802.3ae IEEE 802.3ba	TEC/IR/TX/ETH/0 08/01.JUN.12
	10GE WAN	9.95 Gbit/s		
	10GE LAN	10.31 Gbit/s		
	40GE	41.25Gbit/s		
	100GE	120.579 Gbit/s		
SAN service	FC100	1.06 Gbit/s	ANSI X3.296	
	FC200	2.12 Gbit/s	ANSI X3.230	

interfaces	FC400	4.25 Gbit/s	ANSI X3.303	
	FC800	8.5 Gbit/s		
	FC1200	10.51 Gbit/s		
	FC-1600			
	FC-3200			
OTN interfaces	OTU1	2.67 Gbit/s	ITU-T G.709 ITU-T G.959.1 GR-2918-CORE	TEC/GR/TX/OTA/001/01.MAR.11
	OTU2	10.71 Gbit/s		
	OTU2e	11.10 Gbit/s		
	OTU3	43.02 Gbit/s		
	OTU4	111.80 Gbit/s		
	OTUCn			

7.0 DWDM equipment functional blocks

7.1 The DWDM equipment shall provide the following functionalities -

a) Terminal Blocks:

- Line interface from/to OTN block
- Multiplexing/de-multiplexing element
- Booster/pre-amplification
- OSC termination
- Power Monitoring Unit, if used
- Optics for Coherent detection

b) In Line Amplifier Block:

- Optical line amplification
- OSC termination

c) FOADM/ ROADM Block:

The GR envisages a common platform for Reconfigurable Optical Add/Drop Mux and Fixed Optical Add/Drop Mux. The ROADM shall have East West separation resulting in traversing the east direction traffic not sharing the common cards with add/drop channels in the west direction and vice versa.

The FOADM/ ROADM shall provide the following functionalities:

a) Multiplex/de-multiplex of wavelengths for channel add/drop functionality,
b) Booster/pre-amplification,
c) OSC termination,
d) Power Monitoring Unit, if used,

7.2 Mux/Demux:

The Multiplexer of the DWDM equipment shall combine a maximum of 40/80/ 96 colored DWDM channels into a multi-channel signal. Similarly, the Demux shall provide the reverse function.
Note: The requirement of 96 channels is optional and may be decided by the purchaser or user.

The Mux/Demux shall contain passive optical DWDM filter components to combine and split the light of different ports associated with different DWDM wavelengths.

Various DWDM Mux/Demux characteristics for 'Add-out insertion loss (max.) per channel for Mux', 'Drop-in insertion loss (max.) per channel for De-Mux', are left open for implementation to manufacturer subject to conformance to parametric limits as stipulated in Table 1 & 2/ Annexure-I at all relevant reference points 'RMn/SDn' and 'MPI-S/MPI-R'.

a. It shall be possible to upgrade the Optical Terminal Multiplexer equipment to Fixed/Reconfigurable Optical Add/Drop Multiplex equipment.
b. The details of technology and characteristics (other than defined in this document) of Multiplexer/Demultiplexer shall be specified by the manufacturer.
c. Upgrades to additional add/drop channels shall be hitless and shall be supported in field.

NOTE: Cross-talk values - ‘Maximum adjacent channel cross-talk for De-Mux’, ‘Minimum Isolation (for adjacent as well as non-adjacent channels) for Mux & De-Mux’ shall be complied at relevant ‘SDn’ reference point (for the disturbed channel) at De-Mux, S’ reference point on ILA/ROADM and MPI-S reference point at MUX output under the following conditions:

1. The channel power for the disturbed channel at ‘RMn’ reference point at MUX is at a minimum.
2. The powers at other channels at respective ‘RMn’ reference points are at a maximum.
3. The optical filter characteristics in Mux/De-Mux shall be such as to compensate for channel-power disparities to adhere to cross-talk specifications.

7.3 Optical Amplifier:

The DWDM system shall provide EDFA Booster Amplifiers (at Mux end), Pre-Amplifiers (at Demux end) and ILA’s at enroute stations to compensate fibre-attenuation etc. The Optical In-Line Amplifier shall amplify the optical signals received at the input and shall have the characteristics as given in the Table-1 & 2/Annexure-I.

The Optical Amplifiers shall amplify the aggregate DWDM optical signal received at the input using EDFA technology. At least two types of Line Amplifiers shall be supported viz. Longhaul Amplifier and Very Longhaul Amplifiers based on the amplification capabilities. The equalization and other parameters shall be the same for both types unless these are specified.

There shall be active control and instantaneous adaptation of express traffic due to any degradation arising out from rapid reconfigurations. Sudden addition/removal of channels at intermediate site must not affect whole transmission of DWDM signals.

The optical amplifiers shall respond automatically to changes in the number of channels without the need for manual intervention or realignment. Integrated VOA shall allow the amplifier units to automatically compensate for variations in span-attenuation due to ageing and splicing etc.

The adaptation response for restoration after ILA fault, fibre-plant restoration or change in power levels etc., shall be immediate.

The system shall restore autonomously on the restoration of link after fibre plant breakdown or a faulty amplifier.

The optical amplifiers shall be capable to accommodate the optical gain and power requirements up to a full channel capacity per node.

NOTE: The above bindings shall hold good for the optical amplifiers that are part of Terminals, FOADM and ROADM.

7.4 Optical Add/Drop Multiplex Block

Two types of OADM units are envisaged to be used in the network viz FOADM (Fixed OADM) and ROADM (Reconfigurable OADM). The usage of the 2 types of OADMs is dependent on the application and shall be as per the purchaser's requirements. The equipment vendor shall support both types of OADMs.

Design Requirements

The add-drop channels traversing the east direction do not share common cards with add/drop channels in the west direction. This allows for protection of local traffic at a particular OADM. For example, let's assume that there is one protected channel originating from an OADM, whereby the working channel traverses east and the protected channel traverse west. If there are common cards that are shared by both the east and

west channels and these cards fail, both the working and protection channel will fail and the local traffic in the OADM is lost.

The OADM architecture shall guarantee east-west separation such that optical card failures(s) involving either the east or west direction of transmission shall not impact optical channels traversing in the respective west or east direction.

7.4.1 FOADM (Optional)

Two variants of Fixed Optical Add/Drop multiplexers shall be supported:

i. Low Capacity FOADM:
   Such a FOADM shall support a maximum of 4 optical wavelengths for add/drop traffic (fixed & pre-defined) with the remaining optical wavelengths passed through to outgoing path without 3R regeneration.
ii. High Capacity FOADM:
   Such a FOADM shall support any subset of add/drop traffic in steps of 4 optical wavelengths up to the full system capacity, with the remaining optical wavelengths passed through to any other location without 3R regeneration. The architecture used shall be flexible enough to allow for in-service scaling of add/drop capacity from 4 optical wavelengths up to the maximum of 40 optical wavelengths. There shall be no restrictions on wavelength assignment to the add/drop channels, allowing any or all unique optical wavelengths to be added/dropped at any location. Both symmetric add/drop (whereby no. of dropped channels is equal to no. of inserted channels) and asymmetric add/drop (whereby no. of dropped channels is not equal to no. of inserted channels) shall be supported.

   The system design shall be such that it implements wavelength reuse at Optical Add/Drop Multiplexers, allowing any particular wavelength that has been dropped from a previous optical multiplex section to be

reinserted into any subsequent optical multiplex section to carry new traffic. Any insertion losses incurred in the add/drop process shall be compensated within the system.

The wavelengths drop/insert shall be random and not necessarily in order of sequence. The OADM design shall be such as to allow unrestricted continued re-use of same channel/channels in the subsequent cascaded spans for the dropped channels.
Upgrades to additional add/drop channels shall be hitless and shall be supported in field.

NOTE: The user shall clearly specify the variant of FOADM at the time of procurement.

7.4.2 Reconfigurable Optical Add-Drop Multiplexer (ROADM)

A reconfigurable optical add-drop multiplexer (ROADM) is a form of optical add-drop multiplexer that adds the ability to remotely configure wavelengths in OADM system. This allows individual wavelengths carrying traffic channels to be added, dropped or pass through from a transport fibre without the need to convert the signals on all of the WDM channels to electronic signals and back to optical signals.

Such an Optical Add Drop Multiplexer shall support the add/drop of any channel in resolution of single channel of bi-directional optical wavelengths up to the maximum capacity of the bidirectional optical wavelengths, with the remaining optical wavelengths passed through to any other location without 3R regeneration. There is no, in fact, any restrictions on wavelength assignment to the add/drop channels, allowing any or all unique optical wavelengths to be added/dropped at any location. The system also provides both symmetric add/drop facility whereby no. of dropped channels is equal to no. of inserted channels and asymmetric add/drop facility whereby no. of dropped channels is not equal to no. of

inserted channels.

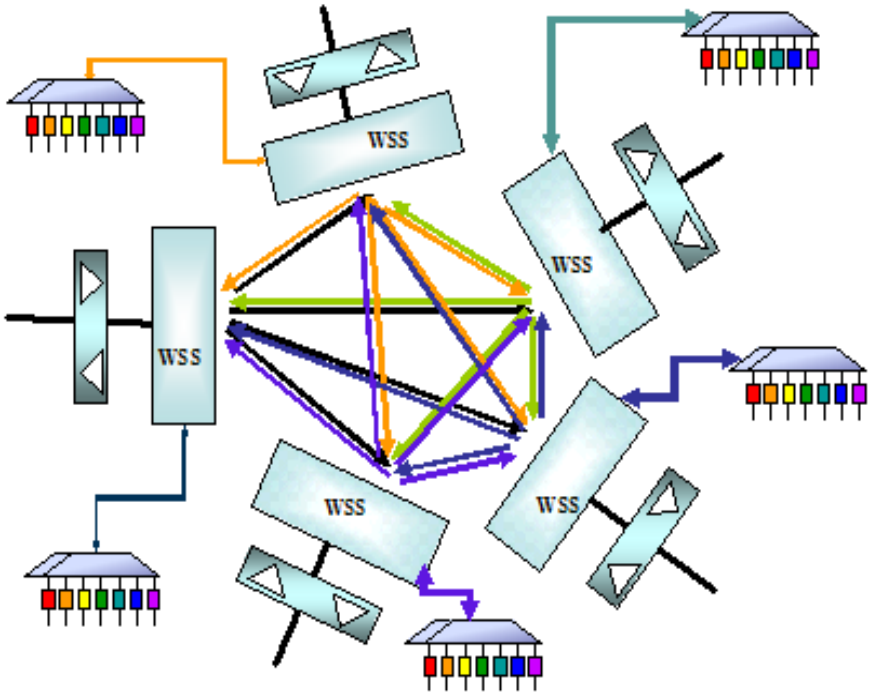

Figure-8: A model diagram for ROADM supporting 5 directions

NOTE: The user shall specify the degree of ROADM during the procurement of the equipment.

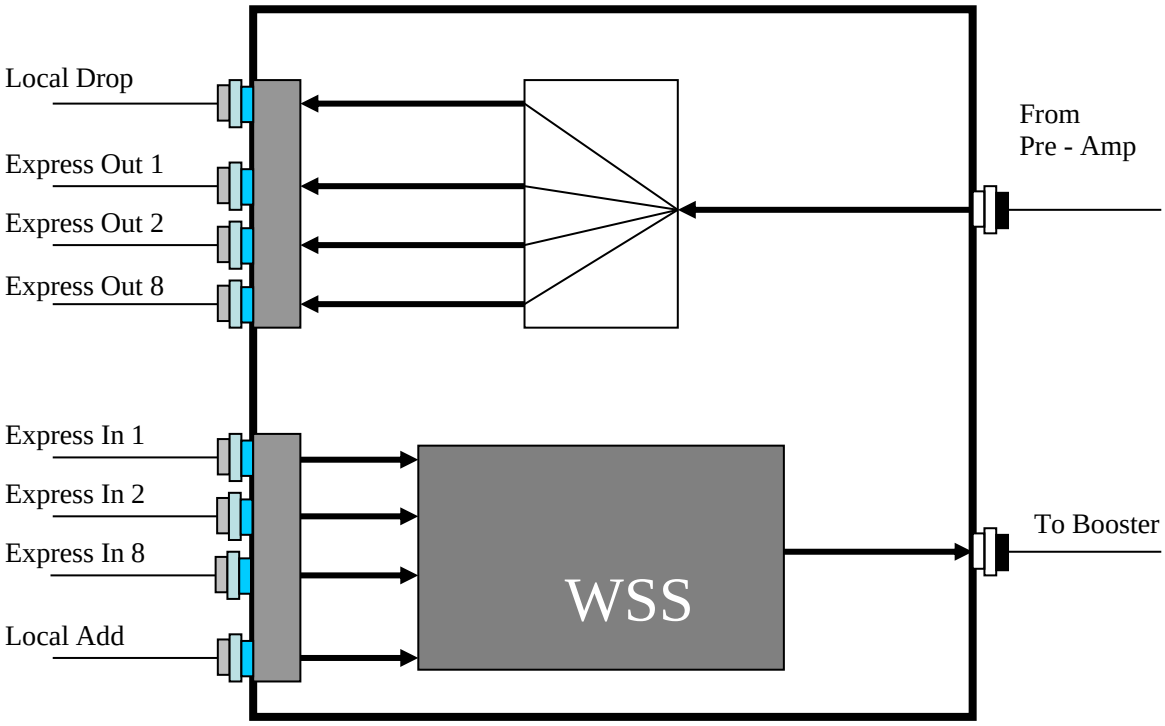

Figure-9: Block diagram of the WSS ROADM

A reconfigurable optical add-drop multiplexer (ROADM) shall be colorless,

directionless, contentionless and flexible and shall support up to eight degrees. ROADM shall be a wavelength selective switch (WSS) based on Micro-Electro-Mechanical Systems (MEMS) or LCOS technology or a combination of both and shall support the following functionalities:

1. The planning of entire bandwidth assignment need not be carried during initial deployment of a system. The configuration can be done as and when required.
2. ROADM shall allow for remote configuration and reconfiguration.
3. In ROADM, as it is not clear beforehand where a signal can be potentially routed, there is a necessity of power balancing of these signals. ROADMs shall allow automatic power balancing.
4. The ROADM shall be compact in size and shall be of low power consumption and low insertion loss type.
5. It shall provide Express channel equalization.
6. ROADM shall provide add/drop scalability from 0 to 40/80 channels.
7. It shall be highly reliable.
8. Each ROADM node shall be a multi-degree node supporting 8 directions. However, during the evaluation testing, support of at least 3 directions shall be demonstrated.

7.4.3 General Design requirements of OADM (FOADM/ROADM)

It shall be ensured that add/drop channels traversing the east direction do not share common cards with add/drop channels in the west direction. This allows for protection of local traffic at a particular OADM. For example, let's assume that there is one protected channel originating from an OADM, whereby the working channel traverses in the eastern direction and the protection channel traverses in the western direction. If it is a common card which is shared by both the east bound and west bound channels and the card fails, both the working and protection channel will fail and the local traffic in the OADM is lost. The OADM architecture shall, therefore, guarantee east-west separation (EWS) such that optical card

failure(s) involving either the east or west direction of transmission shall not impact optical channels traversing in the respective west or east direction.

A separate booster and preamplifier cards for the two directions are a precondition for EWS. An OADM with random channel add/drop is envisaged in the GR. OADM node shall provide an EDFA amplifier to offset various losses i.e., insertion loss for channel add/drop and fiber-attenuation etc.
Upgrades to additional add/drop channels up to limits proposed, shall be hitless and shall be supported in field.

8.0 Technical requirements and characteristics of DWDM system:

8.1 DWDM window of operation:

The optical window of operation of the DWDM system shall be in the range from 1529 nm to 1565 nm (C-band) as per ITU-T Rec. G.694.1.

8.2 Channel spacing:

The nominal central wavelength spacing shall be 100/75/50 GHz/ flexible grid. The source wavelength variation shall be as per Table-1 & 2/Annexure-I. Any consecutive 40/80/96 wavelengths may be chosen by the user from DWDM-grid as specified in ITU-T Rec. G.694.1 or flexible grid.

Note: The requirement of 96 channels is optional and may be decided by the purchaser or user.

8.3 Central frequency:

The allowed channel frequencies are based on ITU-T grid with reference frequency at 193.1 THz.

8.4 Equipped channel capacity of the equipment:

The DWDM system shall provide an end to end capacity for 40 channels @ OTU-4/OTUCn, on day one. The exact number of actual equipped interface cards shall be as per the requirements of the purchaser. Proper termination of the unused channels shall be provided by the manufacturer as part of system design. It shall be possible to utilize the unequipped channels at a later date without affecting the existing traffic.

8.5 Type of connectors:

The connectors used at the OTM, Optical Amplifiers and OADMs shall be SC/LC type with automatic shutters having spring-action. When out-of-use, they shall remain closed or otherwise the optical connectors shall be so positioned as to be leaning down towards ground to avoid direct laser-beam incidence on the user. The Return Loss of the optical connectors shall be ≥40dB. At the ODF/FDF-end, the connectors used shall be Angle Polished FC/SC/LC/APC type. In case, the connectors provisioned are other than FC/SC/LC/APC, the manufacturer shall supply two sets of suitable patch cords for each port for DWDM Add/Drop Mux & Terminals and eight patch-cords for optical amplifier sites for compatibility with the existing ODF/FDF.

NOTE: The user shall take care not to exceed the above mentioned span limits.

9.0 Optical Monitoring (OM)

The objective of optical monitoring is to detect anomalies, defects, degradations and fault affecting the quality of DWDM systems at optical layer. The optical monitoring of the DWDM system shall provide the facility of locally and remotely monitoring of some important parameters as specified in the ITU-T Rec. G.697. The parameters shall facilitate in-service fault analysis and performance degradation of DWDM system and enhance the reliability of the system. The methodology of “Optical Monitoring” shall

be as specified in ITU-T Rec.G.697. The local and remote monitoring of following Optical parameters of the DWDM system shall be supported by the system through its EMS.

1. Channel power: The equipment shall support the channel power measurements at the following points:
   a. Channel power before the DWDM multiplexer,
   b. Channel power after the DWDM demultiplexer.
2. Total power: The equipment shall support the total channel power measurements at the following points:
   a. Total power at input of various stages of optical amplification,
   b. Total power at output of various stages of optical amplification,

10.0 Performance requirements

The equipment shall be tested for error performance as follows:

The equipment shall support the following performance parameters relating to the ODU-k as specified in ITU-T Recs.G.8201 and G.7710.

1. Optical Channel Transport Unit Background Block Error (OTU_ BBE).
2. Optical Channel Transport Unit Errored Second (OTU_ ES).
3. Optical Channel Transport Unit Severely Errored Second (OTU_ SES).
4. Optical Channel Transport Unit Unavailable Second (OTU_ UAS).
5. Optical Channel Transport Unit Far End Error Background Block Error (OTU_FEBBE).
6. Optical Channel Transport Unit Far End Errored Second (OTU_FEES).
7. Optical Channel Transport Unit Far End Severely Errored Second (ODU_FESES)
8. Optical Channel Transport Unit Far End Unavailable Second (OTU_ FEUAS).
9.
10. Optical Channel Data Unit Path Monitoring Background Block Error (ODU_PM_BBE).

11. Optical Channel Data Unit Path Monitoring Errored Second (ODU_PM_ES)
12. Optical Channel Data Unit Path Monitoring Severely Errored Second (ODU_PM_SES).
13. Optical Channel Data Unit Path Monitoring Unavailable Second (ODU_PM_UAS).
14. Optical Channel Data Unit Path Monitoring Far End Errored Second (ODU_PM_FEES).
15. Optical Channel Data Unit Path Monitoring Far End Severely Errored Second (ODU_PM_FESES)
16. Optical Channel Data Unit Path Monitoring Far End Unavailable Second (ODU_PM_FEUAS)

(New clause): Optical Channel Data Unit Path Monitoring Far End Background Block Error (ODU_PM_FEBBE).

In laboratory:

BER performance over a simulated-section shall be tested for 48 hours and BER performance shall be better than 10^{-12} (with FEC enabled). For Ethernet clients, end to end IETF RFC 2544 compliance shall be tested.

In field:

BER performance for 48 hours shall conform to ITU-T Rec. G.828 for SDH payloads. For Ethernet clients, end to end IETF RFC 2544 compliance shall be tested.

11.0 Alarms:

11.1 The following DWDM related alarm conditions shall be reported by the EMS:

1. Input power failure of the Transponder/Mux-ponder interface (including Ethernet interfaces).
2. Input power failure of the Amplifiers

3. Output power failure of the Amplifiers
4. Fan/s failure
5. Output power out of range for OA, OADMs
6. Input power out of range for OA, OADMs
7. Derived power supply failure alarm
8. Loss of input at Optical Add/Drop Multiplex equipment
9. Input channel failure at Optical Add/Drop Multiplex equipment
10. Hardware mismatch alarm
11. Low input power of the client interface signal
12. Low input power at OA, Optical Add/Drop multiplex equipment
13. Degraded input at OA, Optical Add/Drop multiplex equipment
14. Degraded output of OA, Optical Add/Drop multiplex equipment
15. Degraded output of the dropped channel.
16. GFP related alarm for Ethernet clients. (optional, may be decided by the purchaser)

These alarms shall be categorized as Urgent, Non-urgent and Deferred alarms, with threshold programming by software, wherever applicable.

11.2 The following ODU-k related alarms listed in ITU-T G.798 shall be reported by the equipment through the EMS:

1. OTU-k Loss of Frame alarm (OTU -LOF).
2. OTU-k Loss of Multiframe alarm (OTU -LOM).
3. Loss of Payload alarm (LOS-P).
4. Open Connection Indication alarm (OCI).
5. OTU-k Degrade Defect alarm.
6. OTU-k Trace Identifier Mismatch alarm (OTU-k TIM).
7. ODU-k-AIS alarm
8. OTU-k Backward Defect Indication alarm (OTU-BDI).
9. ODU-k Payload Mismatch alarm.
10. ODU-k AIS alarm at path layers

11. ODU-k Backward Defect Indication alarm (ODU-kp BDI) at path.
12. ODU-k Locked Defect alarm at path layers.
13. ODU-k signal degrade alarm (ODU-kp DEG)
14. ODU-k loss of frame and multi frame. ODU-LOFLOM)
15. ODU-k Trace Identifier Mismatch alarm (ODU-k TIM) at path level.
16. ODU-k Payload mismatch alarm at path level (ODU-kp PLM)

12.0 Architecture of Automatically Switched Optical Network (ASON)

The architecture of Automatically Switched Optical Network (ASON) shall be based on ITU-T Rec. G.8080/Y.1304, which specifies a control plane that enables the equipment to facilitate fast and efficient configuration of connections within a transport network layer, supporting switched as well as soft permanent connections, reconfigure or modify the connections that have already been set up and perform a restoration function. The equipment shall support all the components which shall be required to meet the above functionalities as defined in ITU-T Rec. G.8080/Y.1304. The model showing the overview of the relationship architectural between the components shall be as per Figure-1/G.8080/Y.1304. The important components of the control plane which shall be implemented by the equipment shall be as per ITU-T Rec. G.8080/Y.1303 and shall be as given below:

1. Connection Controller Function (CC): The connection controller shall be responsible for coordination among the Link Resource Manager, Routing Controller for the purpose of the management and supervision of connection setup, release and modification.
2. Routing Controller (RC): The role of the RC shall be to respond to requests from CC for route information needed to setup a connection, and to respond to requests for topology information for network management purposes.
3. Link Resource Management (LRM): The LRM component shall be responsible for the management of network links including the

allocation and de-allocation of resources, providing topology and status information.

4. Traffic Policing (TP): The role of the TP shall be to check that the incoming user connection is sending traffic according to the parameters agreed upon.
5. Call Controller: There shall be two types of call controller, a calling/called party call controller and a network call controller. The role of the call control shall be the generation and processing of call requests.
6. Protocol Controller (PC): The PC shall provide the function mapping of the parameters of the abstract interfaces of the control components into messages that are carried by a protocol to support interconnection via an interface.

12.1 ASON/GMPLS/G.8080 Planning Tools:

The implementation of ASON/GMPLS/G.8080 shall require a Planning Tool to facilitate network operators to plan and simulate networks with an automated control plane such as GMPLS/ASON/G.8080. The Planning Tool emulates the behavior of GMPLS/ASON/G.8080 networks in all the possible operative scenarios such as link, node and Shared Risk Link Group (SRLG) failures.

The goal of the ASON/GMPLS/G.8080 -Planner is to maximize the quality of service provided to customer and to optimize the network resources.

The Planning Tool shall be a multi-layer, multi-technology network planning tool that helps network operators to plan, develop, manage and upgrade their transport network. The requirement of the Planning Tool has been detailed in Appendix-II.

NOTE: The purchaser shall ask for the ASON/GMPLS/G.8080 Planner during the procurement of the equipment. The implementation may be carried out by the purchaser or the vendor may be asked to implement the same. In the latter case, the purchaser shall make available all the

necessary network related information to the vendor.

12.2 The equipment shall support ASON, GMPLS/G.8080 and OIF framework to facilitate faster and efficient configuration and restoration of connections, easier network operation, higher network reliability, scalability and easier planning. The ASON and GMPLS shall characterize three autonomous planes, which shall be interacting with each other for the exchange of information:

1. Control plane: The control plane, using signaling, shall provide setting up of connections and may restore a connection in case of failure. It represents transport infrastructure for control traffic and could either be in band or out of band. The control plane topology can be different from the transport network topology.
2. Management plane: The management plane shall perform FCAPS functions and shall also provide co-ordination between all planes.
3. Transport plane: The Transport plane shall provide the flow transfer for user information from one location to another. It shall also provide flow transfer for some control and network management information.

12.3 The ASON shall provide two types of connections:

1. Permanent connections

   The permanent connection shall be set up from the management of the system with network management protocols.
2. Soft permanent connections

   The Soft permanent connections shall be set up from the management system which shall use network generated signaling and routing protocols to establish connections.

12.4 Network resilience and disaster recovery time shall be significantly improved by network resource auto-discovery. This mechanism shall ensure that optimal use is made of any connectivity available without complex operator involvement. The degree of control given to the network elements shall be managed by the central EMS/NMS to ensure the traffic

engineering requirements of the user are met. The ASON control software shall be distributed fully to all the network elements in the network.

12.5 Both the routing and signaling shall be fully distributed to network elements. The path-selection function shall be distributed to the network elements.

12.6 Every node shall maintain its own database of the entire network. This shall avoid single point of failure in the network.

12.7 The ASON shall take in to account the underlying protection schemes, to allow efficient integration with established standards. A circuit that is established via ASON control plane may cross a protection in the client layer. For these reasons, an ASON backbone shall have to inter-operate with such kind of protection schemes. The ASON component shall implement this kind of interworking to provide end-to-end circuits with the degree of protection allowed by various parts of the network they traverse.

12.8 There are a number of added values related to such a capability and equipment shall support these capabilities:

1. Traffic engineering of optical channels: Where bandwidth assignment shall be based on actual demand patterns.
2. Mesh network topologies and restoration: Mesh network topologies shall, in general, be engineered for better utilization for a given demand matrix. Ring topologies might not be as efficient due to the asymmetry of traffic patterns.
3. Managed bandwidth to core IP network connectivity: A switched optical network shall provide bandwidth and connectivity to an IP network in a dynamic manner compared to the relatively static service available today.

12.9 Automatic Discovery for Transport entities:

The requirement of automatic discovery for transport entities and the methodology shall be implemented as specified in ITU-T Rec. 7714 and its further extensions in ITU-T Rec. G.7714.1/Y1705 and G.7714.1/Y1705 Amd.1.

12.10 Architectural requirements and routing in ASON:

The architectural and routing requirements of switched connections (SC) and soft permanent connections (SPC) for ASON based network shall be as per ITU-T Rec. G.7715/Y.1706. The ASON routing architecture, concepts for its implementation including Link State Protocol, routing area hierarchies' realization model, routing attributes shall be implemented as per ITU-T Rec. G.7715/Y.1706

12.11 Frame work of ASON management:

The TMN of equipment shall support the requirements specified in ITU-T Rec. G.7718/Y1709 on "Frame work of ASON management". to keep ASON management within TMN context and addresses the management aspects of ASON control plane and the interactions between the management plane and the ASON control plane. The architecture, methodology, model and the requirements of ASON management shall be compliant to the ITU-T Rec. G.7718/Y.1709.

12.12 Distribution call and connection management:

The equipment shall support the distribution call and connection management and the signaling based on the GMPLS/G.8080 RSVP-TE shall also be implemented as specified in ITU-T Rec.G.7713/Y.1704. The support of attribute specifications, message specifications, signal flow, DCM state diagrams and management of DCM by the equipment shall be as per ITU-T Rec.G.7713/Y.1704.

12.13 GMPLS Implementation Requirements(Optional):

The GMPLS architecture shall be as per IETF RFC 3945. The GMPLS traffic engineering, routing, Link Management Protocol, signalling function, signalling RSVP-TE, signalling procedure etc shall be as per various IETF RFCs as indicated in Table-3 below:

Table-3: List of IETF RFCs documents

IETF RFC 4802	GMPLS Traffic engineering management information base
IETF RFC 4202	Routing extension in support of GMPLS
IETF RFC 4361	Link Management Protocol mgmt. information base
IETF RFC 3471	GMPLS signaling function
IETF RFC 3473	GMPLS signaling Resource Reservation Protocol – Traffic Engineering (RSVP-TE)

12.14 ASON CoS and Customer SLA Requirements:

The OTN based equipment shall support all the traditional protection schemes such as SNCP and MSP protection. Additionally, the equipment shall support ASON/ GMPLS based restoration.

Combining the traditional based protection schemes and ASON/ GMPLS based restoration, it is envisaged that the following variants of Service Level Agreements are achieved within the ASON/GMPLS architecture:

a) Platinum Service: Permanent 1+1 path protection + ASON/ GMPLS based restoration
b) Gold Service: Permanent 1+1 path protection
c) Silver Service: ASON/ GMPLS based restoration
d) Bronze Service: No protection mechanism shall be implemented for network restoration.

12.15 ASON Implementation Guidelines

ASON is basically a software tool which is implemented either in OTN switch or in optical switch i.e., ROADM. In OTN ASON switching takes place within 50 msec. and restoration within 10 sec. On the other hand, in Optical ASON switching takes place within 50 msec but restoration takes a few seconds. Therefore, from the networking point of view, it is effective to implement OTN ASON for long haul applications and Optical ASON for Metro applications.

An overview of both the models – OTN ASON and Optical ASON are depicted in the figures below –

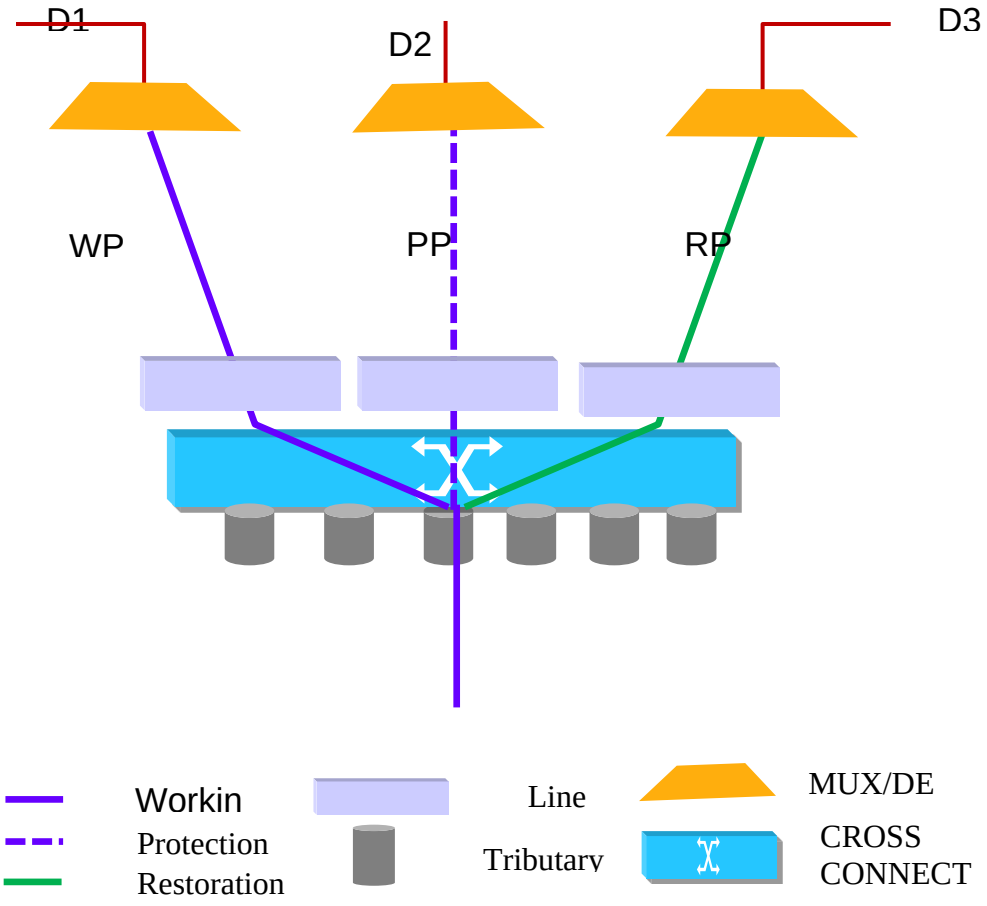

Figure-10: OTN ASON Model

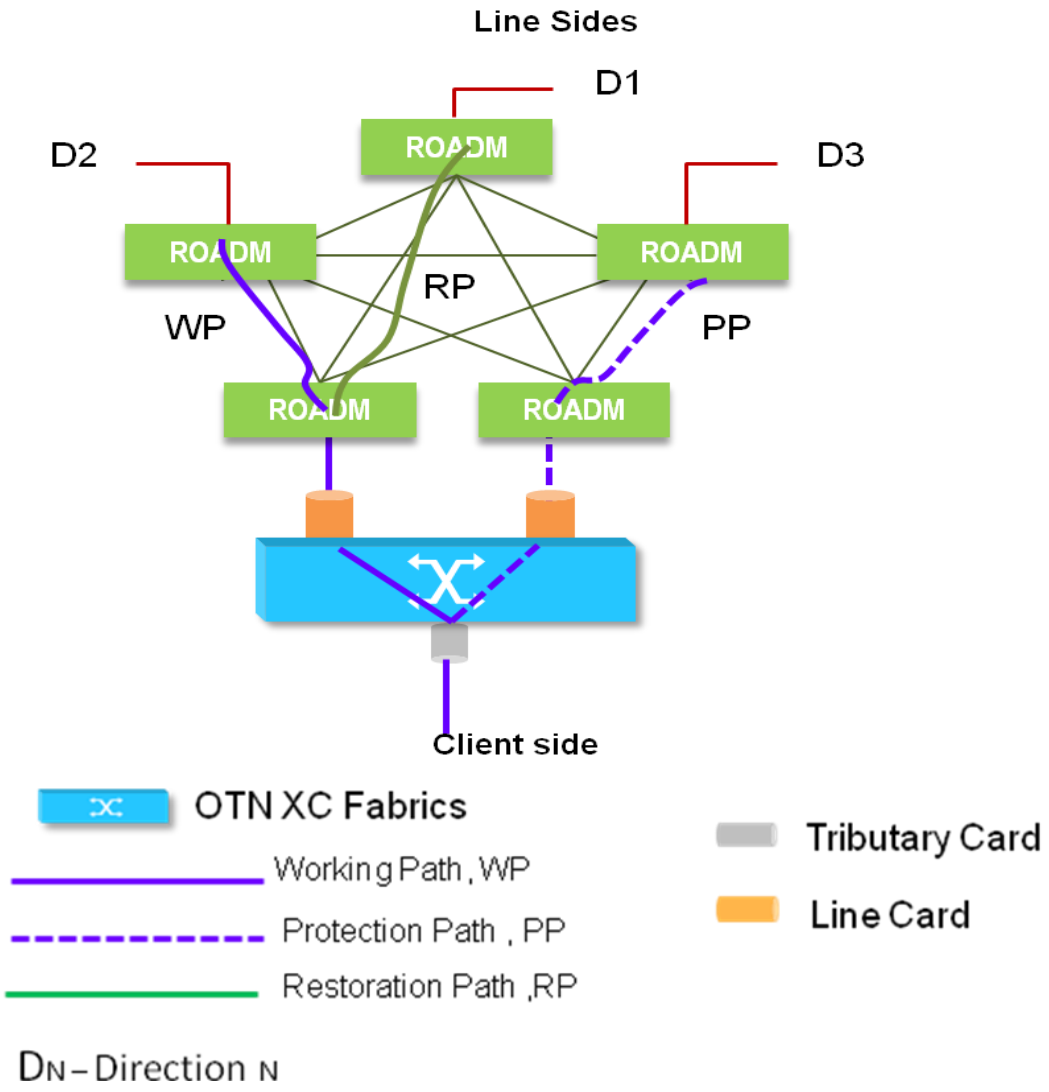

Figure-11: Optical ASON Model

13.0 Mechanical standards:

1. The equipment shall be housed in the standard 19'' width sub-racks or ETSI standard racks or custom 23” rack. The sub-racks shall be fitted with mother-board duly masked to avoid short-circuiting.

2. The height of the main rack shall be 2750 mm maximum or as per ETSI standards. No mini rack shall be accepted. The PCB’s back and forth movement shall be very smooth without any significant sideway play.
3. The connectors used on the PCB and their mating-connectors on the mother-board shall have tight grip to avoid jacking problems.

4. No damage shall take place to PCBs when loaded in the wrong slot except in power supply units. The PCBs shall have the provision of locking/ screwing to the sub-rack.
5. There shall be proper covers on the sub-racks/ main-racks or similar arrangements to avoid the ingress of dust.
6. The permanent wiring such as distribution of power supply and ground etc. shall be pre-wired. During Type Approval and supply of the equipment, the racks and sub-racks quality supplied by the manufacturer shall be ensured.
7. The front opening of the sub-rack/main rack is envisaged. The access to data terminations shall be from the front- side only. There may be provision for rear access in case chassis width is 600nm.

14.0 Engineering requirements:

1. The equipment shall be fully solid-state and adopt state-of-the-art technology. For all standard configurations, the system shall be manageable as a single network element.
2. The equipment shall be compact and composite in construction and shall be light-weight. The actual dimensions and weight of the equipment shall be furnished by the manufacturer.
3. All connectors shall be reliable and of standard type to ensure failure-free operation over long periods under specified environmental conditions. All cables & components shall be CACT approved.
4. All connectors and cables used shall be of low-loss type and suitably shielded.
5. The equipment shall be housed in standard 19" or ETSI standard rack or custom 23” rack and shall provide front access.
6. the manufacturer may use fans for cooling purposes provided:

    i. The fan failure is reported through LCT/EMS.
    ii. Multiple fans are there in one tray with N+1 redundancy in each fan tray module.

iii. Fans are located at convenient place in the equipment not disturbing the internal equipment layout.
iv. Fans are DC operated.
v. MTBF is better than 1,00,000 hours.
vi. Inclusion of fans for cooling purposes does not deteriorate the MTBF values of the equipment.
vii. There shall be fan failure alarm for each of the installed fan.

7. The supervisory indications, built-in test equipment (BITE), if any, and other control/ switches shall be provided at convenient locations for ease of maintenance.
8. The plug-in units shall be hot-swappable to allow easy removal/ insertion while the equipment is in energized condition.
9. The mechanical design and construction of each card/ unit shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage & transport and shall conform to the latest quality manuals of the purchaser.
10. Each sub-assembly shall be clearly marked with schematic references to show its function, so as to be easily identifiable from the layout diagram in the handbook.
11. Each terminal block and individual tag shall be numbered suitably with clear identifying code and shall correspond to the associated wiring drawings.
12. All controls, switches & indicators etc., shall be clearly marked to show their circuit designation and functions.
13. Important Do's and Don'ts about the operation of the equipment shall be clearly indicated at a convenient place on the equipment.

15.0 Operational requirements:

15.1 The manufacturer shall guarantee satisfactory performance of the equipment without any degradation up to an altitude of 3,000 meters. A certificate to this effect shall be admissible.

15.2 The equipment shall be able to work without any degradation in saline atmosphere near coastal areas and should be protected against corrosion. A certificate to this effect shall be admissible.

15.3 Visual indication to show power ON/OFF status shall be provided.

15.4 Suitable visual indications shall be provided. (It is suggested that 'green' colour for healthy and 'red' colour for unhealthy conditions may be provided. Some other colour, preferably 'Amber', may be used for non-urgent alarms).

15.5 The software/hardware in equipment shall not pose any problem due to changes in date and time caused by events such as changeover of millennium/ century, leap year etc., in the normal functioning of the equipment.

16.0 Quality requirements

16.1 The manufacturer shall furnish the MTBF/MTTR values MTBF values wherever specified in the standard, shall be met. The calculations shall be based on the latest operator's quality manual on "Reliability Methods and Predictions" or any other international standard.

16.2 a) The equipment shall be manufactured in accordance with international quality management system ISO-9001:2015 for which the manufacturer shall be duly accredited. A quality plan describing the quality assurance system followed by the manufacturer, shall be required to be submitted.

The equipment shall also meet the latest quality manual of the operator on

a. Quality and reliability in product design,
b. Guidelines for standard of workmanship for printed boards and assemblies,

c. Guidelines for standard of workmanship for surface mounted devices,

The supplier shall furnish a certificate from the manufacturer to this effect which shall be verified at the time of technical evaluation of the system.

New Clause : The equipment shall conform to the requirement for the latest operator's quality manual for specification for environmental testing of electronic equipment for transmission and switching use for operation, transportation and storage, including vibration test.

16.3 The equipment shall conform to the requirements for environment as specified in the TEC document SD: QM-333 (or TEC 14016:2010) {latest issue} "Standard for environmental testing of Telecommunication Equipment . The applicable tests shall be for environmental category " A" including vibration test.

17.0 **General Electromagnetic Compatibility (EMC) Requirements:** -The DWDM equipment shall conform to the EMC requirements as per the following standards and limits indicated therein. A test certificate and test report shall be furnished from a test agency.

a) Conducted and radiated emission:

Name of EMC Standard: "CISPR 32 {2015}-Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment".

Limits:-

i) To comply with Class A of CISPR 32 {2015}

ii) The values of limits shall be as per TEC Standard No. TEC/SD/RD/EMC-002/02 Oct.2016 with Amendment No. 1 dated 01.01.2008.

iii) For radiated Emission tests, limits below 1Ghz shall be as per Table 4(a) or 5(a) for measuring distance of 10m or Table 4(a1) or 5(a1) for measuring distance of 3m

b) Immunity to Electrostatic discharge:

Name of EMC Standard: IEC 61000-4-2 {2008) "Testing and measurement techniques of Electrostatic discharge immunity test".

Limits: -

i) Contact discharge level 2 {± 4 kV} or higher voltage;

ii) Air discharge level 3 {± 8 kV} or higher voltage;

c) Immunity to radiated RF:

Name of EMC Standard: IEC 61000-4-3 (2010) "Testing and measurement Techniques-Radiated RF Electromagnetic Field Immunity test"

Limits: -

i) Under Test level 2 {Test field strength of 3 V/m} for general purposes in frequency range 80 MHz to 1000 MHz and

ii) Under test level 3 (10 V/m) for protection against digital radio telephones and other RF devices in frequency ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.

d) Immunity to fast transients (burst):

Name of EMC Standard: IEC 61000- 4- 4 {2012) "Testing and measurement techniques of electrical fast transient's/burst immunity test"

Limits: -

Test Level 2 i.e. a) 1 kV for AC/DC power lines; b) 0. 5 kV for signal / control / data / telecom lines;

e) Immunity to surges:

Name of EMC Standard: IEC 61000-4-5 (2014) "Testing & Measurement techniques for Surge immunity test"

Limits: -

i) For mains power input ports: (a)2.0 kV peak open circuit voltage for line to ground coupling (b) 1.0 kV peak open circuit voltage for line to line coupling

ii) For telecom ports: (a) 2 kV peak open circuit voltage for line to ground (b) 2 KV peak open circuit voltage for line to line coupling.

f) Immunity to conducted disturbance induced by Radio frequency fields:
Name of EMC Standard: IEC 61000-4-6 (2013) with amendment 1 (2004) & amendment 2 (2006) "Testing & measurement techniques- Immunity to conducted disturbances induced by radio- frequency fields"

Limits:-

Under the test level 2 {3V r.m.s.} in the frequency range 150 kHz-80 MHz for AC / DC lines and Signal /Control/telecom lines.

New Clause: Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any):

Name of EMC Standard: Name of EMC Standard: IEC 6100-4-11 (2020) “Testing & measurement techniques- voltage dips, short interruptions and voltage variation immunity tests”

Limits:

i. A voltage dip corresponding to reduction of the supply voltage of 30% for 500 ms (i.e 70 % supply voltage for 500 ms)

ii. A voltage dip corresponding to reduction of the supply voltage of 60% for 200 ms (i.e 40 % supply voltage for 200 ms)

iii. A voltage dip corresponding to reduction of the supply voltage of > 95% for 5 s

iv. A voltage dip corresponding to reduction of the supply voltage of > 95% for 10 ms

New Clause: Immunity to voltage dips & short interruptions (applicable to only DC power input ports, if any):

Name of EMC Standard: IEC 61000-4-29:2000: Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

Limits:

i. Voltage Interruption with 0% of supply for 10ms. Applicable Performance Criteria shall be B.

ii. Voltage Interruption with 0% of supply for 30ms, 100ms, 300ms and 1000ms. Applicable Performance Criteria shall be C.

iii. Voltage dip corresponding to 40% & 70% of supply for 10ms, 30 ms. Applicable Performance Criteria shall be B.

iv. Voltage dip corresponding to 40% & 70% of supply for 100ms, 300 ms and 1000 ms. Applicable Performance Criteria shall be C.

v. Voltage variations corresponding to 80% and 120%of supply for 100 ms to 10s as per Table 1c of IEC 61000-4-29. Applicable Performance Criteria shall be B.

NOTE-1: The test agency for EMC tests shall be an accredited agency and details of accreditation shall be submitted.

NOTE-2: For checking compliance with the above EMC requirements, the method of measurements shall be in accordance with TEC Standard No. TEC/SD/RD/EMC-002/02.OCT.2016 and the references mentioned therein unless otherwise specified specifically. Alternatively, corresponding relevant Euro Norms of the above IEC/CISPR standards are also acceptable subject to the condition that frequency range and test level are met as per above mentioned sub clauses (a) to (f) and TEC Standard No. TEC/SD/RD/EMC-002/02.OCT.2016. The details of IEC/CISPR and their corresponding Euro Norms are as follows:

Table 4: Euro Norms

IEC/CISPR	Euro Norm
CISPR 32	EN 55032

IEC 61000-4-2	EN 61000-4-2
IEC 61000-4-3	EN 61000-4-3
IEC 61000-4-4	EN 61000-4-4
IEC 61000-4-5	EN 61000-4-5
IEC 61000-4-6	EN 61000-4-6
IEC 61000-4-11	EN 61000-4-11
IEC 61000-4-29	EN 61000-4-29

18.0 Safety requirements

18.1 The equipment shall conform to IEC 62368-1:2023 “Audio/video, information and communication technology Equipment- Part 1: Safety Requirements.

18.2 If the fibre is broken or an optical connector is opened, the laser shall be automatically shut down or the optical power to be decreased to a value less than -10 dBm. Optical connectors, if used in the system, shall be self-protective against entry of dust when not occupied by external patch cord.

19.0 Optical safety:

The optical safety shall be as defined in ITU-T Rec. G.664 & IEC 60825-1 (latest edition). The optical access ports shall be designed to protect themselves against the entry of dust when they are not occupied by an external fibre-optic connection. The optical access port shall be easy to clean by the user.

20.0 Protection requirements:

a. The equipment shall have a terminal for grounding the rack.
b. Protection against short circuit/ open circuit in the accessible points shall be provided.
c. All switches/controls on front panel shall have suitable safeguards

against accidental operation.

d. The equipment shall be adequately covered to safe-guard against entry of even dust, insects etc.

21.0 Power supply

The power supply to the equipment shall be fed from the station power-plant. The equipment shall meet the following requirements in respect of the power supply:

a) Nominal power supply is -48V DC with a variation over the range -40V to -60V. The equipment shall operate over this range without any degradation in performance.

b) The equipment shall be protected in case of voltage variation beyond the range specified in sub-clause (a) above and also against reverse input polarity. The manufacturer shall furnish the value of guaranteed input voltage up to which no irreversible damage to the equipment shall occur.

c) The derived DC voltages in the equipment shall have protection against over- voltage, short-circuit and overload.

d) The equipment shall have the option of operating from two independent sources of input power supply.

e) The equipment requiring AC mains shall operate from single phase AC power supply without any degradation in the performance. The nominal AC voltage shall be 230V with variation of –15 % to +10 % at 50 Hz ± 2 Hz.

The actual power consumption shall be furnished by the manufacturer.

22.0 Element Management System

22.1 Functional Requirements:

(1) The EMS shall be multi-user system and based on Graphical User Interface.

(2) It shall provide the graphical layout of the network elements with modules drawn using different colours to indicate their status.

(3) It shall be possible to execute schedulable administrative command i.e. NE backup, software download, performance, operator log-in/log-out etc., at any time by attaching a time tag to the command and it shall be executed when the Network real time matches the time tag. It shall be possible to define both time and date. If no date is mentioned, the command shall be executed daily at the time indicated.

(4) The EMS shall have a messaging system which will generate and send alert messages on telephone (fixed & mobile), e-mail or SMS to the designated personnel depending upon the location of NE, on generation of alarms.

(5) Response time for query/command on any operator terminal, local or remote shall be 10 seconds or better. For updation on topological information on the terminals, the response time shall be better than 20 seconds under all conditions. The response time of any terminal shall however, be reviewed depending upon total NE load and topology by purchaser during testing of EMS.

(6) It shall be possible to manage complete DWDM link involving distant-end terminal, Optical Line Amplifiers and Optical Add/Drop Multiplexers enroute.

(7) It shall be possible to have a view of selected sub-networks/rings controlled by the Element Management System as per requirement. By zooming-in, it shall be possible to drill down up to module-level in each NE for configuration and fault management. It shall also provide the ability to drill down to the individual element, then to subsystem, then to card and then to port level configuration template from the domain-map by clicking on the icon of the network element. The same shall be provided through user-friendly GUI commands.

(8) The Element Manager shall provide the complete view of the network elements and the interconnecting links. The EMS shall have the ability to include the network elements and the links in the

visual/graphical map of the domain. The visual maps shall display the elements and the links in different colour depending upon the status of the links. It is preferable that green colour for healthy and amber/yellow colour for degraded condition and red for unhealthy condition is used.

(9) It shall be possible to produce customised reports based on the data available in the database.

(10) It shall be possible through a single Man-Machine Command or through GUI to obtain a list and the total number of equipment of a particular domain in various states (e.g. managed, Loss of Association, in-service, blocked etc.).

22.2 Configuration Management:

(1) It shall be possible to configure the DWDM equipment for various capabilities and features like enabling/disabling of optical wavelengths, transponders configuration, optical channels addition/deletion, restricting client-speed at GigE interfaces, protection enabling/disabling at all wavelengths & inventory details of the local station as well as remote station at card level etc. The GUI shall provide efficient mechanisms to edit, re-groom, or decommission the service when necessary.

(2) Users shall be able to identify explicit routing through the network, or just define the end-points and service characteristics and select from a list of automatically generated viable recommended paths through the network.

(3) The system shall support 'Point & Click' provisioning in the DWDM sub-network, in respect of following:

a) Network Element creation in the NE Management domain.

b) Programming of a multiple interface unit.

c) Create, update, delete and retrieve the managed network topology data.

d) Assigning the equipment protection to a

unit/interface/wavelength/channel.

e) Selection of protection switching within the managed network and protection switching granularity enable/disable at individual channel level.

f) Error detection thresholds.

g) Network Element configuration.

h) Software download (local & remote).

i) It should be possible to provide an end-to-end wavelength service from an EMS Client system.

j) Power values overlaid on the topology map/drop down menus for selected Lambda by User

   i. Per lambda Power

   ii. Total AMP Power

   iii. OSC (Optical Supervisory Channel) Power

k) It should be possible to define the threshold (High/Low) for Power levels and EMS should be able to display if Power level is crossing the threshold.

l) The configuration of the various network elements like creating, viewing, and editing shall be possible from the EMS. The configurations of the network elements shall also be stored in EMS which can be retrieved in case of failure.

22.3 Fault Management:

(1) The EMS shall support 'Fault Management Functions'. The 'Equipment Management Function' within the NE shall perform a persistency check on the fault-cause, before it declares an alarm which is causing failure in the DWDM network. Each alarm/failure and clearance, thereof, shall be time-stamped.

(2) The equipment shall carry out surveillance of alarms & their detection, reporting of relevant events and conditions that lead to the generation of alarm after filtering. The system shall produce, store and display the alarm history on demand. Further, the element

management system shall have the following capabilities:

a) Path alarm notification to be generated and recorded, the alarm notification shall include: type, occurrence, severity, probable cause and clearing.
b) Path alarm shall be graphically shown by the EMS/LCT.
c) Alarm and status display.
d) .
e) Fault correlation control.
f) Storing and processing of current alarm information, up to module/unit level.
g) Storing and processing of historical alarm information for 30 days minimum. The EMS/LCT shall provide on-line logging capability for historical alarms and events with sufficient information such as managed resources, alarm/event type, alarm severity, day and time of occurrence etc. The retrieving functions with filtering capabilities for historical alarms and events shall be provided as well.
h) FCS errors for Ethernet clients.
i) Assigning alarm severity i.e., Urgent, Non-urgent and Deferred.
j) The EMS shall be able to diagnose its own faults by running diagnostic software.
k) The information model shall be as per specified standards. The EMS shall support correlation (filtering and suppression) to avoid multiple alarms from a single source of failure within the sub-network. Single Alarm shall be provided for the events that are correlated and are due to a common cause. However, it may be possible for the user to see other related alarms.
l) The EMS shall provide the visual presentation of the Network Element's status and the alarms. It shall also present the complete map of the network domain with suitable icons and in suitable colour like green for healthy, red for non-operational, yellow for degraded mode of operation etc.
m) From the EMS, it shall be possible to view the status of any Card

of Network Element whether it is out-of-service or in-service.

n) The EMS shall carry out the systematic Health Monitoring of the elements of the Network. Check on the health of the card of any element of the Network shall be possible through command with settable periodicity - @ 24 Hrs, 1 week, 1 month.

o) It shall be possible to log recent operations which be re-displayed on request through GUI.

p) From a service assurance perspective, service to fault alarm correlation shall be supported. For each service there shall be an alarms tab visible on the service Display tab which displays the alarms impacting that specific service.

q) The DWDM related alarm conditions, as mentioned under Clause 11.1 and 11.2 in this GR shall be displayed by the EMS.

22.4 Performance Management:

(1) The EMS shall support the 'Performance Management' functions which shall consist of a set of functions that define, evaluate and report on the behavior of the Network Elements and their effectiveness relating to the overall functions carried out by the network.

(2) EMS shall provide the information regarding degradation of the optical paths. It shall have the capability to monitor and display certain important parameters like optical power, λ & OSNR measurements of channels and of DWDM Central Office equipment, Line System and Remote Terminal. The EMS shall provide non-intrusive B-1 byte monitoring of individual channel of DWDM system and shall provide error-ratio/error-count along with other ITU-T Rec. G.826 parameters provisioning. EMS shall also be capable of setting the equipment performance thresholds in the range of 10^{-5} to 10^{-12}.

(3) There shall be a provision for near-end performance monitoring, far-end performance monitoring, performance-data collection and performance history. The main performance functionality to be provided shall be as under:

a. Configuration of threshold concerning the error counters.
b. Performance monitoring by BIP check.
c. Performance monitoring and reporting.
d. Performance History (data logging).

(4) EMS shall store the performance data of the system including NE name, date and the time. The collection of the performance counters will have to be performed at pre-assigned rate. In addition, it shall also be possible to take print out of the statistics and histograms.

(5) It shall be possible to configure scheduling of performance measurement, collection, storage and transfer of traffic/ performance statistics for at least one month in the EMS system, after which it shall be possible to transfer the data to external media like USB, CD or any other server. It shall also be possible to generate daily, weekly, monthly reports for the individual element as well as complete domain. The report generation shall be supported in Text, CSV, Excel format and graphic reports as and when requested as well as at configurable interval automatically.

(6) The EMS shall store the performance data of the sub-network in terms of configured circuits.

(7) It shall be possible to generate reports that can be customized for various types of faults, performance history, security management etc. It shall also be possible to generate reports at various client's levels to facilitate monitoring of performance statistics in predefined/customised format.

22.5 Security Management:

(1) The management system shall provide adequate security in respect of the data and the access to the management system as per the following details:

a) The EMS shall have the capability of supporting the management of network through local and remote operator terminals. The authorizations and the privileges of the operator terminals (Remote and Local) shall depend upon the Login and Password.

b) Low level protection for read only access to faults and performance information.

c) Medium level protection for reads only access to configuration status and features.

d) High level protection for access to change in the configuration and control parameters.

(2) The EMS shall support multi-level passwords as below-

a. EMS shall allow the System Administrator to define the level of access to the network capabilities or feature for each assigned password. It shall be desirable that the EMS shall block the access to the operator in case of wrong login password and ID and also for unauthorized commands being tried for five consecutive times in both the occasions.

b. The system administrator shall be able to monitor and log all operator activities in the EMS including operator terminal and Local Craft Terminal.

c. The dynamic password facility shall be provided in which the operator may change its password at any time.

(3) It should be mandatory for the system to have a record of all log-ins in read only password protected file for a period of at least six months after which a backup should be possible under system administrator command. All log-in and log-out attempts shall be logged in the security log file of the EMS system.

(4) The man-machine communication programs shall have the facility of restricting the use of certain commands or procedures to certain passwords and terminals.

(5) LCT should normally manage one node at a time. Remote management of any node in the sub-network should be possible via LCT.

(6) It shall be possible to provide the connectivity of EMS and the network elements through IP-MPLS-VPN network for providing the inherent security required for the management information in addition to the

login and Password based authorization for the operators of the Network Manager.

(7) The EMS shall be able to back up and restore the data base to and from external storage media.

22.6 Inventory management:

(1) It shall indicate the presence or absence of any physical module in hardware elements. It shall also indicate the usage of module i.e. how many ports are in use, which interfaces are in use and which are free to be used.

(2) The EMS shall be able to discover, keep and display the device information

(3) The EMS shall be able to keep track and report chronologically on any change in the network inventory.

(4) The EMS shall be capable of providing the inventory information to the Network Management layer (NML)/Service Management Layer (SML) so that SML is able to create and activate a service to the customer.

(5) The EMS shall provide the complete view of location wise network elements and the interconnecting links, in map format, list or rack picture format etc. for each independent links/networks as well as for all the links/networks under management of the EMS.

22.7 Software Management:

It shall be possible for the EMS to carry out the following tasks under the software management function:

(1) Loading of new system software in EMS/local terminals/remote terminals and the LCTs.

(2) Managing different versions of software.

(3) Managing multiple versions of software for individual elements. In this case, one software version shall remain active and other versions shall be passive.

(4) Installation of software patches.

(5) Examine contents and utilisation of all system memory and disk memory.

(6) Local & remote software download via management system to NEs and LCT shall be possible, including the means of identification of software module versions. No loss of data/traffic & connection-map shall take place during the software downloading process. At the time of downloading the software, the message shall be displayed that the software has been downloaded successfully or failed and at what stage.

(7) Downloading of Software, configuration, patches etc., to the Network Element through FTP/TFTP. No loss of data/loss of connection map shall take place during the software downloading process.

(8) The operator terminals (local & remote) shall not allow loading of any software without the EMS administrator's authorization.

(9) Changing the system configuration, reconfiguration of input and output devices.

(10) All commands which are executed over the EMS program or data shall be logged in a file (read only) and it shall be possible to retrieve the same on demand whenever required, using Man-Machine Commands. The EMS shall have suitable system level backup mechanism for taking backup of EMS data of at least one month on DVD, CD or transfer to another storage through LAN. The file usage of up to 50%, 75% and 90% shall generate alerts in the server platform, of suitable category prompting the operator to initiate the backup operation.

(11) During the log-in by the system administrator, the system will provide the visibility of at least last 20 commands on the screen as system log.

(12) The EMS of the DWDM equipment shall have e-protection from the virus.

22.8 EMS Server

(1) EMS system shall consist of Application and Database servers and it shall possible to mount these servers on different or on single server.

(2) The memory of the Database Server shall be sufficient to store the data of minimum 500 fully loaded NEs with a capability of storing performance/ fault history of 30 days.

(3) Application and Database servers as well as firewall system (if provided) shall have redundancy for control module, disk, power supply and LAN interface.

(4) Industry standard Relational Database Management system (RDBMS)/SQL/Oracle for storing all the data related to the network and the system shall be used.

(5) The database interface shall be open so that an EMS if upgraded at a future date is able to retrieve information from the EMS database using TCP/IP stack and do post processing. The data base structure for all the databases used in the system shall be provided.

(6) TEC GR No. TEC/GR/IT/SRV-01. FEB2014 may be referred for servers.

22.9 Firewall [optional requirement]:

If EMS is required to be connected to public network, it is desirable to provide security to EMS from public network. In such case a dual redundant hardware based Firewall system may be provided at each of the EMS locations for providing security to the various servers at the EMS. For Firewall System specifications TEC GR No. TEC/GR/IT/FWS-001/04.MAR.2014 may be referred.

NOTE: For offering DWDM system for Type Approval, Firewall shall not be mandatory.

22.10 Local Crafts Terminal/Client Terminal/Work Station:

1) Local Craft Terminal performs two types of functions in a network at NE

level namely Configuration Management and Fault Management.

2) LCT can be installed on a client PC or Laptop. The LCT shall be able to access a local NE through a LAN or a serial port on DWDM equipment and any remote NE through data communications channel (DCC)/optical supervisory channel (OSC) of the DWDM system. For fault management it shall handle only basic alarm functions like Alarm Monitoring Policy Settings, Alarm Viewing and Alarm Deletion etc.

22.11 Typical minimum Desktop/Laptop configuration for LCT/EMS terminal shall be as follows

a) Core I5, 2 GHz and above
b) 17” Colour Monitor (for PC) / 15” LCD/TFT display (for Laptop)
c) 8GB RAM
d) 48X CD-ROM drive
e) LAN port (10/100Mbps Ethernet interface)
f) Inbuilt Modem
g) 2 Nos. USB Ports
h) Printer port
i) Mouse port
j) PS-2 Keyboard port (not for laptop)
k) Licensed Operating software preloaded/Recovery CDs.
l) Key board (Not for laptop)
m) HDD 1TB or 512GB SSD

22.12 EMS Architecture

22.12.1 Though the EMS can be PC based system for a small network, for a network having large numbers of NEs, Centralised EMS with server based architecture should be provided.

(1) To ensure EMS connectivity to the sub-network under control-card failure, it shall be possible to dual home the EMS to two Gateway NEs (GNEs) in a sub-network so that performance and fault data for the sub-network shall be available even if the master control-card at one

GNE fails.

(2) In case of loss of EMS connectivity, the LCT privilege shall not be affected for monitoring and for local configurations, as per the privileges assigned by EMS administrator.

(3) It shall be possible to operate the Main and DR locations in 1+1 mode, either with manual switchover or with automatic switchover. The system shall have data replication and synchronization mechanism so that servers at both locations have same data. Synchronization shall be in real time or in steps of 15 minutes or less.

(4) Any failure in EMS including software bugs shall not affect the healthy working of the DWDM system.

(5) It shall be possible to assign rights to each local and remote terminal for EMS function for monitoring and issue of commands for all links or any number of independent links or sub-networks by the EMS administrator.

(6) In case of total loss of EMS connectivity, the performance data of the NE shall be stored in the controller card of the equipment, and shall be sent to central EMS server upon restoration of EMS connectivity. Minimum 6400 performance and fault data messages containing a minimum of 100 alarms shall be stored by the system.

22.12.2 Scalability Aspects:

(1) The EMS/NMS should be able to support at least 500 NEs. NE is an OADM or TM or ILA with fully equipped line and client side interfaces. These elements may be spread over any number of independent links or sub-networks of the capacity up to 10G.

(2) Operating system and applications for EMS including database server shall be multi-user with minimum 25 concurrent users including local terminals at EMS site and remote terminals which access the EMS through a WAN.

(3) The EMS shall be equipped to connect to at least 10 local terminals at EMS site. It shall also be upgradeable to 25 local terminals.

(4) EMS of the system shall have the capability of supporting dual stack 32/128 bit IP addressing, for internal communication with the equipment. The GNE shall automatically assign internal IP addresses for each equipment with in its domain via DHCP protocol or any other suitable/standard mechanism.

22.13 Management Interface:

22.13.1 Southbound Interface of EMS:

EMS shall provide south bound interface towards NE as implemented in the Gateway NEs (GNEs).

22.13.2 Northbound Interface:

The North bound interface meant for connectivity with NMS shall be open interface such as SNMP v2 or better/ XML/TL-1/ MTNM TMF-508, 613, 814 specified CORBA or JSON or Web service, using standard MIBs/ GDMO/ PICS etc., as per ITU-T Rec. G.873.1.

New Clause : Security: OTN Payload Encryption Support for AES 128/ 256

New Clause : Energy Efficiency and Dynamic Power Management
Support energy-efficient operation with dynamic power management features such as adaptive power control, shutdown of unused client ports, and power scaling based on traffic load.

New Clause: Compliance with ITU-T G.698 for Multi-Vendor Interoperability
Support for multi-vendor optical interoperability particularly ITU-T G.698.2 for amplified DWDM applications with single-channel interfaces, to enable

transport of alien wavelengths over the optical line system.

23.0 DWDM Equipment required for Type Approval

23.1 Minimum Equipment for Testing

Minimum five DXC nodes with equipped interfaces as per the following loading information shall be offered for testing along with all control and management entities in a wired chassis.

23.2 Interfaces to be offered against different categories of cross connect:

For offering the interfaces for testing, the following two conditions shall apply

a. In the case of testing against a Purchase Order, the interfaces and the quantum of interfaces mentioned in the PO shall be offered by the vendor for testing.

23.3 The minimum nos. of OTN Cross Connect with DWDM equipment required to be offered for testing:

Table 5: Minimum OTN with DWDM Equipment for Linear Add/Drop system

Sl. No.	Item	Quantity
1.	OTN client interface and processing modules	Minimum equipped OTN cross connect with 10 channels @OTU-4/OTUCn.
2.	Cross Connect	5 nos. As per the Cl. 5.1 & Cl. 23.1.
3.	Terminals (inclusive of MUX/De-MUX for both directions of traffic along with protection related redundant equipment, if any)	2 nos. TEs equipped for 10 channels (DXC Channels). These channels can be configured over 80 channels grid.

4.	In-Line Amplifiers	4 nos. for Long haul equipment 2 nos. for Very Long haul equipment.
5.	ROADM (inclusive of both directions of added/dropped traffic) for linear-chain DWDM system	3 nos. equipped for a total of 5 bi-directional channels (DXC Channels) in both fibre-directions for Long-haul equipment 2 nos. equipped for a total of 5 bi-directional channels in both fibre-directions for Very Longhaul equipment. (Applies only to the applied application code).
6.	Common equipment with an NMS/EMS & LCT along with software.	1 no. each

Note: Number of channel count at respective ROADM will be DXC channels.

Table 6: Minimum OTN Cross Connect with DWDM Equipment for Ring System

Sl. No.	Item	Quantity
1.	OTN client interface and processing modules	Minimum equipped OTN cross connect with 10 channels @OTU-4/OTUCn.
2.	Cross Connect	5 nos. As per Cl. 5.1 & Cl. 23.1.
4.	In-Line Amplifiers	4 nos. for Longhaul equipment 2 nos. for Very Longhaul equipment. (If OADM not offered for testing, there shall be 7 & 4 ILAs for longhaul and very longhaul application codes respectively).

5.	ROADM (inclusive of both directions of added/dropped traffic)	5 nos. equipped for a total of 5 bi-directional channels (DXC Channels) in both fibre-directions for Long-haul equipment
6.	Common equipment with an EMS & LCT along with software.	1 no. each

Note: Number of channel count at respective ROADM will be DXC channels.

New Table : Minimum OTN Cross Connect with DWDM Equipment for Mesh System

Sl. No.	Item	Quantity
1.	OTN client interface and processing modules	Minimum equipped OTN cross connect with 10 channels @OTU-4/OTUCn.
2.	Cross Connect	5 nos. As per Cl. 5.1 & Cl. 23.1.
3.	In-Line Amplifiers	4 nos. for Longhaul equipment
4.	ROADM (inclusive of both directions of added/dropped traffic)	5 nos. equipped for a total of 10 bi-directional channels (DXC Channels).
5.	Common equipment with an EMS & LCT along with software.	1 no. each

Note: Number of channel count at respective ROADM will be DXC channels.

The details for minimum equipment required for type approval are elaborated as follows:

a) Longhaul application:

Table 7: Minimum OTN with DWDM Equipment detail for Longhaul applications.

S. No.	Item	Quantity
1.	OTN client interface and processing modules	Minimum equipped OTN cross connect with 10 channels @OTU-4/OTUCn.
2.	Cross Connect	5 nos. As per Cl. 5.1 & Cl. 23.1.
3.	DWDM terminal Equipment	2 no. each
4.	Inline Amplifiers	4 nos
5.	Reconfigurable Optical Add /Drop Mux along with provision for channel add/drop capability	3 nos.
6.	Optical fibre 25dB loss irrespective of length	G.652 SMF: 10/7 Spools for 40/80 Channels G.655 SMF: 7/6 Spools for 40 Channels
7.	NMS supporting LCT and Work Station	1 no.

b) Very Long haul application:

Table8: Minimum OTN with DWDM Equipment detail for Very Longhaul applications.

S. No.	Item	Quantity
1.	OTN client interface and processing modules	Minimum equipped OTN cross connect with 10 channels @OTU-4/OTUCn.

2.	Cross Connect	5 nos As per Cl. 5.1 & Cl. 23.1.
3.	DWDM terminal Equipment	2 nos.
4.	Inline Amplifiers	2 nos.
5.	Reconfigurable Optical Add /Drop Mux along with channel add/drop	2 nos
6.	Optical fibre 33dB loss irrespective of length	G.652 SMF: 3/2 Spools for 40/80 Channels G.655 SMF: 3/2 Spools for 40/80 Channels
7.	NMS supporting LCT and Work Station	1 no.

NOTE 1: The TAC can be applied against any of the DWDM network topologies -, linear add/drop, ring, & mesh (ASON). The same shall be outlined on the TAC.

NOTE 2: The TAC can be applied for any of the application codes – Metro, Longhaul and Very Longhaul.

24.0 Field Trial:

The equipment shall be subjected to field trial for a minimum of 4 weeks with working traffic. The equipment shall be loaded with maximum possible live-traffic & in case of unavailability of live traffic, simulated traffic shall be loaded for the entire capacity of the system to assess the actual performance of the equipment in the field.

CHAPTER-2

25.0 Application codes

The GR envisages two different application codes for a, linear-chain & ring in accordance with Table-1 & 2/Annexure-I of the GR. Under all network topologies, viz., , linear add/drop & DWDM ring architecture, all fibre-spans between 'MPI-S & MPI-R', S' & R' and 'Sn & Rn' reference points of figure nos. 7, shall be limited by Table-1 & 2/Annexure-I specifications for both application codes for the worst-case channel. All the optical amplifiers shall be designed for nominal 22db span-loss for Long Haul applications and 30db span-loss for Very Long Haul applications.

25.1 Longhaul application code

The LH 40 channels DWDM equipment shall acquire approximately 640/550 km (G.652 /G.655 SMF) route length before acquiring 3R regeneration. This is based on 0.28 db/km loss over single mode optical fibre. Based on these projections, total dispersions requirements shall be 14400/ 1100 ps/nm for LH 40 channels configuration @ 18/ 2 ps/nm.km over C-band for G.652/G.655 SMF.

The LH 80 channels DWDM equipment shall acquire approximately 550/475 km (G.652 /G.655 SMF) route length before acquiring 3R regeneration. This is based on 0.28 db/km loss over single mode optical fibre. Based on these projections, total dispersions requirements shall be 9900/ 950 ps/nm for LH 80 channels configuration @ 18/ 2 ps/nm.km over C-band for G.652/G.655 SMF.

Span-loss between MPI-S & R', S'& MPI-R and S' & R' reference points for all spans shall be 22 dB. The number of spans for long haul application is detailed later in the document. The dispersion – CD as well as PMD in the link shall be addressed through coherent detection technique as indicated in cl. 3.28.

25.2 Very Longhaul application code

The VLH 40 channels DWDM equipment shall acquire approximately 300 km (for both G.652 & G.655 SMF) route length before acquiring 3R regeneration. This is based on 0.28 db/km loss over single mode optical fibre. Based on these projections, total dispersions requirements shall be 5400/ 600 ps/nm for VLH 40 channels configuration @ 18/ 2 ps/nm.km over C-band for G.652/G.655 SMF.

Span-loss between MPI-S & R', S'& MPI-R and S' & R' reference points for all spans shall be 30 dB. The number of spans for Very long haul application is detailed later in the document. The dispersion – CD as well as PMD in the link shall be addressed through coherent detection technique as indicated in cl. 3.28.

NOTE 1: The above power-budgets shall be valid even for the worst-case channel for which proper channel equalization scheme shall be implemented in the system to adhere to end-to-end OSNR requirements in uniformity with other channels.
NOTE 2: The exact distances covered shall be subject to actual fibre-attenuation coefficient and dispersion parameters for the worst-case channel.
NOTE 3: All enroute nodes for both Longhaul & Very Longhaul application codes shall include ILAs, FOADMs/ ROADMs or a combination of them. The insertion-loss of FOADMs/ ROADMs shall be compensated by the OA element contained within OADM node. The OA element shall be designed accordingly.

25.3 Span attenuation:

The span-loss of the optical cable including splice-losses and cable-margin etc. shall be as detailed above, for respective application codes. The span-losses specified in the clause are beginning-of-life values and a

margin for the ageing of fibre and optical amplifiers etc., to adhere to end-of-life values shall be tested. Testing of the link shall be performed for a span-loss 3db higher than beginning-of-life values during testing.

25.4 Number of spans without 3R-Regenerator:

For a comprehensive network planning, the purchaser may ask the vendor to provide the relevant network planning tool for the network design. Since the DWDM equipment is required to function in both Longhaul as well as Very Longhaul applications and the no. of spans in respect of both these applications vary depending upon the type of NEs used i.e., TMs, ILAs, ROADMs, the purchaser may ask the vendor to carry out the complete network planning as per the network information provided by the purchaser.

The DWDM link over the Single-mode Optical fibre shall support the number of spans as under:

Table-9: No. of spans as per application and type of fiber

Long Haul Application @ 40Channels	
Fibre Type	**No. of Spans**
G.652	8
G.655	7
Long Haul Application @ 80 Channels	
Fibre Type	**No. of Spans**
G.652	7
G.655	6
Very Long Haul Application @ 40Channels	
Fibre Type	**No. of Spans**
G.652	3
G.655	3
Very Long Haul Application @ 80Channels	

Fibre Type	No. of Spans
G.652	2
G.655	2

25.5 Network Protection:

For the various topologies, namely, Linear Add-Drop topology Two fibre DWDM ring and mesh topology, traffic shall be protected at client layer by using 1+1 Optical Sub-Network Connection protection..

The protection switching excluding fault detection time, fault propagation time, etc., shall be completed within 50 ms.

The user shall specify the exact requirement of protection mechanism during the procurement of the equipment.

25.6 Equipment redundancy requirements

1. Control/Processor:

   The Control/Processor unit/module and Power supply shall not affect the working traffic as the same shall have the redundancy. Further, there shall not be any disruption to system-working when the faulty card is taken out and the healthy one is inserted back. Immediately upon insertion of a healthy card, the system shall revert back to its pre-failure EMS configuration.

   There shall be support for dual-homing for EMS connectivity for no loss of EMS connectivity, through two Gateway NEs (GNE's) on a DWDM link. In case of total loss of EMS connectivity to the system/network, the system design shall provide local storage of all performance & fault data, as specified in Appendix-I of the GR, for all connections pertaining to all NEs, in the sub-network. Such connectivity loss might happen due to control-card failure at both GNE's and/or failure of DCN

link to EMS. In-built intelligence shall be there in EMS for selection of appropriate GNE at distant end of a DCN link upon failure of control card at one of the GNE's, for EMS connectivity.

2. Switch matrix

   The universal cross-connect matrix cards having dimension and capacity as per specific category of equipment (clause 5.1 of the GR) shall provide N:1 protection. Upon failure of any of the working card, the protection card shall take-over within 50ms (along with a replica of existing connection-map).

3. Power Supply:

   If the power-supply is provided through a centralized power-supply unit at chassis level, a hot-standby power-supply shall be provided at chassis level, to ensure smooth working of the equipment during failures.

   Further, there shall be provision for dual-feed arrangement to the chassis power-supply, such that in case of failure of one feed, the system shall be able to function in a healthy manner without traffic interruption.

4. There shall be complete redundancy for Timing Circuitry against failures. The changeover of all redundancy actions shall be completed within 50ms.

26.0 Maintenance requirements

Maintenance philosophy is to replace faulty units/subsystems after quick on-line analysis through monitoring sockets, alarm indications and Built-in Test Equipment/ hand-held terminal/laptop PC. The actual repair will be undertaken at centralized repair-centers. The corrective measures at site shall involve replacement of faulty units/sub-systems.

a) The equipment shall have easy access for servicing and maintenance.
b) Suitable alarms shall be provided for identification of faults in the system and faulty units.
c) Suitable provision shall be made for extension of summary alarms.
d) Ratings and types of fuses used are to be indicated by the supplier.

27.0 Accessories:

The supplier shall provide one complete set of:

a) All the necessary interfaces, connectors, connecting cables and accessories required for satisfactory and convenient operation of the equipment. Types of connectors, adapters to be used and the accessories of the approved quality shall be clearly indicated in the operating manuals, which should be in conformity with the detailed list in the GR;
b) Software and the arrangement to load the software at site.

NOTE 1: Additional sets may be ordered optionally.

NOTE 2: Special tools, extender boards, extender cables and accessories essential for installation, repair, operation and maintenance of the equipment shall be clearly indicated and supplied along with the equipment.

28.0 Documentation:

Technical literature in English language for assembly of modules and wiring shall be supplied. All aspects of installation, operation, maintenance shall be covered in the manuals. The soft copy of the manuals shall also be provided in pen drive/by email. The soft copy or hard copy of the manuals may also be provided in Hindi language, if feasible. The manuals shall include the following:

i) Installation, Operation and Maintenance Manual-

a) Safety measures to be observed in handling the equipment;

b) Precautions for installation, operation and maintenance;

c) Test jigs and fixtures required and procedures for routine maintenance, preventive maintenance, trouble-shooting and sub-assembly replacement;

d) Illustration of internal and external mechanical parts.

e) The detailed description about the operation of the software used in the equipment including its installation, loading and debugging etc.

ii) Repair Manual (to be supplied when ordered)-

a) List of replaceable parts used including their sources and the approving authority;

b) Detailed ordering information for all the replaceable parts shall be listed in the manual to facilitate reordering of spares as and when required;

c) Procedure with flow chart for troubleshooting and sub-assembly replacement shall be provided.

ABBREVIATIONS

ALS	:	Automatic Laser Shutdown
ASON	:	Automatically Switched Optical Network
BER	:	Bit Error Ratio
BIP	:	Bit Interleaved Parity
BSNL	:	Bharat Sanchar Nigam Limited
CD	:	Chromatic Dispersion
CD-ROM	:	Compact Disc- Read Only Memory
CISPR	:	Special International Committee on Radio Interference
CORBA	:	Common Object Request Broker Architecture
DC	:	Direct Current
DCM	:	Dispersion Compensation Module
DCN	:	Data Communication Network
DHCP	:	Dynamic Host Control Protocol
DUCS	:	Dispersion Under Compensation Scheme
DVB-ASI	:	Digital Video Broadcasting Asynchronous Serial Interface
DVD	:	Digital Versatile Disc
DWDM	:	Dense Wavelength Division Multiplexing
EDFA	:	Erbium Doped Fibre Amplifier
EMC	:	Electro Magnetic Compatibility
EMS	:	Element Management System
EOW	:	Engineering Order Wire
ESCON	:	Enterprise Systems Connection
ETSI	:	European Telecommunications Standards Institute
EWS	:	East West Separation
FC	:	Fiber Channel
FC/APC	:	Fibre Connector/ Angle Polished Connector
FDDI	:	Fiber Distributed Data Interface
FDF	:	Fibre Distribution Frame
FE	:	Fast Ethernet
FEC	:	Forward Error Correction
FICON	:	Fiber Connection

FOADM	:	Fixed Optical Add/Drop Multiplexer
FTP	:	File Transfer Protocol
FWM	:	Four Wave Mixing
GbE	:	Gigabit Ethernet
GDMO	:	Generic Guidelines for Definition of Model Objects
GE	:	Gigabit Ethernet
GFP	:	General Framing Procedure
GMPLS	:	Generalized Multiprotocol Label Switching
GNE	:	Gateway Network Element
GR	:	Generic Requirements
GUI	:	Graphical User Interface
HDD	:	Hard Disc Drive
HD-SDI	:	Bit-serial digital interface for high-definition television Systems
IaDI	:	Intra Domain Interface
IEC	:	International Engineering Consortium
IEC	:	International Electro-Technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IETF	:	Internet Engineering Task Force
ILA	:	In Line Amplifier
IP	:	Internet Protocol
IPSec	:	Internet Protocol Security
IrDI	:	Inter Domain Interface
ISO	:	International Standard Organization
ITU	:	International Telecommunication Union
LAN	:	Local Area Network
LCT	:	Local Craft Terminal
LOF	:	Loss of Frame
LOM	:	Loss of Multiframe
LOS	:	Loss of Signal
MEMS	:	Micro Electromechanical System
MIB	:	Management Information Board
MPI	:	Multiple Path Interference

MPI-R	:	Main Path Interface at the receiver
MPI-S	:	Main Path Interface at the transmitter
MPLS	:	Multi-Protocol Label Switching
MSPP	:	Multi-service Provisioning Platform
MTBF	:	Mean Time Between Failures
MTNM	:	Multi-Technology EMS/NMS
NDA	:	Non-Disclosure Agreement
NE	:	Network Element
NML	:	Network Management Layer
NMS	:	Network Management System
NOC	:	Network Operation Centre
NZDSF	:	Non-Zero Dispersion Shifted Fibre
OA	:	Optical Amplifier
OADM	:	Optical Add Drop Mux
OCh	:	Optical Channel
OCI	:	Open Connection Indication
OD	:	Optical Demultiplexer
ODF	:	Optical Distribution Frame
ODU	:	Optical Data Unit
OLS	:	Optical Laser Source
OM	:	Optical Multiplexer
OPU	:	Optical Payload Unit
OS	:	Operating System
OSC	:	Optical Supervisory Channel
OSI	:	Open Systems Interconnection
OSNR	:	Optical Signal to Noise Ratio
OTM	:	Optical Terminal Mux
OTN	:	Optical Transport Network
OTU	:	Optical Transport Unit
PCB	:	Printed Circuit Board
PICS	:	Protocol Information Compliance Statement
PKI	:	Public-Key Infrastructure
PLM	:	Payload Mismatch

PMD	:	Polarization Mode Dispersion
QA	:	Quality Assurance
QM	:	Quality Manual
RAID	:	Redundant Array of Independent Disks
RDBMS	:	Relational Database Management System
RFC	:	Request for Comments
RISC	:	Reduced Instructions Set Computing
ROADM	:	Reconfigurable Optical Add Drop Mux
ROM	:	Read Only Memory
RX	:	Receiver
SC	:	Square Connector
SDH	:	Synchronous Digital Hierarchy
SDI	:	Serial Digital Interface
SFEC	:	Super Forward Error Correction
SFP	:	Small Form Factor Pluggable Transceiver
SLM	:	Single-Longitudinal Mode
SMF	:	Single Mode Fibre
SML	:	Service Layer Management
SNCP	:	Sub Network Connection Protection
SNMP	:	Simple Network Management Protocol
SNR	:	Signal to Noise Ratio
SPM	:	Self Phase Modulation
SRS	:	Stimulated Raman Scattering
STM-16	:	Synchronous Transport Module at 2.5Gbps
STM-64	:	Synchronous Transport Module at 10Gbps
TCP	:	Transmission Control Protocol
TIM	:	Trace Identifier Mismatch
TM	:	Terminal Multiplexer
TMF	:	Tele Management Forum
TRE	:	Terminal Receiving Equipment
TX	:	Transmitter
UDP	:	User Datagram Protocol
UNIX	:	Uniplexed Information and Computing System

VOA	: Variable Optical Attenuator
WSS	: Wavelength Selective Switch
XFP	: 10 Gigabit Small Form Factor Pluggable
XPM	: Cross Phase Modulation

======== End of the document ========

ANNEXURE-I

Table-1: Parametric values of 40 Channel DWDM system @ OTU4

Parameters	Units	Values	
No. Of Channels		40	
Bit rate per channel		OTU4	
No. of spans		G.652: 8 G.655: 7	G.652: 3 G.655: 3
Individual Transmitter output at Sn point			
Launched Power range	dBm	-5 to +5	-5 to +5
Maximum Spectral Width	MHz	0.5 nm (@-20 dB)	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12	12
Central Frequency	THz	193.1+ n x 0.1	193.1 + n x 0.1
Minimum Wavelength Spacing	GHz	100	100
Maximum Wavelength Deviation	Pm	+/- 25 pm	+/- 25 pm
Optical Interface at MPI - S_M & S_M			
Optical Trans side Cross talk	dB	< -22dB for adjacent channel < -25dB for non-adjacent channel	
Mean channel output Power	dBm	1	1
Channel output power -max	dBm	4	4
Channel output power- min	dBm	-2	-2
Total launched power			
min	dBm	5	5
Max		20	20
Max. Channel power difference	dB	6	2.5
Optical Line Amplifier			
Multi-Channel gain variation	dB	< 2	< 2
Multi-Channel gain tilt	dB	< 1.6	< 1.6
Multi-channel gain change difference	dB	2	2
Total received power			
min	dBm	-22	-29
max	dBm	3.5	-3.5

Total Launched Power -min	dBm	5	5
max	dBm	20	20
Signal spontaneous Noise Figure	dB	7	7
Optical path(MPI-S_M ~ MPI-R_M)			
Maximum Discrete Reflectance	dB	< -35	< -35
Minimum Return Loss	dB	24	24
Optical interface at MPI-R_M & R_M			
Mean channel input Power			
max	dBm	-17	-17
min	dBm	-25	-25
Total Input Power Min	dBm	-22	-29
max	dBm	3.5	-3.5
Channel Signal to Noise Ratio-min (S-FEC)	dB	15	15
Max. Channel power difference at MPI-R & R'	dB	6	2.5
Maximum differential group delay(1dB OSNR penalty)	Ps	24	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel	
Individual Receiver inputs at Rn Points			
Receiver sensitivity	dBm	-20 to +5	-20 to +5
Receiver Overload	dBm	0	0
Receiver Reflectance	dB	-27	
Receiver OSNR Tolerance (EOL)	dB	19	19
Minimum receiver wavelength	Nm	1529	
Maximum Receive wavelength	Nm	1565	

Table-2: Parametric values of 80 Channel DWDM system @ OTU4

Parameters	Units	Values
No. Of Channels		80

Bit rate per channel		OTU3/OTU4	
No. of spans		G.652: 7 G.655: 6	G.652: 2 G.655:2
Individual Transmitter output at Sn point			
Launched Power range	dBm	-5 to +5	-5 to +5
Maximum Spectral Width	MHz	0.5 nm (@-20 dB)	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12	12
Central Frequency	THz	193.1+ n x 0.05	193.1 + n x 0.05
Minimum Wavelength Spacing	GHz	50	50
Maximum Wavelength Deviation	pm	+/- 25 pm	+/- 25 pm
Optical Interface at MPI - S_M & S_M			
Optical Trans side Cross talk	dB	< -22dB for adjacent channel < -25dB for non-adjacent channel	
Mean channel output Power	dBm	1	1
Channel output power -max	dBm	4	4
Channel output power- min	dBm	-2	-2
Total launched power			
Min	dBm	5	5
Max	dBm	20	20
Max. Channel power difference	dB	5	2.5
Optical Line Amplifier			
Multi-Channel gain variation	dB	< 2	< 2
Multi-Channel gain tilt	dB	< 1.6	< 1.6
Multi-channel gain change difference	dB	2	2
Total received power			
min	dBm	-22	-29
max	dBm	3.5	-3.5
Total Launched Power -min	dBm	5	5
Max	dBm	20	20
Signal spontaneous Noise Figure	dB	7	7
Optical path(MPI-S_M ~ MPI-R_M)			

Maximum Discrete Reflectance	dB	< -35	< -35
Minimum Return Loss	dB	24	24
Optical interface at MPI-R_M & R_M			
Mean channel input Power			
max	dBm	-17	-17
min	dBm	-25	-25
Total Input Power min	dBm	-22	-29
Max	dBm	3.5	-3.5
Channel Signal to Noise Ratio-min (S-FEC)	dB	15	15
Max. Channel power difference at MPI-R & R'	dB	4.5	2.0
Maximum differential group delay(1dB OSNR penalty)	ps	24	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel	
Individual Receiver inputs at Rn Points			
Receiver sensitivity	dBm	-20 to +5	-20 to +5
Receiver Overload	dBm	0	0
Receiver Reflectance	dB	-27	
Receiver OSNR Tolerance (EOL)	dB	19	19
Minimum receiver wavelength	nm	1529	
Maximum Receive wavelength	nm	1565	

Annexure-II

ASON Planning Tool

ASON Planning tool shall facilitate network operators to plan and simulate networks with an automated control plane such as GMPLS/ASON. GMPLS/ASON networks behave differently from legacy transport networks. The flexibility and benefit of having a transport layer control plane often results in a complex network planning process based on the operator's Traffic Engineering policies. The ASON-Planning Tool emulates the behavior of GMPLS/ASON networks in all the possible operative scenarios such as link, node and Shared Risk Link Group (SRLG) failures.

The goal of the ASON-Planner is to maximize the quality of service provided to customer and to optimize the network resources.

The ASON-Planning Tool shall be a multi-layer, multi-technology network planning tool that helps network operators to plan, develop, manage and upgrade their transport network.

1.0 Applications:

1.1 Planning the needed capacity of a network

The ASON Planning Tool shall be able to perform capacity planning of new network builds. For an optimal design of the network, the tool shall provide an option to specify the following parameters:

a) The traffic matrix, and more specifically:

i. The number of circuits to be created with the same characteristic;
ii. The source and a (the) destination(s);
iii. The required protection/restoration scheme;
iv. The required diversity between worker and protection/restoration circuit (link, node or SRLG)
v. Resources (link, node or SRLG) to be included or excluded in the network

vi. Traffic parameters for the circuit(s) e.g. the bandwidth.

b) The physical topology of the network, including the connectivity among the network elements,

c) The required network survivability specifying the number and type of the failure(s) policy, e.g. double links failure, single SRLG failure etc.

d) The type of network interfaces to be used during the capacity planning process,

1.2 Periodical check of the network status:

With the ASON Planning Tool, it shall be possible to update the snapshot of the network status, either from management system or directly from the network via standard Simple Network Management Protocol (SNMP) interface.

These snapshots shall be used to:

a) Perform the sensitivity analysis or 'what if' scenarios of failures or planned works,

b) verify if there are enough resources to accommodate new traffic requests when a new or modified traffic matrix is applied to the snapshot,

c) check if the network status is in line with the forecast.

2.0 Functionality:

2.1 Capacity Planning:

Having the current network topology (and the current network occupation) as input, the capacity planning analysis function should generate a batch of circuits according to the traffic matrix.

If some link or node exceeds a configurable percentage of occupation, an extension of the link/node capacity would be required. This operation could require the addition of ports and pairs of fiber to the links (or in case of DWDM links, of the number of transponders required by the line

terminals). The ASON Planning Tool shall be able to perform such automated operations.
The required modifications shall be stored and available on screen or file.

2.2 Fault Analysis:

Fault analysis allows the simulation of network faults and evaluation of the possibility to recover traffic. According to the current network configuration, the risk and the lost circuits can be evaluated.
It shall be possible to simulate faults on every link, node or SRLG of the network. The report will highlight the quantity of circuits protected and the circuits not saved by the network resource.
This can be useful for discovering possible weak points of the network.

2.3 Availability Analysis:

The ASON Planning Tool shall facilitate an Availability Analysis providing the estimation of the total availability of a network configuration on a per-circuit or per-SLA basis.
It shall be possible to use this feature to compare different protection/restoration schemes for the same network. It shall produce failure times for all the protection/restoration schemes (with or without control plane) and in case of single or multiple failures, it shall provide traffic impact data in case there are not enough resources to protect/restore the failure(s).

2.4 Bottleneck Analysis:

The bottleneck analysis shall allow the ability to find out network bottlenecks, that nodes or links that need to be or that will be upgraded in order to properly satisfy the traffic requirements of the network. Having the current network topology (and the current network occupation) as input, the bottleneck analysis function shall generate a batch of circuit creation

according to the traffic matrix.

2.5 Network Inventory:

The network inventory allows generation of a list of all the resources available in the network, and the map of the circuits. It should be possible to customize the network inventory depending on the need of the Network Operator, the level of details produced ranging from; all possible details to only circuits or node traffic interface inventory.

2.6 Available Reports

For each of the ASON – Planning tool functionalities, it should be possible to generate a report. The reports should be available in text file, Word and Excel compatible formats.
Moreover, it should be possible to customize each report, including all the available details or only a summarized view of the feature performed.

2.7 ASON Planner to NE

The ASON-Planning tool shall be able to plan the networks; the output of the planning activity shall be configuration files that can be directly downloaded to the Network Elements.

2.8 ASON-Planner GUI

ASON-Planning tool shall provide the network operator with a user friendly graphical interface; this GUI can be used to have a view of network or a frontal view of the network element.

3.0 Features

a) Map view of the network topology, allowing to create or modify a network directly from the map. Background map should be available.
b) Support of traffic at ODU1, ODU2/e, ODUflex, ODU3 etc.
c) Additional Constraints: Administrative colors, Explicit routes or inclusion/exclusion of certain categories of network resources.

d) Restoration with diversity W/P on nodes, links or SRLG Ids (Shared Risk Link Group Ids). Diversity from a list of selected existing circuits.
e) Support of Traffic engineering. Configurable TE policy.
f) Import from and export to ASON Planning tool of network topology files.
g) Import from and export to NMS of network topology files.
h) Network reports including: Bottleneck analysis, Fault Analysis, Capacity Planning, Network Inventory and Availability Analysis.
i) Support of ASON control plane
j) Automatic generation of ASON parameters
k) Import/Export of Traffic Matrix data from/to Excel (CSV); Full import/export of network data from/to Excel (CSV)
l) Fully configurable list views of network resources
m) Link details (including ASON parameters) on the map
n)