



## Specification document: Optical Network Equipment Specification



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## 1 INTRODUCTION

Broadband Infraco operates a national long distance fibre network using Dense Wave Division Multiplexing (DWDM) technology. The services that are provided on the network range from Synchronous Digital Hierarchy (SDH), Optical Transport Network (OTN), Ethernet and Internet Protocol (IP) and are provisioned over the DWDM network.

The current Broadband Infraco Transmission Network relies on traditional coherent and non-coherent Fixed Optical Add/Drop Multiplexer (FOADM), Reconfigurable Optical Add/Drop Multiplexer (ROADM), and Photonic Cross-connect (PXC) Dense Wavelength Division Multiplexer (DWDM) structures. These structures have limitations and cannot adequately accommodate the dynamic and unpredictable network traffic demand. Traditional OADM architectures, which switch traffic at the wavelength level, require a large number of ports as traffic volume increases.

Therefore, Broadband Infraco envisions a long-term solution to reduce the number of required ports, resulting in cost savings and simplified control complexity. The proposed solution is to adopt the coherent DWDM transport architecture known as Colourless, Directionless, Contentionless, and Gridless (CG/CDG/CDCG) ROADM nodes. In (CG/CDG/CDCG)-ROADMs, ports are not dedicated to specific wavelengths or node degrees, allowing multiple ports to simultaneously add/drop different channels at the same wavelength. Moreover, the (CG/CDG/CDCG) capabilities eliminate the need for manual technician intervention, a significant improvement compared to the earlier generations of ROADMs.

Additionally, to facilitate the flexible allocation of spectral resources, Bandwidth Variable (BV) ROADMs have emerged in the market to leverage the evolving trend in DWDM transport technology.

The approved design for SA Connect Phase 2 project involves the optimisation and upgrade of the existing national transport network of Broadband Infraco. This upgrade entails transitioning from the traditional Fixed Frequency Grid and reconfigurable DWDM to a modern Flex-grid DWDM infrastructure, incorporating (CG/CDG/CDCG) ROADM architecture.

This transformation is imperative due to the substantial capacity requirements due to the SA Connect Phase 2 project on the Broadband Infraco long-distance network. As a result, it is critical to upgrade the capacity of the Broadband Infraco national long-distance network to adequately cater to both current and future demands associated with the SA Connect Phase 2 project.

## 2 GENERAL REQUIREMENTS

The primary aim of this tender is for Broadband Infraco to implement its multivendor strategy, aiming to prevent dependence on a single transmission network vendor, as such reliance can lead to vendor lock-in, increased acquisition costs, and technical limitations that hinder flexibility. As a result, Broadband Infraco has recognized the importance of segmenting its transmission network into logical blocks and assessing various vendor domain scenarios for each potential ring.

Below are the general technical requirements for DWDM and OTN systems:

- The equipment shall be implemented with 100Gbps/200Gbps on the line side and OTU4/100GbE, OTU2e/OTU2/10Gb2e/10GbE and 1GE on client side.
- The DWDM system shall have the modularity and scalability of at least 80 Ch system architecture for Point-to-Point, ring and mesh network application.
- The devices are capable of being configured to any type of DWDM systems i.e., OTU, OADM, OLA etc. and associated with Elements Management System (EMS) and Network Management System (NMS).
- The equipment must support the Wavelength Selective Switch WSS architecture and implementation of Generalized Multiprotocol Label Switching (GMPLS) (RFC 3945) and/or Automatic Switching Optical Networks (ASON) (ITU-T G.8080) for restoration requirement in the offered model and sub-rack. The GMPLS/ASON control plan is adopted in Optical Channel (Och) scenarios.
- The equipment shall have a plan/concrete roadmap of inter-working with the IP/MPLS routers. The inter-working should be based on ITU-T, IETF, and OIF standards.
- The DWDM network shall be based on a minimum of 100Gbps line per channel with Flex grid Och Add/Drop Mux with required number of Ports according to Traffic Matrix at each node and other mentioned condition regarding this must be met.
- The DWDM network shall be 400Gbps and 800Gbps per channel ready for future traffic capacity upgrade or expansion requirements.
- The DWDM equipment shall support non-blocking CDCG ROADM architecture. Any client port of source node must be able to configure in any client port of destination network through any path between two nodes through all available direction.
- Equipment should support multiple protection architecture based on OCH/OMS or OTS with optical switching module or OTN switch, having protection switching achieved within 50ms.
- The Client ports and line (Transponder) ports may be on separate cards and shall be connected through backplane or line port and client port may be in same card provided all technical requirement of line port and client port stated in tender document is/are complied.
- The line card (Transponder) must be able to sync fast enough so that effective switching time from main to protection path does not exceed 50ms. Service-level switching time must

not exceed 50ms neither for line side protection switching nor for client-side protection switching.

- For bidding 100Gbps/200Gbps service boards, pluggable coherent CFP/CFP2/CFP4 optical modules shall be used to facilitate subsequent maintenance, improve device integration, and reduce power consumption.
- Wavelength Grid and DWDM system capacity shall be, as defined in ITU-T recommendation G.694.1 Wavelength channel spacing, should be flexible (flex grid supported).
- The Optical Supervisory Channel (OSC) channel and service channel must be separated and OSC channel shall not be amplified.
- From day one, the DWDM system flex grid add/drop MUX with required number of ports according to the traffic matrix of the node must be configured and other mentioned condition regarding this must be met.
- The line card (Transponder) must be tunable type and can be tuned to any of 80 or more channels on standard and/or offset ITU-grid within the full C-Band spectrum.
- The supplier's solution shall support CG/CDG/CDCG WSS/ROADM architectures for wavelength grooming with reference topology for 50 GHz/100 GHz operation.
- The DWDM system shall support and provide all types and capacity of CG/CDG/CDCG WSS (ROADM) to Re-Route any optical channel from any path to any path among all paths connected to that node (For all possible restoration paths).
- DWDM system shall support Remote NMS Reconfiguration having at least 80 Och reconfiguration with access to all channels and capable of switching between common port and switched ports.
- The DWDM system shall support a modular and flexible architecture, in order to allow scaling, the equipment in accordance with the network requirements.
- Optical equipment should be able to cater for the required link Budget (total loss of cable for each span) along with 3 dB End of Life (EOL) margin for each span.
- It shall be possible to equip the DWDM system progressively, in accordance with the number of wavelengths transmitted, in order to allow real "pay as you grow" configurations.
- The DWDM system shall be in-service upgradeable from one wavelength up to its maximum wavelength capacity.
- The proposed DWDM system should be able to ensure hitless in-service insertion of new channels or removal of channels, with the ability to automatically adjust/tune.
- The DWDM system shall support Automatic Power Equalization (APE). The system shall be capable of automatically adjusting power per channel to its optimum value, if and when channels are added or removed without the need for manual adjustment.
- The DWDM system shall support all types of architecture i.e., Optical Terminal Multiplexers (OTM), Reconfigurable Optical Add and Drop Multiplexers (ROADM), sharing the common modules, in order to minimize the number of spares.
- The DWDM system shall support Protection and subsequent Restoration of traffic using Layer 0 (L0)-ASON/GMPLS/Optical ASON.

- The DWDM system shall support in built OTDR functionality and be able to measure fibre parameters without impacting traffic while DWDM system is in service.
- Alien Wavelength (AW) provisioning from other Vendors' equipment must be supported and able to be carried from point to point as when required.

### 3 DWDM EQUIPMENT SPECIFICATION

The DWDM equipment/system shall conform to the following ITU-T and IEEE Recommendations. The latest version of ITU-T and IEEE Recommendations at date of tender award will also be considered:

- a) G.661 'Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems'
- b) G.662 'Generic characteristics of optical amplifier devices and subsystems'
- c) G.663 'Application related aspects of optical amplifier devices and subsystems'
- d) G.667 'Characteristics of adaptive chromatic dispersion compensators'
- e) G.671 'Transmission characteristics of optical components and subsystems'
- f) G.672 'Characteristics of multi-degree reconfigurable optical add/drop multiplexers'
- g) G.681 'Functional characteristics of interoffice and long-haul line systems using optical amplifiers, including optical multiplexing'
- h) G.692 'Optical interfaces for multichannel systems with optical amplifiers'
- i) G.693 'Optical interfaces for intra-office systems'
- j) G.694.1 'Spectral grids for WDM applications: DWDM frequency grid'
- k) G.696.1 'Longitudinally compatible intra-domain DWDM applications'
- l) G.709 'Interfaces for the optical transport network'
- m) G.783 'Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks'
- n) G.798 'Characteristics of optical transport network hierarchy equipment functional blocks'
- o) G.806 'Characteristics of transport equipment - Description methodology and generic functionality'



- p) G.8251 'The control of jitter and wander within the optical transport network (OTN)
- q) IEEE 802.3ba 'Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gb/s and 100 Gb/s Operation'
- r) G.8080/Y.1304 'Architecture for the automatically switched optical network'
- s) RFC 3945 'Generalized Multi-Protocol Label Switching (GMPLS) Architecture'

### 3.1 Requirements of Online System Performance Monitoring

- a. The DWDM equipment system shall have the capability to monitor system performance online without circuit interruption.
- b. The DWDM equipment system shall support monitoring and estimating OSNR, measuring optical power of each channel. Operator shall be able to view the related data in NMS.
- c. The DWDM system shall support OTDR functionality. Operator shall be able to view the related data in NMS.
- d. The NMS must support optical impairment awareness of the user during trail creation and beyond. This means the user can see the actual measurements from the network and judge whether the optical trail's OSNR meets OCh signal performance requirements.
- e. The DWDM system shall support OTDR functionality. Operator shall be able to view the related data in NMS.
- f. The NMS shall support latency detection and map function.
- g. The NMS must support Graphical network usage chart – graphically show used/free resources over the whole network or drill-down into a link (lambda and sub-lambda levels). For links, it should be possible to display availability in case of network growth.

### 3.2 OADM and OTN Requirements

OADM and OTN shall have the following basic functions:

- a. The electronic subrack of the bidding equipment shall support at least a minimum of 14 slots.
- b. The cross-connection capability of the bidding equipment shall be greater than or equal to 800 Gbit/s ODUk. (k=0, 1, 2, 2e, 3, 4, flex).

- c. The power supply, control, clock, and cross-connect boards of the bidding equipment shall be configured with 1+1 protection.
- d. Support add/drop of wavelength of 100/200 Gb/s single channel signal rate.
- e. The operation of drop wavelength shall not affect passthrough or straightway wavelengths.
- f. In case of upstream optical fiber breaking, it will not affect the normal work of the downstream business.
- g. In case that addition of new channels is required in DWDM node, the addition should not influence/stop service, performance and function in existing channels.
- h. Optical amplifiers such as pre-amplifier and booster can be used, if necessary.
- i. The maximum transporting distance (reach of line card/transponder) needs to be sufficient to cover the Broadband Infraco longest path requirement within the NLD Single Mode Fibre (SMF) fibre network.
- j. Optical amplifier needs to compensate the loss of optical power according to type of use.
- k. The system must support clock recovery and stamping based on NTP for Synchronization requirements.
- l. The bidding equipment shall support CG/CDG/CDCG ROADM networking and ROADM function must be configured at all service add/drop sites.
- m. Bidding equipment shall be environmental (site cooling) and power efficient to sustain South Africa power grid loadshedding effects.

### 3.3 Service Protection Requirements

- a) The system must support Optical Line Active/Protection switching using Optical Protection switch (OPS) or OTN switch.
- b) The bidding equipment shall use the OTN architecture and support multiple protection modes, such as optical line 1+1 protection, ODUK SNCP protection, intra-board 1+1 protection, and client 1+1 protection. The switching time must be less than 50 ms excluding detection time.

- c) It should be easily managed by the same NMS system as DWDM equipment and other optical card (amplifier card, MUX/DEMUX card etc.).
- d) Protection switch of all traffic shall be triggered on optical power monitoring and there shall be provision to set the LOS thresholds.
- e) Automatic switching shall be triggered by line faults (LOS, LOF etc.), OCh layer faults.
- f) The switching priority of Optical Line Active/Protection switching should support functions like Clear Switching, Forced Switching, Automatic Switching.
- g) Revertive operation must be provided.
- h) Non-revertive operation must be provided.
- i) Provisionable "generic hold-off function" must be provided.
- j) Lockout of protection and forced switch commands shall be supported.
- k) The system should have a fault notification function in order to notify the external terminal equipment connecting to downstream system of fault occurred on the network.

### 3.4 Service Restoration Requirements

- a. For Restoration, all OADM sites must be able to Re-Route optical channels. Re-routing will be possible from any path to any path among all paths connected to that node.
- b. Restoration path from source node to destination node must be created automatically.
- c. The system must be able to create consecutive restoration paths one after another at multiple fibre cut scenario, as long as a single path is available between the two nodes.
- d. The solution shall support and provide all type and capacity of CG/CDG/CDCG WSS (ROADM) to Re-Route any optical Channel from any path to any path between all paths connected to that node.
- e. The equipment must support the WSS and implementation of GMPLS (RFC 3945) and/or ASON (ITU-T G.8080) for restoration requirement in the offered model and sub-rack. The GMPLS/ASON control plan is adopted in OCh scenarios.
- f. The control plane should support automatic discovery of the network topology and network resources.
- g. ASON/GMPLS should support the calculation of the source node route.

### 3.5 Requirements for system reliability

- a) Flex grid Och Add/Drop Mux with at least No. of Ports according to Traffic Matrix at each node and other mentioned condition regarding this must be met.
- b) The Optical (photonic) part i.e., WSS, Amplifier, OSC, Optical Packet Switch (OPS) etc. must be equipped in optical sub-racks.
- c) Line cards (Transponder), Client cards, OTN Switch, if used, can be equipped in separate sub racks from the optical sub-racks.
- d) All sub-rack must have power redundancy.
- e) All sub-rack must have controller redundancy.
- f) OTN switch, if used, must have switching fabric redundancy.
- g) All the ports in any type of card or/and device be active or passive must be usable instantly when required without any further requirements of related software/license.

### 3.6 OTU Requirements

- a. Access service: Support 100GbE, 10 Gb (STM-64), 10GbE and 1GE.
- b. 100GbE overhead processing shall conform to the IEEE802.3ba standard.
- c. Optical interface of OTU S/R side shall meet one or more optical interface standard defined in ITU-T G.691, ITU-T G.693, ITU-T G.959.1, and IEEE 802.3ba, 10 × 10 MSA technical specifications.
- d. 10 x STM-64/10Ge/10G2e/OTU2/OTU2e multiple to 100 Gb/s
- e. Optical interface for client shall support the transparent transmission of 10 Gb/s. The wavelength from output in the line side shall meet the standard of ITU-T G.694.1.
- f. Branch route optical interface shall possess the ability to intercommunicate with the optical interface using the same standard from other manufacturers.
- g. 10 x 10GbE multiply to 100 Gb/s
- h. The proposed system shall comply with GFP mapping according to ITU-T G.7041 and the bidder shall describe its support to the following Ethernet encapsulation schemes referencing the offered 10G/100G Transponders/Muxponders as applicable. Moreover, the bidder shall clarify if the mapping of Ethernet to OTN is

according to G.709 and if both GFP-F and GFP-T mapping options are available, emphasizing the benefits of the supported encapsulation scheme. 10 GbE into ODU2e in timing transparent manner

- i. The bidder shall describe their solution for mapping 10GE LAN PHY/10GE WAN PHY to ODU-2.
- j. The bidder's solution shall support 10 x STM-64 / 10GBE LAN PHY / 10GE WAN PHY signals mapped into ODU4.
- k. The bidder's solution shall support STM-64 / 10GE signals mapped into ODU4.

### **3.7 Automatic gain equalization and power control requirements**

- a) Must have automatic gain equalization and automatic power control function.
- b) The process of Channel power dynamic control does not affect the other channel which is adjusted and the work of online business service.
- c) N x 100/200 Gb/s DWDM system can support the function of line power dynamic adjustment which does not influence the regular working service.
- d) Increase/decrease the channel without interrupting the business service.
- e) Automatic power gain equalization function can realize the dynamic power adjustment.
- f) The equipment shall support in-service gain/tilt adjustment without interruption of service.

### **3.8 OTDR Functional requirements**

DWDM system must have OTDR function. The following parameters must be complied with:

- a. Operating Wavelength: Any or multiple wavelengths between 1500 nm to 1650 nm.
- b. Resolution:  $\pm 3$  meter
- c. Should measure at least 20 dB per direction.
- d. Measure from both end sides into same link span fibre.
- e. OTDR measurements should be possible while DWDM system is in service.
- f. OTDR measurements should be done without impacting traffic while DWDM system is in service.

No extra optical fibre core will be required or allocated for OTDR function

### 3.9 Optical Supervisory Channel requirements

- a. Must have separate optical supervisory channel.
- b. The wavelength of optical supervisory channel is 1510 nm or 1620nm  $\pm$  10nm.
- c. OSC transmitter and receiver signal power level measurement feature must be available as part of link performance monitoring functionality
- d. The BER performance of optical supervisory channel should be in the range of 1.0Exp (-3) to 1.0Exp (-12).
- e. The failure and replacement of filters units cannot affect the DCN connectivity via OSC.
- f. The failure of an OSC unit must be non-traffic affecting.

### 3.10 Hardware (HW) Resiliency

- a) The life cycle of the equipment shall not be less than 10 years.
- b) The solution will be of modular chassis architectures.
- c) The solution must support insertion, replacement and removal of modules whilst the equipment is powered up without affecting traffic or/and damaging any module.
- d) Each shelf shall have an individual shelf control card.
- e) The solution shall provide indications on each individual module to indicate a failure of the module.
- f) The equipment shall also have an alarm display showing at least major and minor summary alarms.

### 3.11 Software Resiliency

- a. The supplier shall indicate if control and forwarding parts are separated (autonomous) and if a control failure does affect (or not) the forwarding part.
- b. The supplier shall confirm that SW upgrade and patches can be performed without any service interruption and that its solution supports the upgrade of all operating software without any traffic interruption.
- c. Regarding in-service configuration backup and restore features, the supplier shall confirm that its solution has the capability to batch download software and firmware and switch in bulk.
- d. The supplier shall confirm that their solution is capable of autonomous operation, without assistance from the Management System.

## 4 NETWORK MANAGEMENT SYSTEM

The Network Management System (NMS) solution for the monitoring and management of the devices and network is required. The NMS shall be fully centralized for management of all network elements (NE), offering the possibility to perform network management tasks from a single site or several sites. The NMS shall be of Server and clients-based architecture.

The NMS system shall be provided with user-friendly interfaces based on Unix and/or Linux and/or windows operating system. The NMS shall be able to provide an on-screen view of the managed network.

It shall be possible to access any managed NE from the whole network in the managed domain. The NMS shall be able to depict the failure state of each link and node in the displayed network. Further, it shall be possible from the NMS system to get the details of status of an individual managed NE, such as equipment presence, settings, alarm status etc.

NMS shall support multivendor approach with multi-domain GMPLS/Path Computation Element (PCE) Control Plane able to manage flexible transmission and switching network of 100G/200G per lambda and beyond 400G/lambda capacity

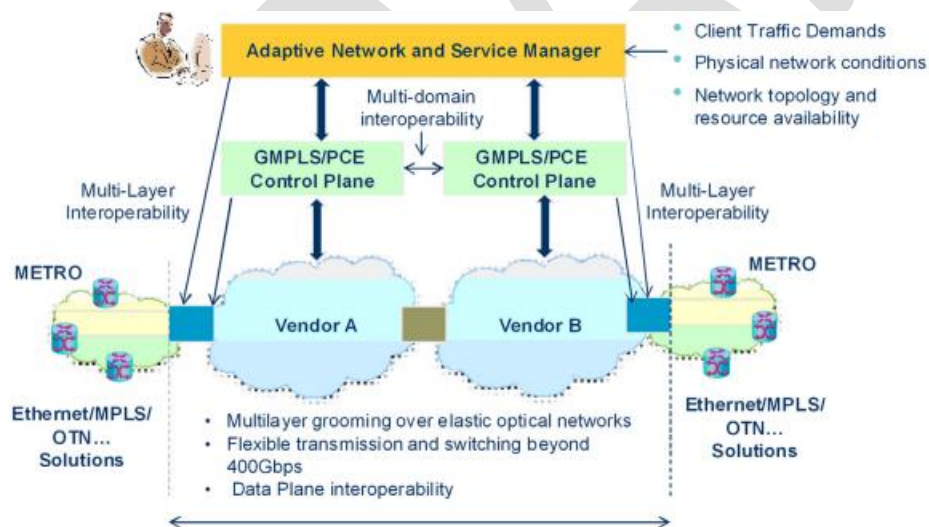


Figure 1: Network Control and Service Management Architecture

### 4.1 NMS Capabilities

The following Management facilities must be provided:

- Fault Management
- Configuration Management
- Inventory Management



- d. Security Management
- e. Alarm & Event Management
- f. Performance Management
- g. Software upload/download capability
- h. Backup and Restoration Management of all NE

#### **4.2 Visualisation of network domain**

- a. NMS shall provide end-to-end visualization of wavelength paths.
- b. NMS shall provide end-to-end display of optical power measurements.
- c. NMS shall provide details for end-to-end wavelength channel provisioning and automated wavelength channel restoration.
- d. NMS shall provide visualization of OTDR report of fiber spans.
- e. The NMS shall support latency detection and map function.

#### **4.3 NMS Requirements**

- a) The NMS shall run on Unix/Linux/Windows platform.
- b) NMS shall be connected to the proposed node equipment via IP interface.
- c) NMS should provide web-based client interface which enables anywhere management.
- d) NMS must support E2E service configuration, monitoring and performance checking.
- e) NMS must support user-friendly GUI and easy point & click operations.
- f) NMS should support quicker end-to-end provisioning of multi-service, including WDM circuit, SDH circuit, Ethernet circuit, and wavelength transport.
- g) NMS should provide Fault, Configuration, Performance & Security features in their respective Window.
- h) NMS must support Ethernet OAM standards such as Y.1731,
- i) The NMS shall provide management functionalities and web-based management.
- j) The NMS shall support remote downloading of all types of software and firmware required by DWDM and OTN equipment.
- k) The system shall support up-gradation of the software version preloaded in the system without loss of traffic or configuration.
- l) System shall allow revert back to the previous version of the software.
- m) Download failure on the NE shall not affect other applications running on NMS.
- n) The NMS should have the capability of auto discovery of new NE.



- o) NMS shall provide the inventory details of all systems in the network up to card and SFP/XFP level with simple operation.
- p) NMS shall have report generation capacity such as Number of configured WDM circuits, SDH circuits, Ethernet paths, used and unused capacity of each Network Element etc.
- q) NMS shall provide Comprehensive network map (geographic and synoptic) of all the managed elements with a sophisticated alarm and traffic status display, real time alarm and traffic monitoring and giving a full access to all NE technical management features through a user-friendly interface.
- r) NMS shall support Simple Network Management Protocol (SNMP), Telemanagement Forum (TMF), Common Object Request Broker Architecture (CORBA) & REST Northbound Interface (NBI)
- s) NMS shall support Fault, Configuration, Accounting, Performance and Security (FCAPS) via REST NBI
- t) NMS shall have the capability for interworking with 3rd. Party SDN/Orchestration Solutions.
- u) NMS shall have the capability for integration of 3rd. Party NEs via Southbound Interface (SBI).
- v) NMS shall support Warm/Hot Standby Server Redundancy Solution (Max. 10 Sec. for Switching over between Main & Standby Servers).
- w) In Warm/Hot Standby concept, NMS shall support automatic switch-over between Main Server and Standby Server (without user-intervention).
- x) In Warm/Hot Standby concept, after switch-over to Standby server, all clients must be automatically switched-over to Standby Server (without user-intervention).

#### **4.4 NMS Hardware requirements**

- a. The NMS shall consist of Server and clients-based architecture.
- b. There will be provision to use Laptop/Notebook as Local Craft terminal (LCT) with appropriate software to connect DWDM and OTN equipment directly so that configuration and monitoring can be done from the Laptop. The LCT shall be able to connect all network elements on the same network (autonomous system) from a locally connected device.
- c. Required HW resource for Server, Client workstations, Local Craft Terminal i.e.

CPU (type and number of cores, speed)

RAM (Capacity)

Disk (Capacity + required partitioning)

Number of network interfaces

Platform power consumption, power protection

Other HW requirements

HW should be chosen for each management entity according to the total size of the network and no. of node / NE to be managed and monitored by the NMS.

#### 4.5 NMS Software requirements

The NMS software shall be based on Unix and/or Linux and/or Windows based operating system. The NMS shall be a multi-task and multi-user **system**. The offered software architecture shall be open and configurable to enable future extensions. Software license shall be quoted for lifetime.

#### 4.6 General Functions of the NMS

##### Fault and Alarm Management

All faults and alarm events shall be reported. Adequate arrangement for display and logging shall be provided if there is any event received at the NMS. All alarms received at the NMS shall cause a change of color/add object on the appropriate object on screen. There shall be a visible indication on screen that there is an alarm somewhere in the system. In addition to the displays, alarm details may be displayed in tabular format.

- a) NMS should provide real time surveillance of network faults from the various alarm captured from the network elements.
- b) Alarms in any Node/NE shall be shown by the NMS.
- c) Fiber Link/Path (Fiber Cut / High Loss) alarm shall be shown by the NMS.
- d) The reported alarm shall have date and time stamped.
- e) Alarms shall be displayed on NMS screen in different color/object representing the severity (critical, major and minor) and the state of the alarm. The operator shall be able to acknowledge and investigate the cause of the alarm.
- f) Single alarm window for all NEs displaying network active alarms, cleared alarms, severity of alarms.
- g) Alarm list, threshold and severity should be customized.

- h) System shall be capable to log performance parameters on 15 min/24 hours basis and made available whenever required through NMS beside current register counters, NMS shall be capable of storing history register counters for the last one months and if required can be exported to the external hard disk.
- i) There should be a facility to send SMS/Mail for various alarms. This should be configurable on the basis of alarms and SMS/Mail list to be configurable.

#### **4.7 Configuration Management**

Following configurations should be possible:

- a) E2E service provisioning
- b) Port settings.
- c) Loopbacks.
- d) All configurable parameters for the equipment shall be configured using the NMS.
- e) Should be possible to create, configure, provision and manage the traffic based on bandwidth and QoS requirements.
- f) NMS should be able to provide service provisioning and changes reports for individual user or operator.

#### **4.8 Performance Management**

- a) System has to be able to collect all standard quality parameters/indicators for WDM/OTN/SDH based part as well as for packet switch part in accordance with related standard. Data shall be available for online and offline data analysis. System shall provide tools to analyze and report quality parameters/indicators from network-to-network level (for each network service). It means that the system shall provide quality reports not only on node/element level but also on network service level.
- b) standards.
- c) For Performance reports, all performance parameters to be monitored on 15min, hour, day, month and weekly basis.
- d) The receiving level monitoring is to be provided on a real time basis - both in a table as well as graphical view with time stamp.
- e) The system should be able to monitor service quality parameters regarding availability on a real-time basis.
- f) It should be possible to monitor packet drops in the case of Ethernet interface.

- g) Comprehensive Ethernet performance counters & utilization reports generation must be supported by NMS.
- h) Support to Management Information Base (MIB) access must be available for integration / real time utilization monitoring by third party systems i.e., Multi Router Traffic Grapher (MRTG) etc.
- i) Facilities should be available to backup stored log data and other data.

#### 4.9 Access Security Management

Facilities shall be provided to ensure that only authorized users are allowed to access all or a certain part of the system. These include comprehensive log-in operator identities and password facilities. Low level protection for read only access to faults and performance information, Medium-level protection for access to configuration status and features and High-level protection for control of access to aforesaid clauses and to change in the configuration and control parameters. All log in and log out attempts with every work activity shall be logged in the security Log File of the NMS system.

System shall support following authentication and authorization mechanisms for security management on management system level as well as on element level:

RADIUS or TACACS+ or Microsoft authentication protocol

## 5 MANDATORY SYSTEM REQUIREMENTS

Type of Equipment	Number and Location	Mandatory
The system shall support a minimum of 40 channels BoL configuration		
Colourless, Directionless, Contentionless and Gridless (CG/CDG/CDCG) Reconfigurable Optical Add Drop Multiplexer (ROADM) DWDM equipment with Protection and Restoration facility using Layer 0 (L0)- ASON/GMPLS/Optical ASON along with Optical Channel Monitor (OCM)		

and Optical Time Domain Reflectometer (OTDR) Facility.		
Motivation and justification shall be provided where <b>non-(CG/CDG/CDCG)</b> (except OLA/R) nodes architecture might be recommended		
Optical Transport Network (OTN) with Protection and Restoration using Layer 1 – Automatic Switching Optical Networks/Generic Multiprotocol Layer Switching (ASON/GMPLS)		
Optical Line Amplifier/Repeater (OLA/OLR) equipment along with Optical Time Domain Reflectometer (OTDR) Facility		
Network Management System (NMS) Server Hardware (Active and Standby)		
NMS Client Hardware		
Portable Terminal for O&M of DWDM and OTN Equipment (LCT)		
Only equipment manufactured to recognised relevant international standards, and complying with the relevant ITU-T, IEEE, ETSI performance recommendations and reports, shall be accepted.		
The MTBF figures (in years) of all offered equipment shall be stated. For modular systems the supplier shall specify the MTBF figures for each replaceable component. The assumed environmental conditions in the given MTBF figures shall also be specified.		
The metric system shall be used in all technical documentation.		

**In order to achieve the intended goal of the purchaser, Bidder during designing and configuring the equipment at each site shall follow the following fundamental rules:**

- Fixed Optical Add Drop Multiplexer (FOADM) shall not be allowed in the network.
- For line side, Optical Channel (Och) of only minimum 100G lambda shall be used.
- Line signal Protection and Restoration facility must be implemented.
- Automatically Switched Optical Network (ASON) must be implemented using Layer 0/1 (LO/1)-ASON/GMPLS/Optical ASON for Restoration. **The Bidder shall provide ASON/GMPLS commercial used case in South Africa**
- DWDM Regeneration of line signal in between Source and destination node (Anywhere in between the Main, Protection and restoration paths) is not allowed.
- Use of the external Dispersion Compensation module is not allowed.
- Inbuilt Optical Channels Monitoring (OCM) and OTDR functionality must be provided for all fiber connectivity between all nodes.
- Wavelength Selective Switch (WSS)/ROADM function and Amplifier function must be in different cards. Justification should be provided whereby one card combination is applicable.
- The equipment shall support the centralized cross-connection architecture to save wavelengths.
- The ROADM function must be configured at all service add/drop sites.
- The services from/to different directions shall be provisioned in different line boards to ensure high network reliability and service routing resilience.
- The tributary and line boards shall not be configured in the same board to ensure high network reliability and services availability.
- The NMS shall be capable of managing the national backbone network equipment, including DWDM, OTN, IP routers for (NLD and metro) and microwave equipment where applicable.

**Supplier shall quote the DWDM equipment for the all the (ROADM and OLA/OLR) and OTN nodes complying with technical specifications specified. For all equipment offered, the supplier shall state their support and maintenance contract options, terms, costs and durations thereof. The duration of continuing support (repairs and supply of spares) for the equipment beyond the manufacture discontinuation date must be stated.**

## **6 SCOPE**

This specification defines the Broadband Infraco requirement for a DWDM/OTN equipment that can be used to expand the existing network. The specification covers requirements relating to ITU-T recommendations, Network Management System and the network planning tool.

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The scope and proposal shall be based on the following Broadband Infraco requirements.

Broadband Infraco requires DWDM/OTN transmission systems and professional services (Implementation, Support Service and Training on the following sections of its existing fibre network as Phase 1 of the proposed ring systems upgrade and expansion:

- Teraco Isando – Teraco Durban = Legacy equipment replacement route
- Bloemfontein – Pietermaritzburg = Legacy equipment replacement route
- Bloemfontein – East London = New route build
- Northern Ring = OTN expansion as Phase 1

The DWDM/OTN will enable the IP layer of the Broadband Infraco Long distance network as illustrated in the diagram below.

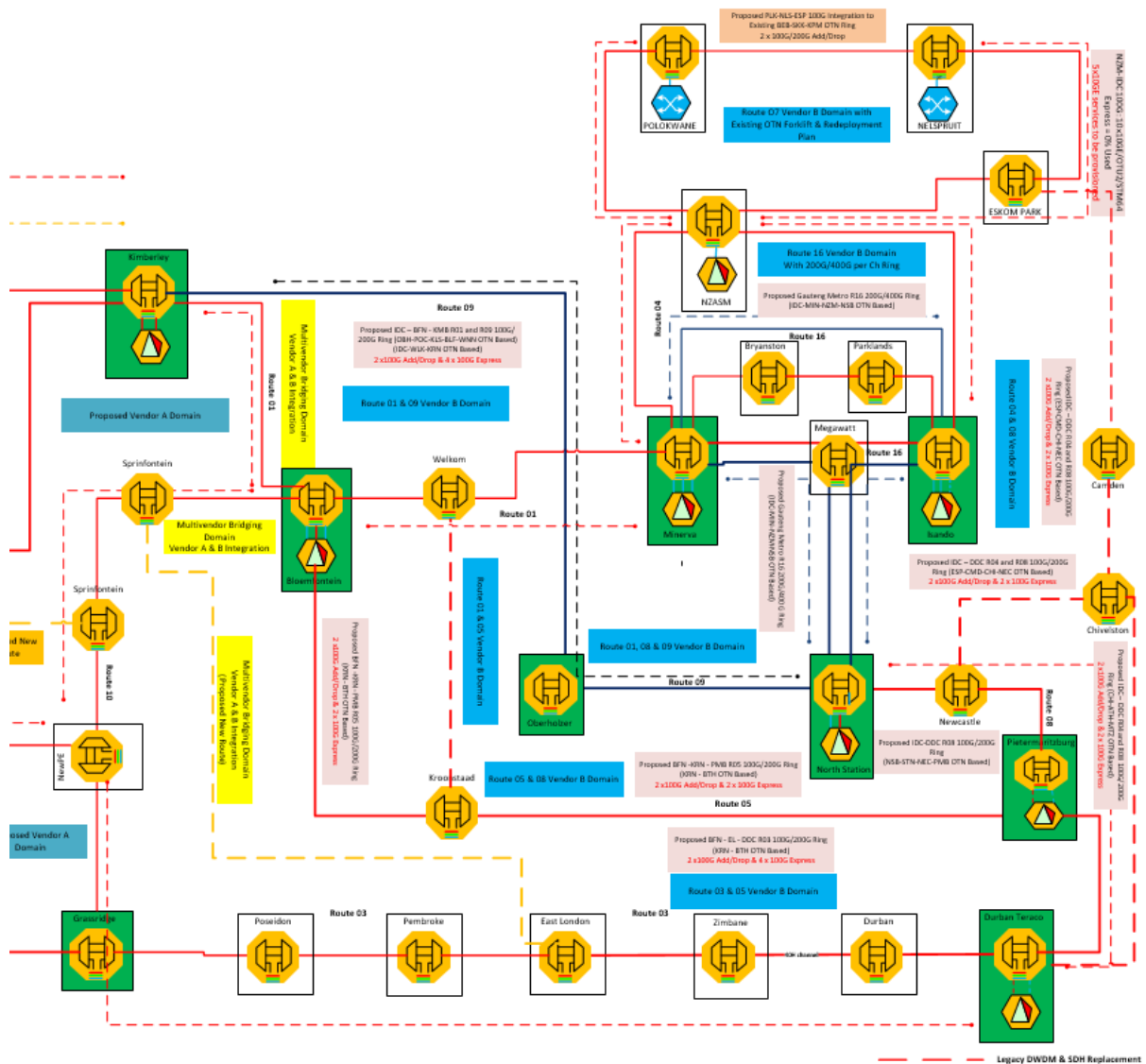
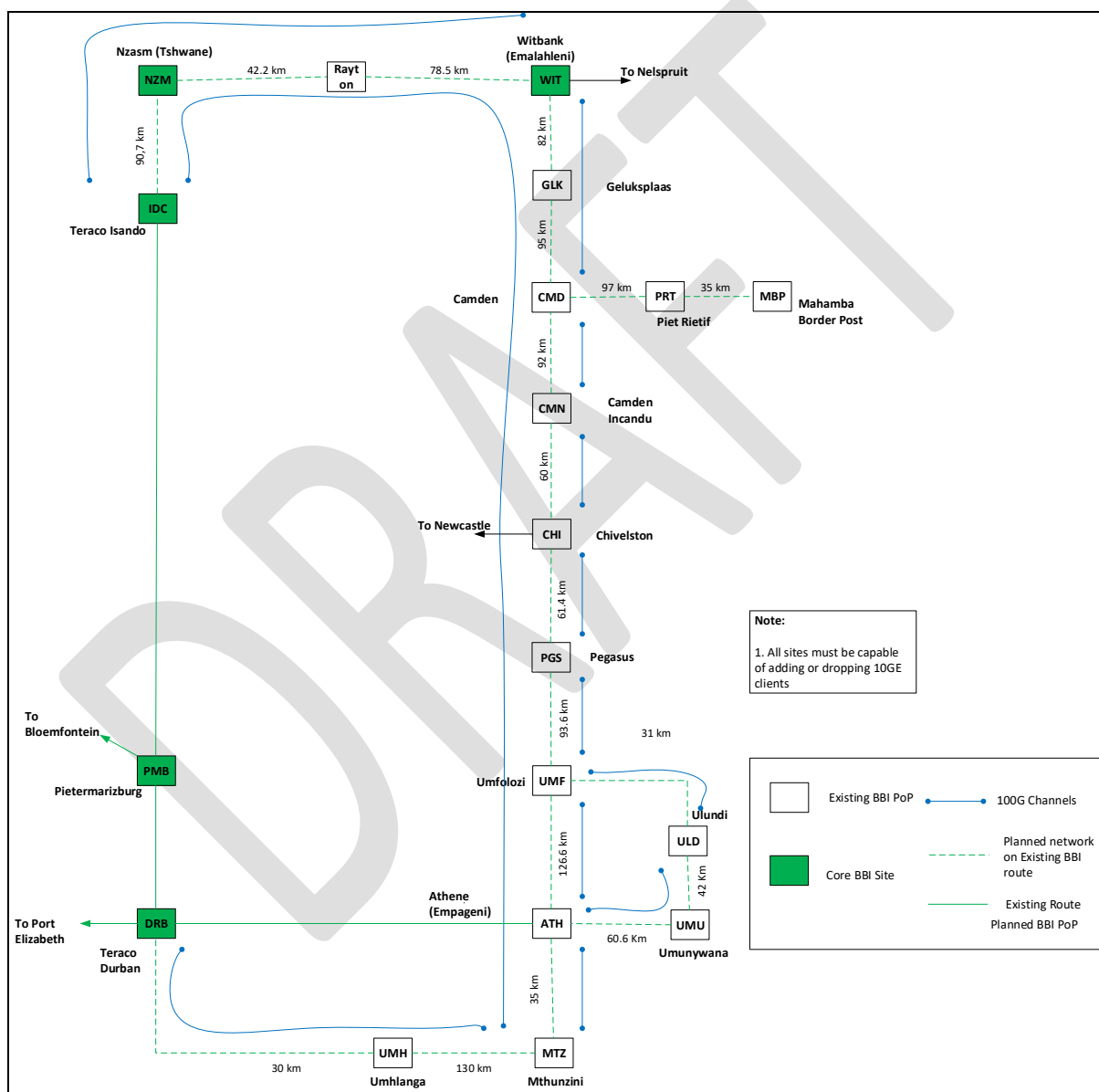


Figure 2: Vendor-B DWDM/OTN Network Architecture

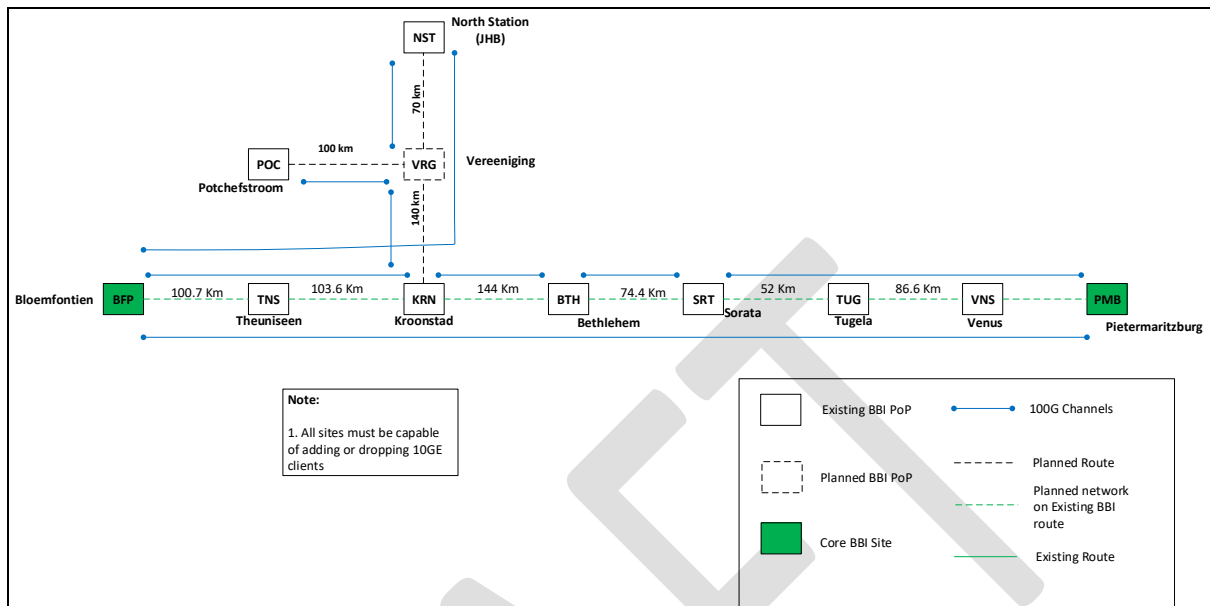


Broadband Infraco requires a proposal that includes the technical design and related bill of material, and services, as per the diagram below, illustrating the Broadband Infraco initial capacity requirements and should form part of complete Figure 2 scope. The proposal should include a network management system.

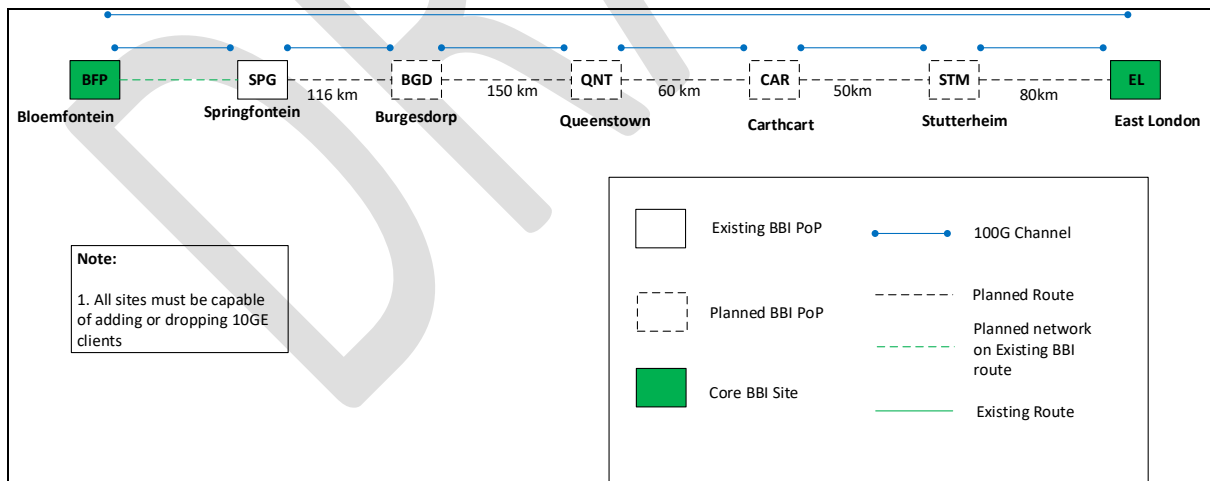
## 6.1 Teraco Isando – Teraco Durban



## 6.2 Bloemfontein – Pietermaritzburg



## 6.3 Bloemfontein – East London



## 7 NORMATIVE AND INFORMATIVE REFERECES

### 7.1 Normative

- I. ITU-T Rec. G.709 Interfaces for the Optical Transport Network.
- II. Recommendation ITU-T G.694.1: Spectral grids for WDM applications: DWDM frequency grid.
- III. ITU-T G.8112/Y.1371 Interfaces for the MPLS transport profile layer network.
- IV. ITU-T G.698.2 Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces.
- V. ITU-T G.692 Optical interfaces for multichannel systems with optical amplifiers.
- VI. MEF 6.2 EVC Ethernet Services Definitions.
- VII. MEF 54 Ethernet Interconnection Point.
- VIII. MEF 55 Lifecycle Service Orchestration.

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## APPENDIX A: ACRONYMS

	Acronym	Description
1	ADM	Add/Drop Multiplexer
2	APS	Application Program System
3	BBI	Broadband Infracore
4	BoM	Bill of Materials
5	BOM	Bill of Material
6	C/DWDM	Coarse/Dense Wavelength Division Multiplexing
7	CD	chromatic dispersion
8	CIP	Critical Infrastructure Protection
9	CORBA	Common Object Request Broker Architecture
10	DC	Direct Current
11	DCN	Data Communication Network
12	DCN	Data Communications Network
13	DWDM	Dense wavelength division multiplexing
14	EDFA	Erbium Doped Fibre Amplifiers
15	ER	Extended Reach
16	ETSI	European Telecommunications Standards Institute
17	EVC	Ethernet Virtual Connection
18	FC	Fibre Channel
19	FCAPS	Fault, Configuration Accounting, Performance and Security
20	FEC	Forward Error Correction
21	GE	Gigabit Ethernet
22	IEEE	Institute of Electrical and Electronics Engineers
23	IP	Internet Protocol
24	ITU	International Telecommunication Union
25	LR	Long Reach
26	MEF	Metro Ethernet Forum
27	MPLS-TP	Multiprotocol Label Switching - Transport Profile
28	MTBF	Mean time between failures
29	NMS	Network Management System
30	ODU	Optical channel Data Unit
31	OSNR	Optical Signal to Noise Ratio
32	OTN	Optical Transport Network
33	out	Optical channel Transport Unit
34	PMD	Polarisation Mode Dispersion

	Acronym	Description
35	ROADM	Reconfigurable Optical Add-Drop Multiplexing
36	SDH	Synchronous Digital Hierarchy
37	SNMP	Simple Network Management Protocol
38	SOA	Semi-Conductor Amplifiers
39	SR	Short Reach
40	STM	Synchronous Transfer Mode
41	Tbps	Terabit per second
42	WDM	Wavelength Division Multiplexing
	Acronym	Description
1	OADM	Optical Add/Drop Multiplexer
2	APS	Application Program System
3	ASON	Automatic Switching Optical Networks
	BBI	Broadband Infraco
4	BoL/EoL	Beginning of Life/End of Life
5	BoM	Bill of Materials
6	C/DWDM	Coarse/Dense Wavelength Division Multiplexing
7	CDCG	Colourless, Directionless, Contentionless and Gridless
8	CD	chromatic dispersion
9	CIP	Critical Infrastructure Protection
10	CORBA	Common Object Request Broker Architecture
11	DC	Direct Current
12	DCN	Data Communication Network
13	GMPLS	Generic Multiprotocol Layer Switching
14	BoL/EoL	Beginning of Life/End of Life
15	EDFA	Erbium Doped Fibre Amplifiers
16	ER	Extended Reach

	Acronym	Description
17	ETSI	European Telecommunications Standards Institute
18	EVC	Ethernet Virtual Connection
19	FC	Fibre Channel
1	FCAPS	Fault, Configuration Accounting, Performance and Security
20	FEC	Forward Error Correction
21	GE	Gigabit Ethernet
	GMPLS	Generic Multiprotocol Label Switching
22	IEEE	Institute of Electrical and Electronics Engineers
23	IP	Internet Protocol
24	ITU	International Telecommunication Union
25	LR	Long Reach
26	MEF	Metro Ethernet Forum
27	MPLS-TP	Multiprotocol Label Switching - Transport Profile
28	MTBF	Mean time between failures
29	NMS	Network Management System
30	ODU	Optical Data Unit
	OLA	Optical Line Amplifier
	OLR	Optical Line Repeater
31	OSNR	Optical Signal to Noise Ratio
	OTDR	Optical Time Domain Reflector
32	OTN	Optical Transport Network
33	OUT	Optical Transport Unit
34	PMD	Polarization Mode Dispersion
	PXC	Photonic Cross-connect

	Acronym	Description
35	ROADM	Reconfigurable Optical Add-Drop Multiplexing
36	SDH	Synchronous Digital Hierarchy
37	SNMP	Simple Network Management Protocol
38	SOA	Semi-Conductor Amplifiers
39	SR/LR	Short Reach/Long Reach
40	STM	Synchronous Transfer Mode
41	Tbps	Terabit per second
42	WDM	Wavelength Division Multiplexing
43	WSS	Wavelength Selective Switch



## APPENDIX B: COMPLIANCE SCHEDULE

Tenderers are required to submit a compliance statement as part of their response. The tenders should respond to the requirements as follows:

1. **Full Compliance (FC)** - This means that the Tenderer's Proposal meet the requirements in the Tender Documents.
2. **Partial-Compliance (PC)** - This means that the Tenderer's Proposal does not meet the requirements in the Tender Documents with a workaround or alternative approach and method. A description of the workaround or alternative must be placed in the "Details of Compliance" column including supporting documentation.
3. **Non-Compliance (NC)** – This means that the Tenderer's Proposal does not meet the requirements in the Tender Documents. Reasons for non-compliance must be placed in the "Details of Compliance" column.

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
1	<b>Mandatory Requirements</b>		
a)	The system shall support a minimum of 40 channels beginning of Life (BoL) configuration		
b)	The system shall support: 1. Colourless, Directionless, Contention less and Gridless <b>(CG/CDG/CDCG)</b> Reconfigurable Optical Add Drop Multiplexer (ROADM) DWDM equipment with Protection and Restoration facility using Layer 0 (L0)-ASON/GMPLS/Optical ASON along with Optical Channel Monitor (OCM) and Optical Time Domain Reflectometer (OTDR) Facility.		
c)	The system shall support: 1. Optical Transport Network (OTN) with Protection and Restoration using Layer 1 – Automatic Switching Optical Networks/Generic Multiprotocol Layer Switching (ASON/GMPLS).		
c)	The system shall support: 1. Optical Line Amplifier/Repeater (OLA/OLR) equipment along with Optical		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
	Time Domain Reflectometer (OTDR) Facility.		
d)	The system shall support: 1. Network Management System (NMS) Server Hardware (Active and Standby).		
e)	The system shall support NMS client hardware.		
f)	The system shall support Portable Terminal for O&M of DWDM and OTN Equipment.		
g)	Only equipment manufactured to recognised relevant international standards, and complying with the relevant ITU-T, IEEE, ETSI performance recommendations and reports, shall be accepted.		
h)	The MTBF figures (in years) of all offered equipment shall be stated. For modular systems the supplier shall specify the MTBF figures for each replaceable component. The assumed environmental conditions in the given MTBF figures shall also be specified.		
i)	The metric system shall be used in all technical documentation.		
J)	The equipment shall implement 100Gbps OR 200Gbps on the line side and OTU4/100GbE, OTU2/10GbE and 1GE on client side.		
K)	The DWDM network shall be based on a minimum of 100Gbps line per channel with Flexible wavelength grid.		
L)	Equipment should support multiple protection architecture based on OCH/OMS or OTS with optical switching module or OTN switch, having protection switching achieved within 50ms.		
m)	The Optical Supervisory Channel (OSC) channel and service channel must be separated and OSC channel shall not be amplified.		
n)	The line card (Transponder) must be tunable type and can be tuned to any of 80 or more channels on standard and/or offset ITU-grid within the full C-Band spectrum.		
O)	The DWDM system shall support Remote NMS Reconfiguration having at least 80 Och reconfiguration with access to all channels and capable of switching between common port and switched ports.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
p)	Optical equipment should be able to cater for the required link Budget (total loss of cable for each span) along with 3 dB End of Life (EOL) margin for each span.		
q)	The DWDM system shall be in-service upgradeable from one wavelength up to its maximum wavelength capacity.		
r)	The DWDM system shall support Automatic Power Equalization (APE). The system shall be capable of automatically adjusting power per channel to its optimum value, if and when channels are added or removed without the need for manual adjustment.		
s)	The DWDM system shall support in built OTDR functionality and be able to measure fibre parameters without impacting traffic while DWDM system is in service.		
t)			
<b>2</b>	<b>Generic Requirements</b>		
a)	The DWDM system shall have the modularity and scalability of at least 80 Ch system architecture for Point-to-Point, ring and mesh network application.		
b)	The devices are capable of being configured to any type of DWDM systems i.e., OTU, OADM, OLA etc. and associated with Elements Management System (EMS) and Network Management System (NMS).		
c)	The equipment must support the WSS and implementation of GMPLS (RFC 3945) and/or ASON (ITU-T G.8080) for restoration requirement in the offered model and sub-rack. The GMPLS/ASON control plan is adopted in Optical Channel (Och) scenarios.		
d)	ITU-T, ETSI and IEEE terminology shall be adhered to where applicable.		
e)	For all equipment offered the supplier shall state their support and maintenance contract options, terms, costs and durations thereof.		
f)	The supplier shall state the launch date and the planned manufacture discontinuation date for each piece of equipment offered.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
g)	The duration of continuing support (repairs and supply of spares) for the equipment beyond the manufacture discontinuation date must be stated.		
h)	The supplier shall state the frequency and budgetary costs for network element software upgrades, if any, over the next 5 years. Actual planned dates should be stated if available.		
i)	i) Both technical and marketing brochures for all equipment offered shall be supplied with the response documentation to the enquiry.		
j)	Technical handbooks giving detailed information about the systems on offer shall be provided for all equipment offered.		
k)	The equipment must support the WSS and implementation of GMPLS (RFC 3945) and/or ASON (ITU-T G.8080) for restoration requirement in the offered model and sub-rack. The GMPLS/ASON control plan is adopted in Optical Channel (Och) scenarios.		
l)	The equipment shall have a plan/concrete roadmap of inter-working with the IP/MPLS routers. The inter-working should be based on ITU-T, IETF, and OIF standards		
m)	The DWDM network shall be 400Gbps and 800Gbps per channel ready for future traffic capacity upgrade or expansion requirements.		
n)	The line card (Transponder) must be able to sync fast enough so that effective switching time from main to protection path does not exceed 50ms. Service-level switching time must not exceed 50ms neither for line side protection switching nor for client-side protection switching.		
o)	For proposals with 100Gbps/200Gbps service boards, pluggable coherent CFP/CFP2/CFP4 optical modules shall be used to facilitate subsequent maintenance, improve device integration, and reduce power consumption.		
q)	The DWDM system shall support incremental equipping to align with the number of wavelengths transmitted, facilitating flexible and scalable 'pay-as-you-grow' configurations.		
<b>3</b>	<b>System Requirements</b>		
<b>3.1</b>	<b>Client Interface Requirements</b>		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
a)	STM-1 (optical)		
b)	STM-4		
c)	STM-16		
d)	STM-64		
	<b>OTH/MPLS-TP</b>		
e)	OTU-1		
f)	OTU-2		
g)	OTU-4		
	<b>Fast Ethernet/MPLS-TP/IP/FC</b>		
h)	100BASE-TX		
i)	100BASE-FX		
j)	100BASE-SX		
	<b>Gigabit Ethernet/MPLS-TP/IP/FC: 1000BASE-</b>		
k)	1000BASE-SX		
l)	1000BASE-EX		
m)	1000BASE-ZX		
	<b>10 Gigabit Ethernet/MPLS-TP/IP/FC</b>		
n)	10GBASE-SR		
o)	10GBASE-LR		
p)	10GBASE-ER		
<b>3.2</b>	<b>Traffic cross connection requirements</b>		
a)	The system shall have a fully meshed backplane to support soft cross connection between all cards.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
b)	The power supply, control, clock, and cross-connect boards of the bidding equipment shall be configured with 1+1 protection.		
c)	The system shall support a minimum of 1 Terabits of traffic switching		
d)	The system configuration to support the requirement in (c) shall be provided.		
e)	The maximum traffic switching shall be provided, and the upgrade path and process stated.		
f)	The system shall support automatic switching for all services with use of Automatically Switched Optical Network (ASON) and traditional schemes.		
g)	The supplier shall state additional automatic switching protocol supported by their system.		
h)	The maximum transporting distance (reach of line card/transponder) needs to be sufficient to cover the Broadband Infracore longest path requirement within the NLD Single Mode Fibre (SMF) fibre network.		
a)	Optical amplifiers such as pre-amplifier and booster can be used, if necessary. Optical amplifier needs to compensate the loss of optical power according to type of use.		
b)	The system must support clock recovery and stamping based on NTP for Synchronization requirements.		
c)			
<b>3.3</b>	<b>Line Interface Requirements</b>		
a)	Support of ITU-T G.652d single-mode optical fibre is mandatory.		
b)	The supplier shall state modulation schemes used to achieve the OUT-k line rates described in ITU-T G.709 recommendations.		
c)	The supplier shall state highest line rate that their system can achieve. Details on how the line rate is achieved shall be provided.		
d)	The supplier shall state whether the modulation schemes are user-configurable, i.e. adaptable modulation.		
e)	The supplier shall state whether the modulation schemes software selectable per wavelength.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
f)	Compliance to ITU-T G.694.1 Spectral grids for WDM applications: DWDM Frequency Grid is mandatory. Any advancement from the standard ITU-T grid shall be stated and explained in detail.		
g)	Reconfigurable Optical Add-Drop Multiplexing (ROADM) capability is mandatory.		
h)	The supplier shall provide information of the architecture and capabilities of the ROADM, including capabilities of remote re-configurability, and colourless, directionless and contention-less multiplexing.		
i)	The supplier shall state the minimum and maximum number of wavelengths that the equipment supports. A minimum of 40 channels is mandatory.		
j)	The equipment shall support point-to-point, ring, star, and mesh topologies.		
k)	The equipment shall be able to add or drop any wavelength of 100 Gbps or 200 Gbps at any access nodes.		
l)	The solution shall support automatic optical power management, auto levelling, and monitoring.		
m)	The equipment shall be able to monitor the transmit and receive fibre strands and provide fibre traces similar to the traditional Spectrum Analyzer.		
n)	The supplier shall describe the Forward Error Correction (FEC) used and its associated coding gain and overheads.		
o)	The supplier shall describe the maximum system reach without regeneration, with details of how the reach is achieved.		
p)	The details required under (o) are: rate per channel, number of channels used (maximum), channels spacing, placement of repeaters, OSNR values for each span, type and description of signal amplification used for each span, the hop lengths, and the modulation scheme used per channel.		
q)	The bidder's solution shall support 10 x STM-64 / 10GBE LAN PHY / 10GE WAN PHY signals mapped into ODU4.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
r)	The bidder shall describe their solution for mapping 10GE LAN PHY/10GE WAN PHY to ODU-2.		
s)	The proposed system shall comply with GFP mapping according to ITU-T G.7041 and the bidder shall describe its support to the following Ethernet encapsulation schemes referencing the offered 10G/100G Transponders/Muxponders as applicable. Moreover, the bidder shall clarify if the mapping of Ethernet to OTN is according to G.709 and if both GFP-F and GFP-T mapping options are available, emphasizing the benefits of the supported encapsulation scheme. 10 GbE into ODU2e in timing transparent manner		
t)	100GbE overhead processing shall conform to the IEEE802.3ba standard.		
<b>3.4</b>	<b>Amplification</b>		
a)	The supplier shall state the preferred optical amplifier technology:		
	I. Semi-Conductor Amplifiers (SOA).		
	II. Erbium Doped Fibre Amplifiers (EDFA).		
	III. Raman Amplifiers.		
	IV. Hybrid Amplifiers.		
b)	Must have automatic gain equalization and automatic power control function		
c)	The equipment shall support a hop distance of 200km without a repeater. Parameters for ITU-T G652D shall be used.		
d)	The supplier shall state the maximum hop distance, with and without amplification that is supported by the equipment as well as, the amplification technology used.		
a)	N x 100/200 Gb/s DWDM system can support the function of line power dynamic adjustment which does not influence the regular working service.		
b)	The equipment shall support in-service gain/tilt adjustment without interruption of service.		



Require ment	Description	Supplier Statement of Compliance	Details of Compliance
c)	The system shall support adding or removing channels without interrupting services.		
<b>3.5</b>	<b>Optical Receiver Requirements</b>		
a)	The supplier shall state the worst case minimum required Optical Signal to Noise Ratio (OSNR) for each transporter or muxponder provided.		
b)	The equipment shall support electronic dispersion compensation.		
c)	The supplier shall state the maximum tolerable chromatic dispersion (pm/nm)		
d)	The supplier shall state the maximum tolerable mean Differential Group delay measured in picoseconds (as related to polarisation mode dispersion (PMD))		
a)	<p>The system shall support the following optical supervisory channel parameters:</p> <p>a. Must have separate optical supervisory channel.</p> <p>b. The wavelength of optical supervisory channel is 1510 nm or 1620nm <math>\pm</math> 10nm.</p> <p>c. OSC transmit and receive power level measurement feature must be available as part of link performance monitoring functionality.</p> <p>d. The BER performance of optical supervisory channel should be in the range of 1.0Exp (-3) to 1.0Exp (-12).</p> <p>e. The failure and replacement of filters units cannot affect the DCN communication via OSC.</p> <p>f. The failure of an OSC unit must be non-traffic affecting</p>		
<b>3.6</b>	<b>Power Requirements</b>		
a)	All transmission equipment shall operate a nominal voltage of 48 V DC positive earthed supply (Range: 40.8 V to 57.6 V).		
b)	The Network Management System computers and workstations shall operate a nominal voltage of 230 V AC (Range: 216.2 V to 243.8 V), and nominal frequency 50Hz (range 47.5 Hz to 52.5 Hz), mains power.		
c)	The equipment shall have reverse polarity protection.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
d)	Power feed to sub-racks shall be arranged using DC circuit breakers so as to permit disconnection of any sub-rack without affecting supply to other connected sub-racks within the rack.		
e)	The supplier shall state the DC power consumption of all offered equipment.		
f)	Bidding equipment shall be environmental (site cooling) and power efficient to sustain South Africa power grid loadshedding effects.		
<b>3.7</b>	<b>Environmental Requirements</b>		
a)	All equipment shall operate as specified under the following environmental conditions:		
b)	Altitude: 0 - 2500 metres above sea level		
c)	Temperature: -5° C to +50° C		
d)	The equipment shall fit into a standard cabinet as specified in Broadband Infracore Specification NE-NT-SP-0001: Cabinet Specification		
<b>3.8</b>	<b>Reliability, Availability, Scalability and Security</b>		
a)	The equipment shall have dual, redundant power inputs.		
b)	The equipment shall have dual, redundant control modules/processors		
c)	The supplier shall provide details on how highly available and dependable links (such as 99.95% of time) may be achieved. State the assumptions to be considered, as well as the calculation methodology used.		
d)	The system must support Optical Line Active/Protection switching using Optical Protection switch (OPS) or OTN switch		
e)	The bidding equipment shall use the OTN architecture and support multiple protection modes, such as optical line 1+1 protection, ODUk SNCP protection, intra-board 1+1 protection, and client 1+1 protection. The switching time must be less than 50 ms excluding detection time.		
f)	Protection switch of all traffic shall be triggered on optical power monitoring and there shall be provision to set the LOS thresholds.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
g)	Automatic switching shall be triggered by line faults (LOS, LOF etc.), OCh layer faults.		
h)	The switching priority of Optical Line Active/Protection switching should support functions like Clear Switching, Forced Switching, Automatic Switching		
i)	Revertive and non-revertive protection operation must be provided.		
j)	Provisionable protection "generic hold-off function" must be provided.		
k)	The system should have a fault notification function in order to notify the external terminal equipment connecting to downstream system of fault occurred on the network		
<b>3.9</b>	<b>Requirements of Online System Performance Monitoring</b>		
a)	The DWDM equipment system shall support monitoring and estimating OSNR, measuring optical power of each channel. Operator shall be able to view the related data in NMS.		
b)	The NMS must support optical impairment awareness of the user during trail creation and beyond. This means the user can see the actual measurements from the network and judge whether the optical trail's OSNR meets OCh signal performance requirements.		
c)	The NMS shall support latency detection and map function.		
d)	The NMS must support Graphical network usage chart – graphically show used/free resources over the whole network or drill-down into a link (lambda and sub-lambda levels). For links, it should be possible to display availability in case of network growth.		
e)	For Restoration, all OADM sites must be able to Re-Route optical channels. Re-routing will be possible from any path to any path among all paths connected to that node.		
f)	The system must be able to create consecutive restoration paths one after another at multiple fibre cut scenario, as long as a single path is available between the two nodes.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
g)	The solution shall support and provide all type and capacity of CG/CDG/CDCG WSS (ROADM) to Re-Route any optical Channel from any path to any path between all paths connected to that node.		
h)	The equipment must support the WSS and implementation of GMPLS (RFC 3945) and/or ASON (ITU-T G.8080) for restoration requirement in the offered model and sub-rack. The GMPLS/ASON control plan is adopted in Och scenarios.		
i)	The control plane should support automatic discovery of the network topology and network resources.		
j)	ASON/GMPLS should support the calculation of the source node route.		
k)			
<b>4</b>	<b>Network Management System</b>		
a)	Suppliers shall provide details of the Network Management System for managing the equipment, including its Fault, Configuration Accounting, Performance and Security (FCAPS) management of capabilities.		
b)	Suppliers shall provide hardware, software and third party software requirements for the network management system.		
c)	Suppliers shall provide management system requirements pertaining to the design of the Data Communications Network (DCN).		
d)	A support and philosophy of hot standby configuration Network Management System (NMS) that automatically assumes control of the network elements in the event of failure of the main NMS, shall be provided.		
e)	Suppliers shall provide information on support of hardware virtualisation and the requirements thereof.		
f)	Suppliers shall provide information on the north-bound interfaces supported by the management system (for example SNMP, CORBA).		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
g)	Suppliers shall provide information on the south-bound interfaces supported by the management system.		
d)	NMS shall provide end-to-end visualization of wavelength paths.		
e)	NMS shall provide end-to-end display of optical power measurements		
f)	NMS shall provide details for end-to-end wavelength channel provisioning and automated wavelength channel restoration.		
g)	NMS shall provide visualization of OTDR report of fibre spans.		
h)	NMS shall be connected to the proposed node equipment via IP interface.		
i)	NMS should provide web-based client interface which enables anywhere management.		
j)	NMS must support E2E service configuration, monitoring and performance checking.		
k)	NMS should support quicker end-to-end provisioning of multi-service, including WDM circuit, SDH circuit, Ethernet circuit, and wavelength transport.		
l)	NMS must support Ethernet OAM standards such as Y.1731		
m)	The NMS shall support remote downloading of all types of software and firmware required by DWDM and OTN equipment.		
n)	The system shall support up-gradation of the software version preloaded in the system without loss of traffic or configuration.		
o)	The NMS should have the capability of auto discovery of new NE.		
p)	NMS shall provide the inventory details of all systems in the network up to card and SFP/XFP level with simple operation		
q)	NMS shall have report generation capacity such as Number of configured WDM circuits, SDH circuits, Ethernet paths, used and unused capacity of each Network Element etc.		
r)	NMS shall provide Comprehensive network map (geographic and synoptic) of all the managed elements with a sophisticated alarm and traffic		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
	status display, real time alarm and traffic monitoring and giving a full access to all NE technical management features through a user-friendly interface.		
s)	NMS shall support Simple Network Management Protocol (SNMP), Telemanagement Forum (TMF), Common Object Request Broker Architecture (CORBA) & REST Northbound Interface (NBI)		
t)	NMS shall have the capability for interworking with 3rd. Party SDN/Orchestration Solutions.		
u)	NMS shall support Warm/Hot Standby Server Redundancy Solution (Max. 10 Sec. for Switching over between Main & Standby Servers).		
v)	In Warm/Hot Standby concept, NMS shall support automatic switch-over between Main Server and Standby Server (without user-intervention).		
w)	In Warm/Hot Standby concept, after switch-over to Standby server, all clients must be automatically switched-over to Standby Server (without user-intervention).		
x)	The NMS shall support network management of Optical and IP equipment from the bidder's product portfolio.		
y)	The NMS shall consist of Server and clients-based architecture.		
z)	There will be provision to use Laptop/Notebook as Local Craft terminal (LCT) with appropriate software to connect DWDM and OTN equipment directly so that configuration and monitoring can be done from the Laptop. The LCT shall be able to connect all network elements on the same network (autonomous system) from a locally connected device		
aa)	The NMS software must operate on Unix, Linux, and/or Windows-based operating systems. It should support multi-tasking and multi-user functionality. The software architecture offered should be open and configurable to accommodate future extensions. The quotation for the software license should cover the lifetime of the system.		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
bb)	NMS should provide real time surveillance of network faults from the various alarm captured from the network elements.		
cc)	The NMS Should shall support the creation, configuration, provisioning and management of the traffic based on bandwidth and QoS requirements.		
dd)	The NMS shall provide service provisioning and changes reports for individual user or operator.		
ee)	The system shall be able to collect all standard quality parameters/indicators for WDM/OTN/SDH based part as well as for packet switch part in accordance with related standard. Data shall be available for online and offline data analysis. System shall provide tools to analyze and report quality parameters/indicators from network-to-network level (for each network service). It means that the system shall provide quality reports not only on node/element level but also on network service level.		
ff)	For Performance reports, all performance parameters to be monitored on 15min, hour, day, month and weekly basis. d)The receiving level monitoring is to be provided on a real time basis - both in a table as well as graphical view with time stamp.		
gg)	The system should be able to monitor service quality parameters regarding availability on a real-time basis.		
hh)	The system shall support monitoring of packet drops in the case of Ethernet interface.		
ii)	Support to Management Information Base (MIB) access must be available for integration / real time utilization monitoring by third party systems i.e., Multi Router Traffic Grapher (MRTG) etc.		
jj)	Facilities should be available to backup stored log data and other data.		
kk)	System shall support following authentication and authorization mechanisms for security management on management system level as well as on element level:		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
	RADIUS or TACACS+ or Microsoft authentication protocol		
II)	Facilities shall be provided to ensure that only authorized users are allowed to access all or a certain part of the system. These include comprehensive log-in operator identities and password facilities. Low level protection for read only access to faults and performance information, Medium-level protection for access to configuration status and features and High-level protection for control of access to aforesaid clauses and to change in the configuration and control parameters. All log in and log out attempts with every work activity shall be logged in the security Log File of the NMS system.		
mm)	The NMS shall be capable of managing the national backbone network equipment, including DWDM, OTN, IP routers for (NLD and metro) and microwave equipment where applicable		
<b>5</b>	<b>Network Planning Tool</b>		
a)	Design and Planning Tools.		
b)	The supplier shall provide an optical link design tool, with the following minimum capabilities:		
	I. Optical link budget calculation.		
	II. Chromatic Dispersion calculation.		
	III. Optical Signal to Noise (OSNR) Determination.		
	IV. Production of a Bill of Material (BOM).		
	V. A detailed report of the planned channel.		
	VI. A network inventories.		
	VII. What if analysis.		
	VIII. Capacity utilization report.		



Requirement	Description	Supplier Statement of Compliance	Details of Compliance
c)	The planning tool shall be able to interchange data with the Network Management System as per below diagram.		
d)	The supplier shall provide information on software and hardware requirements of the optical link design planning tool.		
<b>6</b>	<b>Miscellaneous Requirements</b>		
a)	<b>Spares</b>		
	I. The supplier shall provide a spares breakdown for each item of equipment offered.		
b)	<b>Tools and Test Equipment</b>		
	I. The supplier shall provide a list of test equipment considered necessary to perform on-site maintenance and fault-finding on all offered equipment. Test sets that are proprietary to the manufacturer shall only be recommended where commercial general-purpose test equipment cannot be employed, or where its use would be grossly uneconomic.		
	II. The supplier shall supply a list of special tools, connector cords, card extenders, etc. that are considered necessary to perform on-site maintenance and fault finding on the on all offered equipment.		
c)	<b>Documentation</b>		
	I. Handbooks (Instruction Manuals) are required for each piece of equipment. They must be comprehensive enough to enable a competent Technician to identify each component, test point and terminal and to check supply voltages and signal voltages/signal conditions throughout the module/unit/equipment.		
	II. All critical voltages and voltage limits shall be indicated on circuit diagrams or included in the text. All signal levels or signal conditions shall be similarly detailed, together with permissible limits for satisfactory operation of the equipment.		
d)	<b>Warranty</b>		

Require ment	Description	Supplier Statement of Compliance	Details of Compliance
	I. Suppliers shall state the warranty period on all offered equipment after installation and the terms thereof.		
e)	<b>Repairs</b>		
	I. The supplier shall provide a repair service for faulty units, sub-units and modules removed from site Broadband Infracore's technicians. This service shall form part of the support service to be negotiated with the supplier post awarding.		
f)	<b>System</b>		
	I. The system shall support Intelligent Network Control Plane (e.g. GMPLS).		