

**Changes to UCR 2008, Change 2, Section 5.5, Network Infrastructure Product Requirements**

<b>SECTION(S)</b>	<b>CORRECTION</b>	<b>EFFECTIVE DATE</b>
5.5.3.1.2	#5 Changed to read -40 dB instead of 40 Db.	Immediate
5.5.3.1.2	#7 Changed to read: "The connector reflectance shall be less than 40 dB.	Immediate
5.5.3.1.2	Added new requirements: [Required] The ORL of each fiber span shall be greater than 30 dB.	Immediate
5.5.3.2.2.1	Revised to read #17 as "Options, at all Nodes (Terminals, OADMS, and OLAS)."	Immediate
5.5.3.2.3	Deleted requirement #5	Immediate
5.5.3.2.2.1	#4 Deleted 2.5Gbps, Added 100Gbps	Immediate
5.5.3.2.2.1	#6 Replaced "in-band" with "out of band"	Immediate
5.5.3.2.2.1	#8 Rewrite to read: The OTS shall support at least standard single mode fiber (ITU-T Recommendation G.652), non-zero dispersion shifted fibers C (ITU-T Recommendation G.655) such as TrueWave-RS®, TrueWave Classic (TWC, TW+), enhanced large effective area or (E-LEAF) or Large Effective Area (LEAF).	Immediate
5.5.3.2.2.1	#9 Replaced "Gigahertz" with "Gbps"	Immediate
5.5.3.2.3	#24 changed to optional	Immediate
5.5.3.2.3	Deleted #25 [Required] Internal OSAs shall have the ability to show eye diagrams (not critical).	Immediate
5.5.3.2.3.1	#4 make OPTIONAL	Immediate
5.5.3.2.5	#11 added "back to back" to eliminate unnecessary Optical/Electrical (O/E) conversions to read "eliminate unnecessary back to back Optical/Electrical (O/E) conversions"	Immediate
5.5.3.2.5.1	#7 delete "in the future" from "100 Gbps in the future"	Immediate
5.5.3.2.6	Rewrite #8 to read: It shall be possible to add or drop, or express any optical channel at a ROADM site in any order.	Immediate
5.5.3.2.6 - 30	Delete entire requirement	Immediate
5.5.3.2.6 - 31	Delete entire requirement. Number requirements 32-35 to 30-33	Immediate
5.5.3.4 -1	Change "24" to "28" in digital signal bullet. Also delete "(? Correct)" in the same bullet.	No Action Required
5.5.3.6.3 -20	Change "factional" to "fractional"	No Action Required
5.5.3.6.6 - 3	Move requirement to section 5.5.3.6.5 as requirement 5.5.3.6.5-7	No Action Required

## Errata Sheet

SECTION(S)	CORRECTION	EFFECTIVE DATE
5.5.3.6.6 – 4 and 5	Move both requirements to section 5.5.3.6 as requirements 5.5.3.6 – 22 and 23	No Action Required
Several	Updated Reference to reflect Telcordia GR-253 (issue 4 Dec. 2005)	18 Months (unless already compliant)
5.5.6	Delete last four sentences as internal design considerations are not requirements and size categories are not in the DOTS or DTEP.	Immediate
5.5.6.1	Reword and delete last sentence to read as follows: The interface requirements specified in the following paragraphs will be implemented on DISN routers as appropriate for specific DISN infrastructure and customer requirements.	Immediate
5.5.6.1.3	Updated Requirement to add PIM, OSPF, MPBGP, BGP4	18 Months (unless already compliant)
5.5.6.2	Update requirement “specified in the DoD IPv6 Profile, version 5.0 and UCR 2008, Change 2”	18 Months (unless already compliant)
5.5.6.3.1	Revised to reflect corrected IETF RFC numbers	18 Months
5.5.6.5	Revised references to IETF RFC numbers	18 Months
5.5.6.5.6	Replace RFC 2385 by 5925 since 2385 is made obsolete by 5925	18 Months (unless already compliant)
5.5.6.7	Revised references IETF RFCs s	18 Months
5.5.6.7	Revised to reflect Requirement [11]	18 Months
5.5.6.7.11	Replace RFC 3469 with 5462	18 Months (unless already compliant)
5.5.6.8.1	Replace RFC 3036 by 5036 since 3036 is made obsolete by 5036	18 Months (unless already compliant)
5.5.6.9.1	RFC 2474 modified to read “as updated by 3168, 3260”	18 Months (unless already compliant)
5.5.6.9.3	RFC 2597 modified to read “as updated by 3260.”	18 Months (unless already compliant)
5.5.6.9.4 and 5.5.6.9.5	RFC 3270 modified to read “as updated by 5462. “	18 Months (unless already compliant)
5.5.6.13	Revised reference to IETF RFC	18 Months
5.5.6.15	Revised reference to IETF RFC	18 Months

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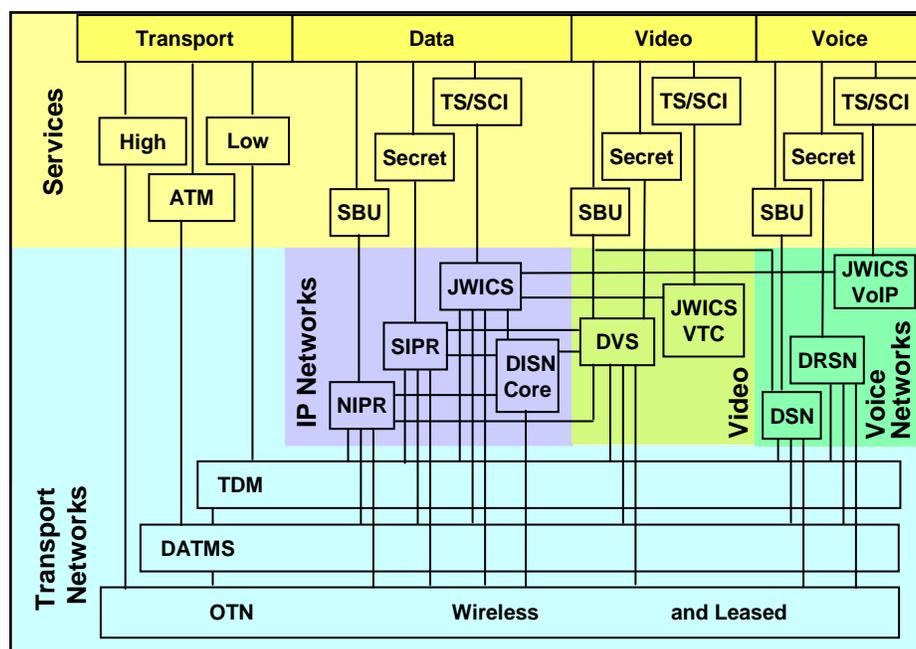
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## 5.5 NETWORK INFRASTRUCTURE PRODUCT REQUIREMENTS

### 5.5.1 DISN Terrestrial Network Overview

Defense Information Systems Network (DISN) services include transport, data, voice, video, messaging, and other UC along with ancillary enterprise services, such as directories. The DISN services also provides less apparent but critical support services, such as timing and synchronization (T&S), SA of the network, address assignment services, and domain name services.

Currently, DISN uses a composite of separate networks to provide customers with transport, data, voice, and video services as well as the means to satisfy their classified and SBU requirements. These networks and their relationship to each other and to the DISN service are shown in [Figure 5.5.1-1](#), Current DISN Services and Networks Overview.



**Figure 5.5.1-1. Current DISN Services and Networks Overview**

[Figure 5.5.1-2](#), Current DISN Site Categories and Equipment, shows the extension of DISN services outward from the DISN Optical Core and the current equipment (as of 2009) typically deployed at each site type. Though connected via leased circuits, the DISN Extension sites are considered part of the Optical Transport Network (OTN) due to the presence of Multi-Service Provisioning Platforms (MSPPs) and the availability of SONET transport services. Remote sites extend DISN services using leased trunks primarily to ATM switches as well as TDM and M13 (multiplexes DS1s into a DS3) devices. The Classes 1 through 4 sites are DISN Subscription

Service (DSS) sites. There are approximately 400 DSS sites, with the exact number varying from one fiscal year to the next based on decisions from the various agencies. The non-subscription sites are connected among themselves and into the DSS sites via leased services that are paid for by the user. The equipment covered in this document is only that equipment provided by DISA at the DSS and other sites DISA uses to provide the DISN. Regardless, connections from customer equipment must interoperate with equipment specified in this document.

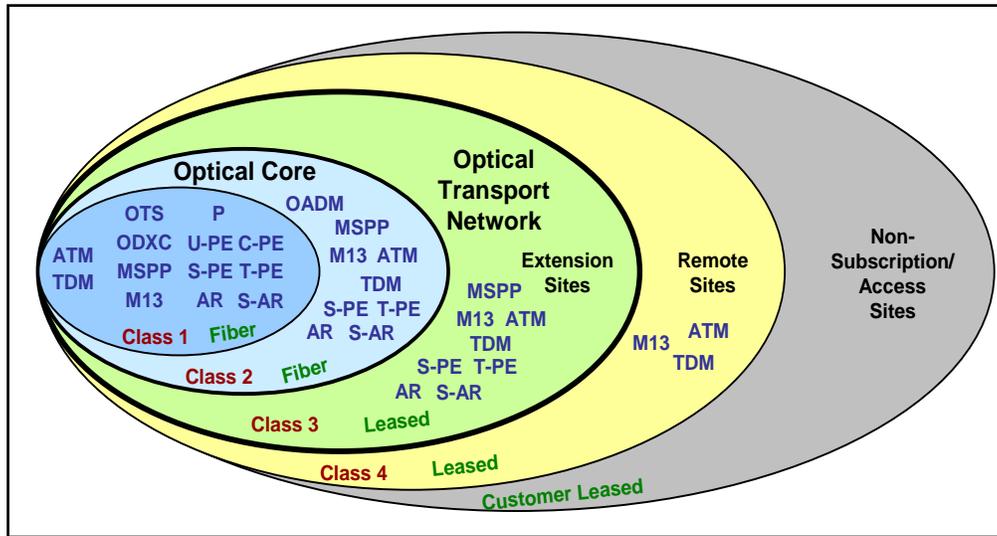


Figure 5.5.1-2. Current DISN Site Categories and Equipment

Changes to the DISN are being undertaken via technology refreshment in discrete steps called spirals. [Figure 5.5.1-3](#), DISN Evolution Spirals, depicts the Near-Term, Mid-Term, and Far-Term evolutionary spirals from the current DISN to the target DISN services and infrastructure. Reference calendar years to achieve the Near-Term, Mid-Term, and Far-Term spirals are nominally 2012, 2016, and 2020. Each spiral will consist of planning and engineering activities to implement technologies that result in enhanced network capabilities and services. Spiral initiation is not necessarily dependent on the completion of a previous spiral, and activities among spirals may overlap and influence each other.

The DISN will continue a process of phasing out service-specific networks with the completion of each spiral. As shown in [Figure 5.5.1-4](#), DISN Convergence Evolution, converging to a common integrated IP and optical infrastructure will support multiple service offerings at all necessary classification levels.

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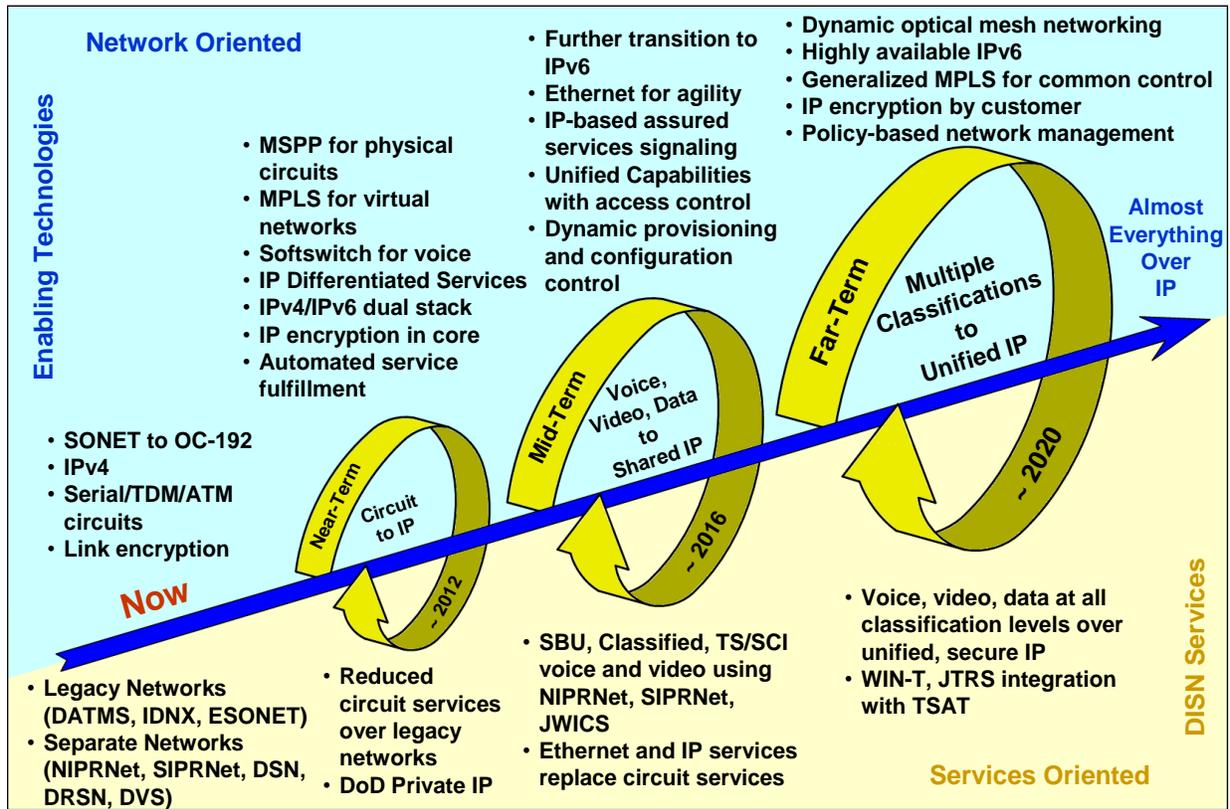


Figure 5.5.1-3. DISN Evolution Spirals

	Today			Near-Term			Mid-Term			Far-Term		
	SBU	Secret	TS/SCI	SBU	Secret	TS/SCI	SBU	Secret	TS/SCI	SBU	Secret	TS/SCI
Voice	DSN	DRSN	DRSN	DSN RTS	DRSN	DRSN		DRSN	DRSN			
Video	DVS NIPRNet OTN	DVS SIPRNet DATMS	JWICS	DVS NIPRNet OTN	DVS SIPRNet OTN	JWICS	NIPRNet RTS	SIPRNet RTS	JWICS RTS			Black Core RTS
Data	NIPRNet	SIPRNet		NIPRNet	SIPRNet							
Transport	TDM Mux OTS Commercial Lease	DATMS ODXC Wireless	ESONET MSP/M13 Wireless	TDM Mux OTS Commercial Lease	DATMS ODXC Wireless	MSP/M13 Wireless	Carrier Ethernet OTS Commercial Lease Wireless			Dynamic Optical Switching Commercial Lease Wireless		

Figure 5.5.1-4. DISN Convergence Evolution

Technology refreshment for the near-term of the NIPRNet and SIPRNet Aggregation Routers (ARs) will add capabilities to support enhanced services, such as Multiprotocol Label Switching (MPLS) VPN, IP QoS, and IPv6. Improvements in the near-term to the transport infrastructure will be made to enhance the DISN Ethernet service offering. The significant infrastructure changes in the near-term include the reduction of ATM and TDM/multiplexer (MUX) devices. The existing fiber routes will be evaluated for improved capacity, and new fiber routes that

**Section 5.5 – Network Infrastructure Product Requirements**

improve diversity and survivability will be investigated. The resulting equipment for each class of site is shown in [Figure 5.5.1-5](#), Near-Term DISN Infrastructure.

This update to the UCR will cover both the current infrastructure and enhancements for the Near-Term Spiral. The requirements are defined around functions. When it is time to purchase the equipment, one or more functions may be found in a single device.

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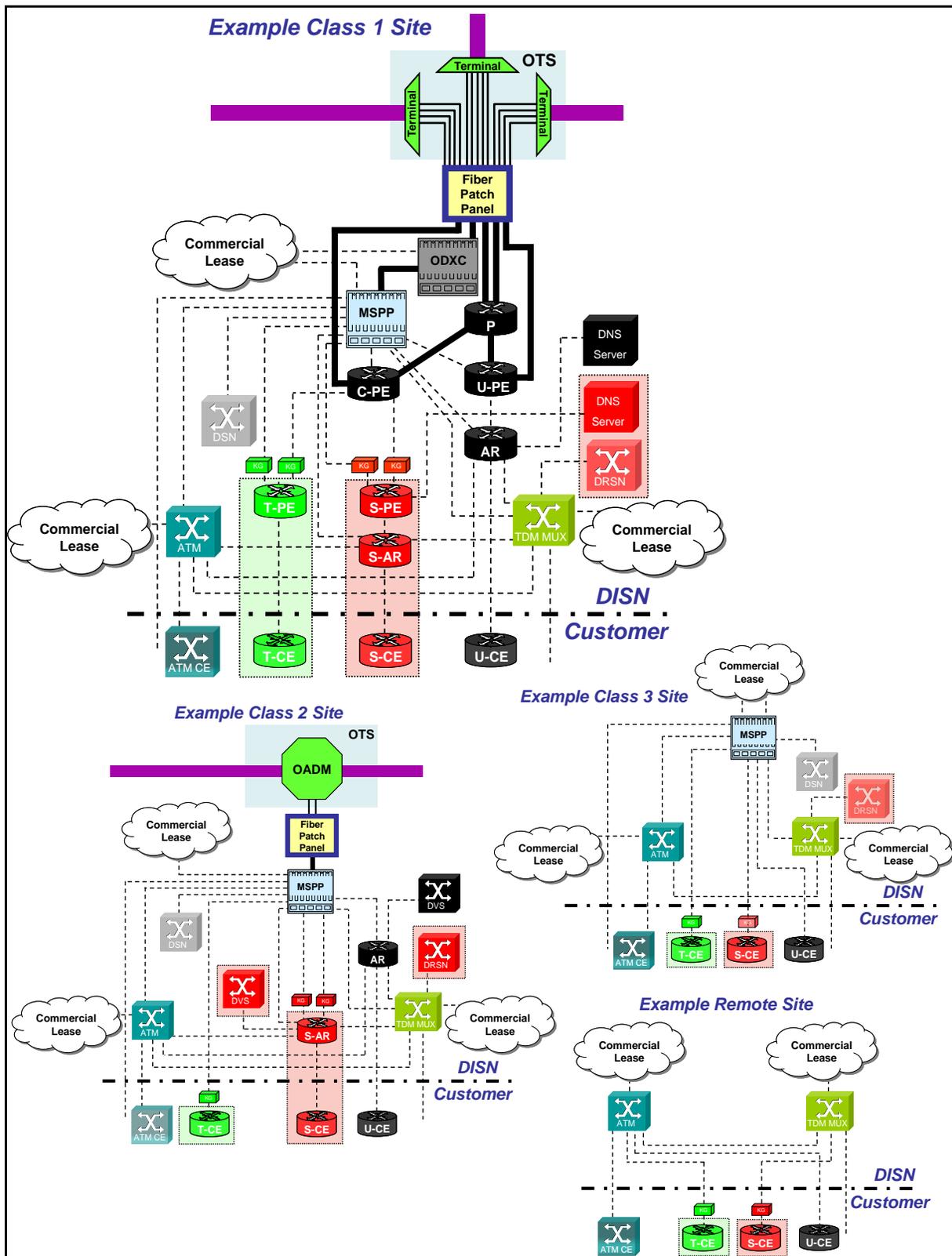


Figure 5.5.1-5. Near-Term DISN Infrastructure

## **5.5.2 DISN Terrestrial Network Functions**

The DISN network performs four distinct transport functions and a set of routing functions. The transport functions are as follows:

- Fiber Plant
- Optical Transport System (OTS) Function
- Transport Switching Function (TSF)
- Access Grooming Function (AGF)
- Access Aggregation (AAG) Function

In addition, the DISN provides T&S for the DISN equipment, and circuits where needed.

The four functions are provided by the following equipment suites:

1. Fiber.
2. The OTS Function, which consists of the following functional components:
  - a. Optical Line Amplifier (OLA)
  - b. Transponder
  - c. Muxponder
  - d. Reconfigurable Optical Add Drop Multiplexer (ROADM)
3. The TSF efficiently packs high bandwidth OC-12/OC-48/OC-192 trunks with Synchronous Transport Signal-1 (STS-1) or STS-Xc channels. Within the current DISN, the Optical Digital Cross-Connect (ODXC) is used to satisfy this function at Class 1 sites and sometimes Class 2 sites.
4. The AGF efficiently packs OC-N and DS3 trunks with Virtual Tributary 1.5 (VT1.5), DS3, or STS-X/STS-Xc channels. It will also convert 1.544 Mbps circuits between the DS1 format and VT1.5 format and extract/pack DS3s with DS1s. Lastly, it will provide timing for DS1 circuits. Within the current DISN, the MSPP provides this function at Classes 1 through three sites.
5. The AAG Function multiplexes lower speed circuits into higher bandwidth trunks but does not do grooming. This function can be fulfilled by a number of different devices, including the M13 (used in DISN currently) and Serial to IP, which is a future device for DISN.

The requirements that follow for fiber, OTS, and TSF will most often be used by DISA in the DISN core network, and infrequently by DoD services and agencies. The Channel Access functions will be used both by DISA within the DISN for wide area communications and by

DoD services and agencies for local or by intra-site level communications. The T&S applies to the DISN Classes 1 through 3 sites and at larger DoD service and agency sites. The DISN T&S equipment will sometimes provide that capability to DoD service and agency site equipment.

### 5.5.3 Requirements

#### 5.5.3.1 *Fiber Plant*

##### 5.5.3.1.1 *Description*

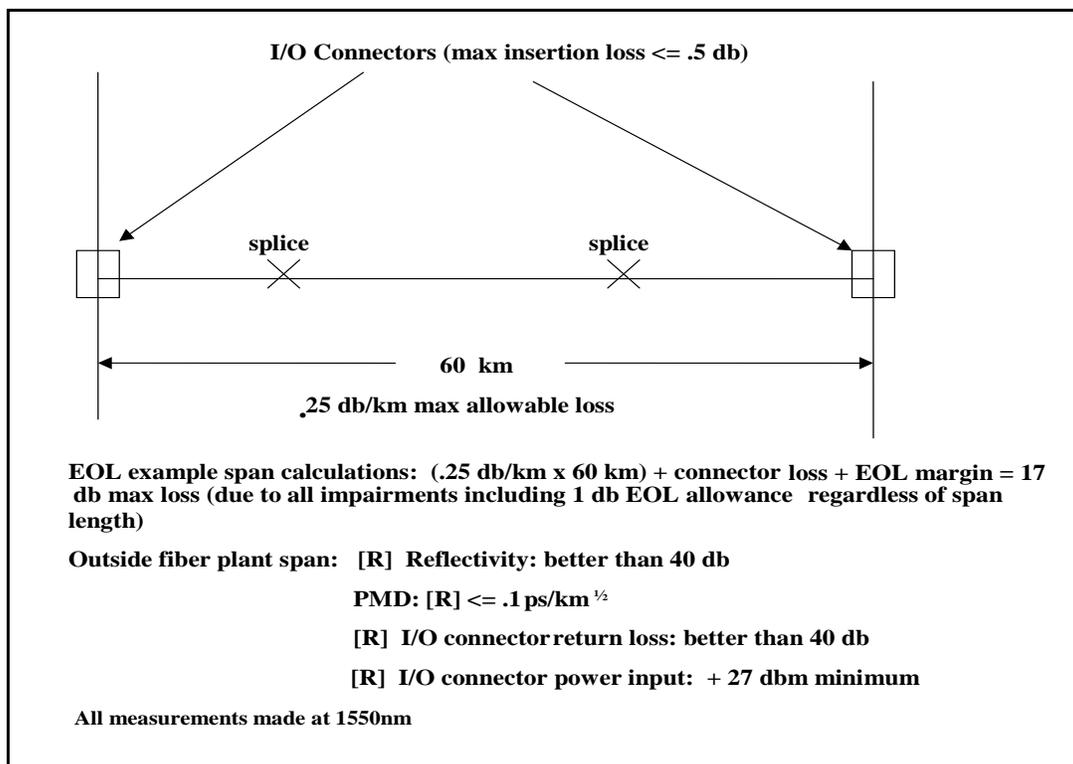
The requirements in this section apply to fiber where DISA has an Indefeasible Right of Use, which is a long-term lease (greater than 20 years) to use a fiber. This requirement does not apply where DISA leases a service and fiber is used by the carrier to provide that service.

##### 5.5.3.1.2 *Requirements*

The required performance parameters for field-testing of fiber optic links to support Dense Wave Division Multiplex (DWDM) transmission is link attenuation (alternative and equivalent term: insertion loss), chromatic dispersion, and polarization mode dispersion (PMD). Interface points to Government equipment are designated as the Fiber Service Delivery Point (FSDP). The link is defined as connecting FSDP to FSDP, as depicted in [Figure 5.5.3-1](#), End-of-Life Calculation. All test equipment shall be connected to the Government side of the FSDP for acquired fiber. Any new fiber to be tested after installation shall be spliced with a high-quality fusion splice.

Industry standard chromatic dispersion and PMD measurement test sets are required to be used. The calibration of all utilized test equipment must be current and traceable.

1. **[Required]** Per ITU-T Recommendations G.655 and G.652, the attenuation coefficient due to all impairments shall be no greater than 0.25 dB/km at 1550 nm per span and 0.35 dB/km at 1625 nm per span at the end of life (EOL). Regardless of fiber span length, the EOL attenuation coefficient shall not be more than 1 dB from the initial value (see [Figure 5.5.3-1](#), End-of-Life Calculation).
2. **[Required]** Per ITU-T Recommendations G.655 and G.652, the PMD due to all impairments shall be less than or equal to 0.1 ps/km<sup>½</sup> for any single fiber on the span when measured at 1550 nm. Total accumulated PMD from end terminal to end terminal on a span cannot exceed 10 ps/km<sup>½</sup>.
3. **[Required]** The chromatic dispersion measured at 1550 nm shall be greater than or equal to 2.0 ps/km nm.



**Figure 5.5.3-1. End-of-Life Calculation**

4. **[Required]** Connectors shall only be present at equipment interface points at Government FSDP or in vendor facilities between Government locations. If total loss and/or reflectivity requirements cannot be met, intermediate connectors may require elimination via fusion splicing.
5. **[Required]** Any single reflectance event in the OTDR trace shall be less than -40 dB.
6. **[Required]** Fiber and connectors shall support a launch power of a minimum of +27 dBm.
7. **[Required]** The connector reflectance shall be less than -40 dB.
8. **[Required]** The ORL of each fiber span shall be greater than 30 dB.
9. **[Required]** The connector insertion loss shall be less than 0.5 dB.
10. **[Required]** Per Defense Threat Reduction Agency Balanced Survivability Assessment, Critical Infrastructure Protection Plan, no Government fiber pair shall travel in the same physical path or through the same physical facilities as any other Government fiber pair (except within 50 meters of a Government site as described in Requirement 13).

11. **[Required]** Per Defense Threat Reduction Agency Balanced Survivability Assessment, Critical Infrastructure Protection Plan, the contractor shall provide physically diverse fiber routes between two designated FSDPs located at two geographically separated Government sites (e.g., base/camp/stations).
12. **[Required]** Per Defense Threat Reduction Agency Balanced Survivability Assessment, Critical Infrastructure Protection Plan, the physically diverse fibers shall travel separate paths, and shall not originate at or use any of the same local facilities. The physically diverse fiber paths shall be no less than 20 feet apart.
13. **[Required]** Per Defense Threat Reduction Agency Balanced Survivability Assessment, Critical Infrastructure Protection Plan, as the fiber paths approach near Government sites, the physically diverse fiber paths will maintain a minimum separation of 20 feet except for where the fibers are within 50 meters of the base boundary, but it is desired that they be as far apart as possible.
14. **[Required]** Direct-buried fiber is not acceptable; a conduit or duct shall protect the fiber.
15. **[Required]** A fiber shall be buried at a minimum depth of 48 inches or below the frost line, whichever is deeper. A buried fiber cable shall have a locating wire or conductive shield.
16. **[Required]** For all fiber cable within a conduit, the cable may be without armor wrap, but shall be installed in conduit appropriate for the local conditions and necessary protection from electrical discharge and rodents.
17. **[Required]** The ORL of each fiber span shall be greater than 30 dB.

#### **5.5.3.1.2.1 Aerial Installations**

1. **[Required]** Aerial fiber shall only be considered where buried conduit is unavailable or impossible to construct. Aerial fiber includes fiber along a bridge span. If aerial fiber is used, it shall adhere to the following requirements:
  - a. **[Required]** Aerial fiber shall be encased in conduit on a physically secure structure.
  - b. **[Required]** Pole line fiber is acceptable only where no other means is available. Fiber cable shall be enclosed in a protective structure (i.e., one that minimizes the effects of weather and environmental conditions such as wind, rain, snow, ice, and excessive sunlight) for every aerial installation. Pole line fiber shall be attached to a support wire or stranded messenger cable, double-lashed at the minimum.

- c. **[Required]** The cable and all associated hardware shall meet local Government requirements for clearances over roads, driveways, freeways, rail lines, structures, waterways, or other areas. All installation practices shall include calculation of strand sag, down-guys, overhead guying, anchors, and related items.

#### **5.5.3.1.2.2 Underwater Installation**

1. **[Required]** Underwater and marine cabling shall conform to international, national, state, and local laws, regulations, and standards.
2. **[Required]** Underwater and marine cabling shall be armored and installed in a way and a location (i.e., not a high-threat area) to protect it against external aggression (e.g., anchors, fishing equipment, hooks, grapnels, coral, rocks, sharks).
3. **[Required]** In the event of an underwater or marine cable cut, the cable shall be repaired within 3 days for ocean cable, and 1 day for inland streams, lakes, or other smaller bodies of water.

#### *5.5.3.1.3 Standards Compliance Requirements*

1. **[Required]** ITU-T Recommendation G.652 (2000).
2. **[Required]** ITU-T Recommendation G.655 (2000).

#### **5.5.3.2 Optical Transport System**

##### *5.5.3.2.1 OTS Description*

The OTS multiplexes the optical signals from various sources (i.e., router, TSF, Channel Access Grooming (CAG)) at the optical core site or customer-dedicated signals onto fiber and the transport signals to other optical core sites over the fiber plant. In 2009, OTS system supports 80 point-to-point channels using DWDM, where each channel is 10 Gbps. It consists of the following components: Terminal, ROADM, and OLA. There is an optical supervisory channel (OSC) that runs between these elements. The terminal is composed of two elements: the transponder and the muxponder.

Definitions of terms in this section can be found in Section A2, Glossary and Terminology Description, of Appendix A.

This section is organized as follows:

- Requirements applicable to all OTS elements

- OLA
- Muxponder element within the terminal
- Transponder element within the terminal
- ROADM
- Requirements applicable to both transponder and ROADM
- OSC

### 5.5.3.2.2 *Requirements Applicable to all OTS Elements*

#### 5.5.3.2.2.1 **Overall Requirements**

1. **[Required]** The OTS family of equipment shall be currently available, COTS equipment.
2. **[Required]** The OTS shall support a minimum of 80 ITU-T Recommendation G.694.1 grid wavelengths per line-side optical fiber.
3. **[Conditional]** The OTS shall support a minimum of 160 ITU-T Recommendation G.694.1 grid wavelengths per line-side optical fiber.
4. **[Required]** The OTS shall support mixed bit rate signals: 10 Gbps, 40 Gbps, and 100 Gbps.
5. **[Required]** The OTS shall use the ITU-T specified OSC for out of-band management communication.
6. **[Required]** The OTS shall support all specified wavelengths for all specified bit rate and signal format.
7. **[Required]** The OTS shall support at least standard single mode fiber (ITU-T Recommendation G.652), non-zero dispersion shifted fibers C (ITU-T Recommendation G.655) such as TrueWave-RS®, TrueWave Classic (TWC, TW+), enhanced large effective area or (E-LEAF) or Large Effective Area (LEAF).
8. **[Required]** The OTS shall support the ability of 80, 10Gbps wavelengths to traverse a minimum of 5 ROADM using fibers specified previously for a minimum reach of 2,000 Km without regeneration (optical-to-electrical-to-optical (OEO) conversion) at a BER less than  $1 \times 10^{-15}$ .
9. **[Required]** The OTS shall support the ability of 80, 40G wavelengths to traverse a minimum of 5 ROADM using fibers specified previously for a minimum reach of 1,500 km without regeneration (OEO conversion) at a BER less than  $1 \times 10^{-15}$ .

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10. **[Required]** The OTS shall support the ability of 80, 100G wavelengths to traverse a minimum of 5 ROADM using fibers specified previously for a minimum reach of 1,200 km without regeneration (OEO conversion) at a BER less than  $1 \times 10^{-15}$ .
11. **[Required]** The OTS shall support span length up to 150 km and span loss up to 50 dB. The reach shall not be limited by OSC performance.
12. **[Required]** The OTS shall allow the remote configuration of wavelengths added or dropped from the system.
13. **[Required]** Client interfaces available on the OTS shall meet the accepted standards or specifications for the interface (e.g., OC-192 Telcordia Technologies GR-253-CORE standards, Synchronous Transport Module (STM)-16 and STM-64 ITU-T Recommendations G.707 standards, and Gigabit Ethernet (GbE) and 10GbE IEEE 802.3 standards).
14. **[Required]** The OTS shall support remote shelf location with up to 6 dB optical power budget between terminal and remote locations.
15. **[Required]** The OTS shall support universal (or single part code) MUX/demultiplexer (DEMUX) circuit-packs at all terminals and ROADM nodes.
16. **[Required]** The OTS shall enable pre- and post-dispersion compensation options, at all nodes (terminals, ROADMs, and OLAs).
17. The OTS T&S requirements are defined in [Section 5.5.4.2.3](#), General DISN NE Requirements, and [Section 5.5.4.2.4](#), Optical Transport System.

**5.5.3.2.2.2 Performance Requirements**

1. **[Required]** Jitter tolerance shall be in compliance with Telcordia Technologies GR-253-CORE (issue 4, December 2005) Type II and ITU-T Recommendation G.958.
2. **[Required]** Jitter transfer shall comply with Telcordia Technologies GR-253-CORE (issue 4, December 2005) and ITU-T Recommendation G.958.
3. **[Required]** In a single vendor environment, a wavelength shall traverse up to at least 20 transponders before termination of the signals is required at a terminal site. This shall be true for all data rates specified.
4. **[Required]** The OTS shall tolerate a persistent input channel signal timing deviation of at least +/- 20 parts per million (ppm). This implies that the OTS must (1) operate properly in

normal condition (i.e., without alarms) when any or all tributaries have long-term frequency offsets of up to +/- 20 ppm, and (2) maintain the system performance objectives for concatenated OTS systems.

5. **[Required]** When a signal passes through concatenated OTS sections, the output jitter shall not exceed the network interface limits of ITU-T Recommendation G.825.
6. **[Required]** When one or more channel (up to 90 percent) fails or is removed (either instantaneously or sequentially), the remaining channels shall not experience increasing bit errors or loss of operating margin. In addition, when failed channels are restored or new channels are added, the existing channels shall not experience any transient or long-term performance deterioration.
7. **[Required]** The maximum uncompensated PMD the system can tolerate at 40/100 Gbps shall not exceed that tolerated at 10 Gbps.

#### **5.5.3.2.2.1 Reliability and Quality Assurance**

1. **[Required]** The OTS equipment shall meet the following quality program requirements, unless specifically overridden or modified by another requirement in this document:
  - Telcordia Technologies GR-282-CORE
  - Telcordia Technologies GR-2911-CORE
  - Telcordia Technologies TR-NWT-000179
  - Telcordia Technologies TR-NWT-000418
  - Telcordia Technologies SR-NWT-002419
2. **[Required]** A list shall be available of country of origin of the critical components as well as final assembly location of the system.

#### **5.5.3.2.2.3 Common Physical Design Requirements**

All equipment to be deployed in the central office environment, regardless of application, must comply with the requirements of this section. Mission criticality or presence of network traffic bring other criteria into play, but this set must always be present to protect the people working in the facility and the other more critical equipment.

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1. **[Required]** Each OTS element shall meet requirements addressed in this document and shall have met European Community (EC) or Pacific Host Nation approvals required for foreign countries. Provide information on the countries that currently approve the equipment, including equipment part numbers and other applicable documentation.
2. **[Required]** The vendor shall have a program underway to obtain approvals and permits for connection and operation of the equipment to the public networks in the EC and Pacific areas. A list of counties where such approval has been obtained or where it is actively working toward approval will be maintained. (NOTE: this list will change with time.)
3. **[Required]** Each NE shall meet requirements addressed in this section and shall be compliant, at a minimum, without future hardware and/or memory upgrades or replacements.
4. **[Required]** Equipment racks' weight shall be within acceptable standards defined for raised floor application.
5. **[Required]** Equipment racks shall allow cable installation above and below each rack.
6. **[Required]** Each OTS element shall be able to receive all types of cables from the top or bottom of the bay or cabinets. When receiving from the bottom, it shall be able to accommodate a raised floor environment.
7. **[Required]** All inter-bay cabling shall be routed above and below each rack allowing various different cable lengths up to 100 meters. If the equipment cannot support 100 meters, the vendor shall state the maximum cable length supported.
8. **[Required]** Within a OTS element, all intra-system cabling shall maximize separation of redundant cables and fibers (i.e., working/protection, east/west, timing cables, switch cables).
9. **[Required]** All working signal cables shall be routed on separate physical paths from the protection cables within the system. Between systems, all separations shall be maintained. All intersystem connections shall be able to support a minimum distance of 100 meters.
10. **[Required]** A and B power cables shall have physically diverse routing within the bay or cabinet.
11. **[Required]** Current drain information shall be provided to outline current draws in both normal and worst case voltage scenarios. (The latter information shall also address impacts of failed feeds and temperature where variable speed fans or other factors make such considerations appropriate. When multiple configurations are possible because of card

variety, test data on several “generic” configurations shall be provided with a table of power numbers to help the user interpolate the approximate values of other configurations.

12. **[Required]** Each OTS element, shelf, or circuit pack, whichever is the smallest independent load device of the OTS element shall obtain power from two completely independent power units. Furthermore, the return path from the power units shall remain completely independent (Telcordia Technologies TR-NWT-000295). If one of the power units fails, an alarm shall be generated and the load shall be carried by the other unit without manual intervention and without interruption of service or functionality. The other power unit shall support the operation of the element, shelf, or circuit pack until the problem with the faulty unit is corrected.
13. **[Required]** All OTS elements shall conform to the spatial and environmental criteria specified in Telcordia Technologies FR 796 and GR-63-CORE.
14. **[Required]** All OTS elements, along with its power distribution panel and all associated or ancillary hardware, shall be capable of being mounted in a standard EIA 310C 23-inch relay rack, 84-inch in height.
15. **[Required]** All OTS elements shall be capable of being operated and maintained with access only to the front of the unit.
16. **[Required]** All OTS elements shall be capable of being mounted in a back-to-back arrangement or directly against a building wall.
17. **[Required]** All OTS elements, along with their power distribution panel and all associated or ancillary hardware, shall be capable of being mounted in a standard EIA 310C 23-inch relay rack, 78 inches in height.
18. **[Required]** All OTS elements, along with their power distribution panel and all associated or ancillary hardware, shall be capable of being mounted in standard EIA 19-inch relay rack, 78 inches in height.
19. **[Required]** All OTS elements, along with their power distribution panel and all associated or ancillary hardware, shall be capable of being mounted in X-Mark/CDT cabinets, part number XSL78-4-1S0002, size 78 inches x 23 inches x 30 inches.
20. **[Required]** All OTS elements shall demonstrate an operational availability of all functions and services of 99.9997 percent.

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21. **[Required]** All OTS elements shall comply with the earthquake, office vibration, and transportation vibration criteria specified in Telcordia Technologies GR-63-CORE, Section 4.4, Earthquake, Office Vibration, and Transportation Vibration.
22. **[Required]** All OTS elements shall be fully Network Equipment-Building System (NEBS), Level 3 compliant.
23. **[Required]** All OTS elements shall meet the environmental conditions described in Telcordia Technologies GR-63-CORE.
24. **[Required]** All OTS elements shall meet the environmental conditions described in European Telecommunications Standards Institute (ETSI) ETSI 300 019.
25. **[Required]** All OTS elements shall be designed to operate in a communication equipment environment, adjacent to or in the vicinity of others types of equipment that may include digital radio equipment, fiber optic terminal equipment, frequency-division multiplexing (FDM) analog microwave, very high frequency (VHF)/ultra high frequency (UHF) base stations, satellite ground terminals, transfer trip and power line carrier equipment, and telephone signaling equipment.
26. **[Required]** All OTS elements shall meet the electromagnetic compatibility (EMC)/electromagnetic interference (EMI) requirements defined in Telcordia Technologies GR-1089-CORE.
27. **[Required]** All OTS elements shall meet the EMC/EMI requirements defined in Federal Communications Commission (FCC) Part 15 Class A.
28. **[Required]** All OTS elements shall meet the EMC/EMI requirements defined in ETSI EN 50082.
29. **[Required]** All OTS elements shall meet the EMC/EMI requirements defined in ETSI EN 55022.
30. **[Required]** All OTS elements shall meet the EMC/EMI requirements defined in ETSI EN 300-386.
31. **[Required]** All OTS elements shall be designed to operate continuously in the following environment ranges without degradation: Temperature: 0 to +50°C; Humidity: 5 to 95 percent relative humidity, without condensation.

32. **[Required]** All OTS elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C; Humidity: 5 to 95 percent relative humidity, without condensation.
33. **[Required]** All OTS elements shall be designed to operate continuously in the following environment range without degradation: Altitude: -100 to 15,000 ft above mean sea level (AMSL).
34. **[Required]** All OTS elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
35. **[Required]** All OTS elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and electrostatic discharge (ESD) safety, and shall be operable using standard 48V direct current (dc) power as well as having redundant isolated power input feeds. For certain sites, an alternative alternating current (ac)/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220V with redundant isolated power modules.
36. **[Required]** All OTS elements shall be fully operational throughout the battery voltage range of -41.5 to -56 volts direct current (VDC).
37. **[Required]** All OTS elements shall not be damaged and recover to normal performance following application of the following maximum transient voltages for the duration's given (nominal voltage 48 VDC): 75 VP-P for 1 msec, 60 VP-P for 500 msec.
38. **[Required]** All OTS elements in the transport layer primary operating system interface shall provide the capability for reporting alarms of external equipment and general housekeeping alarms. A minimum of 16 user-defined alarms shall be provided, with the option to expand to 32 user-defined alarm points. Capability shall be provided for a minimum of eight user-defined remote control points for external functions. This capability shall be provided by relays, not Transistor-Transistor Logic.
39. **[Required]** The OTS shall support having all data cross connects stored locally and redundantly; and automatically restored without user intervention, in the case of failure, within a period of 5 minutes.
40. **[Required]** The OTS shall provide the capability to roll back to the previous operational version of software.

41. **[Required]** The OTS shall conform to memory administration, and system administration and security standards as documented. (Telcordia Technologies GR-472-CORE and GR-253-CORE (issue 4, December 2005).
42. **[Required]** All future software for the OTS shall interoperate with the previous deployed GIG-Bandwidth Expansion (GIG-BE) system operational software version/release.
43. **[Required]** The OTS shall support software upgrades that directly use or translate the previous version's configuration database.
44. **[Required]** The software of the OTS shall be designed and upgraded in a modular fashion so that an entire code does not have to be replaced when a portion is upgraded.
45. **[Required]** The OTS shall be designed with an accessible file system to allow for multiple versions of software, logs, and file manipulation or integrity checks to be performed before upgrading or downgrading software and/or firmware.
46. **[Required]** All equipment shall have been tested and registered as compliant to the following electrical safety standards: UL-1950, EN60950, and International Electrotechnical Commission (IEC) 60950.

#### **5.5.3.2.2.4 Protection and Restoration**

1. **[Required]** The OTS shall support 1+1 wavelength protection and restoration.
2. **[Required]** The Active and Standby wavelengths shall be diversely routed.

#### **5.5.3.2.3 Optical Amplifier**

1. **[Required]** The system shall support the use of an optical connector for connecting an optical amplifier (OA) to the outside plant fiber; Raman amplifiers may not be directly spliced to the transmission fiber and must be field-replaceable, without the need for special equipment.
2. **[Required]** The total optical power emitted from the OTS to be coupled into the fiber shall not exceed the power limit of IEC Class 3B (+27 dBm).
3. **[Required]** The OTS shall monitor and report on the operation of the Raman pumping lasers including power on, off, optical output power, operating current, and total optical return loss (ORL).

4. **[Required]** After detecting the failure of Raman pumping lasers, the OTS shall generate an alarm, but shall not shut off the system.
5. Reserved.
6. **[Required]** The OTS shall have an integrated power management algorithm, which invokes power monitoring and adjustment devices to compensate for power variations across the optical wavelengths.
7. **[Required]** The OLA system shall be able to balance individual wavelengths so that power output levels exhibit less than 0.5 dB variance from the mean output level without remote or direct intervention from a network operator.
8. **[Required]** When one or more channels fail or are removed, the remaining channels shall not experience increased bit errors or loss of operating margin.
9. **[Required]** When failed channels are restored or new channels are added, the existing channels shall not experience any transient or long-term performance deterioration.
10. **[Required]** The power management algorithm shall cause no interruptions in OSC communications at any time.
11. **[Required]** The OSC signals shall experience no increased errors at any time up to EOL, including during wavelength provisioning or line equalization.
12. **[Required]** Amplifiers shall require less than 1 ms to return all wavelength power output levels to within 1 dB of preinsertion/drop levels; transient suppression statistics shall be provided for OLA systems.
13. **[Required]** The OA shall maintain safe (Hazard level 1) system operation in the event of input signal loss or fiber cut.
14. **[Required]** Chromatic dispersion compensation shall be able to fully compensate a 150 km span for each fiber type, as specified in [Section 5.5.3.1, Fiber Plant](#).
15. **[Required]** Chromatic dispersion compensation shall be provided for different fiber lengths in 10, 20, or 30 km increments, if the technique requires the compensation to be periodically dispersed.
16. **[Required]** The OTS shall enable pre- and post-dispersion compensation options.

17. **[Required]** A secured external monitor port is required at each OA. For devices that contain a full-featured internal Optical Spectrum Analyzer (OSA), an external monitor port shall still be required.
18. **[Conditional]** Internal OSA functionality shall support 25 GHz ITU grid spacing with a minimum 5 percent wavelength accuracy.
19. **[Required]** Internal OSA functionality shall provide a minimum accuracy of 0.2 dB for each wavelength.
20. **[Required]** Internal OSAs shall provide sweep times of less than 1 second.
21. **[Required]** Internal OSAs shall provide the ability to display all wavelengths simultaneously.
22. **[Required]** Internal OSAs shall provide the ability to retrieve data to be stored at a remote storage site.
23. **[Required]** Internal OSAs shall provide the ability to view various calculated data, such as gain tilt, output tilt, gain variation, gain difference, noise level, total received power, and total launched power.
24. **[Optional]** Internal OSAs shall provide the ability to report Quality (Q) factor (not critical).
25. **[Required]** Internal OSAs shall have the ability to estimate Optical Signal to Noise Ratio (OSNR) for each wavelength.
26. **[Required]** All measurements made available at the internal OSA shall be available at the external OSA port (not critical).

#### **5.5.3.2.3.1 OLA Physical Design Requirements**

1. **[Required]** The OLA shall support hot swappable modular components including, but not limited to, fans, amplifier modules, in-band/out-of-band management interfaces, power supplies, and control processor.
2. **[Required]** The OLA shall support redundant fans, management interfaces, power supplies, and control processors.
3. **[Required]** The OA shall be able to fit in either a standard 19-inch or a 23-inch rack with depth no greater than 30 inches and height no more than 84 inches.

4. **[Optional]** The OLA overall dimensions shall be no more than one 7.2 foot standard Telco rack for a full 80 wavelengths bi-directionally, or two racks for 160 wavelengths, including out-of-band management functions.
5. **[Required]** The OLA power consumption shall be kept below 2000 watts for all equipment at an OLA site.
6. **[Required]** The vendor shall identify its OLA power and space requirements for all specified configurations.

#### 5.5.3.2.4 *Muxponder Requirements*

To better use the wavelength capacity, 4:1 muxponders would be needed for SONET/synchronous digital hierarchy (SDH) signals and an 8:1 muxponder for 10GbE signal.

1. **[Required]** Transponders shall support a four-into-one muxponder (four 10G signals multiplexed into one 40G signal). If the vendor equipment supports this functionality, the equipment shall meet the requirements listed in this section
2. **[Required]** The OTS shall support a 4:1 40G multiplexer. The 4:1 40G multiplexer shall receive four standards compliant OC-192/STM-64 signals, from one to four sources, and multiplex them onto a signal for transport over a 40G wavelength on the system.
3. **[Required]** The 4:1 40G multiplexer shall transmit a 40G channel in each operating band specified by the vendor. The vendor shall indicate any excluded band.
4. **[Required]** The 4:1 40G multiplexer shall occupy no more physical space than an OC-192/STM-64 transmit/receive pack.
5. **[Required]** The 4:1 multiplexer shall transfer the OC-192/STM-64 signals through the system transparently.
6. **[Required]** The engineering rules for the 4:1 40G multiplexer configuration shall be the same as the standard OC-768/STM-256 configuration without the need to change any system components, including dispersion compensation.
7. **[Required]** The OC-192/STM-64 interface (e.g., short reach (SR)) for a 4:1 40G multiplexer shall have identical compliance to all the requirements for an OC-192/STM-64 interface to an OC-192/STM-64 standard transponder as specified in this document.
8. **[Required]** An OC-48/STM-64 through the OTS that is multiplexed and demultiplexed through the 4:1 10G multiplexers shall meet the same performance requirements as an

OC-192/STM-64 signal through the OTS using OC-192/STM-64 transponders. Performance requirements include, but are not limited to, BER, Errored Seconds (ES), Severely Errored Seconds, and Availability.

9. **[Required]** An OC-192/STM-64 through multiple concatenated systems containing 4:1 10G multiplexers shall meet the same performance requirements as an OC-192/STM-64 signal through concatenated OTSs using OC-192/STM-64 transponders. The same number of concatenated 4:1 10G multiplexers shall be supported as the number of concatenated OC-192/STM-64 transponders. Performance requirements include, but are not limited to jitter generation and tolerance.
10. **[Required]** The maximum number of 40G channels equipped with 4:1 40G multiplexers in an OTS must be equal to the maximum number of OC-768/STM-256 channels supported in an OTS.
11. **[Required]** The 4:1 10G multiplexer shall operate without degradation if less than four of the OC-192/STM-64s have a valid OC-192/STM-64 signal
12. **[Required]** The loss of one or more provisioned OC-192/STM-64 inputs to a 4:1 10G multiplexer shall not affect the performance of any other provisioned OC-192/STM-64 on that multiplexed channel.

#### *5.5.3.2.5 Transponder Requirements*

1. **[Required]** Transponders shall comply with the DWDM wavelength grid as specified in ITU-T Recommendation G.694.1.
2. **[Required]** Transponders shall support tunable lasers, which are tunable over whole band.
3. **[Required]** All transponders shall support a built-in self BER test function.
4. **[Required]** All transponders shall support local and remote loopback capability on the line side for a built-in self BER test.
5. **[Conditional]** All transponders shall support total end to end signal propagation delay (at transponder ingress to egress) reporting function.
6. **[Required]** All transponders shall support user selectable line side Forward Error Correction (FEC) i.e., no FEC, ITU-T Recommendation G.709-compliant standard FEC or Super FEC, and enhanced FEC (EFEC) modes.

7. **[Required]** Transponders shall support ITU-T Recommendation G.709 specifications for OTN services.
8. **[Required]** Transponders shall support switching of framing protocols (OTN, SONET, 10GbE) without requiring downloading or switching of firmware or software, and physical removal of the transponder from the slot.
9. **[Required]** Transponders shall have non-intrusive SONET/SDH B1 monitoring capability.
10. **[Conditional]** Transponders shall have integrated EDC (Electronic Dispersion Compensation) for all specified fiber types to support minimum unregenerated reach of 2000 kames.
11. **[Required]** The vendor shall supply through-transponder(s) to eliminate unnecessary back to back Optical/Electrical (O/E) conversions for wavelength regeneration at ROADM, optical cross-connect (OXC), and regenerator sites.
12. **[Required]** The vendor shall provide a transponder to interface with 10/40/100 Gbps unframed wavelength services.
13. **[Required]** A transponder shelf shall support all types of transponders, or a combination of them. No slot shall be bit-rate specific.
14. **[Required]** There shall be no human intervention, including: manual wavelength tuning or power equalization via external attenuators after adding transponders.
15. **[Required]** Transponders shall support all wavelengths and required transmission rates with a minimum reach of 2000 km without OEO regeneration on all specified fiber types (ITU-T Recommendations G.652, G.655).

#### **5.5.3.2.5.1 Interface Requirements**

1. **[Required]** Transponders shall support an OC-48/STM-16 interface.
2. **[Required]** Transponders shall support an OC-192/STM-64 interface.
3. **[Required]** Transponders shall support a GigE interface.
4. **[Required]** Transponders shall support a 10 GigE WAN physical layer (PHY) interface.
5. **[Required]** Transponders shall support a 10 GigE LAN PHY interface.

6. **[Required]** The transponders shall support OC-768/STM-256 interfaces.
7. **[Required]** The transponder shall support all OTN rates including ODU1/ODU2/ODU3 and 100 Gbps.
8. **[Required]** The transponders shall support SR, Long Reach (LR) (LR-1, LR-2, LR-3), and Intermediate Reach (IR) (IR-1, IR-2), client interface types per Telcordia Technologies GR-253-CORE.
9. **[Required]** The transponders shall support client interfaces at 1310 and 1550 nm.
10. **[Required]** The transponders shall support client interfaces at 850 and 1310 nm for GigE signals.

#### *5.5.3.2.6 ROADM*

1. **[Required]** The ROADM shall be capable of supporting a minimum of eight network-side interfaces and perform both optical bypass and adds and drop functions.
2. **[Required]** The ROADM shall support directionless wavelength routing.
3. **[Required]** The ROADM shall be capable of colorless wavelength routing.
4. **[Required]** The system shall support cascading of a minimum of eight ROADMs for a total unregenerated reach of 2000 km.
5. **[Required]** Any wavelength not explicitly dropped or added shall be passed through the ROADM.
6. **[Required]** It shall be possible to reuse wavelength at ROADM.
7. **[Required]** There shall be no restrictions on ADD/DROP and EXPRESS (pass through) wavelengths at ROADM site.
8. **[Required]** It shall be possible to add, drop, or express (pass through) any optical channel at a ROADM site in any order.
9. **[Required]** If a wavelength is dropped at an ROADM site, then the same wavelength shall be able to be added at that site. However, there shall be no requirement that the wavelength that is dropped must be matched by a corresponding wavelength that is added, and vice versa, implying wavelength translation capability at the ROADM. At a ROADM

it shall be possible to drop an incoming wavelength and not add a new corresponding outgoing wavelength including the following:

- a. Accepting a non-provisioned incoming wavelength and adding a new outgoing wavelength.
  - b. Dropping an incoming wavelength and adding a new corresponding outgoing wavelength
10. **[Required]** The ROADM shall be capable of supporting dynamic wavelength selection without precabing being required.
  11. **[Required]** The ROADM shall be capable of dropping all wavelengths from each of eight line-side fiber connections to tributary-side optics.
  12. **[Required]** The ROADM shall be capable of adding all wavelengths to each of eight line side fiber connections from tributary side optics.
  13. **[Required]** The ROADM shall be capable of dropping any specific wavelength, independent of other wavelengths to be dropped.
  14. **[Required]** The ROADM shall be capable of adding any specific wavelength, independent of other wavelengths to be added.
  15. **[Required]** The ROADM shall support a wavelength hair-pinning capability.
  16. **[Required]** The ROADM shall support wavelength regeneration, including wavelength conversion, using back-to-back transponders or through-transponders via hair-pinning capability.
  17. **[Required]** The activation of additional services on interfaces in the ROADM shall be non-service affecting to existing traffic and shall not cause any increase in bits errors.
  18. **[Required]** The deletion of active services on interfaces in the ROADM shall be non-service affecting to the remaining traffic and shall not cause any increase in bits errors.
  19. **[Required]** Hardware upgrades of the ROADM to support higher tributary interface density shall not disrupt operational traffic.
  20. **[Required]** Hardware upgrades of the ROADM to support higher line interface density shall not disrupt operational traffic.

21. **[Required]** The ROADM shall provide a latching capability. (Latching is the ability of the ROADM to maintain its current state in the event of power failure.)
22. **[Required]** The ROADM shall provide an optical multicasting capability. (Multicasting is the ROADM's ability to allow one input wavelength to be duplicated on multiple output tributary and line ports).
23. **[Required]** The ROADM shall support dynamic per-wavelength power leveling.
24. **[Required]** The addition or deletion of a wavelength service on the ROADM shall not cause an increase in BER or data loss on other wavelengths.
25. **[Required]** The ROADM shall not incur increased bit errors associated with wavelength provisioning or line equalization.
26. **[Required]** The failure of an upstream line system shall not cause the ROADM to increase in BER or lose data on the remaining active wavelengths.
27. **[Required]** The OSNR penalty for any signal passing through a ROADM shall be less than 0.5 dB.
28. **[Required]** The system is required to automatically redirect working paths to available spare fibers or wavelengths in the event of a primary path failure. The ROADM shall not inhibit ring or linear protection switching initiated by an ODXC, MSPP, or other electronic device.
29. **[Required]** The ROADM shall support a 1+1 protection functionality with fully diverse routing. The ROADM shall not inhibit ring or linear protection switching initiated by an ODXC, MSPP, or other electronic device.
30. **[Required]** The ROADM shall support redirection of light paths via the EMS/NMS.
31. **[Required]** The ROADM shall support linear protection topologies. The ROADM shall not inhibit ring or linear protection switching initiated by an ODXC, MSPP, or other electronic device.
32. **[Required]** The ROADM shall support ring protection topologies. The ROADM shall not inhibit ring or linear protection switching initiated by an ODXC, MSPP, or other electronic device.

#### 5.5.3.2.6.1 ROADM Specific Physical Design Requirements

1. **[Required]** The vendor shall comply with all requirements listed in General Physical Requirements of this document. The vendor shall list all discrepancies.
2. **[Required]** The ROADM shall support hot swappable modular components including, but not limited to, fans, switch fabric, interface ports, power supplies, and control processor.
3. **[Required]** The ROADM shall support redundant fans, switching fabrics, power supplies, and control processors.
4. **[Required]** The ROADM equipment shall be able to fit in either a 19-inch or a 23-inch rack with depth no greater than 32 inches and height no more than 84 inches.
5. **[Required]** The fully configured ROADM (excluding the transponder shelves) shall not exceed two full 84-inch racks.
6. **[Required]** The fully configured ROADM shall not exceed one full 84-inch rack.
7. **[Required]** The ROADM shall not require contiguous rack locations.
8. **[Required]** The ROADM weight shall be so that the device can be mountable in a standard Telco rack or secure cabinet with standard rack screws and shall not require unusual hardware.

#### 5.5.3.2.7 Requirements Common to Transponder and ROADM

##### 5.5.3.2.7.1 Framed Formats

1. **[Required]** The OTS shall support the transport of the following SONET/SDH services: OC-192/STM-64, OC-48/STM-16, and OC-768/STM-256.
2. **[Required]** The OTS shall support the transport of the following Ethernet services: GigE (via 10:1 Muxponder), 10GigE WAN PHY, and 10GigE LAN PHY.
3. **[Conditional]** The OTS shall support the transport of the following OTN services: OTU-1, OTU-2, and OTU-3.
4. **[Required]** The OTS shall be transparent to the bit pattern of all optical channels (i.e., the OTS shall not modify the payload bit pattern of any signal that traverses it).

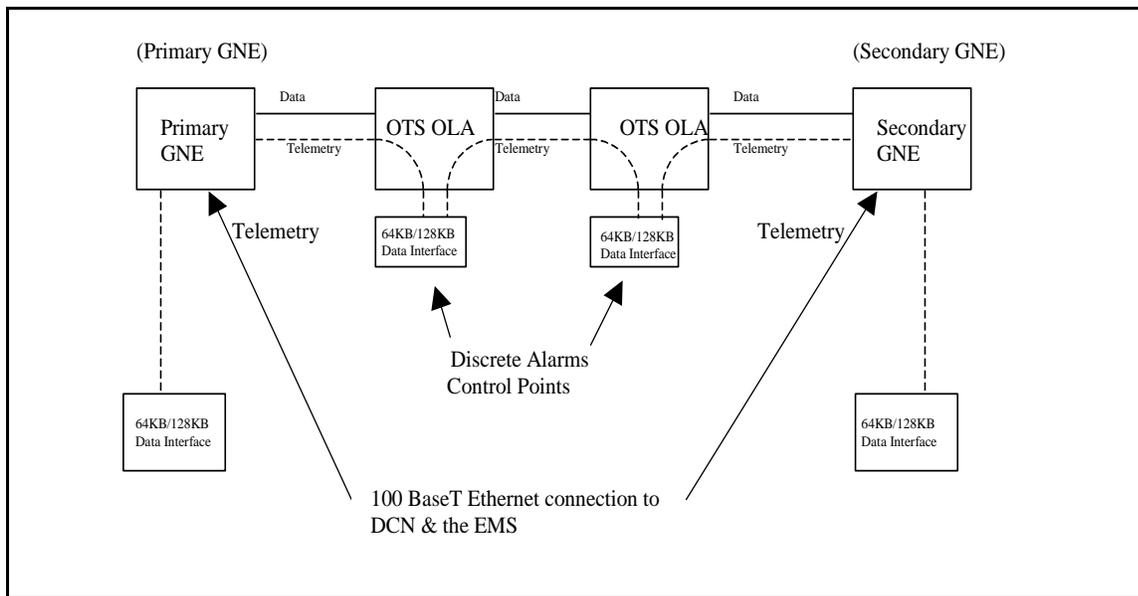
5. **[Required]** Framed wavelength services shall be supported for 2.5, 10, and 40 Gbps SONET/SDH and OTN transport (ITU-T Recommendation G.709).
6. **[Required]** Framed wavelength services shall be supported for GigE/10 GigE signals, and signals formatted for OTN transport (ITU-T Recommendation G.709).
7. **[Required]** Framed wavelength services shall be supported for 40 (ITU-T Recommendation G.709) and 100 Gbps (STD TBD) signals.
8. **[Required]** The OTS shall support, in hardware and in software, the possibility to feed a specified ITU-T grid wavelength, with undefined framing, directly into the multiplexer through a “colored interface” that shall verify the wavelength and power levels (commonly known as alien wavelength) and to identify other characteristics of the tributary signal required to be known and monitored for proper OTS system operation with such tributary signals.
9. **[Required]** “Alien wavelength” regeneration shall be supported.

#### **5.5.3.2.7.2 Unframed Formats**

1. **[Required]** The OTS shall support unframed wavelength services.
2. **[Required]** The OTS shall support mixed framed and unframed wavelength services

#### **5.5.3.2.8 *Optical Supervisory Channel***

The OTS shall include an OSC linking the two OTS Gateway NEs (GNEs), with access at each OTS OLA site. All telemetry, data, and voice traffic originating at OTS OLA sites shall be routed over this service channel. A diagram of the OSC appears in [Figure 5.5.3-2](#), Optical Supervisory Channel. The optical line rate, the optical format, and interface partitioning internal to the OTS may be a proprietary implementation.



**Figure 5.5.3-2. Optical Supervisory Channel**

1. **[Required]** The OLA, ROADM, and end terminal (ET) elements shall terminate or insert an OSC with a wavelength that adheres to ITU-T specifications.
2. **[Required]** The OLA, ROADM, and ET elements shall use the ITU-T-specified OSC for out-of-band management communications.
3. **[Required]** The OLA, ROADM, and ET elements shall use the same OSC wavelength.
4. **[Required]** The internal diagnostics for OLA, ROADM, and ET elements shall report OSC failure.
5. **[Required]** It shall be possible to turn up and sustain transmission between two nodes in the absence of an OSC.
6. **[Required]** The OLA, ROADM, and ET elements shall report any OSC channel input/output failure (via out-of-band Data Communications Network (DCN)).
7. **[Required]** The OLA, ROADM, and ET elements shall report any OSC channel BER threshold violation.
8. **[Required]** The OLA, ROADM, and ET elements shall provide OSC interfaces that allow for interoperability with all adjacent equipment within the optical network (i.e., wavelength, modulation, protocol) from the same vendor.

9. **[Required]** The OSC shall be able to operate error free across 150 Km of each specified fiber type with a span loss of 50 dB at the OSC frequency or wavelength. The span loss shall not be inclusive of the OSC insertion loss.
10. **[Required]** The OSC circuit pack shall report optical span loss between two adjacent nodes.
11. **[Required]** The OSC shall operate at 2 Mbps or higher data rates.
12. **[Required]** Architecturally, the OSC shall be passively optically and separated from the transport optical signals immediately after input connection of the OTS.

#### *5.5.3.2.9 OTS Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfy multiple versions of the standards. Testing will need to be undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.652 (10/2000) (2005)
2. **[Required]** ITU-T Recommendation G.655 (10/2000) (2006)
3. **[Required]** ITU-T Recommendation G-694.1 (2002)
4. **[Required]** ITU-T Recommendation G.709/Y.1331
5. **[Required]** ITU-T Recommendation G.825 (2000)
6. **[Required]** ITU-T Recommendation G.958 (1994), Digital Sections and Digital Line Systems
7. **[Required]** Telcordia Technologies GR-63-CORE, Issue 1, October 1995 (Issue 3, March 2006)
8. **[Required]** Telcordia Technologies TR-NWT-000179, Issue 2, June 1993
9. **[Required]** Telcordia GR-253-CORE, Issue 3, September 2000 (Issue 4, December 2005)

10. **[Required]** Telcordia Technologies GR-282-CORE, December 1997 (Issue 4, July 2006)
11. **[Required]** Telcordia Technologies TR-NWT-000295, Issue 2, July 1992
12. **[Required]** Telcordia Technologies NWT-000418, December 1999
13. **[Required]** Telcordia Technologies GR-472-CORE, Issue 2, November 1996
14. **[Required]** Telcordia Technologies FR-796, Reliability and Quality Generic Requirements, Issue 5, April 2008
15. **[Required]** Telcordia Technologies GR-1089-CORE, Issue 2, Revision 1, February 1999 (Issue 4, June 2006)
16. **[Required]** Telcordia Technologies SR-NWT-002419, Issue 1, 1992
17. **[Required]** Telcordia Technologies GR-2911-CORE, 1995
18. **[Required]** ETSI ETS 300 019, 1994
19. **[Required]** ETSI ETS-FN-50022
20. **[Required]** ETSI EN 50082
21. **[Required]** ETSI EN 300 386
22. **[Required]** British Standards Institute BS EN 60950-1, August 6, 2006
23. **[Required]** IEC 60950-1, 2006
24. **[Required]** Code of Federal Regulations (CFR) FCC Part 15, Class A
25. **[Required]** Network Equipment - Building System (NEBS), Level 3
26. **[Required]** Underwriters Laboratories, Inc UL-1950, Standard for Safety, Information Technology Equipment Including Electrical Business Equipment, First Edition 1989
27. **[Required]** EIA 310C

### **5.5.3.3     *Transport Switch Function***

The TSF T&S requirements are defined in [Section 5.5.4.2.3](#), General DISN NE Requirements, and [Section 5.5.4.2.5](#), Channel Transport Switching (TSF) Functional Device. Today, the TSF functionality is satisfied by the ODXC equipment within the DISN.

#### **5.5.3.3.1     *Description***

The TSF is a cross-connect device that is located primarily at Class 1 sites but it could also be deployed at select Class 2 sites. The lowest level that it will cross-connect is an STS-1.

#### **5.5.3.3.2     *TSF SONET/SDH Interface Requirements***

1.   **[Required]** The TSF shall support SDH or SONET on any combination of ports or port cards.
2.   **[Required]** It shall be possible to use any port on the systems as network-side interfaces or tributary-side interfaces.
3.   **[Required]** The network-side interfaces shall include OC-768/STM-256 (if supported), OC-192/STM-64, OC-48/STM-16, and OC-12/STM-4.
4.   **[Required]** The tributary-side interfaces shall include OC-48/STM-16, OC-12/STM-4, and OC-3/STM-1.
5.   **[Desired]** The network-side interfaces shall include 10 Gbps DWDM using the ITU grid (C and L band).
6.   **[Required]** The TSF shall provide optical interfaces for OC-192, OC-48, OC-12, and OC-3 signals consistent with the SR-1, IR-1, IR-2, LR-1, LR-2, and LR-3 application specifications of Telcordia Technologies GR-253-CORE, Section 4.
7.   **[Desired]** The TSF shall provide optical interfaces for OC-768 signals consistent with the SR-1, IR-1, IR-2, LR-1, LR-2, and LR-3 application specifications of Telcordia Technologies GR-253-CORE, Section 4.
8.   **[Desired]** The TSF shall provide optical interfaces for OTU-1, OTU-2, and OTU-3 optical signals consistent with the application specifications of ITU-T Recommendation G.709.
9.   **[Required]** The TSF shall provide optical interfaces for STM-256, STM-64, STM-16, STM-4, and STM-1 signals consistent with the application codes I-n, S-n.x, and L-n.x in ITU-T Recommendation G.957. There should be no differences between single-channel

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optical interfaces for SONET terminations according to Telcordia Technologies GR-253-CORE and the level-comparable SDH optical interfaces specified in ITU-T Recommendation G.957-CORE.

10. **[Required]** The TSF shall support the SR-1 interface and at least one of the IR-1, IR-2, or IR-3 interface for OC-3, OC-12, OC-48, and OC-192 signals consistent with the requirements in this document.
11. **[Desired]** The TSF shall support the SR-1 interface and at least one of IR-1, IR-2, or IR-3 interface for OC-768 signals consistent with the requirements elsewhere in this document.
12. **[Required]** The TSF shall support the Intraoffice (I-x) interface and any Short-haul (S-n.x) interface for STM-1 (if supported), STM-4, STM-16, STM-64, and STM-256 (if supported) signals consistent with the requirements in this document.
13. **[Desired]** The OC-192 SONET/STM-64 interfaces shall support Very Short Reach (VSR) optics as defined in ITU-T Recommendation G.693.
14. **[Required]** The TSF shall support the capability to provide physical loopback toward the line side and cross-connect matrix for all supported interfaces.

#### 5.5.3.3.3 *TSF Ethernet Interface Requirements*

1. **[Required]** The TSF shall provide interfaces for Gigabit Ethernet Services in conformance with the IEEE 802.3 for Ethernet LAN interfaces. The Logical Link Interworking Function (IWF) shall terminate the Media Access Control (MAC) layer of Ethernet as described in the Ethernet Standard IEEE 802.3.
2. **[Desired]** The TSF interfaces shall include 100 Gigabit Ethernet consistent with the application specifications of IEEE 803.
3. **[Required]** The TSF shall provide interfaces for 10 Gigabit Ethernet Services in conformance with the IEEE 802.3ae for Ethernet WAN PHY interfaces. The Logical Link IWF shall terminate the MAC layer of Ethernet as described in the Ethernet Standard IEEE 802.3.
5. **[Required]** The Gigabit Ethernet interfaces shall accommodate Ethernet packets greater than 4470 bytes.
6. **[Required]** The 10 Gigabit Ethernet interfaces shall accommodate Ethernet packets greater than 4470 bytes.

7. **[Required]** The TSF shall be able to provision, monitor, and detect faults on, and restore Gigabit Ethernet services in a standardized and automated fashion.
8. **[Required]** The TSF shall be able to provision, monitor, and detect faults on, and restore 10 Gigabit Ethernet services in a standardized and automated fashion.
9. **[Required]** The TSF's Ethernet services shall support both port-based and flow-based Virtual LANs (VLANs) for multiple rates and customer interfaces as defined by IEEE Standard 802.1Q-1998, Virtual Bridged Local Area Networks.
10. **[Required]** The TSF shall not, by default, perform any Layer 3 routing.
11. **[Required]** The TSF shall support VLAN Tagging as specified by IEEE 802.1Q.
12. **[Required]** The TSF shall selectively provide point-to-point Ethernet services with dedicated non-shared bandwidth without queuing or buffering of Ethernet frames.
13. **[Required]** The TSF shall support ITU-T Recommendation G.7041/Y.1303 (2003).
14. **[Required]** The TSF shall support ITU-T Recommendation G.7043/Y.1343 (2004).
15. **[Required]** The TSF shall support ITU-T Recommendation G.7042/Y.1305 (2004).
16. **[Required]** GE VCSA interface according to ITU-T Recommendation G.7042 [
17. **[Desired]** The TSF shall support OTU-1 and OTU-2 interfaces according to ITU-T Recommendation G.709.
18. **[Desired]** The TSF shall support OTU-3 interface according to ITU-T Recommendation G.709.

#### *5.5.3.3.4 TSF Framing Requirements*

1. **[Required]** The TSF shall conform to the standard SONET STS-1, STS-N, and STS-Nc frame structures per Telcordia Technologies GR-253-CORE.
2. **[Required]** The TSF shall conform to the standard SDH optical interfaces, rates and formats documented in ITU-T Recommendation G.707 for each of the following optical interfaces: STM-1, STM-4, STM-16, and STM-64.

3. **[Desired]** The TSF shall conform to the standard OTU optical interfaces, rates and formats documented in ITU-T Recommendation G.709 for each of the following optical interfaces: OTU-1, OTU-2, and OTU-3.
4. **[Required]** All SONET overhead bytes are to be defined, generated, and processed according to the specifications of Telcordia Technologies GR-253-CORE. All SDH overhead bytes are to be defined, generated, and processed according to the specifications of ITU-T Recommendation G.707.
5. **[Desired]** All OTU overhead bytes are to be defined, generated, and processed according to the specifications of ITU-T Recommendation G.709.
6. **[Required]** If any SONET/SDH overhead bytes are used for proprietary purposes, it shall be possible to ignore these bytes at the receive side without affecting any transmission capability described in Telcordia Technologies GR-253-CORE or in ITU-T Recommendation G.783, respectively.
7. **[Required]** The capability to read or write the 16-byte frame and format of ITU-T Recommendation G.707 and clause 3 of ITU-T Recommendation G.831 shall be provided for both the Section Trace (J0) and the Path Trace (J1) bytes.
8. **[Required]** The capability to read or write the 64-byte frame and format of ITU-T Recommendation G.707 and clause 3 of ITU-T Recommendation G.831 shall be provided for both the Section Trace (J0) and the Path Trace (J1) bytes.

#### *5.5.3.3.5 TSF Switch Fabric Requirements*

1. **[Required]** The SONET cross-connects shall have an STS-1 granularity.
2. **[Required]** The SDH cross-connects shall have a Virtual Circuit (VC) VC-3 VC-4 granularity.
3. **[Required]** The TSF shall not modify the user payload. Except for internetworking functions associated with optional Ethernet services, the system shall not perform any user protocol conversions.
4. **[Required]** The TSF shall not impart any errors onto the connections during cross-connects, grooming, or multiplexing.
5. **[Required]** The TSF shall support virtual concatenation as defined in ANSI T1.105-2001 or ITU-T Recommendation G.707.

6. **[Required]** No single failure in the switch fabric shall affect service. The system shall meet Telcordia Technologies GR-2996-CORE requirements for fabric availability.
7. **[Required]** The interface cards shall be capable of switching between the working and protection switch fabric in an errorless manner for manual operation, and in a hitless manner for automated operation. No bits shall be lost or corrupted with errorless switching. Bit errors are allowed with hitless switching. However, hitless switching shall not cause downstream reframing to occur.

#### *5.5.3.3.6 TSF Performance Requirements*

1. **[Required]** The TSF shall meet the jitter criteria for SONET systems in Telcordia Technologies GR-25-CORE, Section 5.6.
2. **[Required]** The TSF shall meet the jitter criteria for SDH systems according to ITU-T Recommendation G.825.
3. **[Required]** The TSF shall meet the interface jitter criteria specified for User Network Interfaces (UNIs) for ITU-T OTNs.
4. **[Required]** The jitter tolerance measured at the OC-N interface on the switch shall meet input jitter tolerance specification documented in ANSI T1.105.03-1994.
5. **[Required]** The jitter generation measured at an OC-N interface on the switch shall be less than 0.01 Unit Interval Root Mean Square (UIrms) when measured using a high-pass filter with 12-kilohertz (kHz) cutoff frequency as defined in ANSI T1.105.03-1994, Section A.3.3.
6. **[Required]** The maximum delay for a full STS passed through the Switch or for an STS add/drop from the switch shall not exceed the values defined in Telcordia Technologies GR-2996-CORE.
7. **[Desired]** The TSF shall perform hair-pinning, drop, continue, and drop-and-continue add-drop multiplexing (ADM) functions as specified in Telcordia Technologies GR-496-CORE.
8. **[Desired]** The TSF shall provide the ability to hub or nest lower STSs in a linear or ring configuration from line-side interfaces.

### 5.5.3.3.7 General Link Protection Requirements

1. **[Required]** It shall be possible to provision any SONET port for 1+1 Automatic Protection Switching (APS), 1:N APS; 1:N Optical Protection (OP), 2-fiber Unidirectional Path Switched Ring (UPSR) per Telcordia Technologies GR-1400-CORE, or 2/4-fiber Bidirectional Line Switched Ring (BLSR) per Telcordia Technologies GR-1230-CORE.
2. **[Required]** It shall be possible to provision any SDH port for 1+1 APS, 0:1 APS, 1:N APS, 1+1 2/4-Fiber Unidirectional Ring, or 2-Fiber Multiplex Section (MS) Shared Protection Ring per ITU-T Recommendation G.841.
3. **[Required]** When the TSF participates in point-to-point UPSR or BLSR protection, switching shall take place in less than 50 ms. These protection mechanisms shall be definable and selectable from the EMS, and shall offer the selection of revertive and non-revertive restoration mechanisms.
4. **[Required]** Service restoration via a protection switch shall be automatic and accomplished without human or central management system intervention.
5. **[Required]** The protection switching mechanism shall be independent among separately managed network domains. A protection switch in one separately managed network domain shall not propagate or relay to another separately managed network domain.
6. **[Required]** The maximum detection time to determine if a signal's BER threshold is exceeded shall comply with Telcordia Technologies GR-253-CORE and ITU-T G.783.
7. **[Required]** Once a decision is made to switch, the terminal circuit pack switching shall take place within 50 ms, as described in Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.783.
8. **[Required]** Catastrophic failures on a user-definable Excessive BER (EBER) condition shall be detected by an equipment-protected circuit pack in a terminal within 10 ms as described in Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.783.
9. **[Required]** When equipped, each TSF shall be compliant with types and characteristics of SDH network protection architectures as defined in ITU-T Recommendation G.841.
10. **[Required]** When equipped, the TSF shall be compliant with interworking of SDH network protection architectures as defined in ITU-T Recommendation G.842.

*5.5.3.3.8 Linear Protection Requirements*

1. **[Required]** The linear switching protection mechanisms of the TSF shall be selectable as either revertive or non-revertive during network operation.
2. **[Required]** The SONET linear protection mechanisms of the TSF including APS functions, shall conform to Telcordia Technologies GR-253-CORE. No proprietary APS byte definition and no proprietary linear APS protocol are allowed.
3. **[Required]** The TSF shall support 1+1 APS optical interface protection, unidirectional and bidirectional, and revertive and non-revertive, per ITU-T Recommendation G.841.
4. **[Required]** The SDH linear protection mechanisms of the system, including APS functions, shall conform to ITU-T Recommendation G.841. No proprietary APS byte definition or proprietary linear APS protocol is allowed.
5. **[Required]** When the high-speed interface of the TSF is configured for a linear protection system, it shall support linear protection switching with adjacent equipment. The system shall support both 1+1 and 1:1 protection switching across the network as per Section 5.3.2 of Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.841.
6. **[Required]** When the TSF is configured as a 1:1 linear protection system, it shall support both unidirectional and bidirectional protection switching capabilities, as described in Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.841.
7. **[Required]** The maximum length of protection switching time due to a fiber cut, signal failure, user definable EBER, or an equipment circuit pack failure in a network shall not exceed 60 ms per transmission direction, which includes 10 ms BER detection time as described in Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.841.
8. **[Required]** When the TSF is configured as a 1:1 linear protection system, its default protection switching mode shall be revertive, i.e., the signal shall be automatically reverted to the working fibers after the fibers are repaired and the Wait to Restore (WTR) time has expired, as described in Telcordia Technologies GR-253-CORE. A 1:1 linear system also shall be optionally configurable as non-revertive.
9. **[Required]** The linear protection configuration of the TSF shall:
  - a. Have a switch completion time in both directions of not more than 50 ms.
  - b. Provide the Signal Fail (SF), Signal Degrade (SD), and APS initiation criteria.

- c. Support the WTR feature to prevent frequent oscillations between the working and the protection lines resulting from intermittent failures as described in Telcordia Technologies GR-253-CORE.
- d. Provide a minimum WTR time of 5 minutes.
- e. Provide a maximum WTR time of 12 minutes as described in Telcordia Technologies GR-253-CORE.

#### *5.5.3.3.9 Ring Protection Requirements*

- 1. **[Required]** When equipped, the TSF shall be compliant with Telcordia Technologies GR-1230-CORE.
- 2. **[Required]** When equipped, the TSF shall be compliant with Telcordia Technologies GR-1400-CORE.
- 3. **[Required]** The TSF shall support MS-Shared Protection Ring according to ITU-T Recommendation G.841.
- 4. **[Required]** The TSF shall support Subnetwork Connection Protection (SNCP) ring protection according to ITU-T Recommendation G.841.
- 5. **[Required]** The TSF shall provide the option to use UPSR, 2-fiber BLSR, or 4-fiber BLSR as a ring protection mechanism. When the high-speed interface at a system is configured for any of these protection schemes, it shall support protection switching with other systems in the ring. The maximum length of protection switching time due to a fiber cut, signal failure, user definable EBER, or an equipment circuit pack failure in a network shall not exceed 60 ms per transmission direction, which includes 10 ms BER detection time as described in Telcordia Technologies GR-1230-CORE and GR-1400-CORE.
- 6. **[Required]** When the TSF is in a SONET/SDH BLSR configuration, its APS functions shall conform to Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.841. No proprietary APS byte definition and no proprietary ring APS protocol are allowed.
- 7. **[Required]** The ring protection configurations of the TSF shall:
  - a. Use standard SONET/SDH ring APS protocols to coordinate the protection switching, as documented in Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.841.

- b. Complete the protection switch within 50 ms when there is no extra traffic and no previous bridge requests on the ring, and the length of a ring is less than 1200 km of fiber, as described in Telcordia Technologies GR-253-CORE.
- c. Support a ring size up to at least 16 nodes, as described in Telcordia Technologies GR-253-CORE.
- d. Not exceed a 50 ms length of hits to service when the following ring configuration functions are performed: Ring Node Addition, Ring Node Deletion, and Ring Segmentation, as described in Telcordia Technologies GR-253-CORE. (When the system is configured as a BLSR system, the protection switch completion time can exceed 50 ms when there is extra traffic or previous bridge requests on the ring, as described in Telcordia Technologies GR-253-CORE).

#### *5.5.3.3.10 Fault Management Requirements*

1. **[Required]** The TSF shall send the appropriate Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) to adjacent systems, the EMS, and/or the higher level management system after detecting signal failure or degraded conditions for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
2. **[Required]** The TSF shall remove the appropriate AIS and RDI after the source system has cleared the signal failure or degraded condition for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** Alarms shall indicate circuit-level or signal alarms, as well as alarms in the MSPP itself, such as Span Failure, LOS, Path Switch Complete/Fail, Laser Degradation, Card Failure, and Card Mismatch. These conditions will be reported to the EMS and high management system.
4. **[Required]** Standard SONET and SDH alarms shall be supported by the TSF including LOS, Loss of Pointer (LOP), Loss of Frame (LOF), Receive (Rx) AIS, RDI, and Remote Failure Indication (RFI). These conditions will be reported to the EMS and higher level management system.
5. **[Required]** The TSF shall indicate SONET T&S failures. The MSPP shall give an alarm showing the inability to establish a Phase Locked Loop (PLL). The MSPP shall have the ability to monitor the Building Integrated Timing Supply (BITS) incoming references (BITS-A and BITS-B). The system shall give an alarm when there is any timing change, e.g., a switch from BITS-A to BITS-B. These conditions will be reported to the EMS and higher level management system.

6. **[Required]** Each TSF shall detect, report, and clear the following signal failure events or conditions: LOS, LOF, LOP, Severely Errored Framing (SEF), AIS, and Out Of Frame (OOF), according to ANSI T1.231. These events and conditions will be reported to the EMS and higher management system.

#### 5.5.3.3.11 Performance Management Requirements

1. **[Required]** The TSF shall calculate the Performance Monitoring (PM) parameter values for each SONET/SDH layer from block errors, rather than bit errors, per ITU-T Recommendation G.826.
2. **[Required]** The TSF shall gather PM data based on overhead bits, such as Bit Interleaved Parity-Number, at the section, line, and path layers, or on Ethernet frame overhead, as appropriate.
3. **[Required]** The TSF shall track PM data for appropriate service(s), e.g., SONET errors, Far-End Block Errors (FEBE), pointer adjustments; Ethernet statistics. All statistics shall be tracked in 5-minute intervals, with the ability to reduce intervals for testing and analysis.
4. **[Desired]** The TSF shall use tools such as OSAs and optical monitoring tools to verify optical power levels and detect unauthorized signals and other anomalous events on its interfaces.
5. **[Required]** The TSF shall support status and configuration reporting between nodes in Multi-Ring (Mixed UPSR, BLSR, and 1+1 APS), Linear ADM, Mesh, Regenerator, and Star/Hub node configurations. The NEs shall support near-end and far-end reporting.
6. **[Desired]** The TSF shall support reporting of Resilient Packet Ring (RPR) QoS/CoS parameters.
7. **[Required]** The TSF shall support reporting of trunk and port quality with user-configurable thresholds.
8. **[Required]** The TSF shall support reporting of Ethernet frames dropped.
9. **[Required]** The TSF shall be able to track near-end and far-end statistics in both receive and transmit directions. The MSPP shall be able to track all the performance metrics defined in ITU-T Recommendation M.2101.
10. **[Required]** The TSF shall monitor each optical interface in accordance with ANSI T1.231-1993. Performance monitoring parameters shall include SEFS, Code Violation

(CV), Errored Seconds (ES), SES, Unavailable Seconds (UAS), Protection Switching Counts, and Pointer Justification.

11. **[Required]** For SONET traffic, the TSF shall be able to track section, line, and path errors. Further, it shall track the respective FEBEs and RDIs.
12. **[Desired]** The TSF shall support intermediate Path Monitoring.

#### *5.5.3.3.12 EMS Requirements*

1. **[Required]** The TSF EMS shall report PHY (Layer 1) statistics. Further, it shall report layer 2 errors. It shall report all QoS parameters defined for the RPR as described in IEEE 802.17.
2. **[Required]** The TSF EMS shall be able to track frame errors, P-Bit Parity Errors, C-Bit Parity Errors, and FEBE.
3. **[Required]** The TSF EMS shall be able to provision the MSPP on all interfaces (i.e., Plesiochronous Digital Hierarchy (PDH)/SONET/SDH/Ethernet) and be able to provision a circuit using the different types of cross-connects (VT1.5, VC-11, VC-12, VC-3, VC-4, STS-1, STM-1, STS-3c, STM-4, STS-12c, STM-16, STS-48c, STM-64, STS-192c, STM-256, and STS-768c).
4. **[Required]** The TSF EMS shall be able to build protection topologies APS 1+1, UPSR, and BLSR.
5. **[Required]** The TSF EMS shall be able to provision card parameters required for interoperability to interconnecting carrier systems; SONET/SDH, line loopback, terminal loopback, J0 trace, and J1 trace.
6. **[Required]** The TSF EMS shall be to provision alarms profiles according to network requirements (i.e., minor, major, critical, none service affecting, and none reporting).
7. **[Required]** The TSF EMS shall be to review and retrieve alarm and administration logs.
8. **[Required]** The TSF EMS shall be able to set alarm threshold on any interface (SD and SF).
9. **[Required]** The TSF EMS shall be able to provision all administrated and security screens based on password level (i.e., network IP address, NE name, user accounts, and radius server).

### *5.5.3.3.13 Physical Design Requirements*

1. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in FCC Part 15, Class A.
2. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in Telcordia Technologies GR-1089-CORE.
3. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 50082.
4. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 55022.
4. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 300-386.
5. **[Required]** All TSF elements shall be designed to operate continuously in the following environment ranges without degradation: Temperature: 0 to +50°C; Humidity: 5 to 95 percent relative humidity, without condensation.
6. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
7. **[Required]** All TSF elements shall be designed to operate continuously in the following environment range without degradation. Altitude: -100 to 15,000 ft AMSL.
8. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
9. **[Required]** All TSF elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220-V with redundant isolated power modules.
10. **[Required]** All TSF elements shall be fully operational throughout the battery voltage range of -41.5 to -56 VDC.

11. **[Required]** All TSF elements shall not be damaged and recover to normal performance following application of the following maximum transient voltages for the durations given (nominal voltage 48 VDC): 75 VP-P for 1 msec, 60VP-P for 500 msec.
12. **[Required]** All TSF elements shall be fully NEBS, Level 3 compliant.
13. **[Required]** All TSF elements shall be designed to operate continuously in the following environment ranges without degradation: Temperature: 0 to +50°C; Humidity: 5 to 95 percent relative humidity, without condensation.
14. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
15. **[Required]** All TSF elements shall be designed to operate continuously in the following environment range without degradation: Altitude: -100 to 15,000 ft AMSL.
16. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft. to +40,000 ft. AMSL.
17. **[Required]** All TSF elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220 V with redundant isolated power modules.
18. **[Required]** All TSF elements shall be fully operational throughout the battery voltage range of -41.5 to -56 VDC.
19. **[Required]** All equipment shall have been tested and register as compliant to the following Electrical Safety standards: UL-1950, EN60950, and IEC 60950.

#### *5.5.3.3.14 Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfy multiple versions of the standards. Testing will need to be

undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.691 (2006)
2. **[Required]** ITU-T Recommendation G.693 (2006)
3. **[Required]** ITU-T Recommendation G.707/Y1322 (2007)
4. **[Required]** ITU-T Recommendation G709/Y.1331
5. **[Required]** ITU-T Recommendation G.783 (2006)
6. **[Required]** ITU-T Recommendation G.826 (2002)
7. **[Required]** ITU-T Recommendation G.831 (2000)
8. **[Required]** ITU-T Recommendation G.841 (1998)
9. **[Required]** ITU-T Recommendation G.842 (1997)
10. **[Required]** ITU-T Recommendation G.957 (2006)
11. **[Required]** ITU-T Recommendation M.2101 (2003)
12. **[Required]** ITU-T Recommendation G.7041/Y-1303 (2003) (2008)
13. **[Required]** ITU-T Recommendation G.7042/Y-1305 9 (2004) (2006)
14. **[Required]** ANSI T1.231-1993 [2003 (R2007)]
15. **[Required]** Telcordia Technologies GR-253-CORE, Issue 3, September 2000; (Issue 4, December 2005)
16. **[Required]** Telcordia Technologies GR-282-CORE, December 1997; (Issue 4, July 2006)
17. **[Required]** Telcordia Technologies GR-383-CORE, Issue 1, July 1997; (Issue 3, February 2006)
18. **[Required]** Telcordia Technologies GR-499-CORE, Issue 2, December 1998; (Issue 3, September 2004)

19. **[Required]** Telcordia Technologies GR-1230-CORE, Issue 4, December 1998
20. **[Required]** Telcordia Technologies GR-1400-CORE, Issue 2, December 1999 (Issue 3, July 2006)
21. **[Required]** Telcordia Technologies GR-2996-CORE, Issue 1, January 1999
22. **[Required]** Telcordia Technologies SR-3580, Issue 1, November 1995; (Issue 3, June 2007)
23. **[Required]** IEEE 802.3-2008, Section 5
24. **[Required]** IEEE 802.1Q-2003
25. **[Required]** IEEE 802.17-2004
26. **[Required]** British Standards Institute BS EN 60950-1, August 6, 2006
27. **[Required]** IEC 60950-1, 2006
28. **[Required]** CFR FCC Part 15, Class A
29. **[Required]** Network Equipment- Building System (NEBS), Level 3
30. **[Required]** Underwriters Laboratories, Inc UL-1950, Standard for Safety, Information Technology Equipment Including Electrical Business Equipment, 1ed, 1989

#### **5.5.3.4 Access Grooming Function**

Today, the AGF functional device is provided within the DISA-provided part of DISN by the MSPP.

##### **5.5.3.4.1 Description**

An AGF functional device receives low-speed circuits on multiple ports and multiplexes them via TDM into a high-speed circuit, and transmits it to one of its high-speed ports. The multiplexing is configured via multiple internal cross-connects between the low-speed ports and the high-speed port. The AGF functional device can connect circuits from any port to any other port within the bandwidth limits of the ports.

The AGF functional device can be configured with many different types of ports as follows:

- Concatenated SONET/SDH. For SONET, the port bandwidths are OC-3c, OC-12c, OC-48c, and OC192c. For SDH, the port bandwidths are STM-1c, STM-4c, and STM-16c.
- Unconcatenated SONET/SDH. For SONET, the port bandwidths are OC-3, OC-12, OC-48, and OC-192. For SDH, the port bandwidths are STM-1, STM-4, STM-16, and STM-64.
- Ethernet. Ethernet is a frame-based data communication technology for LAN. The data rate is 10 Mbps for Regular Ethernet, 100 Mbps for Fast Ethernet (FE), 1 Gbps for GbE, and 10 Gbps for 10GbE.
- Digital Signal. DS1, DS3, E1 and E3. A different port, called a transmux, exists that will demultiplex the DS3 into 28 DS1s. The ports will also convert the format from a digital signal format into a SONET format. The DS1 becomes the VT1.5 and then E1 becomes the VT2.0. The DS3 becomes an STS-1. The AGF functional device can also be used to provide timing to DS1s.

#### 5.5.3.4.2 AGF Functional Device SONET Interface Requirements

1. **[Required]** The OC-3/OC-3c optical interface shall conform to the standard SONET rates and formats documented in ANSI T1.105.
2. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category SR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
3. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category IR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
4. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category IR-2 per Telcordia Technologies, GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
5. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category LR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.

6. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category LR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
7. **[Required]** The OC-3/OC-3c optical interface shall conform to optical parameters for application category LR-3 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
8. **[Desired]** The OC-3/OC-3c interfaces shall be capable of having a multi-mode fiber (MMF) interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651 and ANSI 105.06-2002.
9. **[Required]** The OC-3/OC-3c interfaces shall be capable of using Single Mode Fiber (SMF) as described in ITU-T Recommendation G.652 and ANSI 105.06-2002.
10. **[Required]** The OC-12/OC-12c optical interface shall conform to the standard SONET rates and formats documented in ANSI T1.105.
11. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category SR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
12. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category IR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
13. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category IR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
14. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category LR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
15. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category LR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
16. **[Required]** The OC-12/OC-12c optical interface shall conform to optical parameters for application category LR-3 per Telcordia Technologies GR-253-CORE Sections 4.1 and 4.2, and Tables 4-1 through 4-11.

17. **[Desired]** The OC-12/OC-12c interfaces shall be capable of having an MMF interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651 and ANSI 105.06-2002.
18. **[Required]** The OC-12/OC-12c interfaces shall be capable of using SMF as described in ITU-T Recommendation G.652 and ANSI 105.06-2002.
19. **[Required]** The OC-48/OC-48c optical interface shall conform to the standard SONET rates and formats documented in ANSI T1.105.
20. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category SR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
21. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category IR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
22. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category IR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
23. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category LR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
24. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category LR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
25. **[Required]** The OC-48/OC-48c optical interface shall conform to optical parameters for application category LR-3 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
26. **[Desired]** Software programmable SFP that supports OC-3/OC-12 optical interface shall conform to optical parameters for application category per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
27. **[Desired]** Programmable SFP that supports OC-3/OC-3c and OC-12/OC-12c optical interfaces shall be capable of having an MMF interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651 and ANSI 105.06-2002.

28. **[Desired]** Software programmable SFP that supports OC-3/OC-12/OC-48 and OC-3c/OC12c/OC-48c optical interface shall conform to optical parameters for application category per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
29. **[Required]** The OC-192 optical interface shall conform to the standard SONET rates and formats documented in ANSI T1.105.
30. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category SR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
31. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category IR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
32. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category IR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
33. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category LR-1 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
34. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category LR-2 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
35. **[Required]** The OC-192 optical interface shall conform to optical parameters for application category IR-3 per Telcordia Technologies GR-253-CORE, Sections 4.1 and 4.2, and Tables 4-1 through 4-11.
36. **[Desired]** The OC-768 optical interface shall conform to the standard SONET rates and formats documented in ANSI T1.105.
37. **[Desired]** All SONET OC-N interfaces shall be software-provision to SDH STM-N.
38. **[Desired]** The software has to provide options for the OC-3 through OC-48 optical interfaces and the upgrade capability to the next higher optical rate by changing cards unless the optics is software programmable. If the optics is software programmable, then this capability must be allowed by changing the software setting to the next higher rate. Both procedures must preserve the customer data provisioned on the optical interface and

move to the equivalent bandwidth slot starting at the beginning STS. Example: OC-3 upgrade to OC-12, OC-12 to OC-48, and OC-48 to OC-192. Customer provisioned on OC-3 (STS-1 through 3) will occupy STS-1 through 3 on the OC-12 after the upgrade is completed.

#### 5.5.3.4.3 AGF Functional Device SDH Interface Requirements

1. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code I-1 per ITU-T Recommendation G.957, Table 2.
2. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code S-1.1 per ITU-T Recommendation G.957, Table 2.
3. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code S-1.2 per ITU-T Recommendation G.957, Table 2.
4. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code L-1.1 per ITU-T Recommendation G.957, Table 2.
5. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code L-1.2 per ITU-T Recommendation G.957, Table 2.
6. **[Required]** The STM-1/STM-1c optical interface shall conform to optical parameters for application code L-1.3 per ITU-T Recommendation G.957, Table 2.
7. **[Optical/Desired]** The STM-1 interfaces shall be capable of having an MMF interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651.
8. **[Required]** The STM-1/STM-1c interfaces shall be capable of using SMF as described in ITU-T Recommendation G.652.
9. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code I-4 per ITU-T Recommendation G.957, Table 3.
10. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code S-4.1 per ITU-T Recommendation G.957, Table 3.
11. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code S-4.2 per ITU-T Recommendation G.957, Table 3.

12. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code L-4.1 per ITU–T Recommendation G.957, Table 3.
13. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code L-4.2 per ITU–T Recommendation G.957, Table 3.
14. **[Required]** The STM-4/STM-4c optical interface shall conform to optical parameters for application code L-4.3 per ITU–T Recommendation G.957, Table 3.
15. **[Desired]** The STM-4/STM-4c interfaces shall be capable of having an MMF interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651.
16. **[Required]** The STM-4/STM-4c interfaces shall be capable of using SMF as described in ITU-T Recommendation G.652.
17. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code I-16 per ITU-T Recommendation G.957, Table 4.
18. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code S-16.1 per ITU-T Recommendation G.957, Table 4.
19. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code S-16.2 per ITU-T Recommendation G.957, Table 4.
20. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code L-16.1 per ITU-T Recommendation G.957, Table 4.
21. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code L-16.2 per ITU-T Recommendation G.957, Table 4.
22. **[Required]** The STM-16/STM-16c optical interface shall conform to optical parameters for application code L-16.3 per ITU-T Recommendation G.957, Table 4.
23. **[Desired]** Software programmable SFP that supports STM-1/STM-4 and STM-1c/STM-4c Optical interface shall conform to optical parameters for application Code L-16.2 per ITU-T Recommendation G.957, Table 4.
24. **[Desired]** Programmable SFP that supports STM-1/STM-4 optical interfaces shall be capable of having an MMF interface option for both transmit and receive using MMF as described in ITU-T Recommendation G.651.

25. **[Desired]** Software programmable SFP that supports STM-1/STM-4/STM-16 optical interface shall conform to optical parameters for application code L-16.2 per ITU-T Recommendation G.957, Table 4.
26. **[Required]** The STM-64 Optical interface shall conform to ITU-T Recommendation G.691 optical interfaces for Single-Channel STM-64 systems.
27. **[Desired]** The STM-64 Optical interface shall conform to ITU-T Recommendation G.691.
28. **[Required]** The software has to provide options from the STM-1 through STM-16 optical interfaces and the upgrade capability to the next higher optical rate by changing cards unless the optics is software programmable. If the optics is software programmable, then this capability must be allowed by changing the software setting to the next higher rate. Both procedures must preserve the customer data provisioned on the optical interface and move to the equivalent bandwidth slot starting at the beginning STM. Example: STM-1 upgrade to STM-4, STM-4 to STM-16, and STM-16 to STM-64. Customer provisioned on STM-1 (VC3-1 through VC3-3) will occupy STM-1 VC3-1 through 3 on the STM-4 after the upgrade is completed.
29. **[Required]** The AGF functional device shall be able to provision, monitor, and detect faults, and restore optical services in a standardized and automated fashion.

#### 5.5.3.4.3.1 AGF Functional Device Lambda Interface Requirements

1. **[Conditional]** The AGF functional device shall have Lambda interfaces at the 10 Gigabit rates. These shall be compatible with the transport requirements in [Section 5.5.3.3](#), Transport Switch Function.
2. **[Required]** Lambda interfaces shall be compliant with the ITU-T Recommendation G.694.1 grid if an AGF functional device supports Lambda interfaces.

#### 5.5.3.4.4 AGF Functional Device Electrical Interface Requirements

1. **[Conditional]** The AGF functional device shall support STS-1 (EC-1) electrical interfaces that comply with specifications and pulse masks as defined in Telcordia Technologies GR-253-CORE, Chapter 4.4 and ANSI T1.102.
2. **[Required]** The AGF functional device shall support DS1 electrical interfaces that comply with ANSI T1.102.
3. **[Desired]** The AGF functional device shall support DS1 pseudowire transport via gateway SFPs.

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4. **[Required]** The AGF functional device shall support channelized and unchannelized DS1 Superframe (SF) format and Extended Superframe (ESF) format as specified in ANSI T1.403. The ability to read or write the ESF data link is required. The selection of format for any particular DS1 interface shall be user-selectable.
5. **[Required]** The AGF functional device shall support Alternate Mark Inversion (AMI) and Bipolar with Eight-Zero Substitution (B8ZS) line coding formats and unframed, D4, SF, and ESF framing format as specified in ANSI T1.403. The selection of framing format for any particular DS1 interface shall be user-selectable.
6. **[Required]** The AGF functional device shall support both in-band and out-band Facility Data Link (FDL) loop-up and loop-down codes as specified in ANSI T1.403.
7. **[Required]** The AGF functional device shall support FDL status messages and respond as specified in ANSI T1.403.
8. **[Required]** The AGF functional device shall support unframed DS1 electrical signals.
9. **[Required]** The electrical interface shall comply with ITU-T Recommendation G.703.
10. **[Required]** The AGF functional device shall support DS1 bit rate of 1.544 Mbps +/- 32 ppm as specified in ANSI T1.101.
11. **[Required]** The AGF functional device shall support DS1 100 ohms cable with maximum length of 655 feet as specified in ITU-T Recommendation G.703.
12. **[Required]** The AGF functional device shall support E1 electrical interfaces shall comply with ITU-T Recommendation G.711.
13. **[Required]** The AGF functional device shall support both channelized and unchannelized E1 as specified in ITU-T Recommendation G.711.
14. **[Required]** The E1 electrical interface format shall support both 30 and 31 channels when channelized with and without Cyclical Redundancy Check (CRC) as specified in ITU-T Recommendation G.711. The selection of format for any particular E1 interface shall be user-selectable.
15. **[Required]** The AGF functional device shall support E1 bit rate of 2.048 Mbps +/- 50 ppm as specified in ITU-T Recommendation G.703 and G.704.
16. **[Required]** The AGF functional device shall support DS3 electrical tributary interfaces that comply with ANSI T1.102-1993.

17. **[Required]** The AGF functional device DS3 interface shall support DS3 pulse shape that meets both ITU-T Recommendation G.703 and Telcordia Technologies GR-499-CORE.
18. **[Required]** The AGF functional device shall support channelized and unchannelized DS3 signals in either unframed, M13, or C-bit parity formats per ANSI T1.101 and T1.404. The selection of format for any particular DS3 interface shall be user-selectable.
19. **[Required]** The AGF functional device shall support DS3 C-bit far-end alarm and control signal to support alarm/status messages and loopback control on the DS3 and/or individual DS1 as specified in ANSI T1.101 and T1.404.
20. **[Required]** The AGF functional device shall support DS3 bit rate of 44.736 Mbps +/- 20 ppm as specified in ANSI T1.101.
21. **[Required]** The AGF functional device shall support E3 electrical tributary interfaces that comply with ITU-T Recommendation G.703.
22. **[Required]** The AGF functional device shall support channelized and unchannelized E3 signals using line coding of High Density Bipolar 3 Code (HDB-3).
23. **[Required]** The AGF functional device shall support E3 bit rate of 34.368 Mbps +/- 20 ppm as specified in ITU-T Recommendation G.703.
24. **[Required]** The AGF functional device shall be able to provision, monitor, and detect faults, and restore electrical (DS1, E1, DS3, E3) services in a standardized and automated fashion.

#### *5.5.3.4.4 AGF Functional Device Ethernet Interface Requirements*

1. **[Required]** The AGF functional device shall provide interfaces for Ethernet, FE, and GbE services in conformance with IEEE 802.3 for Ethernet LAN interfaces.
2. **[Desired]** The AGF functional device shall provide interfaces for 10GbE Services in conformance with IEEE 802.3 for Ethernet LAN/WAN interfaces.
3. **[Required]** The Logical Link IWF shall terminate the MAC layer of Ethernet as described in Ethernet Standard IEEE 802.3.
4. **[Required]** Ethernet interfaces shall accommodate Ethernet packets greater than 4470 bytes.

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5. **[Required]** Ethernet services shall support port-based and flow-based VLANs for multiple rates and customer interfaces as per IEEE 802.1Q.
6. **[Required]** The AGF functional device shall support transparent VLAN tagging for Ethernet on SONET/SDH service.
7. **[Required]** The AGF functional device shall not, by default, perform any Layer 3 IP routing.
8. **[Required]** The AGF functional device shall be able to provision, monitor, and detect faults, and restore Ethernet services in a standardized and automated fashion.
9. **[Required]** The AGF functional device shall selectively provide QoS/CoS for Ethernet services according to IEEE 802.1Q.
10. **[Desired]** Available Ethernet services shall include RPR (IEEE 802.17b), Generic Framing Procedure (GFP) (ITU-T Recommendation G.7041/Y.1303), Hardware Link Capacity Adjustment Scheme (LCAS), and Virtual Concatenation (VCAT).
11. **[Required]** Ethernet and FE Services on SONET shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, low order VCAT (VT1.5), high order (STS-1) VCAT, and CCAT; STS-1 and STS-3c.
12. **[Desired]** 10GbE services on SONET shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, high order (STS-1 or STS-3c) VCAT, and CCAT; STS-1, STS-3c, STS-12c, STS-48c, and STS-192c.
13. **[Required]** Ethernet and FE services on SDH shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, low order VCAT (VC-12 and VC-3, and CCAT; VC-3 and VC-4).
14. **[Required]** Gigabit Ethernet services on SDH shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, low order VCAT (VC-3), high order (VC-4) VCAT, and CCAT; VC-3, VC-4, VC-4-3, and VC-4-16.
15. **[Desired]** Ten GbE services on SDH shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, high order (VC-4) VCAT, and CCAT; VC-3, VC-4, VC-4-3, and VC-4-16, and VC-4-64.
16. **[Required]** The AGF functional device shall selectively provide point-to-point Ethernet services with dedicated non-shared bandwidth without queuing or buffering Ethernet frames.

17. **[Required]** Gigabit Ethernet and 10GbE interfaces shall be auto-sensing/auto-detecting and auto-configuring between incoming GbE and 10GbE signals.
18. **[Required]** Ethernet and FE interfaces shall be auto-sensing/auto-detecting and auto-configuring between incoming Ethernet and FE signals.

#### *5.5.3.4.6 AGF Functional Device Storage Area Network Interface Requirements*

1. **[Desired]** The AGF functional device shall provide Fiber Connectivity (FICON) tributary interfaces and services as per ANSI X3.230.
2. **[Desired]** The AGF functional device shall provide Enterprise Services Connectivity (ESCON) tributary interfaces and services as per ANSI X3.296.

#### *5.5.3.4.7 AGF Functional Device Cross-Connect Requirements*

1. **[Required]** The AGF functional device shall cross connect with the granularity of STS-1 and VT1.5 on a SONET AGF functional device.
2. **[Required]** The STS-1 (high order) cross-connect fabric shall be capable of supporting at least 320 G of cross connects at the STS-1/STM-0 level.
3. **[Required]** The VT1.5 (low order) cross-connect fabric shall be scalable and capable of supporting at least 10 G of traffic at the VC-11/VC-12 level.
4. **[Desired]** The AGF functional device shall have an Ethernet switch fabrics separate from its STS-1 or VT1.5 TDM fabric.
5. **[Required]** The IP Ethernet switch fabrics shall be scalable and capable of supporting at least 20 G of IP traffic.
6. **[Required]** The AGF functional device shall cross connect with the granularity of VC-12, VC-3, and VC-4 on a SDH AGF functional device (not necessarily simultaneously with STS-1 and VT1.5).
7. **[Required]** The AGF functional device shall perform Time Slot Interchange (TSI) and Time Slot Assignment (TSA) cross connect between DS1 interfaces and channelized DS3 interfaces into a SONET VT1.5 formatted within the STS containers.
8. **[Required]** The AGF functional device shall support structured Administrative Unit-4 (AU-4) mapping for SDH applications using the ITU multiplexing structure in ITU-T Recommendation G.707.

9. **[Required]** The AGF functional device shall be able to map T1, E1, T3, and E3 signals into an AU-4 mapping structure as per ITU-T G.707.
10. **[Required]** The AGF functional device shall support VC-11, VC-12, VC-3, and VC-4 cross-connect capability for SDH AU-4-based system.
11. **[Required]** The AGF functional device shall support SDH/SONET container gateway functionalities (i.e., VC-3 to STS-1 and VC-11 to VT1.5).
12. **[Desired]** The AGF functional device shall have the ability to retime signals from either VT1.5 or DS1 formats, as well as pass timing through the matrix directly to provide timing up to Stratum 1 via DS1 ports.
13. **[Required]** The AGF functional device cross-connects and interfaces shall be compatible with network-side STS or Lambda cross-connects at the DISN switch or the DISN Transport Element.
14. **[Required]** The AGF functional device cross-connects and interfaces at the AGF functional device shall be transparent to all protection switching at the DISN switch or the DISN Transport Element.
15. **[Required]** The AGF functional device shall support SONET provisioning of CCAT formats; OC-3c, OC-12c, OC-48c, and OC-192c.
16. **[Desired]** The AGF functional device shall support SONET provisioning of OC-768c CCAT formats.
17. **[Required]** The AGF functional device shall support SDH provisioning of CCAT formats; VC-4-3c, VC-4-16c, and VC-4-64c.
18. **[Desired]** The AGF functional device shall support SDH provisioning of VC-4-256c CCAT formats.

#### *5.5.3.4.8 AGF Functional Device Interface Performance Requirements*

1. **[Required]** The AGF functional device shall meet the jitter criteria for SONET systems in Telcordia Technologies GR-253-CORE, Section 5.6.
2. **[Required]** The AGF functional device shall meet the jitter criteria for SDH systems according to ITU-T Recommendation G.825 and ITU-T G.732.

3. **[Required]** The AGF functional device shall meet the interface jitter criteria specified for UNI interfaces for ITU-T OTN.
4. **[Required]** The jitter tolerance measured at the OC-N interface on the AGF functional device shall meet Figure A.1 input jitter tolerance specification documented in ANSI T1.105.03.
5. **[Required]** The jitter tolerance measured at the DS3 interface on the AGF functional device shall be at least 5 Unit Interval peak-to-peak (UIpp) between 10 Hertz (Hz) and  $2.3 \times 10^3$  Hz, and at least 0.1 UIpp between  $60 \times 10^3$  and  $200 \times 10^3$  Hz as per Figure 7-1 in GR-499.
6. **[Required]** The jitter transfer measured between an input DS3 interface and the corresponding output DS3 interface on an AGF functional device (with its OC-12 or OC-3 signal looped-back) shall be less than the jitter transfer mask shown in Figure 7-4 of GR-499.
7. **[Required]** The jitter generation measured at the OC-N interface on the AGF functional device shall be less than 0.01 UIrms, when measured using a high-pass filter with 12-kHz cut-off frequency per ANSI T1.105.03, Section A.3.3.
8. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than 0.4 UIpp, without pointer adjustments as per ANSI T1.105.03, Section 6.1.2.1.
9. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than A1 equals A0 plus .3 UIpp for a single pointer adjustment as shown in Table 2 of ANSI T1.105.03-1994.
10. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than 1.3 UIpp for pointer adjustment bursts as shown in Table 3 of ANSI T1.105.03.
11. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than 1.2 UIpp for phase transient pointer adjustment bursts as shown in Table 4 of ANSI T1.105.03.
12. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than 1.3 UIpp for periodic pointer adjustments as shown in Table 6 of ANSI T1.105.03-1994.

13. **[Required]** The jitter generation due to DS3/STS-1 payload mapping for the DS3 interface on the AGF functional device shall be less than 5 UIpp between 10 Hz and 500 Hz, and at least 0.1 UIpp between  $8 \times 10^3$  and  $40 \times 10^3$  Hz per Figure 7-1 of Telcordia Technologies GR-499-CORE.
14. **[Required]** The jitter transfer measured between an input DS1 interface and the corresponding output DS1 interface on the AGF functional device (with its OC-12 or OC-3 signal looped back) shall be less than the jitter transfer mask shown in Figure 7-4 of Telcordia Technologies GR-499-CORE.
15. **[Required]** The jitter generation due to DS1/VT-1.5 payload mapping without pointer adjustments for the DS1 interface on the AGF functional device shall be less than 0.7 UIpp per ANSI T1.105.03s, Section 6.1.1.1.
16. **[Required]** The jitter generation due to DS1/VT1.5 payload mapping and a single pointer adjustment for the DS1 interface on the AGF functional device shall meet the single VT pointer adjustment Maximum Time Interval Error (MTIE) mask shown on Figure 8 of the ANSI T1X1.3/94-001R5 supplement to ANSI T1.105.03.
17. **[Required]** The jitter generation due to DS1/VT1.5 payload mapping and periodic pointer adjustments for the DS1 interface on the AGF functional device shall meet the periodic VT pointer adjustment MTIE mask shown on Figure 10 of the ANSI T1X1.3/94-001R5 supplement to ANSI T1.105.03.
18. **[Required]** The maximum delay for a full STS passed through the AGF functional device (OC-N to OC-N), or for an STS add/drop shall not exceed 25 microseconds ( $\mu$ s) as per Telcordia Technologies TR-496, (R) [3-45].
19. **[Required]** The maximum delay for a floating VT passed through a DISN Access element (OC-N to OC-N), or for a floating VT add/drop (OC-N to low-speed or low-speed to OC-N) shall not exceed 50 microseconds ( $\mu$ s) as per Telcordia Technologies, TR-496, (R) [3-46].

#### *5.5.3.4.9 AGF Functional Device Equipment Redundancy Requirements*

1. **[Required]** No single failure in the switch fabric shall affect service. The AGF functional device shall meet Telcordia Technologies GR-2996-CORE requirements for fabric availability.
2. **[Required]** The interface cards shall be capable of switching between the working and protection switch fabric in an errorless manner for manual operation, and in a hitless manner for automated operation. No bits shall be lost or corrupted with errorless

switching. Bit errors are allowed with hitless switching. However, hitless switching shall not cause downstream reframing to occur.

3. **[Required]** A PDH (DS1, DS3, E1, E3) card shall support a 1:1 configuration.
4. **[Desired]** A PDH (DS1, DS3, E1, E3) card should support a 1:N configuration.
5. **[Required]** The AGF functional device shall support redundant processor and cross-connect matrix working in an active/standby mode.
6. **[Required]** The AGF functional device shall support redundant power supply and electrical feeds.

#### *5.5.3.4.10 AGF Functional Device General Protection Requirements*

1. **[Required]** It shall be possible to provision any SONET port for 1+1 APS, 1:N APS; 1:N OP, 2-Fiber UPSR per Telcordia Technologies GR-1400-CORE, or 2/4-Fiber BLSR per Telcordia Technologies GR-1230-CORE.
2. **[Required]** It shall be possible to provision any SDH port for 1+1 APS, 0:1 APS, 1:N APS, 1+1 2/4-Fiber Unidirectional Ring, or 2-Fiber MS Shared Protection Ring per ITU-T Recommendation G.841.
3. **[Required]** When the AGF functional device participates in point-to-point UPSR or BLSR protection, switching shall take place in 50 ms. These protection mechanisms shall be definable and selectable from the EMS, and shall offer the selection of revertive and non-revertive restoration mechanisms.
4. **[Required]** When the AGF functional device participates in point-to-point UPSR or BLSR protection and the selection of revertive restoration mechanisms shall have a revertive timer that is software programmable in a 30-second increment from 0 to 5 minutes, at a minimum.
5. **[Required]** The service restoration for a protection switch shall be automatic and accomplished without human or central management system intervention.
6. **[Required]** The protection switching mechanism shall be independent among separately managed network domains. A protection switch in one separately managed network domain shall not propagate or relay to another separately managed network domain.

7. **[Required]** The maximum detection time to determine if a signal's BER threshold is exceeded shall comply with Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.783.
8. **[Critical]** Once a decision is made to switch, the terminal circuit pack switching shall take place within 50 ms, as described in Telcordia Technologies GR-253-GORE and ITU-T Recommendation G.783.
9. **[Required]** Catastrophic failures on a user-definable Excessive BER (EBER) condition shall be detected by an equipment-protected circuit pack in a terminal within 10 ms as described in Telcordia Technologies GR-253-GORE and ITU-T Recommendation G.783.
10. **[Required]** When equipped, the AGF functional device shall be compliant with types and characteristics of SDH network protection architectures as defined in ITU-T G.841.
11. **[Required]** When equipped, the AGF functional device shall be compliant with interworking of SDH network protection architectures as defined in ITU-T Recommendation G.842.

#### *5.5.3.4.11 AGF Functional Device Interoperability Requirements*

1. **[Required]** The AGF functional device user interfaces, software, firmware, and hardware shall be fully compatible and interoperable with and without protection mechanisms of the OTS muxponder, OTS ROADM, ODXC, M13, STI, DSN MFS, encryption devices, and DISN Provider (P), Provider Edge (PE), Aggregation Routers (ARs).
2. **[Required]** The AGF functional device cross-connects and interfaces shall be compatible with network-side STS, STM, or Lambda cross-connects at the OTS muxponder, OTS ROADM, and ODXC.
3. **[Required]** The AGF functional device cross-connects and interfaces at the AGF functional device shall be compatible with all protection switching at OTS muxponder, OTS ROADM, ODXC, M13, STI, DSN MFS, encryption devices, and DISN P, PE, and ARs.

#### *5.5.3.4.12 AGF Functional Device Fault Management Requirements*

1. **[Required]** The AGF functional device shall send the appropriate AIS and RDI to adjacent systems, the EMS, and/or the higher level management system after detecting signal failure or degraded conditions for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.

2. **[Required]** The AGF functional device shall remove the appropriate AIS and RDI after the source system has cleared the signal failure or degraded condition for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** Alarms shall indicate circuit-level or signal alarms, as well as alarms in the AGF functional device itself, such as Span Failure, LOS, Path Switch Complete/Fail, Laser Degradation, Card Failure, and Card Mismatch.
4. **[Required]** Standard SONET alarms shall be supported by the system, including LOS, LOP, LOF, Rx AIS, RDI, and RFI.
5. **[Required]** The AGF functional device shall indicate SONET timing synchronization failures. The AGF functional device shall give an alarm showing the inability to establish a PLL. The AGF functional device shall have the ability to monitor the BITS incoming references (BITS-A and BITS-B). The AGF functional device shall give an alarm when there is any timing change, e.g., a switch from BITS-A to BITS-B.
6. **[Required]** Each NE shall detect, report, and clear the following signal failure events or conditions: LOS, LOF, LOP, SEF, AIS, and OOF, according to ANSI T1.231.
7. **[Required]** The AGF functional device shall provide the following DS3 alarms and report them to the EMS: LOS and AIS (or blue alarm). Definitions are the same as with DS1. The AGF functional device shall be able to transmit and receive the Far-End Out Of Frame (FEOOF) alarm for those AGF functional devices that transmit them. In addition, the AGF functional device shall be able to transmit and receive Far-End Alarm and Control (FEAC) signals. The FEAC option allows the AGF functional device to display far-end alarm and status information via the FEAC channel and to transmit FEAC messages from the near end to the far end.
8. **[Required]** The AGF functional device shall provide the following SONET VT alarms and report them to the EMS: include signal label mismatch, receive unequipped, and Rx AIS. Signal label mismatch tells whether the VT payload is locked or floating. Receive unequipped indicates that the far-end SONET port has not been provisioned.
9. **[Required]** The AGF functional device shall provide the following DS1 alarms and report them to the EMS: AIS or yellow alarm, LOS, Remote Alarm Indication (RAI)/yellow alarm, and excess zeroes. Alarm Indication Signal is transmitted as a result of a received LOS. The RAI or yellow alarm is transmitted upstream to indicate a red alarm or LOS downstream. Alarms shall indicate which physical port is receiving or transmitting the alarm. The yellow or RAI alarm is for ESF circuits only. Excess zeroes alarm only applies to D4/Superframe circuits.

10. **[Required]** The AGF functional device shall have LEDs for minor, major, and critical alarms and the LED must be set and cleared when a alarm of the defined category is present or cleared as defined by Telcordia Technologies GR.253-CORE.
11. **[Required]** The AGF functional device shall provide alarm status with at least the following minimum information: reference number, date and time of occurrence, node name, card type/slot, severity (i.e., minor, major, critical, informational), and alarm status (set, clear, and transient).

#### *5.5.3.4.13 AGF Functional Device Performance Monitoring Requirements*

1. **[Required]** The AGF functional device shall provide a performance monitoring capability of all the supported interfaces (i.e., PDH, SONET, SDH) in accordance with Telcordia Technologies GR-253-CORE, and ITU-T Recommendation G.829.
2. **[Required]** The PDH performance monitoring shall provide ES, Severally SES, Unavailable Seconds, BP or CV, LOS, and AIS in accordance with Telcordia Technologies GR-820-CORE and ITU-T Recommendations G.826.
3. **[Required]** The SONET performance monitoring shall provide ES, SES, unavailable seconds, CV, LOS, AIS, and pointer adjustments in accordance with Telcordia Technologies GR-499-CORE.
4. **[Required]** The SDH performance monitoring shall provide ES, SES, unavailable seconds, CV, LOS, AIS, and pointer adjustments in accordance with ITU-T G.829.
5. **[Required]** The Ethernet performance monitoring shall provide Link availability time, various pack sizes, undersize packets, jumbo frames, frame alignment errors, frame check sequence errors, fragmentation, and CRC alignment errors in accordance with IEEE 802.3.
6. **[Required]** The optical card performance monitoring shall provide receive power, transmit power, bias current, low power threshold, and high power threshold in accordance with Telcordia Technologies GR-253-CORE.
7. **[Required]** All interfaces shall provide alarm thresholds for error rates that are determine to be degraded (10E-6) and failed (10E-3) and declare alarms based on the error rates to the user via the alarm in accordance with Telcordia Technologies GR-253-CORE and ITU-T Recommendation G.829.

#### 5.5.3.4.14 AGF Functional Device Requirements

1. **[Required]** The AGF functional device shall perform hair-pinning and ADM functions in accordance with Telcordia Technologies GR-496-CORE.
2. **[Required]** The AGF functional device shall perform drop ADM functions in accordance with Telcordia Technologies GR-496-CORE.
3. **[Required]** The AGF functional device shall perform continued ADM functions in accordance with Telcordia Technologies GR-496-CORE.
4. **[Desired]** The AGF functional device shall perform drop and continue ADM functions in accordance with Telcordia Technologies GR-496-CORE.
5. **[Required]** The AGF functional device shall provide the ability to hub or nest lower DISN Access elements in a linear or ring configuration from user-side interfaces.
6. **[Desired]** The AGF functional device shall not use external connections for ring interconnection. Where multiple rings can be supported by a single shelf, connectivity between rings shall be accomplished via the switch matrix. No external connection between tributary interfaces shall be used to cross connect rings in the same bay.
7. **[Required]** The AGF functional device shall be protocol-transparent to incoming bit streams. Except for internetworking functions associated with Ethernet services within the AGF functional device, the AGF functional device shall not perform any user protocol conversions.
8. **[Required]** The AGF functional device shall not impart any errors onto the connections during cross-connects, grooming, or multiplexing.
9. **[Required]** The AGF functional device shall perform hair-pinning cross-connects without affecting the line capacity rate of the AGF functional device.
10. **[Required]** The AGF functional device shall send the appropriate AIS and RDI to adjacent AGF functional devices, the EMS, and/or higher level management systems after detecting signal failure or degraded conditions for a specified alarm or indication activation time per ANSI T1.231, Tables 2, 6 and 11.
11. **[Required]** The AGF functional device shall remove appropriate AIS and RDI after another AGF functional device has cleared the signal failure or degraded conditions for a specified alarm or indication activation time per ANSI T1.231, Tables 2, 6, and 11.

12. **[Desired]** The AGF functional device shall have internal local and remote terminal loopback capability per Telcordia Technologies GR-253-CORE, (R) 6-380.
13. **[Required]** The AGF functional device shall have a local and remote service loopback capability as per Telcordia Technologies GR-253-CORE, (R) 6-389.
14. **[Required]** The AGF functional device with DS1/E1 line terminations shall provide both DS1/E1 terminal and service loopback capabilities as per Telcordia Technologies GR-253-CORE, (O) 6-397.
15. **[Required]** The AGF functional device with DS3 line terminations shall provide both DS3 terminal and service loopback capabilities per Telcordia Technologies GR-253-CORE, (O) 6-397.
16. **[Desired]** The AGF functional device should support BER Testing using standard test patterns: PRBS15, PRBS20, PRBS23, QRSS, and ATL1s0s.

#### *5.5.3.4.15 AGF Functional Device Interface Performance Requirements*

1. **[Required]** The AGF functional device shall meet the jitter criteria for SONET systems in Telcordia Technologies GR-253-CORE, Section 5.6.
2. **[Required]** The AGF functional device shall meet the jitter criteria for SDH systems according to ITU-T Recommendations G.825 and ITU-T Recommendations G.732.
3. **[Required]** The AGF functional device shall meet the interface jitter criteria specified for UNI interfaces for ITU-T OTNs.
4. **[Required]** The jitter tolerance measured at the OC-N interface on the AGF functional device shall meet Figure A.1 input jitter tolerance specification documented in ANSI T1.105.03.
5. **[Required]** The jitter tolerance measured at the DS3 interface on a DISN Access element shall be at least 5 UIpp between 10 Hz and  $2.3 \times 10^3$  Hz, and at least 0.1 UIpp between  $60 \times 10^3$  and  $200 \times 10^3$  Hz per Figure 7-1 in TR-499.

#### *5.5.3.4.16 AGF Functional Device EMS Requirements*

1. **[Required]** The AGF functional device EMS shall report PHY (Layer 1) statistics. Further, it shall report Layer 2 errors. It shall report all QoS parameters defined for the RPR as described in IEEE 802.17.

2. **[Required]** The AGF functional device EMS shall be able to track frame errors, P-Bit parity errors, C-Bit parity errors, and FEBE.
3. **[Required]** The AGF functional device EMS shall be able to provision the AGF functional device on all interfaces (i.e., PDH/SONET/SDH/Ethernet) and be able to provision a circuit using the different types of cross-connects (VT1.5, VC-11, VC-12, VC-3, VC-4, STS-1, STM-1, STS-3c, STM-4, STS-12c, STM-16, STS-48c, STM-64, and STS-192c).
4. **[Required]** The AGF functional device EMS shall be able to build protection topologies APS 1+1, UPSR, and BLSR.
5. **[Required]** The AGF functional device EMS shall be able to provision card parameters required for interoperability to interconnecting carrier systems; and interface framing format, and line type, line build out.
6. **[Required]** The AGF functional device EMS shall be able to provision alarms profiles according to network requirements (i.e., minor, major, critical, none service affecting, and none reporting).
7. **[Required]** The AGF functional device EMS shall be able to review and retrieve alarm and administration logs.
8. **[Required]** The AGF functional device EMS shall be able to set the alarm threshold on any interface (i.e., SD and SF).
9. **[Required]** The AGF functional device EMS shall be able to provision all administrated and security screens based on password level (i.e., network IP address, NE name, user accounts, and radius server).

#### *5.5.3.4.17 Physical Design Requirements*

1. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in FCC Part 15 Class A.
2. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in Telcordia Technologies GR-1089-CORE.
3. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 50082.

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4. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 55022.
5. **[Required]** All TSF elements shall meet the EMC/EMI requirements defined in ETSI EN 300-386.
6. **[Required]** All TSF elements shall be designed to operate continuously in the following environment ranges without degradation. Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.
7. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
8. **[Required]** All TSF elements shall be designed to operate continuously in the following environment range without degradation. Altitude: -100 to 15,000 ft AMSL.
9. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
10. **[Required]** All TSF elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220 V with redundant isolated power modules.
11. **[Required]** All TSF elements shall be fully operational throughout the battery voltage range of -41.5 to -56 VDC.
12. **[Required]** All TSF elements shall not be damaged and shall recover to normal performance following application of the following maximum transient voltages for the durations given (nominal voltage 48 VDC): 75 VP-P for 1 msec, 60 VP-P for 500 msec.
13. **[Required]** All TSF elements shall be fully NEBS, Level 3 compliant.
14. **[Required]** All TSF elements shall be designed to operate continuously in the following environment ranges without degradation. Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.

15. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
16. **[Required]** All TSF elements shall be designed to operate continuously in the following environment range without degradation. Altitude: -100 to 15,000 ft AMSL.
17. **[Required]** All TSF elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
18. **[Required]** All TSF elements shall adhere to NEBS level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220 V with redundant isolated power modules.
19. **[Required]** All TSF elements shall be fully operational throughout the battery voltage range of: -41.5 to -56 VDC.
20. **[Required]** All equipment shall have been tested and registered as compliant to the following electrical safety standards: UL-1950, EN60950, and IEC 60950.

#### *5.5.3.4.18 AGF Functional Device Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfy multiple versions of the standards. Testing will need to be undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.651.1 (2007)
2. **[Required]** ITU-T Recommendation G.652 (10/2000) (Revised in 2005)
3. **[Required]** ITU-T Recommendation 694.1 (2002)
4. **[Required]** ITU-T Recommendation G.703 (2001)

5. **[Required]** ITU-T Recommendation G.707/Y.1322 (2007)
6. **[Required]** ITU-T Recommendation G.709/Y.1331
7. **[Required]** ITU-T Recommendation G.711 (1988)
8. **[Required]** ITU-T Recommendation G.732 (1988)
9. **[Required]** ITU-T Recommendation G.783 (2006)
10. **[Required]** ITU-T Recommendation G.825 (2000)
11. **[Required]** ITU-T Recommendation G.829
12. **[Required]** ITU-T Recommendation G.841 (1998)
13. **[Required]** ITU-T Recommendation G.842 (1997)
14. **[Required]** ITU-T Recommendation G.872 (2001)
15. **[Required]** ITU-T Recommendation G.957 (2006)
16. **[Required]** ITU-T Recommendation G.7041/Y-1303 (2003) (Revised in 2008)
17. **[Required]** ANSI T1.101
18. **[Required]** ANSI T1.102-1999
19. **[Required]** ANSI T1.105.1-2000
20. **[Required]** ANSI T1.105.03-1994 (Revised 2003 (R2008))
21. **[Required]** ANSI T1.105.06 – 2002 (R2007)
22. **[Required]** ANSI T1.107-2002 (R2006)
23. **[Required]** ANSI T1.231-1993 (Revised 2003 (R2007))
24. **[Required]** ANSI T1.403-1999 (R2007)
25. **[Required]** ANSI T1.404-2002 (R2006)

26. **[Required]** Telcordia Technologies GR-253-CORE, Issue 3, September 2000 (Issue 5, October 2009)
27. **[Required]** Telcordia Technologies GR-496-CORE, Issue 1, December 1998, (Issue 2, August 2007)
28. **[Required]** Telcordia Technologies GR-499-CORE, Issue 2, December 1998 (Issue 3, September 2004)
29. **[Required]** Telcordia Technologies GR-820-CORE, Issue 2, December 1997
30. **[Required]** IEEE 802.3-2008
31. **[Required]** IEEE 802.1Q-2003
32. **[Required]** IEEE 802.17-2004, IEEE standard for information technology-telecommunications and information exchange between systems-local and metropolitan area networks-specific requirements-part 17: resilient packet ring (RPR) access method and physical layer specifications
33. **[Required]** X3-230. ANSI FC-SB-3 and INCITS 230:1994 [R2004]
34. **[Required]** British Standards Institute BS EN 60950-1 August 6, 2006
35. **[Required]** IEC 60950-1, 2006
36. **[Required]** CFR FCC Part 15, Class A
37. **[Required]** Network Equipment - Building System (NEBS), Level 3
38. **[Required]** Underwriters Laboratories, Inc. UL-1950, First Edition 1989

### **5.5.3.5 Access Aggregation Function M13 Device**

#### **5.5.3.5.1 Description**

The M13 functionally multiplexes DS1s into a DS3.

#### **5.5.3.5.2 M13 Electrical Interface Requirements**

1. **[Required]** The M13 shall support DS1 electrical interfaces that comply with ANSI T1.102.

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2. **[Required]** The M13 shall support channelized and unchannelized DS1 Superframe (SF) format and ESF format as specified in ANSI T1.403. The ability to read/write the ESF data link is required. The selection of format for any particular DS1 interface shall be user-selectable.
3. **[Required]** The M13 shall support AMI and B8ZS framing format as specified in ANSI T1.403. The selection of framing format for any particular DS1 interface shall be user-selectable.
4. **[Required]** The M13 shall support both in-band and out-band (FDL) loop-up and loop-down codes as specified in ANSI T1.403.
5. **[Required]** The M13 shall support FDL status messages and respond according as specified in ANSI T1.403.
6. **[Required]** The M13 shall support unframed DS1 electrical signals.
7. **[Required]** The electrical interface shall comply with ITU-T Recommendation G.703.
8. **[Required]** The M13 shall support DS1 bit rate of 1.544 Mbps +/- 32 ppm as specified in ANSI T1.101.
9. **[Required]** The M13 shall support DS1 100 ohms cable with maximum length of 655 feet as specified in ITU-T Recommendation G.703.
10. **[Required]** The M13 shall support DS3 electrical tributary interfaces that comply with ANSI T1.102.
11. **[Required]** The M13 DS3 interface shall support DS3 pulse shape that meets both ITU-T G.703 and Telcordia Technologies GR-499-CORE. Older Promina® equipment will not work correctly on just meeting the pulse shape of Telcordia Technologies GR-499-CORE. The interface can be software selectable to support both pulse shapes.
12. **[Required]** The M13 shall support channelized DS3 signals in either M13 or C-bit parity formats per ANSI T1.107 and T1.404. The selection of format for any particular DS3 interface shall be user selectable.
13. **[Required]** The M13 shall support DS3 C-bit far-end alarm and control signal to support alarm/status messages and loopback control on the DS3 and/or individual DS1 as specified in ANSI T1.107 and ANSI T1.404.

14. **[Required]** The M13 shall support DS3 bit rate of 44.736 Mbps +/- 20 ppm as specified in ANSI T1.101.
15. **[Required]** The M13 shall be able to provision, monitor, and detect faults, and restore electrical (DS1, E1, DS3) services in a standardized and automated fashion.
16. **[Required]** The M13 shall be able to multiplex 28 DS1s into a single DS3.

#### *5.5.3.5.3 M13 Interface Performance Requirements*

1. **[Required]** The jitter tolerance measured at the DS3 interface on the M13 shall be at least 5 UIpp between 10 Hz and  $2.3 \times 10^3$  Hz, and at least 0.1 UIpp between  $60 \times 10^3$  and  $200 \times 10^3$  Hz as per Figure 7-1 in Telcordia Technologies TR-499.
2. **[Required]** The jitter transfer measured between an input DS1 interface and the corresponding output DS1 interface on the M13 (with its DS3 signal looped back) shall be less than the jitter transfer mask shown in Figure 7-4 of Telcordia Technologies GR-499.
3. **[Required]** The jitter generation for the DS1 interface on the M13 shall be less than 0.7 UIpp as per ANSI T1.105.03s, Section 6.1.1.1.

#### *5.5.3.5.4 M13 Equipment Redundancy Requirements*

1. **[Required]** The M13 shall support a redundant processor in an active/standby mode.
2. **[Required]** The M13 shall support redundant power supply/electrical feeds.

#### *5.5.3.5.5 M13 Fault Management Requirements*

1. **[Required]** The M13 shall send the appropriate AIS and RDI to adjacent systems, the EMS, and/or the higher level management system after detecting signal failure or degraded conditions for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
2. **[Required]** The M13 shall remove the appropriate AIS and RDI after the source system has cleared the signal failure or degraded condition for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** Alarms shall indicate circuit-level or signal alarms, as well as alarms in the M13 itself, such as LOS, AIS, LOF, and RDI.

4. **[Required]** The M13 shall provide the following DS3 alarms and report them to the EMS: LOS and AIS (or blue alarm). Definitions are the same as with DS1. The M13 shall be able to transmit and receive the FEOOF alarm for those network elements (NEs) that transmit them. In addition, the M13 shall be able to transmit and receive FEAC signals. The FEAC option allows the M13 to display far-end alarm and status information via the FEAC channel and to transmit FEAC messages from the near end to the far end.
5. **[Required]** The M13 shall provide the following DS1 alarms and report them to the EMS: AIS or yellow alarm, LOS, RAI/yellow alarm, and excess zeroes. Alarm Indication Signal is transmitted as a result of a received LOS. The RAI or yellow alarm is transmitted upstream to indicate a red alarm or LOS downstream. Alarms shall indicate which physical port is receiving or transmitting the alarm. The yellow or RAI alarm is for ESF circuits only. The excess zeroes alarm only applies to D4/Superframe circuits.
6. **[Required]** The M13 shall have LEDs for minor, major, and critical alarms, and the LED must be set and cleared when an alarm of the defined category is present or cleared, as defined by Telcordia Technologies GR.253-CORE.
7. **[Required]** The M13 shall provide alarm status with at least the following minimum information: reference number, date and time of occurrence, node name, card type/slot, severity (i.e., minor, major, critical, and informational), and alarm status (i.e., set, clear, and transient).

#### *5.5.3.5.6 M13 Performance Monitoring Requirements*

1. **[Required]** The M13 shall provide a performance monitoring capability on the DS1 and DS3 interfaces in accordance with Telcordia Technologies GR-820-CORE.
2. **[Required]** The DS1 and DS3 performance monitoring shall provide ES, SES, Unavailable Seconds, BP or CV, LOS, and AIS in accordance with Telcordia Technologies GR-499-CORE and GR-820-CORE.
3. **[Required]** All interfaces shall provide alarm thresholds for error rates that are determined to be degraded (10E-6) and failed (10E-3) and declare alarms based on the error rates to the user via the alarm in accordance with Telcordia Technologies GR-820-CORE.

#### *5.5.3.5.7 M13 Network Element Requirements*

1. **[Required]** The M13 shall send the appropriate AIS and RDI to adjacent NES, the EMS, and/or higher level management systems after detecting signal failure or degraded conditions for a specified alarm or indication activation time as per ANSI T1.231, Tables 2, 6 and 11.

2. **[Required]** The M13 shall remove appropriate AIS and RDI after another NE has cleared the signal failure or degraded conditions for a specified alarm or indication activation time as per ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** The M13 shall have a DS1 and DS3 loopback capability per Telcordia Technologies GR-253-CORE, (R) 6-397.
4. **[Desired]** The M13 should support BER testing using standard test patterns; PRBS15, PRBS20, PRBS23, QRSS, and ATL1s0s.

#### *5.5.3.5.8 M13 EMS Requirements*

1. **[Required]** The M13 EMS shall report PHY (Layer 1) statistics.
2. **[Required]** The M13 EMS shall be able to track frame errors, network errors (i.e., AIS, LOS, LOF, BPV, and CV).
3. **[Required]** The M13 EMS shall be able to provision interface parameters required for interoperability to interconnecting carrier systems; interface framing format, line type, and line build out.
4. **[Required]** The DIM13 EMS shall be able to review and retrieve alarm and administration logs.
5. **[Required]** The M13 EMS shall be able to set an alarm threshold on any interface (i.e., SD and SF).
6. **[Required]** The M13 EMS shall be able to provision all administrated and security screens based on password level (i.e., network IP address, NE name, user accounts, and radius server).

#### *5.5.3.5.9 M13 Physical Design Requirements*

1. **[Required]** All M13 elements shall meet the EMC/EMI requirements defined in FCC Part 15 Class A.
2. **[Required]** All M13 elements shall meet the EMC/EMI requirements defined in Telcordia Technologies GR-1089-CORE.
3. **[Required]** All M13 elements shall meet the EMC/EMI requirements defined in ETSI EN 50082.

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4. **[Required]** All M13 elements shall meet the EMC/EMI requirements defined in ETSI EN 55022.
5. **[Required]** All M13 elements shall meet the EMC/EMI requirements defined in ETSI EN 300-386.
6. **[Required]** All M13 elements shall be designed to operate continuously in the following environment ranges without degradation. Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.
7. **[Required]** All M13 elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
8. **[Required]** All M13 elements shall be designed to operate continuously in the following environment range without degradation: Altitude: -100 to 15,000 ft AMSL.
9. **[Required]** All M13 elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
10. **[Required]** All M13 elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220V with redundant isolated power modules.
11. **[Required]** All M13 elements shall be fully operational throughout the battery voltage range of -41.5 to -56 VDC.
12. **[Required]** All M13 elements shall not be damaged and shall recover to normal performance following application of the following maximum transient voltages for the durations given (nominal voltage 48 VDC): 75 VP-P for 1 msec, 60 VP-P for 500 msec.
13. **[Required]** All M13 elements shall be fully NEBS, Level 3 compliant.
14. **[Required]** All M13 elements shall be designed to operate continuously in the following environment ranges without degradation. Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.

15. **[Required]** All M13 elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
16. **[Required]** All M13 elements shall be designed to operate continuously in the following environment range without degradation. Altitude: -100 to 15,000 ft AMSL.
17. **[Required]** All M13 elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
18. **[Required]** All M13 elements shall adhere to NEBS level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220 V with redundant isolated power modules.
19. **[Required]** All M13 elements shall be fully operational throughout the battery voltage range of: -41.5 to -56 VDC.
20. **[Required]** All equipment shall have been tested and registered as compliant to the following electrical safety standards: UL-1950, EN60950, IEC 60950, and C22-2 No. 950.

#### *5.5.3.5.10 M13 Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfy multiple versions of the standards. Testing will need to be undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.703 (2001)
2. **[Required]** ITU-T Recommendation G.711 (1988)
3. **[Required]** ANSI T1.102-1999
4. **[Required]** ANSI T1.105.03-1994 (Revised 2003 (R2008))

5. **[Required]** ANSI T1.107-2002 (R2006)
6. **[Required]** ANSI T1.231-1993 (Revised 2003 (R2007))
7. **[Required]** ANSI T1.403-1999 (R2007)
8. **[Required]** ANSI T1.404-2002 (R2006)
9. **[Required]** Telcordia Technologies GR-253-CORE, Issue 3, September 2000 (Issue 4, December 2005)
10. **[Required]** Telcordia Technologies GR-499-CORE, Issue 2, December 1998 (Issue 3, September 2004)
11. **[Required]** Telcordia Technologies GR-820-CORE, Issue 2, December 1997
12. **[Required]** ETSI EN-300-386
13. **[Required]** British Standards Institute BS EN 60950-1, August 6, 2006
14. **[Required]** IEC 60950-1, 2006
15. **[Required]** CFR FCC Part 15, Class A
16. **[Required]** Network Equipment GR-637 - Building System (NEBS), Level 3
17. **[Required]** Underwriters Laboratories, Inc. UL-1950, First Edition 1989

### ***5.5.3.6 Access Aggregation Function Serial TDM Multiplexer Functional Device***

#### ***5.5.3.6.1 Description***

The serial TDM multiplexes user serial synchronous and asynchronous data interfaces and 2-wire and 4-wire analog into one or more aggregated higher bandwidth network interface trunks. These services are currently provided by DISA within the DISN using the Promina nodes and D4 channel banks but they may be offered by a similar IP-based device in the future. The network interface trunks supporting these services may be provided via DS1, DS3, E1, E3, Ethernet, FE, GbE or serial data transport as required.

The data transport services offer fixed data rates, fixed end-to-end delay. Data services are offered via the following interfaces:

- RS-232
- RS-422/449
- RS-530
- V.35
- Conditioned Diphase

For analog voice users, the serial TDM multiplexer supports foreign exchange (FX) signaling for extending DSN connectivity to analog stations. The TDM multiplexer includes echo cancellation to provide acceptable echo QoS to voice users. The analog services also support fax and modem bypass. Some of the voice services are:

- FX, office and station unit, with ground start, loop start, automatic ringdown.
- 2-wire and 4-wire E&M signaling

#### 5.5.3.6.2 *Serial TDM Multiplexer Network Interface Requirements*

1. **[Required]** The serial TDM multiplexers shall support DS1 electrical interfaces that comply with ANSI T1.102.
2. **[Required]** The serial TDM multiplexers shall support channelized and unchannelized DS1 SF format and ESF format as specified in ANSI T1.403. The ability to read or write the ESF data link is required. The selection of format for any particular DS1 interface shall be user selectable.
3. **[Required]** The serial TDM multiplexers shall support AMI and B8ZS framing format as specified in ANSI T1.403. The selection of framing format for any particular DS1 interface shall be user selectable.
4. **[Required]** The serial TDM multiplexers shall support both in-band and out-band (FDL) loop-up and loop-down codes as specified in ANSI T1.403.
5. **[Required]** The serial TDM multiplexers shall support FDL status messages and respond as specified in ANSI T1.403.
6. **[Required]** The serial TDM multiplexers shall support unframed DS1 electrical signals.
7. **[Required]** The electrical interface shall comply with ITU-T Recommendation G.703.
8. **[Required]** The serial TDM multiplexers shall support DS1 bit rate of 1.544 Mbps +/- 32 ppm, as specified in ANSI T1.101.

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9. **[Required]** The serial TDM multiplexers shall support DS1 100 ohms cable with maximum length of 655 feet, as specified in ITU-T Recommendation G.703.
10. **[Required]** The serial TDM multiplexers shall support DS3 electrical tributary interfaces that comply with ANSI T1.102-1993.
11. **[Required]** The jitter generation for the DS1 interface on the TDM multiplexer shall be less than 0.7 UIpp per ANSI T1.105.03s, Section 6.1.1.1.
12. **[Required]** Each alarm state shall be reported to the EMS.
13. **[Required]** The serial TDM multiplexers DS3 interface shall support DS3 pulse shape that meets both ITU-T Recommendation G.703 and Telcordia Technologies GR-499-CORE. Older Promina equipment will not work correctly on just meeting the pulse shape of Telcordia Technologies GR-499-CORE. The interface can be software selectable to support both pulse shapes.
14. **[Required]** The serial TDM multiplexers shall support channelized DS3 signals in either M13 or C-bit parity formats per ANSI T1.107 and T1.404. The selection of format for any particular DS3 interface shall be user selectable.
15. **[Required]** The serial TDM multiplexers shall support DS3 C-bit far-end alarm and control signal to support alarm/status messages and loopback control on the DS3 and/or individual DS1 as specified in ANSI T1.107 and ANSI T1.404.
16. **[Required]** The serial TDM multiplexers shall support DS3 bit rate of 44.736 Mbps +/- 20 ppm as specified in ANSI T1.101.
17. **[Required]** The serial TDM multiplexers shall be able to provision, monitor, and detect faults, and restore electrical (DS1, E1, DS3) services in a standardized and automated fashion.
18. **[Conditional]** The serial TDM multiplexers shall support STS-1 (EC-1) electrical interfaces that comply with specifications and pulse masks as defined in Telcordia Technologies GR-253-CORE Chapter 4.4, and ANSI T1.102.
19. **[Required]** The serial TDM multiplexers shall support E3 electrical tributary interfaces that comply with ITU-T Recommendation G.703.
20. **[Required]** The serial TDM multiplexers shall support channelized and unchannelized E3 signals using line coding of HDB-3.

21. **[Required]** The serial TDM multiplexers shall support E3 bit rate of 34.368 Mbps +/- 20 ppm as specified in ITU-T Recommendation G.703.
22. **[Required]** The serial TDM multiplexers shall provide and support the MIL-STD 188c-200 Conditioned Diphase interface at the data rates specified below.
23. **[Required]** The serial TDM multiplexers shall provide interfaces for Ethernet and FE services in conformance with IEEE 802.3 for Ethernet LAN interfaces.
24. **[Required]** The serial TDM multiplexers shall provide interfaces for Ethernet, FE, and Gigabit Ethernet Services in conformance with IEEE 802.3 for Ethernet LAN interfaces.
25. **[Required]** The serial TDM multiplexers shall not, by default, perform any Layer 3 IP routing.
26. **[Required]** The serial TDM multiplexers shall be able to provision, monitor, and detect faults, and restore Ethernet services in a standardized and automated fashion.
27. **[Required]** The serial TDM multiplexers shall selectively provide QoS/CoS for Ethernet Services according to IEEE 802.1Q.
28. **[Desired]** Available Ethernet services shall include RPR (IEEE 802.17b), GFP (ITU-T Recommendation G.7041/Y.1303), Hardware LCAS, and VCAT.
29. **[Required]** Ethernet and FE services on SONET shall support GFP (ITU-T Recommendation G.7041/Y.1303), hardware LCAS, low order VCAT (VT1.5), high order (STS-1) VCAT, and CCAT; STS-1 and STS-3c.
30. **[Required]** The AGF functional device shall selectively provide point-to-point Ethernet services with dedicated non-shared bandwidth without queuing or buffering Ethernet frames.

#### 5.5.3.6.3 *Serial TDM Multiplexer User Side Interface Requirements*

1. **[Required]** An analog interface shall be able to support switched service close-end loop start signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.2.
2. **[Required]** An analog interface shall be able to support switched service open-ended loop start signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.2.
3. **[Required]** An analog interface shall be able to support switched service close-end ground start signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.3.

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4. **[Required]** An analog interface shall be able to support switched service open-end ground start signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.3.
5. **[Required]** An analog interface shall be able to support switched service 2-wire E&M signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.4.
6. **[Required]** An analog interface shall be able to support switched service 4-wire E&M signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.4.
7. **[Required]** An analog interface shall be able to support switched service SF signaling per Telcordia Technologies TR-NWT-000335, Paragraph 4.7.
8. **[Required]** An analog interface shall be able to support special access voice grade 1 (VG1) service per Telcordia Technologies TR-NWT-000335, Paragraph 5.3.1.
9. **[Required]** An analog interface shall be able to support special access voice grade 2 (VG2) service per Telcordia Technologies TR-NWT-000335, Paragraph 5.3.2.
10. **[Required]** An analog interface shall be able to support special access voice grade 3 (VG3) service per Telcordia Technologies TR-NWT-000335, Paragraph 5.3.3.
11. **[Required]** An analog interface shall be able to support special access voice grade 4 (VG4) service per Telcordia Technologies TR-NWT-000335, Paragraph 5.3.4.
12. **[Required]** An analog interface shall be able to support special access voice grade 5 (VG5) service per TR-NWT-000335, Paragraph 5.3.5.
13. **[Required]** An analog interface shall be able to support special access voice grade 6 (VG6) service per Telcordia Technologies TR-NWT-000335, Paragraph 5.3.6.
14. **[Required]** An data interface shall support RS-232 up to 19.2 Kbps using an EIA/TIA-232-F interface. Both Data Communication Equipment (DCE) and data terminal equipment (DTE) connections shall be supported.
15. **[Required]** An data interface shall support up to 6 Mbps using an RS-422/RS-449 interface. Both DCE and DTE connections shall be supported.
16. **[Required]** An data interface shall support up to 2 Mbps per second using an RS-530 interface. Both DCE and DTE connections shall be supported.
17. **[Required]** An data interface shall support up to 6 Mbps per second using a conditioned diphas interface. Both DCE and DTE connections shall be supported.

18. **[Required]** A data interface shall support up to 64 kbps using a V.35 interface. Both DCE and DTE connections shall be supported.
19. **[Required]** The DS1 requirement in [Section 5.5.3.6.3](#) shall apply for user interfaces as well as the network interface.
20. **[Required]** The DS1 user side interfaces shall support fractional T1 services of n x 64 up to at least 768 kbps.
21. **[Required]** The TDM multiplexer shall be able to assign DS0s into any slot within a DS1 to create inverse multiplexer function.
22. **[Required]** For the user-side interfaces, the serial TDM multiplexer shall be able to clock data rates selectable from 1 bps to 6 mbps.
23. **[Required]** For the user-side interfaces, the serial TDM multiplexer shall be able to clock and transport data at rates selectable among the following bps rates:

200	3,600	12,800	32,000	76,800	168,000	384,000	1,024,000
400	4,800	14,400	38,400	86,400	192,000	448,000	1,184,000
800	6,400	16,000	48,000	96,000	224,000	512,000	1,344,000
1,200	7,200	16,800	56,000	112,000	230,400	672,000	1,536,000
1,800	8,000	19,200	57,600	115,200	256,000	768,000	1,544,000
2,400	9,600	24,000	64,000	128,000	288,000	772,000	2,048,000
3,200	12,000	28,800	72,000	144,000	336,000	896,000	

#### 5.5.3.6.4 Serial TDM Multiplexer Equipment Redundancy Requirements

1. **[Required]** The serial TDM multiplexer shall support redundant processor in an active/standby mode with standby diagnostics status indicated locally and via the EMS.
2. **[Required]** The serial TDM multiplexer shall support redundant power supply and indicate their individual locally and via the EMS. Each supply shall be capable of carrying the entire load and shall have separate electrical feeds.

#### 5.5.3.6.5 Serial TDM Multiplexer Fault Management Requirements

1. **[Required]** The serial TDM multiplexer shall send the appropriate AIS and RDI to adjacent systems, the EMS, and/or the higher level management system after detecting signal failure or degraded conditions for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.

2. **[Required]** The serial TDM multiplexer shall remove the appropriate AIS and RDI after the source system has cleared the signal failure or degraded condition for a specified alarm or indication activation time, as described in ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** Alarms shall indicate circuit-level or signal alarms, as well as alarms in the TDM multiplexer itself, such as LOS, AIS, LOF, and RDI.
4. **[Required]** The serial TDM multiplexer shall provide the following DS1 alarms and report them to the EMS: AIS or yellow alarm, LOS, RAI/yellow alarm, and excess zeroes. Alarm Indication Signal is transmitted as a result of a received LOS. The RAI or yellow alarm is transmitted upstream to indicate a red alarm or LOS downstream. Alarms shall indicate which physical port is receiving or transmitting the alarm. The yellow or RAI alarm is for ESF circuits only. An excess zeroes alarm only applies to D4/super frame circuits.
5. **[Required]** The serial TDM multiplexer shall have LEDs for minor, major, and critical alarms, and the LED must be set and cleared when a alarm of the defined category is present or cleared, as defined by Telcordia Technologies GR-253-CORE.
6. **[Required]** The serial TDM multiplexer shall provide alarm status with at least the following minimum information: reference number, date and time of occurrence, node name, card type/slot, severity (i.e., minor, major, critical, and informational), alarm status (i.e., set, clear, and transient)
7. **[Required]** All interfaces shall provide alarm thresholds for error rates that are determined to be degraded ( $10E-6$ ) and failed ( $10E-3$ ) and declare alarms based on the error rates to the user via the alarm in accordance with Telcordia Technologies GR-820-CORE.

#### *5.5.3.6.6 Serial TDM Multiplexer Performance Monitoring Requirements*

1. **[Required]** The serial TDM multiplexer shall provide a performance monitoring capability on all the interfaces in accordance with Telcordia Technologies GR-820-CORE.
2. **[Required]** The DS1 performance monitoring shall provide ES, SES, unavailable seconds, BP or CV, LOS, and AIS in accordance with Telcordia Technologies GR-499-CORE and GR-820-CORE.

#### *5.5.3.6.7 Serial TDM Multiplexer Network Element Requirements*

1. **[Required]** The serial TDM multiplexers shall send the appropriate AIS and RDI to adjacent NEs, the EMS, and/or higher level management systems after detecting signal

failure or degraded conditions for a specified alarm or indication activation time as per ANSI T1.231, Tables 2, 6 and 11.

2. **[Required]** The serial TDM multiplexers shall remove appropriate AIS and RDI after another NE has cleared the signal failure or degraded conditions for a specified alarm or indication activation time per ANSI T1.231, Tables 2, 6, and 11.
3. **[Required]** The serial TDM multiplexers shall have a DS1 loopback capability per Telcordia Technologies GR-253-CORE, (R) 6-397.

#### *5.5.3.6.8 Serial TDM Multiplexer EMS Requirements*

1. **[Required]** The serial TDM multiplexer's EMS shall report PHY (Layer 1) statistics.
2. **[Required]** The serial TDM multiplexer's EMS shall be able to track frame errors, network errors (AIS, LOS, LOF), BPV, and CV.
3. **[Required]** The serial TDM multiplexer's EMS shall be to provision interface parameters required for interoperability to interconnecting carrier systems; interface framing format, line type, and line build out.
4. **[Required]** The serial TDM multiplexer's EMS shall be to review and retrieve alarm and administration logs.
5. **[Required]** The serial TDM multiplexer's EMS shall be able to set an alarm threshold on any interface (i.e., SD and SF).
6. **[Required]** The serial TDM multiplexer's EMS shall be able to provision all administrated and security screens based on password level (i.e., network IP address, NE name, user accounts, and radius server).

#### *5.5.3.6.9 Serial TDM Multiplexer Physical Design Requirements*

1. **[Required]** All serial TDM multiplexers' elements shall meet the EMC/EMI requirements defined in FCC Part 15 Class A.
2. **[Required]** All serial TDM multiplexers' elements shall meet the EMC/EMI requirements defined in Telcordia Technologies GR-1089-CORE.
3. **[Required]** All serial TDM multiplexers' elements shall meet the EMC/EMI requirements defined in ETSI EN 50082.

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4. **[Required]** All serial TDM multiplexers' elements shall meet the EMC/EMI requirements defined in ETSI EN 55022.
5. **[Required]** All serial TDM multiplexers' elements shall meet the EMC/EMI requirements defined in ETSI EN 300-386.
6. **[Required]** All serial TDM multiplexers' elements shall be designed to operate continuously in the following environment ranges without degradation: Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.
7. **[Required]** All serial TDM multiplexers' elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
8. **[Required]** All serial TDM multiplexers' elements shall be designed to operate continuously in the following environment range without degradation: Altitude: -100 to 15,000 ft AMSL.
9. **[Required]** All serial TDM multiplexers' elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
10. **[Required]** All serial TDM multiplexers' elements shall adhere to NEBS Level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220V with redundant isolated power modules.
11. **[Required]** All serial TDM multiplexers' elements shall be fully operational throughout the battery voltage range of -41.5 to -56 VDC.
12. **[Required]** All serial TDM multiplexers' elements shall not be damaged and recover to normal performance following application of the following maximum transient voltages for the duration's given (nominal voltage 48 VDC): 75 VP-P for 1 msec, 60VP-P for 500 msec.
13. **[Required]** All serial TDM multiplexers' elements shall be fully NEBS, Level 3 compliant.

14. **[Required]** All serial TDM multiplexers' elements shall be designed to operate continuously in the following environment ranges without degradation. Temperature: 0 to +50°C, Humidity: 5 to 95 percent relative humidity, without condensation.
15. **[Required]** All serial TDM multiplexers' elements shall be designed to be fully operational after transportation and/or storage in the following environment ranges: Temperature: -40 to +70°C, Humidity: 5 to 95 percent relative humidity, without condensation.
16. **[Required]** All serial TDM multiplexers' elements shall be designed to operate continuously in the following environment range without degradation. Altitude: -100 to 15,000 ft AMSL.
17. **[Required]** All serial TDM multiplexers' elements shall be designed to be fully operational after transportation and/or storage in the following environment range: Transport Altitude: -100 ft to +40,000 ft AMSL.
18. **[Required]** All serial TDM multiplexers' elements shall adhere to NEBS level 3 compliance standards for acceptable voltage ranges, EMI, and ESD safety, and shall be operable using standard 48V dc power as well as having redundant isolated power input feeds. For certain sites, an alternative ac/dc rectifier may need to be supplied to power the system and shall be able to switch 110/220 V with redundant isolated power modules.
19. **[Required]** All serial TDM multiplexers' elements shall be fully operational throughout the battery voltage range of: -41.5 to -56 VDC.
20. **[Required]** All equipment shall have been tested and register as compliant to the following electrical safety standards: UL-1950, EN60950, and IEC 60950.

#### 5.5.3.6.10 *Serial TDM Multiplexer Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfies multiple versions of the standards. Testing will need to be undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.703 (2001)

2. **[Required]** ITU-T Recommendation G.711 (1988)
3. **[Required]** ANSI T1.102-1999
4. **[Required]** ANSI T1.105.03-1994 (Revised 2003 (R2008))
5. **[Required]** ANSI T1.107-2002 (R2006), Digital Hierarchy – Formats Specifications
6. **[Required]** ANSI T1.231-1993 (Revised 2003 (R2007))
7. **[Required]** ANSI T1.403-1999 (R2007)
8. **[Required]** ANSI T1.404-2002 (R2006)
9. **[Required]** Telcordia Technologies GR-253-CORE, Issue 3, September 2000 (Issue 4, December 2005)
10. **[Required]** Telcordia Technologies GR-499-CORE, Issue 2, December 1998 (Issue 3, September 2004)
11. **[Required]** Telcordia Technologies GR-820-CORE
12. **[Required]** EIA/TIA-232-E (January 1991) (superseded by TIA-232-F)
13. **[Required]** TIA-422-B (May 1994) (ANSI/TIA/EIA-422-B-1994) (R2000) (R2005)
14. **[Required]** EIA-449 (January 2000)
15. **[Required]** TIA-530-A (June 1992) (ANSI/TIA/EIA-530-A-92) (R98) (R2003)
16. **[Required]** ETSI EN-300-386
17. **[Required]** British Standards Institute, August 6, 2006 BS EN 60950-1
18. **[Required]** IEC 60950-1, 2006
19. **[Required]** CFR FCC Part 15, Class A
20. **[Required]** Network Equipment - Building System (NEBS), Level 3
21. **[Required]** Underwriters Laboratories, Inc. UL-1950, First Edition, 1989

## 5.5.4 Timing and Synchronization

### 5.5.4.1 Description

Figure 5.5.4-1, DISN Primary Site T&S, depicts the timing flow of a DISN primary site with T&S systems consisting of collocated BITS and MSPPs (NE) with equipment currently used in the DISN. This configuration is considered to be the “baseline” for DISN primary sites.

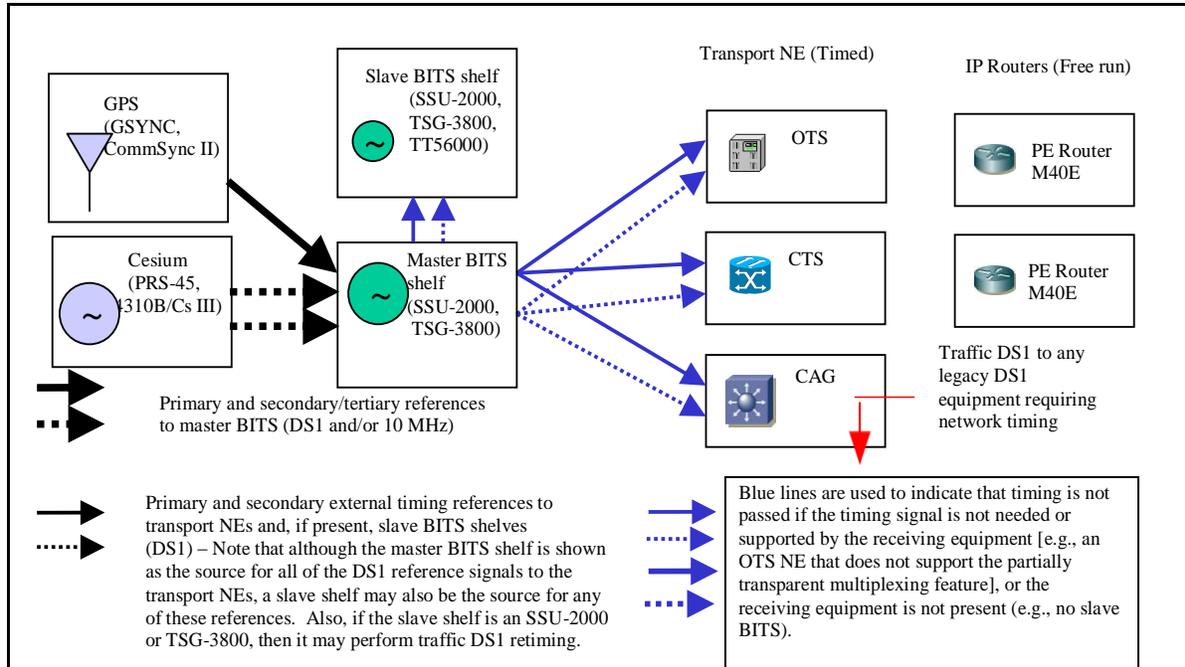


Figure 5.5.4-1. DISN Primary Site T&S

The BITS configuration includes a master BITS shelf and a slave BITS shelf. The BITS receives primary and secondary reference timing from a Cesium source or a Global Positioning System (GPS) source. The BITS provides redundant timing to the NEs of OTS, TSF, and CAG. The PE routers timing is free run. A secondary node does not use BITS, but instead derives timing via a line interface from a SONET CAG that is being timed from an upstream BITS. The following requirements apply to a primary site with BITS and suite of OTS, TSF, CAG, and routers.

### 5.5.4.2 Requirements

This section specifies the requirements (both Required and Conditional) identified for the following:

- T&S system
- BITS

- General DISN NE requirements
- OTS functional devices
- Channel transport switching functional device
- Channel access grooming functional device
- IP Routers

#### *5.5.4.2.1 Timing and Synchronization System*

The T&S system consists of the combination of the BITS and the DISN NEs. This subsection specifies the requirements for the combined T&S system.

1. **[Required]** The T&S system shall conform to the Telcordia Technologies GR-1244-CORE and GR-253-CORE requirements for network timing and synchronization.
2. **[Required]** The T&S system shall conform to the Telcordia Technologies GR-1110 requirements for network T&S.
3. **[Required]** The T&S system shall provide for the external, line, loop, internal, and through timing modes as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
4. **[Required]** For the T&S system neither manual nor autonomous protection switching of clock reference sources or clock units, including manual removal of the active clock unit, shall cause any error on any traffic signal.
5. **[Required]** The T&S system shall provide synchronization status messages (SSMs) and shall conform to the timing message generation, validation, and reaction characteristics in accordance with Telcordia Technologies GR-253-CORE, Section 5.4 to preclude and detect timing loops within the SONET network.
6. **[Required]** The T&S system shall be able to provide a selectable timing option, which will generate timing on DS1s across the DISN to users connected to other DISN Access elements.
7. **[Required]** The T&S system shall be capable of meeting or exceeding the wander and transient specifications defined in Telcordia Technologies GR-1244-CORE.
8. **[Required]** The T&S physical interface for the external timing references shall be DS1 or E1, terminated and transformer-coupled, and compliant with ANSI T1.101 or ITU-T Recommendation G.703 and G.704, respectively.
9. **[Conditional]** If retiming of DS1 is required, the T&S system shall provide for equipment that retimes DS1 signals (e.g., external slip buffers, or NEs that support the bit-

synchronous digital signal 12 (DS12) to VT1.5 payload mapping as a non-proprietary feature).

10. **[Desired]** The T&S system should provide for the capability for a Time of Day (TOD) timestamp accuracy of +/- 10 ms. (Such capability may be a reference GPS, a Network Time Protocol (NTP) server, and sufficient NTP clients.)
11. **[Desired]** The DS1 transmitters of the T&S system should provide for user-provisionable line buildout (LBO) in a convenient range, such as 0-133, 134-266, 267-399, 400-532, and 533-655.

#### *5.5.4.2.2 Building Integrated Timing Supply*

This section specifies the requirements for the BITS including the reference clock and timing distribution system.

1. **[Desired]** The BITS system shall consist of two sets of duplicated clock hardware (i.e., four-fold clock redundancy) that can independently provide system timing. Each set shall consist of two physically separate clock systems. The clock system shall be implemented so that any clock failure, including a loss of a single clock shelf, shall not result in any traffic outage.
2. **[Required]** The BITS shall be compliant with ITU-T Recommendation G.811.
3. **[Required]** The BITS shall be capable of providing a clock signal formatted as electrical D-1 75 or 120 ohms according to ANSI T1.101.
4. **[Required]** The BITS shall be capable of providing a clock signal formatted as electrical E1 75 or 120 ohms according to ITU-T Recommendation G.732.

#### *5.5.4.2.3 General DISN NE Requirements*

This section specifies the general requirements for the DISN NEs.

1. **[Required]** The DISN NE shall be capable of slaving each interface to a specific timing source, such as BITS, internal Stratum 3E Clock, or the timing recovered from any selected port.
2. **[Required]** The DISN NE shall support errorless transitions between external timing and internal timing. An event is errorless if no SES is incurred by the event.

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3. **[Required]** The DISN NEs shall provide appropriate alarms and proper responses when the frequencies of the incoming signals differ in magnitude from their nominal frequency by more than 20 parts ppm.
4. **[Required]** The DISN NE shall provide for the external timing mode as defined in Telcordia Technologies GR-253-CORE, Issue 3, September 2000, Section 5.4.
  - a. **[Required]** The DISN NE shall be capable of receiving a BITS clock signal formatted as an electrical T1, AMI formatted ESF with SSM.
  - b. **[Required]** The DISN NE shall be capable of receiving a BITS clock signal formatted as an electrical E1 75 or 120 ohms according to ITU-T Recommendation G.732.
  - c. **[Required]** The DISN NE shall be capable of receiving two (i.e., primary and secondary) external BITS sources. It shall be capable of switching between the primary and secondary source, and the switch shall not cause any errors to be imparted on data traffic.
  - d. **[Required]** The DISN NEs shall be capable of accepting two (i.e., primary and secondary) external timing sources from a BITS system that is traceable to a Stratum 1 primary reference source, as defined Telcordia Technologies in GR-436-CORE and GR-253-CORE, Sections 5.4, and ANSI T1.101-1999.
5. **[Required]** The DISN NE shall support the Line timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
  - a. **[Required]** The DISN NE shall be capable of accepting its timing reference via a line interface from a SONET MSPP that is being timed from an upstream BITS as defined in Telcordia Technologies GR-253-CORE, Sections 5.4.
  - b. **[Required]** The DISN NEs shall be capable of accepting its timing reference via a line interface from an SDH MSPP that is being timed from an upstream BITS.
6. **[Required]** The DISN NE shall support the loop timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
7. **[Required]** The DISN NE shall support the internal timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
  - a. **[Required]** The DISN NE internal clock shall conform to Telcordia Technologies GR-253-CORE standards for Stratum 3E and higher sources.

- b. **[Required]** The DISN NE internal clock shall conform to Telcordia Technologies GR-253-CORE standards for SONET Minimum Clock (SMC) applications for Stratum 3 and higher sources as per GR-253-CORE, Section 5.4, for free run accuracy, holdover, pull-in/hold in, wander, jitter, phase transients, input tolerance, and transition from self-timing to normal timing modes.
  - c. **[Required]** The DISN NEs shall provide an error-free transition (i.e., no payload errors) between external and internal timing.
8. **[Required]** The DISN NE shall support the Through timing mode as defined in Telcordia Technologies GR-253-CORE, Sections 5.4.
  9. **[Conditional]** If the DISN NE terminates the SONET line layer (e.g., performs STS pointer processing) the system shall support derived DS1 features.

#### 5.5.4.2.4 *Optical Transport System*

This section specifies the specific requirements for the following modes of operation of the OTS for line system functions that require timing:

- Regeneration: In this mode of operation, the OTS NEs are able to provide efficient transparent transport of various client signals for one wavelength to another. This configuration is considered to be the “baseline” for a DISN primary site.
  - OTN/Proprietary Wrapping: In this mode of operation, the OTS adds additional overhead bits or bytes to individual client signals to support functions, such as FEC and protection switching at the optical layer, as part of the fully transparent multiplexing mode.
  - Partially Transparent Multiplexing: In mode of operation the OTS NEs that support this multiplexing function typically use proprietary methods to transfer as much of the information contained in the section and line overheads of the incoming client signals as possible through to the outgoing client signals at the far end.
1. **[Conditional]** If the OTS uses regeneration line system function, the T&S system shall provide for the following:
    - a. Through timing mode as defined in Telcordia Technologies TR-917 and GR-253-CORE, Issue 3, September 2000, Section 5.6

- b. Internal timing mode as defined in Telcordia Technologies TR-917

NOTE: loop, line, and external timing are not applicable to the regeneration function.

2. **[Conditional]** If the OTS uses OTN/Proprietary Wrapping line system function, the T&S system shall provide for the following:
  - a. Through timing mode as defined in ITU-T Recommendation G.8251
  - b. Internal timing mode as defined in ITU-T Recommendation G.8251
3. **[Conditional]** If the OTS uses a Partially Transparent Multiplexing Line System Function, the T&S system shall provide for the following:
  - a. External timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - b. Line timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - c. Internal ST3 timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - d. 27.4 SONET SSM as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - e. Derived DS1 as defined in Telcordia Technologies GR-253-CORE, Section 5.4

#### *5.5.4.2.5 Channel Transport Switching Functional Device*

This section specifies the specific requirements for the following modes of operation of the TSF functional device transport switching TS for Line System functions that require timing:

- SONET Line and Path Termination: In this mode of operation, the NE adjusts the STS pointers and terminates the SONET line layer (which, in turn, implies that the SONET section layer has been terminated. This mode of operation is considered the “baseline” for a DISN primary site.
- SONET Regeneration: In this mode of operation the TSF device supports a Regeneration function in addition to its (normal) SONET Line Termination function.

1. **[Conditional]** If the TSF device uses SONET line and path termination, the T&S system shall provide the following:

- a. External timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - b. Line timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - c. Internal timing as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - d. Derived DS1 as defined in Telcordia Technologies GR-253-CORE, Section 5.4
  - e. SONET SSM as defined in Telcordia Technologies GR-253-CORE, Section 5.4
2. **[Conditional]** If the TSF device uses SONET regeneration, the T&S system shall provide for the following:
- a. Through timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.6 and Telcordia Technologies TR-917.
  - b. Internal timing as defined in Telcordia Technologies TR-917.

#### 5.5.4.2.6 *Channel Access Grooming Functional Device*

This section specifies the specific requirements for the following mode of operation of the MSPP:

- **SONET Line and Path Termination**: This mode of operation is considered to be the “baseline” for a DISN primary site.
1. **[Conditional]** If the CAG functional device uses SONET line and path termination, the T&S system shall provide the following:
    - a. External timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
    - b. Line timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
    - c. Internal ST3 timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
    - d. Derived DS1 as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
  2. **[Conditional]** If a DS1 circuit requires retiming, the CAG functional device shall support DS1 retiming per channel and the retiming requirement shall comply with the

synchronization-related criteria in ANSI T1.101, and the electrical interface criteria in ANSI T1.102 and Telcordia Technologies GR-499-CORE.

#### *5.5.4.2.7 Router*

This section specifies the specific requirements for the following modes of operations of the IP Routers:

- SONET Line and Path Termination: This mode of operation requires only internal timing. It is consider the “baseline” for a DISN primary site.
  - DS1 Circuit Emulation Service (CES): For this mode of operation, the IP routers transport DS1 CES traffic.
1. **[Conditional]** If the IP router uses SONET line and path termination mode of operation, T&S system shall provide for internal SMC timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4.
  2. **[Conditional]** If the IP Router transport DS1 CES, the T&S system shall provide for the following:
    - a. External timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
    - b. Line timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
    - c. Internal SMC timing mode as defined in Telcordia Technologies GR-253-CORE, Section 5.4
    - d. Derived DS1 as defined in Telcordia Technologies GR-253-CORE, Section 5.4

#### *5.5.4.2.8 Standards Compliance Requirements*

The standards in effect when the equipment was first acquired are listed. Updates to the standards since that point in time are identified in brackets. When the manufacturer provides new components for the COTS items to the same device that satisfy updated standards, DISA will often purchase and install those components to accommodate growth, but will not replace existing components unless there is another reason to do so. As such, components will be operational within DISN that satisfy multiple versions of the standards. Testing will need to be undertaken using the standard release that applied to that component, where the revised standard cannot be satisfied by the original component.

1. **[Required]** ITU-T Recommendation G.703 (2001)
2. **[Required]** ITU-T Recommendation G.704 (1998)
3. **[Required]** ITU-T Recommendation G.732 (1988)
4. **[Required]** ITU-T Recommendation G.811 (1997)
5. **[Required]** ITU-T Recommendation G.8251 (2001)
6. **[Required]** ANSI T1.101
7. **[Required]** Telcordia Technologies GR-253-CORE, Issue 3, September 2000 (Issue 4, December 2005)
8. **[Required]** Telcordia Technologies TR-917, December 1990
9. **[Required]** Telcordia Technologies GR-1244-CORE, Issue 2, December 2000 (Issue 5, May 2005)

### **5.5.5 Planning Tools**

To aid in the design and implementation of the network, planning tools are required that model and cost-out the features of the equipment. For optical network design and implementation, an optical layer planning tool shall be provided that can model the OTS system over all anticipated DISN scenarios. Likewise, a TSF/CAG network planning tool shall be available that models the TSF switching and/or CAG aggregation.

#### **5.5.5.1 OTS Planning Tool**

1. **[Required]** A COTS OTS planning tool shall be available.
2. **[Required]** The OTS software planning tool shall be able to run on a standard PC.
3. **[Required]** The OTS planning tool shall enable the user to enter all fiber and other user-settable parameters via an Excel® spreadsheet input.
4. **[Required]** If the OTS planning tool offers a user friendly GUI with menu-driven commands, it shall also enable the network designer to enter all the parameters into a spreadsheet.

5. **[Required]** The OTS planning tool shall provide performance outputs on a per wavelength level for Q and OSNR.
  
6. **[Required]** The OTS planning tool shall enable variations in the following inputs for design purposes:
  - a. Total span loss
  - b. Length per span
  - c. Chromatic dispersion
  - d. Chromatic dispersion slope
  - e. PMD
  - f. Fiber type
  - g. Per channel optical power (transport-side)
  - h. Per channel bit rate
  - i. Per channel protocol
  - j. Per channel format
  - k. Alien wavelength parameters:
    - (1) Minimum optical input power (client-side)
    - (2) Maximum optical input power (client-side)
    - (3) Minimum extinction ratio
    - (4) Maximum extinction ratio
    - (5) Minimum receiver power
    - (6) Maximum receiver power
  
7. **[Required]** The OTS planning tool shall enable the network engineer to input user-settable parameters to create additional default fiber types. This shall include, but not be limited to, settings for:
  - a. Fiber-type/vintage
  - b. Optical attenuation
  - c. Chromatic dispersion
  - d. Chromatic dispersion slope
  - e. PMD
  - f. Effective area
  
8. **[Required]** The OTS planning tool shall enable a single span to consist of up to three types of different fibers for a mixed-fiber implementation analysis.
  
9. **[Required]** The OTS planning tool shall provide the option to set all optical channels to the same user-settable default values in the same amount of steps as a single optical channel setting.

10. **[Required]** If dispersion compensation modules are an option with the OTS, then the OTS planning tool shall provide both options: (1) the tool optimizes the choice and placement of the dispersion compensation modules, and (2) the network engineer chooses and places the dispersion compensation modules.
11. **[Required]** The OTS planning tool shall be capable of simulating and verifying all OTS capabilities, including, but not limited to, all OLA, ROADM, and terminal options.
12. **[Required]** The OTS planning tool shall address risk reduction and deployment design cost effectiveness before procurement, deployment, and service turn-up.
13. **[Required]** The OTS planning tool shall characterize the vendor's equipment in the following categories:
  - a. All optical transport
  - b. OEO functionality
  - c. Alien wavelength transport capability
14. **[Required]** The OTS planning tool shall have graphical views.
15. **[Required]** The OTS planning tool shall provide a topology view of the optical network.
16. **[Required]** If the OTS offers automatic optical protection switching, the OTS planning tool shall provide optical protection analysis.
17. **[Required]** The OTS planning tool shall provide mean time between failures (MTBF) and availability of the equipment.
18. **[Required]** The OTS planning tool shall provide amplifier and optical regeneration system placement analysis.
19. **[Required]** The OTS planning tool shall provide optimal cost solution analysis.
20. **[Required]** The OTS planning tool shall provide simulation through "what if" scenarios. This includes the ability to reset optical channel population distributions and other parameters one at a time and not needing to input an entire reload of data manually every time one parameter needs to be changed.
21. **[Required]** The OTS planning tool shall provide user-constraint settings for analysis.
22. **[Required]** The OTS planning tool shall provide automated failure (link and node) scenarios for analysis.

23. **[Required]** The OTS planning tool shall provide results through printable performance reports, and bill of materials on a per node and network basis with equipment breakdown.
24. **[Required]** The OTS planning tool shall include documentation that includes the following:
  - a. A functional overview on the operation of the tool,
  - b. The simulation engine used,
  - c. Instructions for the network designer to facilitate tool usage,
  - d. The acceptable performance levels (e.g., OSNR, Q) generated by the tool that are needed for  $10^{-15}$  BER transmissions, and
  - e. All limitations and capabilities/trade-off scenarios supported by the tool.

#### **5.5.5.2 Network Layer Planning Tool**

1. **[Required]** The network planning tool shall be able to run on a standard PC.
2. **[Required]** The network planning tool shall be capable of wavelength designations, if ITU grid optics is an option, to provide alien wavelength input to OTS planning tool.
3. **[Required]** The network planning tool shall be capable of digital switching and grooming simulation, analysis, and design.
4. **[Required]** The network planning tool shall enable the user to enter all digital signal demands and other user-settable parameters via an Excel spreadsheet input.
5. **[Required]** The network planning tool shall support emulation of the equipment link state and routing algorithms.
6. **[Required]** The network planning tool shall support user constraints supported by the equipment.
7. **[Required]** The network planning tool shall support protection and restoration features supported by the equipment.
8. **[Required]** The network planning tool shall support MTBF and availability calculations and analysis.

9. **[Required]** The network planning tool shall support optimal cost solution modeling.
10. **[Required]** The network planning tool shall support simulation through “what if” scenarios. The vendor shall list all trade-off scenarios that the network planning tool supports.
11. **[Required]** The network planning tool shall support printable node, link, and connection reports, including the generation of a bill of materials.
12. **[Required]** The network planning tool shall support automated failure (link and node) scenarios.
13. **[Required]** The network planning tool shall have graphical views for all “what if” scenarios.
14. **[Required]** If the network planning tool includes a user friendly GUI with menu-driven user interfaces, then it shall also enable the network designer to enter all the parameters into a spreadsheet.
15. **[Required]** The network planning tool shall support a topology view of the network.
16. **[Required]** The network planning tool shall support traffic engineering.
17. **[Required]** The network planning tool shall support traffic variation analysis.

### **5.5.6 DISN Router Requirements**

The DISN uses a variety of makes and models of routers. The integration of these routers into the DISN architecture is dependent on capabilities, such as backplane capacity and available interfaces. It is customary to assign names to such routers to depict their placement in the architecture. Examples would be P routers and PE routers. Typically, the higher backplane routers, which also support high bandwidth but low port density interfaces, are used in the core of the DISN. However, as technologies evolve, no specific make or model of router should be limited to a particular place in the architecture.

#### **5.5.6.1 Interface Requirements**

The interface requirements specified in the following paragraphs will be implemented on all DISN routers as appropriate for specific DISN infrastructure and customer requirements. All IPv6 implementations shall be capable of legacy support of IPv4.

*5.5.6.1.1 Packet over SONET Interface Requirements*

1. **[Required]** The core NE shall support OC-3c/STM-1 Packet Over SONET (POS) interfaces.
2. **[Required]** The OC-3c/STM-1 POS interfaces shall be configurable to support either SONET or SDH framing.
3. **[Required]** The OC-3c/STM-1 POS interfaces shall conform to ANSI T1.105-2001.
4. **[Required]** The OC-3c/STM-1 POS interfaces shall conform to Telcordia Technologies GR-253-CORE, Issue 4, December 2005, Sections 3, 4, and 5.
5. **[Required]** The OC-3c/STM-1 POS interfaces shall conform to ITU-T Recommendation G.707 and ITU-T Recommendation G.957.
6. **[Required]** The OC-3c/STM-1 POS interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
7. **[Required]** The OC-3c/STM-1 POS interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
8. **[Required]** The definition, generation, and function of the OC-3c/STM-1 POS interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.
9. **[Required]** The definition, generation, and function of the OC-3c/STM-1 SDH interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
10. **[Required]** The OC-3c/STM-1 POS interfaces shall ignore the value contained in unused bits/bytes.
11. **[Required]** The OC-3c/STM-1 POS interfaces shall support point-to-point frame relay encapsulation for link layer framing of packets as defined by RFC 2427.
12. **[Required]** The OC-3c/STM-1 POS interfaces shall support Point-to-Point Protocol (PPP) for link layer framing of packets as defined by RFCs 1662 and 2615.
13. **[Required]** The OC-3c/STM-1 POS interfaces shall support High-Level Data Link Control (HDLC) for link layer framing of packets.

14. **[Required]** The OC-3c/STM-1 POS interfaces shall allow separate Maximum Transmission Unit (MTU) sizes for unlabeled network layer packets and labeled MPLS packets.
15. **[Required]** The OC-3c/STM-1 POS interfaces shall support an MTU size of at least 4470 bytes.
16. **[Required]** The OC-3c/STM-1 POS interfaces shall support appropriate in-band routing and control protocols, such as Intermediate System to Intermediate System (IS-IS), Resource Reservation Protocol (RSVP), and Border Gateway Protocol (BGP).
17. **[Required]** The OC-3c/STM-1 POS interfaces shall support the transport of IPv6 packets.
18. **[Required]** The OC-3c/STM-1 POS interfaces shall clock transmitted data based on an internal source clock.
19. **[Required]** The OC-3c/STM-1 POS interfaces shall clock transmitted data based on an external source clock recovered from the received line.
20. **[Required]** The NE shall support OC-12c/STM-4 POS interfaces.
21. **[Required]** The OC-12c/STM-4 POS interfaces shall be configurable to support either SONET or SDH framing.
22. **[Required]** The OC-12c/STM-4 POS interfaces shall conform to ANSI T1.105-2001.
23. **[Required]** The OC-12c/STM-4 POS interfaces shall conform to Telcordia Technologies GR-253-CORE, Issue 4, December 2005, Sections 3, 4, and 5.
24. **[Required]** The OC-12c/STM-4 POS interfaces shall conform to ITU-T Recommendation G.707, and Recommendation G.957.
25. **[Required]** The OC-12c/STM-4 POS interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
26. **[Required]** The OC-12c/STM-4 POS interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
27. **[Required]** The definition, generation, and function of the OC-12c/STM-4 POS interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.

28. **[Required]** The definition, generation, and function of the OC-12c/STM-4 POS interface SDH overhead and pointer processing shall follow standards defined in ITU-T G.707.
29. **[Required]** The OC-12c/STM-4 POS interfaces shall ignore the value contained in unused bits/bytes.
30. **[Required]** The OC-12c/STM-4 POS interfaces shall support point-to-point frame relay encapsulation for link layer framing of packets as defined by RFC 2427.
31. **[Required]** The OC-12c/STM-4 POS interfaces shall support PPP for link layer framing of packets as defined by RFCs 1662 and 2615.
32. **[Required]** The OC-12c/STM-4 POS interfaces shall support HDLC for link layer framing of packets.
33. **[Required]** The OC-12c/STM-4 POS interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
34. **[Required]** The OC-12c/STM-4 POS interfaces shall support an MTU size of at least 4470 bytes.
35. **[Required]** The OC-12c/STM-4 POS interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and internal BGP.
36. **[Required]** The OC-12c/STM-4 POS interfaces shall support the transport of IPv6 packets.
37. **[Required]** The OC-12c/STM-4 POS interfaces shall clock transmitted data based on an internal source clock.
38. **[Required]** The OC-12c/STM-4 POS interfaces shall clock transmitted data based on an external source clock recovered from the received line.
39. **[Required]** The NE shall support OC-48c/ STM-16 POS interfaces.
40. **[Required]** The OC-48c/STM-16 POS interfaces shall be configurable to support either SONET or SDH framing.
41. **[Required]** The OC-48c/STM-16 POS interfaces shall conform to ANSI T1.105-2001.
42. **[Required]** The OC-48c/STM-16 POS interfaces shall conform to Telcordia Technologies GR-253-CORE Sections 3, 4, and 5.

43. **[Required]** The OC-48c/STM-16 POS interfaces shall conform to ITU-T Recommendations G.707 and G.957.
44. **[Required]** The OC-48c/STM-16 POS interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
45. **[Required]** The OC-48c/STM-16 POS interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
46. **[Required]** The definition, generation, and function of the OC-48c/STM-16 POS interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.
47. **[Required]** The definition, generation, and function of the OC-48c/STM-16 POS interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
48. **[Required]** The OC-48c/STM-16 POS interfaces shall ignore the value contained in unused bits/bytes.
49. **[Required]** The OC-48c/STM-16 POS interfaces shall support point-to-point frame relay encapsulation for link layer framing of packets as defined by RFC 2427.
50. **[Required]** The OC-48c/STM-16 POS interfaces shall support PPP for link layer framing of packets as defined by RFCs 1662 and 2615.
51. **[Required]** The OC-48c/STM-16 POS interfaces shall support HDLC for link layer framing of packets.
52. **[Required]** The OC-48c/STM-16 POS interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
53. **[Required]** The OC-48c/STM-16 POS interfaces shall support an MTU size of at least 4470 bytes.
54. **[Required]** The OC-48c/STM-16 POS interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
55. **[Required]** The OC-48c/STM-16 POS interfaces shall support the transport of IPv6 packets.

56. **[Required]** The OC-48c/STM-16 POS interfaces shall clock transmitted data based on an internal source clock.
57. **[Required]** The OC-48c/STM-16 POS interfaces shall clock transmitted data based on an external source clock recovered from the received line.
58. **[Required]** The NE shall support OC-192c/STM-64 POS interfaces.
59. **[Required]** The OC-192c/STM-64 POS interfaces shall be configurable to support either SONET or SDH framing.
60. **[Required]** The OC-192c/STM-64 POS interfaces shall conform to ANSI T1.105-2001.
61. **[Required]** The OC-192c/STM-64 POS interfaces shall conform to Telcordia Technologies GR-253-CORE, Issue 4, December 2005, Sections 3, 4, and 5.
62. **[Required]** The OC-192c/STM-64 interfaces shall conform to ITU-T Recommendation G.691.
63. **[Required]** The OC-192c/STM-64 POS interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
64. **[Required]** The OC-192c/STM-64 POS interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
65. **[Required]** The definition, generation, and function of the OC-192c/STM-64 POS interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.
66. **[Required]** The definition, generation, and function of the OC-192c/STM-64 POS interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
67. **[Required]** The OC-192c/STM-64 POS interfaces shall ignore the value contained in unused bits/bytes.
68. **[Required]** The OC-192c/STM-64 POS interfaces shall support point-to-point frame relay encapsulation for link layer framing of packets as defined by RFC 2427.
69. **[Required]** The OC-192c/STM-64 POS interfaces shall support PPP for link layer framing of packets as defined by RFCs 1662 and 2615.

70. **[Required]** The OC-192c/STM-64 POS interfaces shall support HDLC for link layer framing of packets.
71. **[Required]** The OC-192c/STM-64 POS interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
72. **[Required]** The OC-192c/STM-64 POS interfaces shall support an MTU size of at least 4470 bytes.
73. **[Required]** The OC-192c/STM-64 POS interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
74. **[Required]** The OC-192c/STM-64 POS interfaces shall support the transport of IPv6 packets.
75. **[Required]** The OC-192c/STM-64 POS interfaces shall support VSR optics as defined by the Optical Internetworking Forum (OIF).
76. **[Required]** The OC-192c/STM-64 POS interfaces shall clock transmitted data based on an internal source clock.
77. **[Required]** The OC-192c/STM-64 POS interfaces shall clock transmitted data based on an external source clock recovered from the received line.
78. **[Conditional]** The NE shall support OC-768c/STM-256 POS interfaces.

#### *5.5.6.1.2 ATM Interface Requirements*

1. **[Required]** The NE shall support OC-12c/STM-4 ATM interfaces.
2. **[Required]** The OC-12c/STM-4 ATM interfaces shall be configurable to support either SONET or SDH framing.
3. **[Required]** The OC-12c/STM-4 ATM interfaces shall conform to ANSI T1.105-2001.
4. **[Required]** The OC-12c/STM-4 ATM interfaces shall conform to Telcordia Technologies GR-253-CORE, issue 4, December 2005, Sections 3, 4, and 5.
5. **[Required]** The OC-12c/STM-4 ATM interfaces shall conform to ITU-T Recommendations G.707 and G.957.

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6. **[Required]** The OC-12c/STM-4 ATM interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
7. **[Required]** The OC-12c/STM-4 ATM interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
8. **[Required]** The definition, generation, and function of the OC-12c/STM-4 ATM interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.
9. **[Required]** The definition, generation, and function of the OC-12c/STM-4 ATM interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
10. **[Required]** The OC-12c/STM-4 ATM interfaces shall ignore the value contained in unused bits/bytes.
11. **[Required]** The OC-12c/STM-4 ATM interfaces shall provide segmentation and reassembly (SAR) of IP packets for transport over ATM Adaptation Layer 5 (AAL5) as defined by RFC 2684.
12. **[Required]** The OC-12c/STM-4 ATM interfaces shall support the ATM Forum UNI.
13. **[Required]** The OC-12c/STM-4 ATM interfaces shall support the ATM Forum UNI 4.1.
14. **[Required]** The OC-12c/STM-4 ATM interfaces shall support the ATM Forum Integrated Local Management Interface (ILMI).
15. **[Required]** The OC-12c/STM-4 ATM interfaces shall support F5 O&AM.
16. **[Required]** The OC-12c/STM-4 ATM interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
17. **[Required]** The OC-12c/STM-4 ATM interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
18. **[Required]** The OC-12c/STM-4 ATM interfaces shall support the transport of IPv6 packets.
19. **[Required]** The OC-12c/STM-4 ATM interfaces shall clock transmitted data based on an internal source clock.

20. **[Required]** The OC-12c/STM-4 ATM interfaces shall clock transmitted data based on an external source clock recovered from the received line.
21. **[Required]** The NE shall support OC-48c/STM-16 ATM interfaces.
22. **[Required]** The OC-48c/STM-16 ATM interfaces shall be configurable to support either SONET or SDH framing.
23. **[Required]** The OC-48c/STM-16 ATM interfaces shall conform to ANSI T1.105-2001.
24. **[Required]** The OC-48c/STM-16 ATM interfaces shall conform to Telcordia Technologies GR-253-CORE, Issue 4, December 2005, Sections 3, 4, and 5.
25. **[Required]** The OC-48c/STM-16 ATM interfaces shall conform to ITU-T Recommendations G.707 and G.957.
26. **[Required]** The OC-48c/STM-16 ATM interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
27. **[Required]** The OC-48c/STM-16 ATM interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
28. **[Required]** The definition, generation, and function of the OC-48c/STM-16 ATM interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.
29. **[Required]** The definition, generation, and function of the OC-48c/STM-16 ATM interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
30. **[Required]** The OC-48c/STM-16 ATM interfaces shall ignore the value contained in unused bits/bytes.
31. **[Required]** The OC-48c/STM-16 ATM interfaces shall provide SAR of IP packets for transport over AAL5 as defined by RFC 2684.
32. **[Required]** The OC-48c/STM-16 ATM interfaces shall support the ATM Forum UNI.
33. **[Required]** The OC-48c/STM-16 ATM interfaces shall support the ATM Forum UNI 4.1.
34. **[Required]** The OC-48c/STM-16 ATM interfaces shall support the ATM Forum ILMI.

35. **[Required]** The OC-48c/STM-16 ATM interfaces shall support F5 O&AM.
36. **[Required]** The OC-48c/STM-16 ATM interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
37. **[Required]** The OC-48c/STM-16 ATM interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
38. **[Required]** The OC-48c/STM-16 ATM interfaces shall support the transport of IPv6 packets.
39. **[Required]** The OC-48c/STM-16 ATM interfaces shall clock transmitted data based on an internal source clock.
40. **[Required]** The OC-48c/STM-16 ATM interfaces shall clock transmitted data based on an external source clock recovered from the received line.
41. **[Required]** The NE shall support OC-192c/STM-64 ATM interfaces.
42. **[Required]** The OC-192c/STM-64 ATM interfaces shall be configurable to support either SONET or SDH framing.
43. **[Required]** The OC-192c/STM-64 ATM interfaces shall conform to ANSI T1.105-2001.
44. **[Required]** The OC-192c/STM-64 ATM interfaces shall conform to Telcordia Technologies GR-253-CORE, Issue 4, December 2005, Sections 3, 4, and 5.
45. **[Required]** The OC-192c/STM-64 ATM interfaces shall conform to ITU-T Recommendation G.691.
46. **[Required]** The OC-192c/STM-64 ATM interfaces shall provide the standard SONET STS-1, STS-N, and STS-Nc frame structures defined in ANSI T1.105-2001.
47. **[Required]** The OC-192c/STM-64 ATM interfaces shall provide the standard SDH AU-3, AU-4, and AU-4-Xc frame structures defined in ITU-T Recommendation G.707.
48. **[Required]** The definition, generation, and function of the OC-192c/STM-64 ATM interface SONET overhead and pointer processing shall follow standards defined in ANSI T1.105-2001.

49. **[Required]** The definition, generation, and function of the OC-192c/STM-64 ATM interface SDH overhead and pointer processing shall follow standards defined in ITU-T Recommendation G.707.
50. **[Required]** The OC-192c/STM-64 ATM interfaces shall ignore the value contained in unused bits/bytes.
51. **[Required]** The OC-192c/STM-64 ATM interfaces shall provide SAR of IP packets for transport over AAL5 defined by RFC 2684.
52. **[Required]** The OC-192c/STM-64 ATM interfaces shall support the ATM Forum UNI.
53. **[Required]** The OC-192c/STM-64 ATM interfaces shall support the ATM Forum UNI 4.1.
54. **[Required]** The OC-192c/STM-64 ATM interfaces shall support the ATM Forum ILMI.
55. **[Required]** The OC-192c/STM-64 ATM interfaces shall support F5 O&AM.
56. **[Required]** The OC-192c/STM-64 ATM interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
57. **[Required]** The OC-192c/STM-64 ATM interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
58. **[Required]** The OC-192c/STM-64 ATM interfaces shall support the transport of IPv6 packets.
59. **[Required]** The OC-192c/STM-64 ATM interfaces shall support VSR optics as defined by the OIF.
60. **[Required]** The OC-192c/STM-64 ATM interfaces shall clock transmitted data based on internal source clock.
61. **[Required]** The OC-192c/STM-64 ATM interfaces shall clock transmitted data based on external source clock recovered from the received line.

#### *5.5.6.1.3 Ethernet Interface Requirements*

1. **[Required]** The NE shall support GbE interfaces.
2. **[Required]** Gigabit Ethernet interfaces shall comply with IEEE 802.3-2002.

3. **[Required]** Gigabit Ethernet interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
4. **[Required]** Gigabit Ethernet interfaces shall support an MTU size of at least 4470 bytes.
5. **[Required]** Gigabit Ethernet interfaces shall support modular, interchangeable optics for SR applications over standard MMF optic cable and extended reach applications over standard single-mode fiber optic cable.
6. **[Required]** Gigabit Ethernet interfaces shall support appropriate in-band routing and control protocols, such as IS-IS, RSVP, and BGP.
7. **[Required]** The NE shall support 10GbE interfaces.
8. **[Required]** The 10GbE interfaces shall comply with IEEE 802.3ae-2002.
9. **[Required]** The 10GbE interfaces shall support VLAN and priority tagging, as defined by IEEE 802.1Q-1998.
10. **[Required]** The 10GbE interfaces shall allow separate MTU sizes for unlabeled network layer packets and labeled MPLS packets.
11. **[Required]** The 10GbE interfaces shall support an MTU size of at least 4470 bytes
12. **[Required]** The 10GbE interfaces shall support appropriate in-band routing and control protocols. These will include IS-IS, RSVP, Protocol Independent Multicast (PIM), Open Shortest Path Fiber (OSPF), Multi-Protocol Border Gateway Protocol (MPBGP) and Border Gateway Protocol 4 (BGP4).
13. **[Required]** The 10GbE interfaces shall support the transport of IPv6 packets.

#### *5.5.6.1.4 Packet Ring Requirements*

1. **[Required]** The NE shall support packet ring technology interfaces, e.g., IEEE 802.17 RPR Working Group.
2. **[Required]** The NE shall support OC-12c/STM-4 packet ring interfaces.
3. **[Required]** The NE shall support OC-48c/STM-16 packet ring interfaces.
4. **[Required]** The NE shall support OC-192c/STM-64 packet ring interfaces.

### 5.5.6.2 *IPv6 Requirements*

The IPv6 requirements for routers must be compliant with the requirements specified in the DoD IPv6 Profile, version 5.0, and UCR 2008, Change 2, Section 5.3.5, IPv6 Requirements.

### 5.5.6.3 *Performance Requirements*

1. **[Required]** The switch fabric shall be non-blocking while operating at maximum full-duplex rate and bandwidth in a fully loaded chassis.
2. **[Required]** Interfaces shall forward at maximum rate for all packet sizes, including 40-byte IPv4 packets, while offering simultaneous services to include ACL filtering, policy routing, and packet marking.
3. **[Required]** Neither internal nor external control plane signaling shall be interrupted by fully loaded data forwarding.
4. **[Required]** Packet loss within the DISN Router, for reasons other than congestion, lack of route, or external corruption, shall be less than 0.1 percent under full load.
5. **[Required]** The NE shall support 10,000 multicast groups with a minimum of 150,000 forwarding cache entries.
6. **[Required]** The NE shall support QoS-aware multicast over DiffServ as discussed in IETF draft-bianchi-qos-multicast-over-diffserv.
7. **[Conditional]** The NE shall be ready to accept 40 Gbps interfaces without chassis replacement, including POS, Ethernet, and ITU-T Recommendation G.709.

#### 5.5.6.3.1 *IS-IS Requirements*

1. **[Required]** The NE shall implement the Integrated Intermediate System to Intermediate System (IS-IS) Routing Protocol as specified in RFCs 5304 and 1142.
2. **[Required]** The implementation of the IS-IS Protocol on the Provider NE shall interoperate with the implementation of the IS-IS protocol on the PE NE.
3. **[Required]** The NE shall be able to authenticate IS-IS routing updates using the HMAC-MD5 algorithm, as specified in RFC 5304.
4. **[Required]** The NE shall support the IS-IS extensions for traffic engineering as specified in RFC 5305.

5. **[Required]** The NE shall support the extended Intermediate System (IS) reachability Type-Length-Value (TLV) 22 with sub-TLV18: default metric traffic engineering, as specified in RFC 5305.
6. **[Required]** The NE shall support the extended IP reachability TLV 135 with the up/down bit as specified in RFC 5305.
7. **[Required]** The NE shall support the Traffic Engineering NE ID TLV 134 as specified in RFC 5305.
8. **[Required]** The NE shall support the IS-IS extended IS reachability TLV 22 with sub-TLV 3: administrative group as defined in RFC 5305.
9. **[Required]** The NE shall support the IS-IS Extended IS reachability TLV 22 with sub-TLV 6: IPv4 Interface Address as specified in RFC 5305.
10. **[Required]** The NE shall support the IS-IS extended IS reachability TLV 22 with sub-TLV 8: IPv4 neighbor address as specified in RFC 5305.
11. **[Required]** The NE shall support the IS-IS extended IS reachability TLV 22 with sub-TLV 9: IPv4 Maximum Link Bandwidth as specified in RFC 5305.
12. **[Required]** The NE shall support the IS-IS Extended IS reachability TLV 22 with sub-TLV 10: Reservable Link Bandwidth as specified in RFC 5305.
13. **[Required]** The NE shall support the IS-IS extended IS reachability TLV 22 with sub-TLV, 11: Unreserved Bandwidth (eight values for priorities 0 through 7) as specified in RFC 5305.
14. **[Required]** The NE shall be compatible with known IS-IS TLV code points as defined in RFC 3359 (i.e. the NE should only use the code points specified in the RFC for the purpose specified in RFC 3359).
15. **[Required]** The NE shall be able to restart the IS-IS routing process and initiate database synchronization without cycling adjacencies through a down state, as described in RFC 5306.
16. **[Required]** The NE shall be able to treat an Ethernet interface that is directly connected to a neighboring NE as a point-to-point circuit with regard to IS-IS routing as specified in RFC 5309.

17. **[Required]** The NE shall be able to reduce the flooding of redundant Link State Protocol Data Unit (LSPs) in IS-IS topologies as specified in RFC 2973.
18. **[Required]** The NE shall be able to dynamically exchange IS-IS hostnames as specified in RFC 5301.
19. **[Required]** The NE shall be able to eliminate IS-IS reliance on reliable protocols at the link layer for point-to-point links as specified in RFC 5303.
20. **[Required]** The core router shall be able to support two new TLVs, a reachability TLV and an interface address TLV, to distribute the necessary IPv6 information throughout a routing domain, as specified in RFC 5308.
21. **[Required]** The core router shall be able to support three new TLVs and two new sub-TLVs of the extended IS reachability TLV, that allow a constrained shortest path first (CSPF) algorithm to calculate traffic-engineered routes using IPv6 addresses, as specified in draft-ietf-isis-ipv6-te.
22. **[Required]** The NE shall recognize IS-IS TLVs defined for Generalized MPLS (GMPLS) traffic-engineering links as specified in the RFC 5307.
23. **[Required]** The NE shall act as an IS-IS Level 1 NE.
24. **[Required]** The NE shall act as an IS-IS Level 2 NE.
25. **[Required]** The NE shall act as an IS-IS Level 1/Level 2 NE.
26. **[Required]** The NE shall be able to perform incremental shortest path first (SPF) calculations, rather than a full calculation, after minor changes in the network topology.
27. **[Required]** The NE shall begin to forward packets on the new route within 50 ms of receiving an LSP that causes the NE to change the SPF route.
28. **[Required]** The NE shall be able to apply filter/access lists to the control plane including route policy to control IS-IS route leaking.
29. **[Required]** The NE shall be able to maintain a minimum of 1,000 prefixes in the IS-IS database.
30. **[Conditional]** The NE shall be able to maintain a minimum of 10,000 prefixes in the IS-IS database.

31. **[Required]** The NE shall support a minimum of 10 IS-IS neighbors (adjacencies).
32. **[Conditional]** The NE shall support a minimum of 50 IS-IS neighbors (adjacencies).
33. **[Conditional]** The NE shall support traffic load distribution over at least four equal-cost nearest-neighbor links between NE while maintaining per-flow packet sequence order.
34. **[Conditional]** The NE shall support multiple independent instances of IS-IS to offer alternate topologies for different services.

#### **5.5.6.4 OSPF Requirements**

1. **[Required]** The NE shall support the OSPF Link State Protocol as defined by RFC 2328.
2. **[Required]** The NE shall support OSPF for IPv6 as defined in RFC 5340.

#### **5.5.6.5 BGP Requirements**

1. **[Required]** The NE shall support the BGP4, as specified in RFCs 4271 and 1772 for the exchange of network reachability information with external networks External BGP (eBGP) and the distribution of external network reachability with internal neighbors Internal BGP (iBGP).
2. **[Required]** The NE shall support the MP-BGP Sub-Address Family Identifier (SAFI) for multicast addresses as specified in RFC 4760.
3. **[Required]** The NE shall support MP-BGP SAFI for global unicast IPv6 addresses as specified in RFC 4760.
4. **[Required]** The NE shall support MP-BGP SAFI for MPLS Layer 3 VPN-IPv4 as specified in RFCs 4364 and RFC 4760.
5. **[Required]** The implementation of the BGP-4/MP-BGP protocol on the Provider NE shall interoperate with the implementation of the BGP-4/MP-BGP protocol on the PE NE.
6. **[Required]** The NE shall be able to authenticate BGP routing information using an MD5 signature as specified in RFC 5925.
7. **[Required]** The NE shall be able to reduce routing oscillations by dampening updates associated with unstable routes as specified in RFC 2439.

8. **[Required]** Enhancements to the BGP-4 protocol to mitigate against the persistent BGP route oscillations introduced in particular configurations that use route reflection or confederation in conjunction with the MULTI\_EXIT\_DISC attribute as documented in RFC 3345.
9. **[Required]** The NE shall be able to tag routes on ingress and egress for common group identification and administration using the Communities attribute as specified in RFC 1997.
10. **[Required]** The NE shall support the Extended Community attribute that extends the range of the Community attribute and adds a Type field for structure of the community space as specified in the RFC 4360.
11. **[Required]** The NE shall be able to distribute an MPLS label with a route in the same update message as specified in RFC 3107.
12. **[Required]** The NE shall be able to act as a BGP route reflector as specified in RFC 4456.
13. **[Required]** The NE shall be able to act as an MP-BGP route reflector.
14. **[Required]** The NE shall be able to participate as a BGP NE within a confederation of autonomous systems that is represented as a single autonomous system to BGP peers external to the confederation as specified in RFC 5065.
15. **[Required]** The NE shall be able to negotiate capabilities with a BGP neighbor by sending and receiving the optional Capabilities parameter as specified in RFC 5492.
16. **[Required]** The NE shall be able to request and respond to requests for re-advertisement of the BGP neighbor outbound routing information base (Adj-RIB-Out) as specified in RFC 2918.
17. **[Required]** The NE shall be able to restart the BGP routing process and initiate database synchronization with neighbors while preserving a forwarding state as specified in RFC 4724.
18. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on prefix.
19. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on a community string.

20. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on address family.
21. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on an Autonomous System (AS) path.
22. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on a BGP next-hop.
23. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on multi-exit discriminator.
24. **[Required]** The NE shall be able to apply policy to affect route acceptance and forwarding based on a local preference.
25. **[Required]** The NE shall be able to perform eBGP multihop to allow two non-directly connected peers to exchange eBGP.
26. **[Required]** The NE shall support the BGP TTL security hack as specified in IETF draft-gill-btsh-02.
27. **[Required]** The NE shall be able to logically group neighbors with similar policy attributes to avoid Routing Information Base (RIB) duplication.
28. **[Required]** The NE shall support multiple configurable NE IDs Router ID (RID) and corresponding routable source address, (e.g., multiple loopback interfaces each with a unique address or single loopback with multiple addresses, to separate and uniquely identify each unicast, multicast, and VPN address family supported.
29. **[Required]** The NE shall stabilize its BGP routing table without requiring intervention or assistance after a full system or routing restart.
30. **[Required]** The NE shall support a minimum of 200,000 best path BGP entries that are unique from each other in a prefix or subnet.
31. **[Conditional]** The NE shall support a minimum of 400,000 best path BGP entries that are unique from each other in prefix or subnet in addition to 600,000 routes that provide alternate paths to those prefixes or subnets.
32. **[Required]** The NE shall support 100 distinct internal neighbors that are not logically grouped to optimize memory or update processing.

33. **[Conditional]** The NE shall support 200 distinct internal neighbors that are not logically grouped to optimize memory or update processing.
34. **[Required]** The NE shall support 100 distinct external neighbors that are not logically grouped to optimize memory or update processing.
35. **[Conditional]** The NE shall support 200 distinct external neighbors that are not logically grouped to optimize memory or update processing.

#### **5.5.6.6**     ***MPLS Requirements***

1. **[Required]** The NE shall act as an MPLS Label Switching Router (LSR) by forwarding inbound labeled packets based on the contents of the packet MPLS header and performing label swapping (inbound packet label pop and outbound packet label push) as defined in RFC 3031.
2. **[Required]** The NE shall act as an MPLS Label Edge Router (LER) by pushing a label onto packets when at the Label Switched Path (LSP) ingress and popping a label off packets when at the LSP egress.
3. **[Required]** The NE shall possess encoding capabilities to produce a valid MPLS-labeled packet from a given label stack and a network layer packet as defined by RFC 3032, Section 2.1.
4. **[Conditional]** The NE shall support label stacks consisting of at least three labels.
5. **[Conditional]** The NE shall support load sharing between multiple LSPs with the same ingress and egress LERs.

#### **5.5.6.7**     ***RSVP Requirements***

1. **[Required]** The NE shall use extensions to RSVP to establish MPLS LSP and enable constraint-based routing traffic engineering as defined by RFC 3209.
2. **[Required]** The implementation of the RSVP on the Provider NE shall interoperate with the implementation of the RSVP on the PE NE.
3. **[Required]** The NE shall authenticate the integrity of RSVP requests for MPLS LSPs as defined by RFC 2747 and updated by RFC 3097.
4. **[Required]** The NE shall support the Summary Refresh Message to reduce the processing overhead requirements of RSVP refresh messages as defined by RFC 2961.

5. **[Required]** The NE shall support the Bundle Message to reduce the processing overhead requirements of RSVP refresh messages as defined by RFC 2961.
6. **[Required]** The NE shall be able to dynamically signal and enforce different bandwidth constraints for different classes of traffic that are transported over separately routed constraint-based LSPs as defined by RFC 4124.
7. **[Required]** The NE shall support Forwarding Adjacencies (FAs) and hierarchal or nested label switched paths as described in RFC 4206.
8. **[Required]** The NE shall support extensions to RSVP for Generalized MPLS (GMPLS) as specified in RFC 4201.
9. **[Required]** The NE shall support protocols for requesting and accepting resources from other physical and link layer NEs and signaling GMPLS traffic-engineered links between nodes as defined by RFC 4204 and OIF UNI 1.0.
10. **[Required]** The NE shall support the bundling of multiple component links into a single logical traffic-engineered bundled link as specified in RFC 4201.
11. **[Required]** The NE shall be able to locally repair an RSVP-Traffic Engineering (RSVP-TE) LSP within 50 ms of downstream link or node failure by rerouting the LSP traffic around the failure using both the one-to-one backup and the facility backup methods as specified in RFCs 4090 and 5462.
12. **[Required]** The NE acting as an ingress MPLS label edge NE shall reroute data traffic to a secondary presignaled LSP in less than 20 ms upon indication of the primary LSP failure.
13. **[Required]** The NE shall support 10,000 bidirectional traffic-engineered LSPs acting as an intermediate LSR.
14. **[Required]** The NE shall be able to originate 500 traffic-engineered LSPs and terminate the same number.

#### **5.5.6.8 LDP Requirements**

1. **[Required]** The NE shall support the Label Distribution Protocol (LDP) for MPLS downstream-unsolicited label distribution as defined by RFC 5036.
2. **[Required]** The implementation of the LDP shall interoperate with the implementation of the LDP on approved NE.

### 5.5.6.9 *DiffServ Requirements*

1. **[Required]** The NE shall support DiffServ in accordance with RFCs 2474 and 3140 as updated by 3168, 3260.
2. **[Required]** The NE shall support the DiffServ EF PHB and code point assignment as defined by RFC 3246.
3. **[Required]** The NE shall support the DiffServ AF PHB classes and code point assignments as defined by RFC 2597 as updated by 3260.
4. **[Required]** The NE shall support DiffServ over MPLS by mapping the DSCP of packets received into MPLS EXP-Inferred LSPs (E-LSP) as defined by RFC 3270 as updated by 5462.
5. **[Required]** The NE shall support DiffServ over MPLS by mapping DSCP code points of packets received into Label-Only-Inferred LSPs (L-LSPs) as defined by RFC 3270 as updated by 5462.
6. **[Conditional]** The NE shall support the 16-bit encoding mechanism for the identification of DiffServ PHB in protocol messages, including both code points defined by standards action and code points not defined by standards action, as specified in RFC 3140.

### 5.5.6.10 *Intserv Requirements*

1. **[Required]** The NE shall support Integrated Services (Intserv) using RSVP for user-signaled per-flow QoS requirements and for reservation of resources as defined by RFCs 2205 and 2210.
2. **[Required]** The NE shall provide Intserv Controlled Load service, which offers a customer service with a low average delay with limited packet loss as defined by RFC 2211.
3. **[Required]** The NE shall provide Intserv Guaranteed service, which offers customers a precisely bounded maximum delay with no packet loss as defined by RFC 2212.
4. **[Required]** The NE shall support preemption priority policy for signaled policy-based admission protocols used to establish MPLS LSPs as an alternate preemption mechanism to DiffServ as defined by RFC 3181. In particular, RSVP will be supported.

### ***5.5.6.11 Congestion Control Requirements***

1. **[Required]** The NE shall provide congestion control based on the EXP field in the MPLS header for E-LSP packets.
2. **[Required]** The NE shall provide congestion control based on the DSCP for IPv4 packets.
3. **[Required]** The NE shall provide congestion control based on the Traffic Class field for IPv6 packets.

### ***5.5.6.12 Queuing Requirements***

1. **[Required]** The NE shall queue packets based on the EXP field in the MPLS header for E-LSP packets.
2. **[Required]** The NE shall queue packets based on the DSCP for IPv4 packets.
3. **[Required]** The NE shall queue packets based on the Traffic Class field for IPv6 packets.

### ***5.5.6.13 Multicast Requirements***

1. **[Required]** The NE shall support Protocol Independent Multicast-Sparse Mode (PIM-SM) as defined by RFCs 2362 and 5059.
2. **[Required]** The NE shall support the bootstrap NE Bootstrap Router (BSR) mechanism for PIM-SM as defined by RFC 5059.
3. **[Required]** The NE shall be capable of performing the Rendezvous Point (RP) function for PIM-SM.
4. **[Required]** The NE shall support multiple RPs in a single domain for load sharing and redundancy as defined by RFC 3446.
5. **[Required]** The NE shall enhance interdomain multicast via Multicast Source Discovery Protocol (MSDP) as defined by RFC 3618.
6. **[Required]** The NE shall support the Generic Routing Encapsulation (GRE) Tunneling Protocol as defined by RFC 2784 for the transport of multicast traffic.
7. **[Required]** The NE shall be able to perform a reverse path forwarding (RPF) check on a GRE tunnel interface.

8. **[Required]** The NE shall support Source-Specific Multicast (SSM) and its assigned address range as defined by RFCs 3569 and 4607, Section 5, Network Element Requirements.
9. **[Required]** The NE shall support the Border Gateway Multicast Protocol (BGMP) as defined by RFC 3913.
10. **[Required]** The NE shall provide multicast routing for native IPv6 packets.

#### ***5.5.6.14 Equipment Redundancy Requirements***

1. **[Required]** The NE shall support at least one redundant component for every N component that is required for full operation (1:N redundancy protection) for all service affecting components.
2. **[Required]** The NE shall support redundant switch fabric elements and schedulers.
3. **[Required]** The NE shall recover to its pre-failure forwarding performance level within 50 ms after the failure of a single switch fabric element or scheduler.

#### ***5.5.6.15 Management Requirements***

1. **[Required]** The NE shall support the Internet Group Management Protocol, Version 3 (IGMPv3) for IPv4 multicast management and multicast group membership reporting to neighboring multicast NE as defined by RFC 3376.
2. **[Required]** The NE shall support Multicast Listener Discovery (MLD), Version 2 for IPv6 multicast NEs to discover the presence of multicast listeners as defined by RFC 4604.
3. **[Required]** The NE shall support administratively scoped addresses (239/8) and multicast administrative boundaries as described in RFC 2365.

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