

## SECTION 27 21 00

### UNIFIED OPTICAL NETWORK

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Functional and performance requirements of Unified Optical Network (UON) system.

##### 1.02 RELATED SECTIONS

- A. Section 01 33 00 Submittal Procedures
- B. Section 01 33 23 Shop Drawings, Product Data and Samples.
- C. Section 01 43 00 Quality Assurance
- D. Section 01 45 00 Quality Control
- E. Section 01 78 23 Operation and Maintenance Data
- F. Section 01 78 39 Project Record Documents
- G. Section 01 78 44 Spare Parts and Maintenance Materials
- H. Section 01 79 00 Demonstration and Training
- I. Section 20 50 13 Raceways for Facility Services.
- J. Section 20 70 19 Indoor Cabinets, Racks, Frames and Enclosures.
- K. Section 20 72 25 Factory and Field Testing.
- L. Section 20 80 00 System Integration Testing.
- M. Section 26 05 26 Grounding and Bonding.
- N. Section 27 13 01 Communication Cables and Related Equipment.

##### 1.03 MEASUREMENT AND PAYMENT

- A. The work specified in this Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

##### 1.04 REFERENCES

- A. American National Standard Institute (ANSI):  
ANSI C2 National Electric Safety Code (NESC).

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- B. California Electrical Code
- C. Code of Federal Registration (CFR):
  - 36 CFR Part 1191 Part of Federal Register, Volume 56, No. 14, the "Americans with Disabilities Act".
- D. Electronics Industries Association (EIA):
  - EIA/ECA-310-E Cabinets, Racks, Panels, and Associated Equipment
  - EIA 455-11-177A Standards for Test Measurements and Inspection of Fiber Cables, Connectors and/or Other Fiber Optic Devices
  - TIA-530-A High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit Terminating Equipment
  - TIA-606-A Administration Standard for the Telecommunications Infrastructure
- E. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
  - IEEE 802.3 Carrier Sense Multiple Access with Collision Detection
  - IEEE 802.1AD Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges
  - IEEE 802.1D Standard for Local and Metropolitan Area Networks Media Access Control (MAC) Bridges
  - IEEE 801.1Q Standard for Local and Metropolitan Area Networks Virtual Bridged Local Area Networks (LAN) Tagging.
- F. The Internet Society:
  - RFC 2475 An Architecture for Differentiated Services
  - RFC 2598 An Expedited Forwarding PHB
  - RFC 3247 Per-Hop Forwarding Behavior
- G. Underwriters Laboratories (UL):
  - UL 1581 Standard for Safety Electrical Wires, Cables and Flexible Cords
- H. Miscellaneous Optical Standards
  - ITU G.709 Interface for Optical Transport Network (OTN)
  - ITU G.975 FEC Encoding/Decoding Application

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ITU-T G.798      Optical Transport Network Functionality Within Equipment

## 1.05 ABBREVIATIONS

BARTnet	BART Data Communications Network
BITS	Building Integrated Timing Supply
BLSR	Bi-Directional Line Switched Ring
CoS	Class of Service
DC	Direct Current
DCC	Data Communication Channel
DS	Digital Signal
DSC	Data Communication Channel
DSCP	Differentiated Services Code Points
DWDM	Dense Wave Division Multiplexing
ECN	Explicit Congestion Notification
GNE	Gateway Network Element
GPS	Global Positioning System
IP	Internet Protocol
IPP	IP Precedence
LAN	Local Area Network
MLPS	Multi-Protocol Label Switching
MM	Multimode
MSTP	Multiservice Transport Platform
NMS	Network Management System
OADM	Optical Add-Drop Multiplexer
OCC	Operations Control Center
ONS	Optical Network System
OSC	Optical Service Channel

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OTN	Optical Transport Network
PHB	Per-Hop Behavior
PTC	Project Test Center
QoS	Quality of Service
RU	Rack Unit (1.75 ins)
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SFP	Small Form-Factor Pluggable
SM	Single mode
SNMP	Simple Network Management Protocol
TCH	Train Control House
TCR	Train Control Room
TDM	Time Division Multiplexing
ToS	Type of Service
UAN	Unified Administration Network
UON	Unified Optical Network
UPSR	Unidirectional Path Switch Ring
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
VRF	VPN Routing and Forwarding
VSS	Video Surveillance System
WDM	Wave Division Multiplexing
XFP	Small Form-Factor Pluggable (10 Gigabit)

### 1.06 BACKGROUND INFORMATION

- A. The existing SONET-based BARTnet system is currently being replaced by a new unified optical network (UON) that is based on wave division multiplexing (WDM) technology. The UON system is comprised of four separate data streams: the video surveillance system (VSS)

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and access control system network called the security network, the unified administration network (UAN) including administrative data and voice, BARTnet (the train control and communications data network) and the T1 network.

- B. Refer to Contract Specifications Section 27 13 01 - Communication Cables and Related Equipment, for product installation and testing requirements of the UON fiber optic cable network.
- C. The UON shall use two fiber strands from single-mode fiber optic cables that connect to each of the WSX UON equipment nodes. The equipment shall be connected to these fibers to form a dual, alternating, collapsed ring, for the transport of voice, data and video services. The alternating nodes will be connected to single-mode fiber pairs from two different cables. Physical separation is gained by routing each cable in physically separated raceways. The dual ring structure shall operate in a self-healing, bi-directional ring configuration. Transmit and receive assignments shall be subject to automatic or manual reconfiguration, caused by a fault, or by intentional shut-down of a network element.
- D. All network hardware shall be designated matching products to match equipment in the existing UON network. Accordingly, UON cabinet layouts shall be submitted for District approval and optical add-drop multiplexer (OADM) slot assignments are provided in Tables 2 through 4 in this Specification Section.

### 1.07 SYSTEM DESCRIPTION

- A. The UON shall be a communications link that will tie all voice, video, and data subsystems together at the node installation sites. The subsystems include, but are not limited to, telephone, automatic fare collection, supervisory control and data acquisition, destination signs, video surveillance, and train control.
- B. The dense wave division multiplexing (DWDM) system for the UON consists of 32 separate wavelengths with 100 GHz (0.8 nm) spacing in the C-band (1,530 to 1,565 nm). The DWDM wavelength plan, including network assignments, for the existing system is shown in Table 1. Three DWDM rings have been configured to provide service to the current BART system; a fourth ring is forecasted that will be deployed to provide service to the San Jose extension in the future.
- C. The security (i.e., video and access control) network on each ring is configured such that separate wavelengths are assigned between each station node and Central. The security network bandwidth shall be 2 Gps (1Gps plus 1Gps Protected / Load sharing point-to-point links).
- D. The BARTnet network on a given ring shares a single wavelength as shown in Table 1 and is associated with crossponder #1. The BARTnet network bandwidth shall be 0.5 Gps.
- E. The UAN network on a given ring shares a single wavelength as shown in Table 1 and is associated with crossponder #2. The UAN network bandwidth shall be 0.5 Gps.
- F. The T1 service, which can support up to 28 T1 channels between stations and Central and 28 inter-station links, operates on a single wavelength as shown in Table 1.
- G. The UON is based on the Cisco ONS 15454 Multiservice Transport Platform (MSTP) which provides traditional time-division multiplexing (TDM) and SONET/SDH services ranging from

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DS-1/E1 to OC-48/STM-16, along with storage area network, Ethernet, and IP services in a single platform. IP services are connected from OADM nodes are connected to a Cisco Catalyst 6509 switch utilizing layer 3 multi-protocol label switching (MPLS) VPNs. Each virtual private network (VPN) has its own unique forwarding table, known as a VPN routing and forwarding (VRF) that maintain route separation for each IP service.

**TABLE 1 - DWDM WAVELENGTH PLAN**

WAVELENGTH (NM)	CISCO 32-CHANNEL PLAN				AD-1C	AD-2C	AD-4C	AD-1B	AD-4B			
	Ring 1	Ring 2	Ring 3	Ring 4								
1530.33	Security	Security	Security	Security	30.30	30.30	30.30	30.30	30.30			
1531.12	Security	Security	Security	Security	31.10							
1531.90	Security	Security	Security	Security	31.90	31.90	30.30	30.30				
1532.68	Security	Security	Security	Security	32.60							
1534.25	Security	Security	Security	Security	34.20	34.20	34.20	34.20				
1535.04	Security	Security	Security	Security	35.00							
1535.82	Security	Security	Security	Security	35.80	35.80	34.20	34.20				
1536.61	Security	Security	Security	Security	36.60							
1538.19	Security	Security	Security	Security	38.10	38.10	38.10	38.10				
1538.98	Security	Security	Security	Security	38.90							
1539.77	Security	Security	Security	Security	39.70	39.70	38.10	38.10				
1540.56	Security	Security	Security	Security	40.50							
1542.14	Security	Security	Security	Security	42.10	42.10	42.10	42.10				
1542.94	Security	Security	Security	Security	42.90							
1543.73	Security		Security		43.70	43.70	42.10	42.10				
1544.53	Security		Security		44.50							
1546.12	Security		Security		46.10	46.10	46.10	46.10				
1546.92	Security		Security		46.90							
1547.72	Security				47.70	47.70	46.10	46.10				
1548.51					48.50							
1550.12	Currently unassigned				50.10	50.10	50.10	50.10				
1550.92					50.90							
1551.72					51.70	51.70	54.10	54.10				
1552.52					52.50							
1554.13					54.10	54.10	54.10	54.10				
1554.94					54.90							
1555.75					55.70	55.70	58.10	58.10				
1556.55					56.50							
1558.17					XPD-3	XPD-3	XPD-3	XPD-3	58.10	58.10	58.10	58.10
1558.98					XPD-2	XPD-2	XPD-2	XPD-2	58.90			
1559.79	XPD-1	XPD-1	XPD-1	XPD-1	59.70	59.70	58.10	58.10				
1560.61	OC48-1	OC48-1	OC48-1	OC48-1	60.60							

*15xx.x in the part number indicates the ordering wavelength of the card (example: 1530.33 = 30.3).*

Service Description	
OC48-1	T1
XPD-1	BARTnet
XPD-2	Unified administrative network

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XPD-3	Fail-over / Disaster Recovery
Ring 1	Assigned to the K, C and R lines
Ring 2	Assigned to the M, W and Y lines
Ring 3	Assigned to the A and L lines; proposed for WSX nodes S06 and S20.
Ring 4	Assigned to the SVRT Extension nodes
<b>Legend:</b> AD - add/drop; XPD - crossponder.	

- H. The headend OADM node for each ring is equipped with a gateway network element (GNE) to interface via a dual interface layer to the three local area networks (LANs) at Central; i.e., Security, BARTnet and the UAN. Each OADM node is also linked to a T1 service OADM node at Central. OADM nodes are connected in a dual ring, alternating link configuration using two single mode fiber pairs. The dual ring structure is required for availability purposes and shall operate in a self-healing bi-directional line switched ring (BLSR) configuration. Under normal operating conditions, both cables will provide a communications service path from alternating station nodes.
- I. The UON shall be capable of providing automatic protection switching for link recovery in the case of failure. If a complete fiber optic cable break should occur, the system shall perform a loop-back operation, isolating the fault, and maintaining communications with all equipment that remains connected to the network. Should a major node failure occur, the network shall automatically create and startup a new configuration without the node. Upon restoration of the failed node, the network-switching algorithm shall support automatic startup and reconfiguration of the network with the restored node. All restoration times shall be limited to a maximum of 50 milliseconds. In addition to the above protection scheme, off-premises, fiber optic-based backup system shall also be provided.

### 1.08 INTERFACES WITH OTHER SYSTEMS

- A. Interface requirements to the existing BART equipment and cable infrastructure in LMA shall be submitted to BART for approval to assess if additional LMA infrastructure is required to support the submitted requirement. If additional LMA infrastructure is required, BART will provide a cost estimate and timeline for material and BART labor will be provided to support the submitted interface requirement.

### 1.09 SUBMITTALS

- A. Provide submittals in accordance with Contract Specifications Section 01 33 00 - Submittal Requirements, Contract Specifications Section 01 33 23 – Shop Drawings, Product Data and Samples, and Contract Specifications Section 01 78 44 - Spare Parts and Maintenance Materials.
- B. Provide manufacturer's data sheets and descriptive information sufficient to determine compliance with these Specifications for the following:
1. OADM assemblies and related equipment.
  2. Network management system.
  3. Fiber and copper distribution panels and cables.
  4. DC circuit breaker panels.

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- C. Provide detail drawings and technical data including list of equipment and material, including manufacturer's descriptive and technical literature, reliability performance charts and curves, catalog cuts, and installation instructions. Drawings shall show proposed layout and anchoring of equipment. System drawings shall show final configuration, including location, type and termination of inter-cabinet cables.
- D. Manufacturer's instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations for approval prior to installation. Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.
- E. Operation and Maintenance Manuals: Submit O and M manuals in accordance with Contract Specifications Section 01 78 23 - Operations and Maintenance Data.
- F. Training Materials: Submit training materials in accordance with Contract Specifications Section 01 79 00 - Demonstration and Training.
- G. Spare Parts List: Submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44 - Spare Parts and Maintenance Materials.
- H. Record Drawings: Submit record drawings in accordance with Contract Specifications Section 01 78 39 - Project Record Documents.

### 1.10 QUALITY ASSURANCE AND QUALITY CONTROL

- A. Refer to Contract Specifications Section 01 43 00 – Quality Assurance, and Contract Specifications Section 01 45 00 - Quality Control, for hardware quality assurance requirements and IEEE STD 730 for software quality assurance requirements.
- B. Products shall be manufactured by firms regularly engaged in manufacturing products described in this section.
- C. Field testing shall be performed by persons having 5 or more years of relevant testing experience.

## PART 2 - PRODUCTS

### 2.01 GENERAL

- A. The UON equipment shall consist of the following products:
  - 1. OADM assemblies.
  - 2. Fiber distribution panels and patch cords.

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3. DC circuit breaker panels.
4. Remote alarm blocks.
5. Equipment cabinets.

### 2.02 UON NODE EQUIPMENT

#### A. OADM Assemblies

1. OADM assemblies shall Designated Matching Product Cisco ONS 15454 SDH Multiservice Transport Platform (MSTP). OADM assemblies shall be fully functional with all the required equipment/component including fiber and copper patch panels; fiber storage shelf and shelf controlled cooling fan tray; timing, communications and control equipment; optical switch and OADM; air ramps; dual power supplies and miscellaneous components necessary to provide a fully functional assembly. Equipment shall include the following:
  - a. Two ONS shelves and common equipment.
  - b. Optical multiplexer modules.
  - c. EtherNet crossponder modules.
  - d. Pluggable modules (SFP and XFP).
  - e. DS1 and DS3 electrical interface modules.
  - f. Alarm collection remote.

#### B. OADM slot assignments at each location shall be as shown in Tables 2 and 3.

#### C. Patch Panels, Patch Cords, Splice Trays and Storage Shelves

1. Fiber patch panels shall be ADC, 2 RU LC patch panels, model # TFP-2UT00-000B or equal.
2. Fiber patch cords shall be LC to LC and LC to SC patch cords, length as required. Fiber zipcord (patchcord) and pigtail outer jacket size shall be 1.6mm by 3.5mm or equal.
3. Fiber splice trays shall have a 48 splice capacity with rear fiber cable and front pigtail access and shall be ADC Model # ADCP-90-341 (FMT-JTU termination and splice panel) with FL1-M-NT (splice trays) or equal. Fiber storage shelves shall be ADC FMT-D-BS-000000-A00B or equal.
4. DSX-1 patch panels shall be Telect 010-2184-SHDB-3 or equal.
5. Cat 6 patch panels shall be 24 or 48 port panels, ADC model PP24/48AC6T or equal.

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- D. Cable Management: 1 RU and 2 RU cable management shall be DAMAC F533-1901/2 or equal. Vertical cable management shall be DAMAC F533-012-8 or equal.
- E. DC Circuit Breaker Panels: DC circuit breaker panels shall be Newmar DST-20A or equal equipped with a minimum of ten A and B 48 VDC plug-in circuit breakers and a remote summary alarm module.
- F. Cat 6 Patch Panels: Cat 6 patch panels shall be 24 or 48 port panels, ADC model PP24/48AC6T or equal.
- G. Cable Management: 1U cable management shall be DAMAC F533-1901 or equal. Vertical cable management shall be DAMAC F533-012-8 or equal.
- H. Network Management System (NMS) Network Switch Connections: Provide and install the following four NMS Category 6 cable connections to the TCR/TCH network switch:
  - 1. Optical service channel (OSC) 1 and 2.
  - 2. Data communication channel (DCC) 1 and 2.
- I. Alarm Collection Remote: The alarm collection remote shall be equipped with 176 discrete inputs, standard wire-wrap terminals for alarm inputs with LAN connectivity and SNMP trap alarm reporting. The alarm collection remote shall be DPS Telecom Remote Alarm Block model # 176N or equal.
- J. Cables and Connectors for LMA: Provide the cables and connectors to BART who will make the connections between the OADM and the existing head-in equipment.

### 2.03 SOFTWARE

- A. The latest release of Cisco ONS 15454 software, complete with a CD and right-to-use license.
- B. Cisco Quality-of-Service Toolset.

**Table 2 – OADM #1 Slot Assignments**

SLOT	CARD	DESCRIPTION
1	15454-OPT-AMP-17C=	ONS 15454 Optical Amplifier - 17dB Gain - C-Band
2	15454-AD-4C-58.1=	Optical mux module – 2 Chn – 100 GHz -1558.17 – 1560.61
3	15454-AD-1C-xx.x=	Optical mux module – 1 Chn – 100 GHz -15xx.xx (See Table 1)
4	15454 Blank Module Slot Filler	
5	15454 Blank Module Slot Filler	
6	15454 Blank Module Slot Filler	
7	15454-TCC3A=	Timing Communications Control Three
8	15454-OSCM=	15454 SONET Platform Optical Transmission Element

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SLOT	CARD	DESCRIPTION
9	15454-AIC-I=	Alarm Interface Controller-International
10	15454-OSCM=	15454 SONET Platform Optical Transmission Element
11	15454-TCC3A=	Timing Communications Control Three
12	15454 Blank Module Slot Filler	
13	15454 Blank Module Slot Filler	
14	15454 Blank Module Slot Filler	
15	15454-AD-1C-xx.x=	Optical mux module – 1 Chn – 100 GHz -15xx.xx (See Table 1)
16	15454-AD-4C-58.1=	Optical mux module – 4 Chn – 100 GHz -1558.17 – 1560.61
17	15454-OPT-AMP-17C=	ONS 15454 Optical Amplifier - 17dB Gain - C-Band

Table 3 – OADM #2 Slot Assignments

SLOT	CARD	DESCRIPTION
1	15454-GE-XP=	Ethernet 20-GE / 2-10GE crossponder
2		
3	15454-GE-XP=	Ethernet 20-GE / 2-10GE crossponder
4		
5	15454 Blank Module Slot Filler	
6	15454-MRC-1-12=	Sonet Card
7	15454-TCC3A=	Timing Communications Control Three
8	15454-XC-VT=	VT1.5 Cross Connect
9	15454-AIC-I=	Alarm Interface Controller-International
10	15454-XC-VT=	VT1.5 Cross Connect
11	15454-TCC3A=	Timing Communications Control Three
12	15454-MRC-1-12=	Sonet Card
13	15454-GE-XP=	Ethernet 20-GE/2-10GE crossponder
14		
15	15454-DS1E1-56	<b>56-Port DS-1/E1 Card</b>
16	15454-DS1E1-56	<b>56-Port DS-1/E1 Card</b>
17	15454 Blank Module Slot Filler	

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**Table 4 – LMA OADM Slot Assignments**

SLOT	CARD	DESCRIPTION
1	15454-40-SMR1-C= or 15454-40-SMR2-C=	40Chs Single Module ROADM with integrated Optical Pre or 40Chs Single Module ROADM with integrated Optical Booster Note – Card selection based on design build out requirement
2		
3		
4		
5	15454-10GE-XP=	Ethernet 4-10GE crossponder
6	15454-10GE-XP=	Ethernet 4-10GE crossponder
7	15454-TCC3A	Timing Communications Control Three
8	15454-OSCM=	15454 SONET Platform Optical Transmission Element
9	15454-AIC-I	Alarm Interface Controller-International
10	15454-OSCM=	15454 SONET Platform Optical Transmission Element
11	15454-TCC3A	Timing Communications Control Three
12	15454-10GE-XP=	Ethernet 4-10GE crossponder
13	15454-10GE-XP=	Ethernet 4-10GE crossponder
14		
15		
16		
17	15454-40-SMR1-C= or 15454-40-SMR2-C=	40Chs Single Module ROADM with integrated Optical Pre or 40Chs Single Module ROADM with integrated Optical Booster Note – Card selection based on design build out requirement

**PART 3 - EXECUTION**

**3.01 UON ASSEMBLY AND CONFIGURATION**

- A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25 – Factory and Field Testing.
- B. Follow the procedures for UON assembly, configuration and factory testing as outlined in Cisco’s ONS 15454 Procedure Guide, R9.0 or later.

**3.02 QoS DEPLOYMENT**

- A. Traffic Classifications:
  - 1. Provide eight classes of traffic as follows:
    - a. Voice (see below for minimum requirements).
    - b. Video (steaming)

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- c. Call-signaling (see below for minimum requirements).
  - d. Network control
  - e. Critical data – train control
  - f. Bulk data – background data flows.
  - g. Best effort - default
  - h. Scavenger – DoS, worm mitigation class (less-than-best-effort).
2. Voice traffic requires 150 ms one-way, end-to-end (mouth-to-ear) delay, 30 ms of one-way jitter and no more than 1 percent packet loss. Provide strict priority servicing for voice traffic; the amount of priority bandwidth assigned for it shall take into account the VoIP codec, the packetization rate, IP/UDP/RTP headers (compressed or not) and Layer 2 overhead. Additionally, provisioning QoS for IP telephony requires that a minimal amount of guaranteed bandwidth be allocated to call-signaling traffic.
- B. QoS Policies: QoS policies shall be implemented in hardware rather than software. Provide the following as a minimum:
1. Classification and Marking – Comply with standards RFC 2475, RFC 2598 and RFC 3247. Perform classifying and marking (with standards-based DSCP markings) as close to the source as technically and administratively feasible.
  2. Policing and Markdown – perform policing as close to the source as possible.
  3. Queuing – Provide queuing on every node that has a potential for congestion. As a guide, do not provision more than 33 percent of a link for realtime traffic and reserve at least 25 percent of a link for the default Best Effort class.
- C. Requirements for Protocol Standards:
1. Layer 2 parameters - 802.1Q Class of Service (CoS) bits.
  2. Layer 3 parameters - IP Precedence (IPP), Differentiated Services Code Points (DSCP) and IP Explicit Congestion Notification (ECN).

### 3.03 TIMING REQUIREMENTS

- A. The existing UON employs a Building Integrated Timing Supply (BITS) distribution amplifier and two Network Time Protocol (NTP) servers linked to two Global Positioning System (GPS) stratum-1 servers which act as the District primary synchronization and timing reference sources. All UON equipment shall be configured to reference the District primary BITS and NTP services. Coordinate all timing requirements with BART's Network Engineering Group.

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### 3.04 FACTORY TESTING

- A. Perform factory tests in accordance with the requirements specified in Contract Specifications Section 20 72 25 – Factory and Field Testing.

### 3.05 INSTALLATION

- A. Installation shall include the following activities as a minimum:
  - 1. Pre-installation inspection of available space and power, cable runs and conduits, device terminal blocks, documentation on device terminal block wiring, and testing performed by others.
  - 2. Confirmation of the physical inventory data and pre-installation visual inspection of the equipment.
  - 3. Post installation inspection of all equipment, mounting, cabling, and wiring.
  - 4. Execution of equipment diagnostics to verify proper operations.
  - 5. Records shall be maintained for all installation and test activities, and shall be delivered to the District upon request.
- B. System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with TIA 606-A. Penetrations in fire-rated construction shall be sealed with fireproof material.
- C. Inter-cabinet cabling shall be installed in accordance with Contract Specifications Section 27 13 01 - Communication Cables and Related Equipment and TIA/EIA 568-B. Cabling, distribution panels, and outlets shall be marked in accordance with TIA 606-A.
- D. Install all inter-facility fiber cable as specified in Contract Specifications Section 27 13 01 - Communication Cables and Related Equipment.
- E. Equipment Racks. Install EIA standard equipment racks as shown in the Contract Drawings and in accordance with Contract Specifications Section 20 70 19 – Indoor Cabinets, Racks, Frames, and Enclosures.
- F. Develop all installation procedures in accordance with the standards defined in this Section.
- G. Install all equipment required by this Section; this includes all grounding equipment, power supplies and power cables.
- H. All grounding shall be in accordance with EIA, National Electric Code, and local standards, Contract Specifications Section 26 05 26 - Grounding and Bonding, and BART drawing K001 in the Contract Documents. Ground each piece of equipment in accordance with the recommendations of the manufacturer. Isolate all signal grounds from the electrical protective ground except at a single common point.

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- I. Warning/ID Signs and Tags.
  1. Affix identification and warning signs and tags to the fiber distribution panels, terminal equipment, patch cords and the fiber optic cables.
  2. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, every 10 feet in communications equipment areas.

### **3.06 FIELD TESTING**

- A. The requirements for test planning, scheduling, performance, recording of data, and reporting of test results shall be as specified in Contract Specifications Section 20 72 25 – Factory and Field Testing, and Contract Specifications Section 20 80 00 – System Integration Testing, including the following:
  1. Verify field assembly, connections, terminations, and splices.
  2. Perform inspection and testing of equipment grounds in accordance with Contract Specifications Section 26 05 26 – Grounding and Bonding.
  3. Verify functions of devices, modules, equipment, software, subsystems, assembled terminals, and networks (using simulated or actual interfaces).
  4. Verify the UON fiber links that connect the OCC with OADM nodes. Refer to Contract Specifications Section 27 13 01 – Communication Cables and Associated Equipment for all physical layer testing requirements.
- B. As specified in Contract Specifications Section 20 72 25 – Factory and Field Testing, the majority of the field testing will be performed at the PTC. Rack mount the OADM GNE assembly and provide the necessary ancillary equipment to make UON Ring fully operable including hardware and software to simulate the connectivity to the network equipment at Central. Upon completion of all UON testing at the PTC, relocate the OADM GNE to Central for installation by the District.
- C. Test the entire UON to verify that the cables are properly installed, spliced and terminated. Verify that the insertion losses of all fibers in the network are within the specified limits.
- D. Field acceptance tests shall consist of exercising each system function through its required operations, under simulated conditions, to prove that the installation complies with specified requirements. Follow the procedures for installation, turn-up, provisioning and acceptance of the UON nodes as outlined in Cisco's ONS 15454 Procedure Guide, R9.0 or later.
- E. Upon completion of field testing at the PTC, provide testing support to the District as required to test the entire UON system in its final configuration.

**END OF SECTION 27 21 00**