

CenturyLink QC Technical Publication

GeoMax®

NOTICE

The purpose of this document is to describe CenturyLink GeoMax service. Sufficient technical detail is furnished to enable a customer to select options and channel interfaces suitable for their application needs. This document describes the technical features of the offering. It's not the intent of this document to provide ordering information beyond specific, available Network Channel and Network Channel Interface Codes.

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1. Introduction

1.1 General

The purpose of this document is to describe CenturyLink® GeoMax service. Sufficient technical detail is furnished to enable a customer to select options and channel interfaces suitable for their application needs. This document describes the technical features of the offering. It's not the intent of this document to provide ordering information beyond specific, available Network Channel and Network Channel Interface Codes.

1.2 Reason for Reissue

To Grandfather support for the following (equipment platform dependent) customer-orderable options:

- Grandfather non-multiplexed OC-192

1.3 Scope

This document describes GeoMax service as offered by CenturyLink to its customers. It covers distinguishing interface features, technical specifications, and defines valid interfaces.

1.4 Organization of Document

Chapter 1	Introduction: Provides the purpose, scope and summary of the Publication and its organization.
Chapter 2	Service Description: Describes the features, functions and interface options of GeoMax service.
Chapter 3	Network Interfaces: Details the physical interfaces offered by this service. Also briefly addresses the form and function of Network Channel Codes and Network Channel Interface Codes as they pertain to this service. Also presents the interface configurations available with this service.
Chapter 4	Performance Specifications: Furnishes expectations for service availability, throughput and protection switching.
Chapter 5	Maintenance: Provides the CenturyLink and corresponding customer maintenance responsibilities of this service.
Chapter 6	Definitions: Presents a listing of acronyms and a glossary of terms related to the Publication.
Chapter 7	References: Provides titles and ordering information for documents referenced in this Publication.

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2. Service Description

2.1 General

While this document describes GeoMax service as provided by CenturyLink to its customers, other non-standard designs may be considered on an Individual Case Basis (ICB).

GeoMax is a multi-protocol, optical data transport service that provides high capacity connectivity between:

- Customer premises
- A customer premises and CenturyLink Wire Center/Central Office (CO)
- CenturyLink Wire Centers/COs

GeoMax will be deployed using Fixed or Reconfigurable Optical Add-Drop Multiplexer (OADM)/ Dense Wavelength Division Multiplexing (DWDM) equipment and dedicated fiber facilities to transport various Storage Area Network (SAN), Ethernet, Optical Transport Network (OTN) and Synchronous Optical Network (SONET) standard protocol channels that are:

- Bidirectional (full duplex), point-to-point
- Protocol and bit-rate specific (e.g., Gigabit Ethernet)
- Transparent to CenturyLink at the higher customer protocol layers
- Provisioned for full rate Layer 1 transport

Customer-orderable options include:

- Unprotected transport channels with a 2 fiber Network Interface at both ends
- Two unprotected channels with CenturyLink-provided diverse OADM network transport and typically used with Customer Provided Equipment (CPE) enabling failover protocols for end-to-end protection.

This configuration will consist of two similar protocol channels each with a 2 fiber customer interface resulting in a 4 fiber Network Interface at both ends. Fiber facility or signal path diversity will be provided within the GeoMax network for the near-end OADM to far-end OADM transport.

- Protected transport channels with a 2 fiber Network Interface at both ends
- Open-Ended protected transport channels with a 2 fiber Network Interface at one end and two individually unprotected channels with CenturyLink-provided diverse OADM network transport on the other end. (Please note: This feature option is limited to client interfaces that can be encapsulated into an OPU2 or OPU2e only).

- SC, FC or LC UPC duplex connectors at premises locations

2.2 Available Protocols

The following protocols are available for transport over GeoMax service.

2.2.1 Storage Area Network (SAN)

IBM® Mainframe Protocols

- Fiber or Fibre Connection (FICON®) channel – a 1.0625 or 2.125 Gbps optical signal which provides full duplex data transfer and multiple concurrent Input/Output (I/O) operations on a single channel such as for sending user data and control information between:
 1. zSeries® or System z™ CPUs (see *IBM System z Connectivity Handbook*, SG24-5444 for further information)
 2. A CPU and a Control Unit or Direct Access Storage Device (DASD)
 3. DASDs in a Peer-to-Peer Remote Copy (PPRC) or Extended Remote Copy (XRC) solution
- InterSystem Channel (ISC), or Coupling Facility link – a 2.125 Gbps (ISC-3 Peer Mode) signal that provides data caching, locking, and queuing services between a Coupling Facility and a CPU. ISC-3 links in Peer Mode can also be used to transport Server Time Protocol (STP) messages between data centers over GeoMax.

GeoMax also supports IBM S/390® or Enterprise Systems Architecture/390 (ESA/390) applications. Details of IBM mainframe protocols and applications can be found on IBM's Redbook web site at: <http://www.redbooks.ibm.com>.

Fibre Channel options include:

- FC-25* at 266 Mbps (This protocol has been discontinued and is only available to existing customers with a GeoMax contract as of December 16, 2009.)
- FC-100 at 1.0625 Gbps
- FC-200 at 2.125 Gbps
- FC-400 at 4.25 Gbps
- FC-1200 at 10.5188 Gbps

* Denotes the effective data transfer rate in MB/s.

2.2.2 Video

- D1 Video at 270 Mbps (This protocol has been discontinued and is only available to existing customers with a GeoMax contract as of December 16, 2009.)

2.2.3 Ethernet

- Fast Ethernet at 125 Mbps*
- Gigabit Ethernet at 1.25 Gbps
- 10 Gigabit Ethernet WAN PHY at 9.953 Gbps
- 10 Gigabit Ethernet LAN PHY at 10.3125 Gbps
- 40 Gigabit Ethernet at 41.25 Gbps (over 4 WDM lanes)
- 100 Gigabit Ethernet at 115.125 Gbps (over 4 WDM lanes)

* Denotes the line-encoded transmission rate.

Customer Ethernet Version 2 (DIX) or IEEE® 802.3 MAC frames are typically GFP-F encapsulated and framed for adaptation to the GeoMax OADM network via an appropriate STS Synchronous Payload Envelope (SPE) Virtual Concatenated Group (VCG), OPU2 or possibly OPU2e (10G LAN PHY) payload mapping for example. With ITU-T Recommendation G.7041, *Generic framing procedure (GFP)* standards based Frame-mapped GFP (GFP-F), the Ethernet MAC bytes from Destination Address through Frame Check Sequence (FCS), inclusive with or without 802.1Q VLAN tags, are placed in the GFP Payload Information field.

Thus the incoming Ethernet line coding, Preamble/Start of Frame Delimiter (SFD) and Inter-Packet Gap (IPG) may be deleted at the GeoMax OADM network ingress and subsequently restored at egress per IEEE 802.3-2008 requirements along with the de-encapsulated frame for transmission to the attached customer Ethernet device.

GeoMax supports full duplex, point-to-point Ethernet circuits including the transport of jumbo frames up to 9600 bytes.

2.2.4 Optical Transport Network (OTN)

- OTU1 at 2.666 Gbps
- OTU2 at 10.709 Gbps
- OTU2e at 11.096 Gbps
- OTU3 at 43.018 Gbps (including over 4 WDM lanes)
- OTU4 at 111.810 Gbps (over 4 WDM lanes)

All OTN (OTUk) bit rates are ± 20 ppm, OTU2e is ± 100 ppm

GeoMax will provide for transport of customers' ITU-T G.709 Optical channel Transport Unit (OTUk) or G.Sup43 OTU2e signals with support of OTN regeneration over the company ROADM/DWDM network. While the OTUk layer will be terminated as necessary; the Optical channel Data Unit (ODUk) and related overhead with customer-mapped payload(s) and any APS signaling, synchronization information, etc. depending upon embedded protocols and end-to-end application will be transparently transported across the GeoMax point-to-point OTUk channel.

Customer-Provided Equipment is responsible for ensuring appropriate OTUk frame structure and bit rate compliance in accordance with the ITU-T G.709 and supporting lower OTN physical layer specifications, including transmission of a null pattern for no or standard (default) Forward Error Correction (FEC) containing the Reed-Solomon RS(255,239) codes with 6.2 dB gain. As different equipment may be used to provide this interface, it's recommended that the customer work with CenturyLink to ensure appropriate provisioning.

2.2.5 SONET

- OC-3 at 155.52 Mbps
- OC-12 at 622.08 Mbps
- OC-48 at 2.488 Gbps
- OC-192 at 9.953 Gbps multiplexed only. (Non-multiplexed is Grandfathered.)
- OC-768 at 39.813 Gbps (Grandfathered)

Depending upon the OADM equipment deployed by CenturyLink at ingress, transport of SONET channels with transparent overhead is provided or provisioned across the GeoMax network. Customer SONET equipment interconnected over a Muxponder or Transponder-based OC-N circuit can communicate over the Section DCC for remote management of far-end CPE, signal 1+1 Linear or BLSR protection switching using the K1/K2 bytes in STS-1 #1, support STS Contiguous Concatenation for transport of super-rate payloads and where available (as provisioned by CenturyLink) Section trace capabilities over the J0 byte, etc.

It should be noted that within a SONET Muxponder for example some of the customer's original Transport (Section/Line) overhead bytes will not be preserved end-to-end whereas the:

- A1/ A2 Framing bytes are always terminated and regenerated.
- The B1 Section Bit Interleaved Parity (BIP)-8 error monitoring byte is terminated on ingress and recalculated on egress. Since the Section BIP-8 is calculated over all bits of the previous STS-N frame (after scrambling) the B1 byte must be recalculated if Section, Line or Path layer content changes.

- The B2 Line BIP-8 error monitoring byte may be terminated on ingress and recalculated on egress. As the Line BIP-8 is calculated over all bits of the Line overhead and the envelope capacity of the previous STS-1 frame (before scrambling) the B2 byte must be recalculated if Line or Path layer content changes.
- H1, H2 and H3 STS Payload Pointer and Action bytes may be terminated on ingress and generated on egress in order to track the frequency and phase alignment of the customer STS SPEs within the aggregate STS-N envelope capacity. This capability allows for the multiplexing of incoming SONET signals timed via different clocks.
- S1 Synchronization Status (Messages) byte has to be generated on egress if multiplexing is performed on ingress to the GeoMax OADM network.

Optical or transparent multiplexing of customer SONET signals may be performed in the Optical Transport Network (OTN) layers as well as via the incoming Section and Line overhead bytes tunneled in and/or non-standard usage of undefined/unused SONET Transport overhead bytes in a Muxponder aggregate (e.g., internal STS-192) signal. Thus while proprietary SONET overhead may be transported across the GeoMax OADM network, the specific transparent bytes within the incoming customer STS-N frame will depend upon the overhead usage, termination and forwarding capabilities of the equipment including different Muxponder and Transponder cards that may be used by CenturyLink to provide the GeoMax customer's SONET OC-3, OC-12, OC-48, OC-192 (multiplexed only), and OC-768 (Grandfathered) channels.

Note the ability for CPE to derive SONET line-timing traceable to a CenturyLink Stratum 1 Primary Reference Source (PRS) is not a feature of GeoMax service (even with CO Node designs). The synchronous timing sources will vary depending upon Muxponder and Transponder cards, application and OADM network design. While OC-3, OC-12 and OC-48 facilities may be delivered from a SONET Muxponder or transport system configured via a Building Integrated Timing Supply (BITS), OC-192 (multiplexed only) and OC-768 (Grandfathered) circuits may use through timing which provides independent synchronization for each direction of traffic.

See Chapter 3 for a complete listing of available protocol interfaces.

2.3 Protocol Channel Requirements

GeoMax interfaces will be delivered from CenturyLink owned OADM/DWDM equipment and may be 2 or 4 fiber, though must be the same at both ends of the channel (see Section 2.8) and symmetrical (no multiplexing options). Protocol channels will conform to the following standards for rate, format and physical interface specifications. Customer equipment is required to generate the appropriate digital optical signal(s) for transmission to CenturyLink for transport over the GeoMax OADM network in conjunction with the ordered protocol channel(s).

Storage Area Network (SAN)

FICON is based on the Fibre Channel (FC) standard and refers to the functions and upper layer (FC-4) mapping protocols and architecture defined by American National Standards Institute (ANSI) InterNational Committee for Information Technology Standards (INCITS) FC-SB-2 (for single byte FICON) and FC-SB-3 (for FICON Cascading), specifications as used by IBM S/390 and zSeries hardware and software for Fibre Channel attachment of I/O devices and systems (IBM and non-IBM).

FICON and Fibre Channel:

- ANSI INCITS 424, *Fibre Channel - Framing and Signaling-2 (FC-FS-2)*, defines the expected frame format and transmission protocol
- ANSI INCITS 404, *American National Standard for Information Technology - Fibre Channel - Physical Interfaces-2 (FC-PI-2)*, specifies the physical layer (FC-0) requirements consisting of transmission media, transmitter devices, receiver devices and their interfaces
- FICON is further defined in IBM specifications such as SG24-6266, *FICON Native Implementation and Reference Guide* and SA24-7172, *System z Fiber Channel Connection (FICON) I/O Interface Physical Layer*.

ISC-3

- IBM specification SA23-0395, *System z Coupling Links I/O Interface Physical Layer*

D1 Video

- ANSI/SMPTE 259M-1997, *10-Bit 4:2:2 Component and 4fsc Composite Digital Signals – Serial Digital Interface*

Ethernet

- Institute of Electrical and Electronics Engineers, IEEE 802.3-2008, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*
- IEEE 802.3ba-2010, *Amendment 4: Media Access Control Parameters, Physical Layers, and Management Parameters for 40 Gb/s and 100 Gb/s Operation*

Clause 37, Auto-Negotiation function, type 1000BASE-X is also applicable to GeoMax Gigabit Ethernet protocol channels. Specifically, auto-negotiation will be enabled for 1000BASE-LX, 1000BASE-SX and 1000BASE-ZX though in some cases the Network Interface may have to be hard coded due to faulty implementations of the IEEE specification, hardware or software incompatibilities with some vendor's equipment. This feature allows for enhanced GeoMax alarm reporting with passage of maintenance signaling to the far-end CPE for proper fault detection and recovery (depending upon customer network configuration). See Appendix VI, Ethernet physical layer defect signals in ITU-T G.7041 for additional information.

Optical Transport Network (OTN)

- Recommendation ITU-T G.709, *Interfaces for the Optical Transport Network (OTN)*
- Recommendation ITU-T G.693, *Optical interfaces for intra-office systems*
- Recommendation ITU-T G.959.1, *Optical transport network physical layer interfaces*
- ITU-T G.Sup43, *Transport of IEEE 10GBASE-R in optical transport networks (OTN)*

SONET

- Telcordia Technologies GR-253-CORE, *Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria*
- ANSI T1.105.06-2002(R2007), *Telecommunications - Synchronous Optical Network (SONET): Physical Layer Specifications*
- For 40G VSR2000-3R2 compliant OC-768 SR-2 optical interfaces, ITU-T Recommendation G.693, *Optical interfaces for intra-office systems* (Grandfathered)
- SONET channels interconnecting with CenturyLink Synchronous Service Transport (SST) will conform to requirements in Technical Publication 77346.

See Chapter 7 for ordering information as well as a list of other relevant technical references and supporting websites.

Since the physical characteristics may include a variety of media with associated transmitters and receivers capable of operating at different speeds, specific GeoMax physical layer requirements at the customer Network Interface including protocol, bit rate, wavelength, fiber type and connector options as well as transmit/receive optical power levels, maximum reach from the CenturyLink OADM equipment and NC/NCI Codes for ordering are listed in Chapter 3.

The GeoMax design provides for native protocol connectivity and complete data security as the OADM/DWDM equipment does not view or process the data being transported. In addition, the network continually monitors signal quality such that service will be automatically rerouted around a point of failure using redundant equipment components and/or an alternate fiber path (optional).

GeoMax is a fully finished service with 24 X 7 monitoring provided by the CenturyLink Network Operations Center (NOC).

2.4 Architecture

The GeoMax network connects two or more customer designated add-drop traffic locations, referred to as Customer Premises or CO Nodes, and may be configured in a single closed ring (Figure 2-1), mesh-based topology (Figure 2-2) or point-to-point/linear (Figure 2-3) physical architecture. Depending upon the design of the OADM/DWDM system, local loop and/or interoffice fiber optic facilities may be used. For customer premises to customer premises applications only such as in Figure 2-3, a GeoMax CO Node is not required.

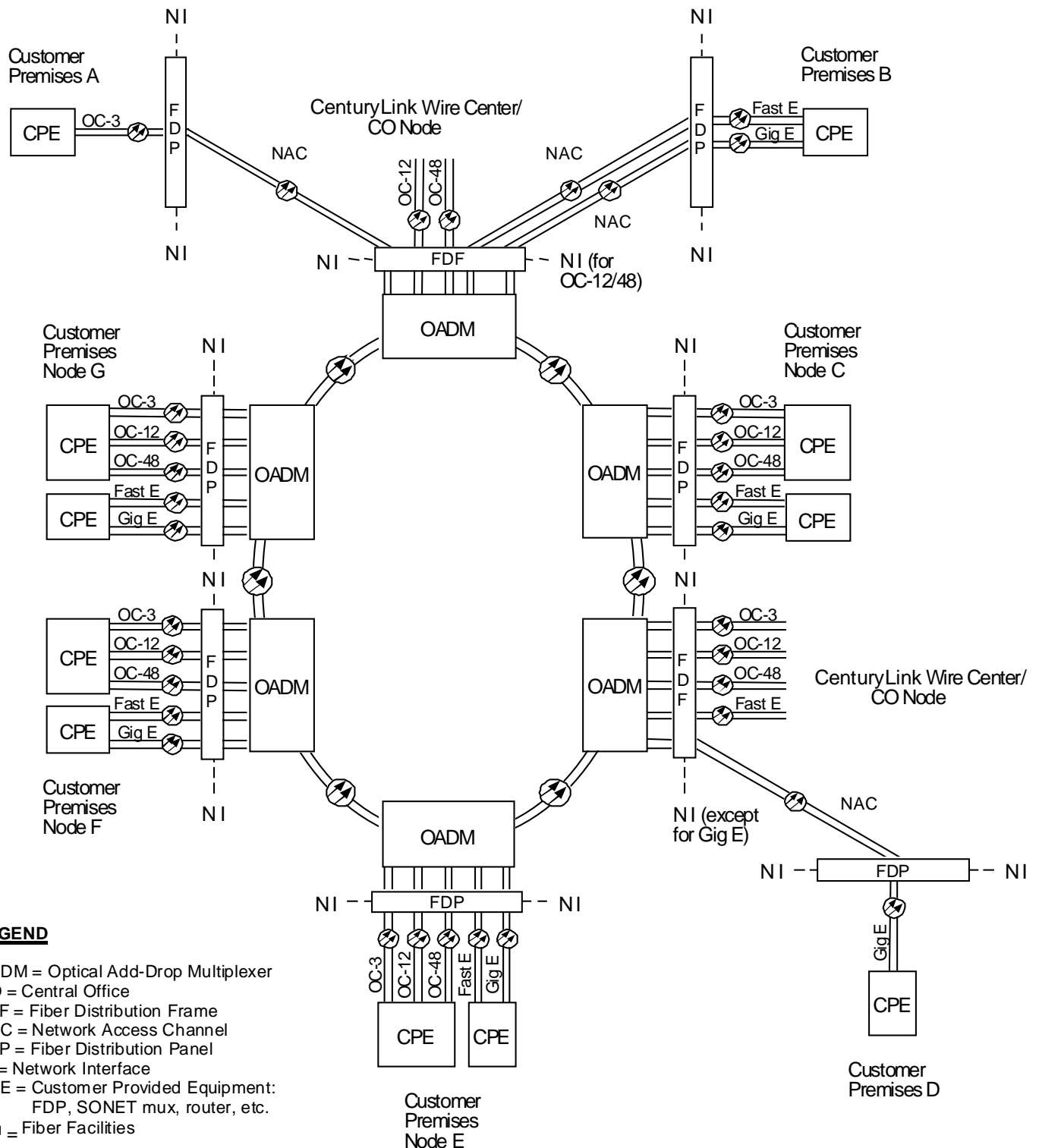
GeoMax CO Nodes may be placed in Serving and/or Remote Wire Centers. When located in a local Serving Wire Center (SWC*), protocols available with a singlemode fiber handoff (see Chapter 3) may be delivered to the Network Interface or a CenturyLink-provided Fiber Distribution Panel at the customer premises via a 2 fiber Network Access Channel (NAC), such as at Customer Premises A, B and D in Figure 2-1.

Although Network Access Channels are an option to Customer Premises Nodes, the following restrictions apply:

- Network Access Channels may not be available via CO Nodes in Remote Wire Centers. NACs for customer premises to Remote Wire Center or customer premises to customer premises with interoffice transport serving arrangements may require a CO Node in the SWC(s).
- The maximum fiber route distance from a GeoMax CO Node to Customer Premises for each protocol is listed in Table 3-2.
- A CO Node is required in any CenturyLink CO where customer traffic is add-dropped. Delivery of GeoMax protocols via a Customer Premises Node or CO Node in a physically different Wire Center and terminating solely on an FDP is not supported.

* May be another Wire Center/CO where supported by CenturyLink Engineering and Local Network policies. For further information concerning Customer Premises Nodes, CO Nodes and Network Access Channels consult the GeoMax Rates and Services Schedule (RSS) No. 1. While NACs are illustrated with the GeoMax ring network example in Figure 2-1, they're similarly offered on other GeoMax system architectures as a customer-specified option for delivery of singlemode fiber protocols to a premises location via a CO Node in the CenturyLink local Wire Center.

Figure 2-1 GeoMax Ring Network Example



2.4.1 Mesh Network Topologies

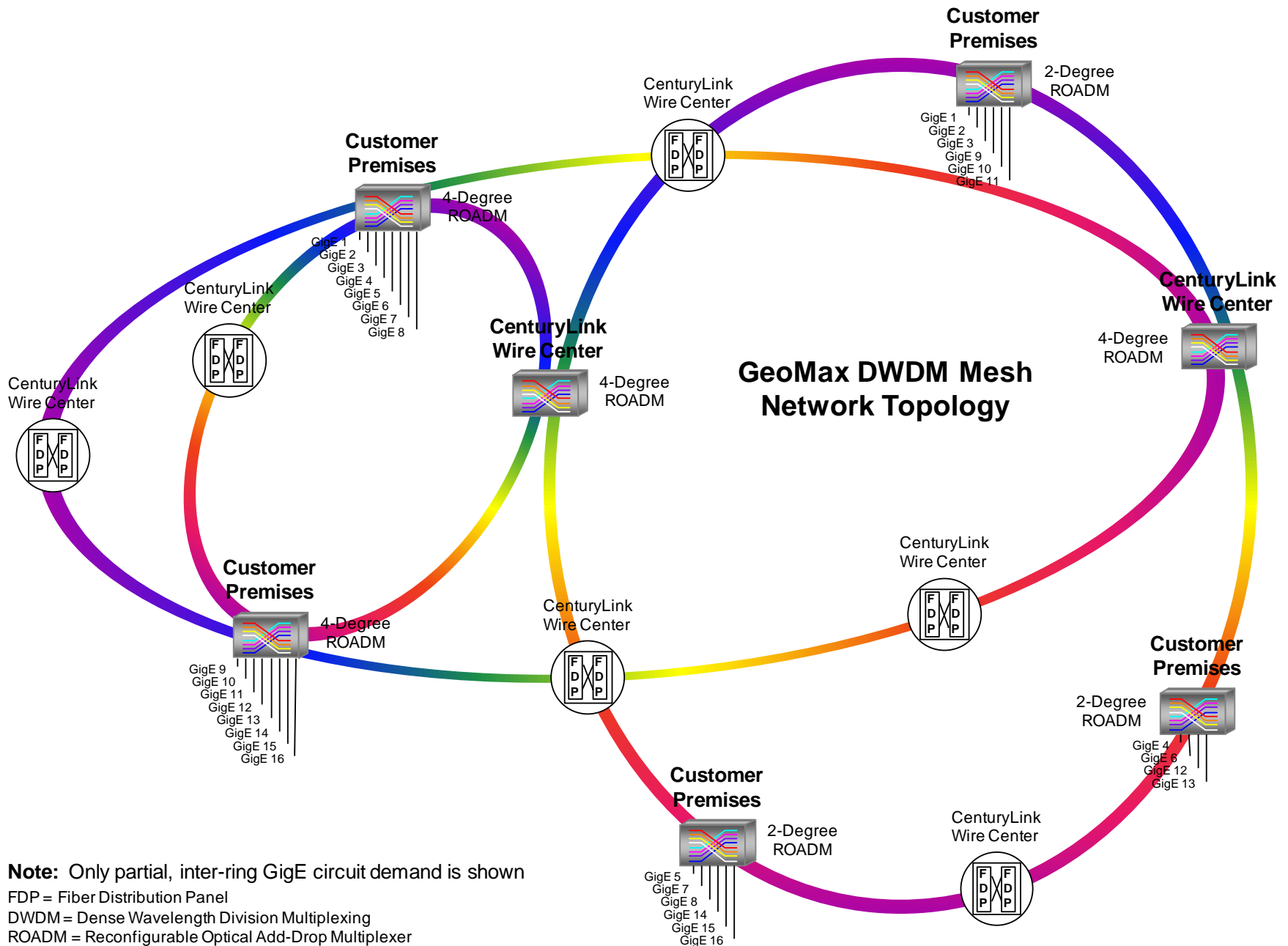
GeoMax customers provisioned on CenturyLink Equipment Platform 2, or Equipment Platform 3 (see Chapter 3) may order a mesh network, which is a physical topology consisting of multiple interconnected DWDM point-to-point and/or ring segments having at least two nodes with two or more fiber paths between them and is a viable solution suited to support distributed traffic with large point-to-point demands. Figure 2-2 illustrates a GeoMax mesh network as three interconnected DWDM rings enabled via a Wavelength Selective Switch (WSS)-based Optical Cross-Connect (OXC) multi-degree Reconfigurable Optical Add-Drop Multiplexer (ROADM) node architecture. A WSS allows for deployments beyond typical OADM configurations (or Fixed OADMs excluding the bridging of wavelengths) with 2 degrees ("east" and "west" only) of DWDM connectivity to support advanced topologies such as interconnected rings, linear mesh networks or spurs.

Up to 8 degrees or directions of DWDM Carrier links (including Express ports) are possible per GeoMax ROADM node with each optical interface supporting up to 88 wavelength channels, though some smaller add-drop traffic locations with 2-degree nodes for example may have (only need) access to 8 wavelengths. The ROADM wavelength fabric will demultiplex each incoming DWDM stream down to its component wavelengths, switch those wavelengths to the desired outgoing port and then re-multiplex all of the signals intended for each output port to a single fiber.

A DWDM mesh provides for the underlying physical layer transport of a GeoMax customer's point-to-point protocol channels with greater available capacity; more direct and alternate routes between nodes on the network vs. a single optical ring. Given the possible configurations with increased complexity, customers considering a partial or full mesh network should work closely with CenturyLink to ensure a GeoMax design with appropriate multi-degree ROADM hub nodes (including proper ordering for more than 2 degrees via the AQCB® or Auto Quote Contract Billing system process) and overall architecture that best meets their traffic needs.

While not shown in the figure and based on the customer's system and circuit level service order requirements, CenturyLink will determine the ROADM Muxponder or Transponder modules and placement along with wavelength activation and provisioning of logical SONET or OTN ("virtual" unidirectional ring or point-to-point) connections on the line-side for transport of the specified protected, unprotected, or two unprotected protocol channels with diverse optical path assignments across the GeoMax mesh network. For protected channels, switching mechanisms will be enabled at an internal SONET or OTN physical sublayer vs. dynamic shared mesh protection or restoration schemes based on path and wavelength reassignment with centralized or distributed control plane signaling functions.

Figure 2-2 GeoMax Mesh Network Example



2.5 Applications

GeoMax can provide Metropolitan Area Network (MAN) data transport solutions for applications such as:

- High speed connectivity
- STS-3c, STS-12c, STS-48c and STS-192c broadband delivery
- LAN transmission
- Mainframe and peripheral linkages
- Video

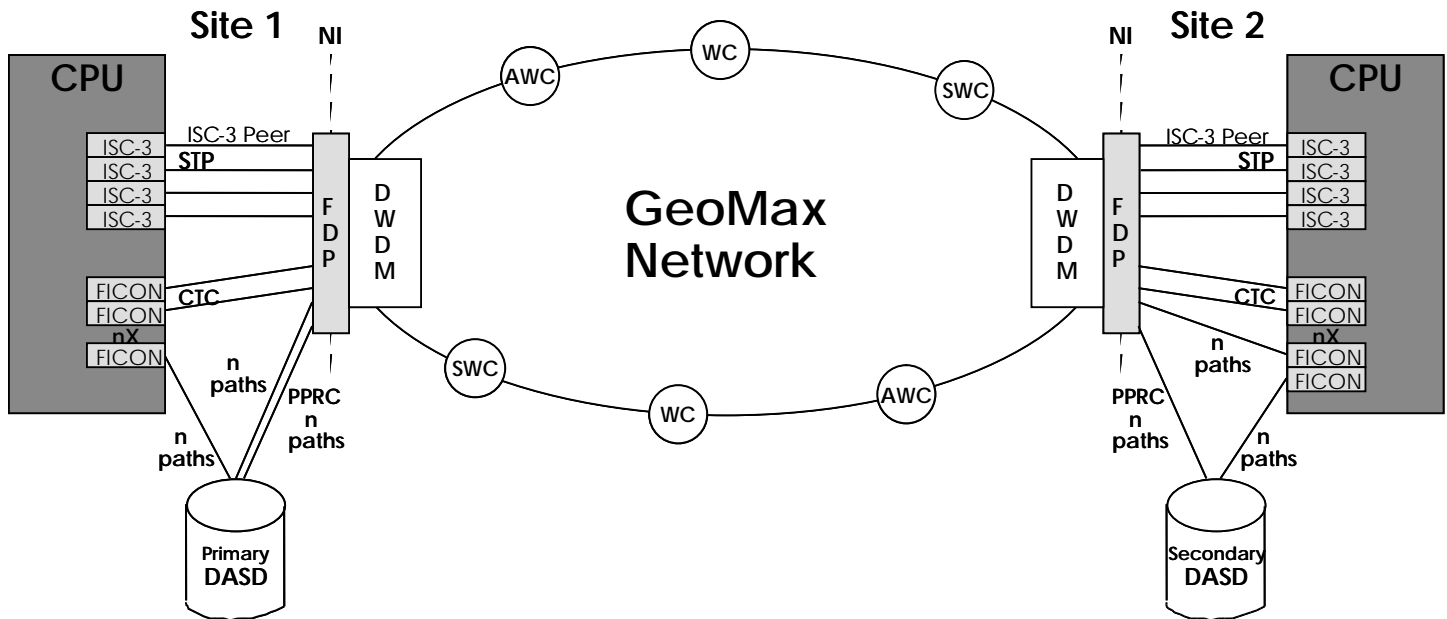
IBM zSeries or System z server applications include:

- Channel extension
- Direct Access Storage Device (DASD), or disk mirroring: Peer-to-Peer Remote Copy (PPRC)
- Tape archiving
- Geographically Dispersed Parallel Sysplex™ (GDPS)
- Data center backup and Disaster Recovery solutions

GeoMax offers transport of FICON and ISC-3 optical interfaces with a high data transfer rate that enables the use of a GDPS® for remote data backup for business continuity/disaster avoidance and real-time recovery. GeoMax provides for extended connections to various CPUs or I/O devices in support of customer FICON Bridge or conversion (FCV mode) as well as the IBM implementation of native FICON Direct Attachment (FC mode).

Figure 2-3 shows a possible GeoMax GDPS application. All equipment and connections on the side of the NI away from the GeoMax Network are the responsibility of the customer. GeoMax is an ideal solution for the transport of mainframe protocols. IBM Redbooks® such as *GDPS Family - An Introduction to Concepts and Capabilities*, SG24-6374 and *z/OS Parallel Sysplex Configuration Overview*, SG24-6485 provide further information.

Figure 2-3 GDPS Application



Note: Each connection line represents a fiber pair.

LEGEND

AWC = Alternate Wire Center
CPU = Central Processing Unit
CTC = Channel-to-Channel
DASD = Direct Access Storage Device
DWDM = Dense Wave Division Multiplexer
FDP = Fiber Distribution Panel
FICON = Fiber Connection
ISC = InterSystem Channel
NI = Network Interface
PPRC = Peer-to-Peer Remote Copy
STP = Server Time Protocol
SWC = Serving Wire Center
WC = Wire Center

2.6 Distance Limitations

In general, the maximum IBM protocol end-to-end fiber route distance (including customer cables) is 100 km (62.1 mi.) for FICON and ISC-3 Peer Mode (1.0625*/2.125 Gbps) point-to-point channels. FICON channel distances may be further limited by specific characteristics of the Control Units and I/O devices. These distance limitations also apply to the protect fiber or signal path for protected channels.

* To support this application, the customer should order Fibre Channel at 1.0625 Gbps. InterSwitch Links (ISL) may also be transported via Fibre Channel on GeoMax with supported distances dependent upon customer's Storage Area Network (SAN) switch vendor.

In general, Optical Fiber Amplifiers (OFAs) or Optical Line Amplifier (OLA) configurations as well as regeneration sites or CenturyLink OADM/DWDM equipment shelves with Dispersion Compensation Modules (DCMs) in some cases may be necessary to support the desired SAN, Ethernet, Optical Transport Network (OTN) and/or SONET transport channel distances on a customer's GeoMax by compensating for span loss between nodes, signal dispersion, or losses related to fiber quality, splice, or signal processing. Amplifiers will support longer distances for the IBM mainframe protocols with expected distances in the 100 to 150 km range. While other protocols are less restrictive, CenturyLink will design the OADM/DWDM network and work with the customer's designated Engineer(s) to determine any specific distance limitations, amplifier requirements, regenerator or DCM placement.

For handoff to the customer, individual protocol channel power levels and approximate maximum reach by Network Interface are listed in Table 3-2.

2.7 Protection

The GeoMax network ensures data survivability regardless of the protocol of the traffic being carried. Automatic Equipment and Path Protection Switching, coupled with protect path diversity, provides end-to-end signal protection against equipment failures and fiber path cuts and improves the reliability of GeoMax service.

2.7.1 Equipment

In the GeoMax network, high availability of the equipment is accomplished by having backup equipment to which traffic is sent if an equipment failure occurs. Equipment switching protects OADM/DWDM equipment that is not protected by path switching and ensures that a failure in one circuit card does not cause a traffic outage in the network.

Equipment protection will be provided with a redundancy of components and 1:1 protection of service affecting plug-in units. A 1:1 protection scheme is an architecture in which a working unit can be bridged to a dedicated protect unit. Equipment switching is non-revertive.

2.7.2 Fiber Path

GeoMax provides options for fiber or signal path protection on a per customer channel basis as listed in Table 2-1.

Path switching of GFP encapsulated or digitally wrapped protocols via an appropriate SONET or OTN payload mapping and (unidirectional ring or point-to-point) protection mechanism increases the survivability of the customer's traffic transparently transported over the GeoMax physical point-to-point, ring or mesh network. This redundant path protection is provided on a 1+1, non-revertive basis. The 1+1 protection is defined as: An architecture in which the head-end signal is permanently bridged to the working and protection channels (dedicated equipment and fiber facilities) to enable the same payload to be redundantly transmitted to the tail-end. At the tail or receive end, the working and protect optical signals are monitored independently and identically for failures. The receiving equipment selects either the working or the protect signal as the one that carries the traffic, based on the quality of the two signals received. When a protection switch is initiated, it's performed only on the affected direction of traffic (i.e., unidirectional switching) and is non-revertive, or does not switch back to the original traffic carrying channel after the failure has been repaired.

Note: Bidirectional mode and/or revertive switching if/where available are not customer-specified options.

GeoMax fiber or signal path switching is not an option for ISC-3 Peer Mode with Server Time Protocol (STP) Messaging links as unidirectional path switching can cause the server time synchronization to incorrectly compensate for asymmetrical fiber propagation delay resulting in out of sync conditions with subsequent data integrity concerns. Furthermore, a multi-site Parallel Sysplex® or Geographically Dispersed Parallel Sysplex (GDPS) could be forced into a split sysplex condition after a GeoMax path switch requiring customer intervention to resolve. Fault tolerance against single points of failure is best achieved by configuring multiple STP (ISC-3 Peer Mode with STP Messaging) links over physically separate fiber paths through the GeoMax network (using multiple unprotected channels in Table 2-1). See IBM Redbooks *Server Time Protocol Planning Guide*, SG24-7280 and *Server Time Protocol Implementation Guide*, SG24-7281 for further information.

GeoMax equipment and fiber or signal path protection switching is also not supported on:

- 4G Fibre Channel with CenturyLink Equipment Platform 1 (see Chapter 3)
- 10G LAN PHY with 850 nm Network Interfaces (10GBASE-SR)

Due to the nature of the Open Fiber Control (OFC) protocol, a link running ISC may take up to 12 seconds to re-initialize after a protection switch. Thus, it is recommended that failover protection be performed by the subtending Customer Provided Equipment with the ordering of two unprotected ISC protocol channels and diverse optical path assignments.

Protect path diversity is provided with GeoMax service. Protect path diversity provides for routing the alternate or protect fiber or signal path between nodes over local loop and interoffice facilities physically separated from the working path by a minimum of 25 feet, from the first terminal/utility vault outside the customer premises/CenturyLink Wire Center to the last terminal/utility vault before the customer premises/CenturyLink Wire Center. The protect path is normally routed through CenturyLink designated Alternate Wire Centers (AWCs).

If special construction charges are required to build an alternate facility route, CenturyLink will present the customer with the option of having GeoMax service without diversity.

Equipment located on the customer's premises will have a single cable entrance unless the building owner elects to provide two physically separated cable entrances into the building.

2.8 Protection Options

Table 2-1 lists the channel protection options available with CenturyLink GeoMax service:

Table 2-1 GeoMax Protection Options

Channel Option	Description	NI ¹	Protection ²		Possible Single Point of Failure	Supported Protocols
			Equipment	Fiber or Signal Path		
Unprotected						
Option 1	Minimum protection	2F	√		Yes in some equipment cards, and there is no redundant fiber or signal path	All
Option 2	This option accepts two sources, or channel paths for the same signal from the customer. The two signals are then sent over separate fiber routes. ³ This option can be seen as “unprotected” from the individual signal, or channel path basis. End-to-end protection is provided by the Customer Provided Equipment (CPE)/protocol ⁴ .	4F ⁵	√ ⁶	√ ⁷	No, if a failure occurs on the working path within the GeoMax network, the CPE will use the protect path	All
Protected	This option accepts only a single source, or channel path from the customer but duplicates the signal and sends it over separate fiber or signal path routes.	2F	√	√	Only at the customer Optical Channel Interface (Transponder) or splitter/combiner equipment level	All except: - ISC-3 Peer Mode with STP Messaging - 10G LAN PHY at 850 nm - 4G FC ⁸

Table 2-1 GeoMax Protection Options (Continued)

Channel Option	Description	NI ¹	Protection ²		Possible Single Point of Failure	Supported Protocols
			Equipment	Fiber or Signal Path		
Open-Ended Protected ⁹	This option accepts only a single source, or channel path from the customer on one end and duplicates the signal and sends it over separate fiber or signal path routes. On the other end of the same channel; two sources, or channel paths are accepted from the same customer. The two signals are then sent over separate fiber routes. The result is an open-ended protected channel with one end that is (2) fiber protection switched, and the other end is (4) Fiber (i.e. (2) individually unprotected channels). (Please note: This feature option is limited to client interfaces that can be encapsulated into an OPU2 or OPU2e only).	2F 4F ⁵	√	√	Only at the customer Optical Channel Interface (Transponder) or splitter/combiner equipment level	- OC-192 - 10G LAN PHY

Table 2-1 Notes:

1. Network Interface: 2 or 4 fiber at both ends of the channel.
2. As defined in Section 2.7.
3. Originating in the near-end (single) CenturyLink OADM equipment shelf at the (single) Serving or local Wire Center and when ordered in conjunction with two 2 fiber NACs, a single fiber route is provided from the CenturyLink local Wire Center to the customer premises.
4. For example, by zSeries or System z multiple channel path support in the z/OS® channel path group, or customer's SONET Automatic Protection Switching.
5. 4 fiber Network Interfaces require the ordering of 2 similar protocol channels.
6. Including provisioning of the two protocol channels on separate Muxponder or Transponder cards in the near-end originating and far-end terminating GeoMax OADM Nodes.

Table 2-1 Notes (Continued):

7. Path protection for this option is limited to protect path diversity from the near-end GeoMax Node to the far-end GeoMax Node.
8. These connections are or may be supported as unprotected only (see Section 2.7.2).
9. This option requires joint engineering with compatible customer equipment and provisioning.
10. Protected channels are recommended for device subsystems where high performance, throughput and availability are critical.
11. These protection options apply only to the GeoMax network, CenturyLink-provided OADM/DWDM equipment and the fiber paths connecting the customer designated Customer Premises and CO Node locations. Physical layer redundancy at the customer Optical Channel Interface card, Transponder Protection Tray or Network Interface level is provided with the 4 fiber Option (2) above. Delivery of a 4 fiber (non-diverse) Network Interface to a CenturyLink-provided Fiber Distribution Panel at the customer premises via a GeoMax CO Node in the SWC requires the ordering of 2 Network Access Channels.

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3. Network Interfaces

3.1 Applicability of Technical Specifications

Technical specifications presented in this document are applicable to CenturyLink GeoMax service only. This document does not attempt to describe the equipment used to provide this interface.

3.2 Available Interfaces

Note: CenturyLink may provision GeoMax on more than one type of Dense Wavelength Division Multiplexing (DWDM)-based equipment platform, herein referred to generically as Equipment Platform 1, Equipment Platform 2, and Equipment Platform 3. Due to inherent differences with fully integrated technology and current positioning of the service, some protocols or interfaces may or may not be available depending upon the specific equipment used by CenturyLink to provide a given customer's GeoMax.

Specifically, Equipment Platform 1 is deployed as a Fixed (filters) Optical Add-Drop Multiplexer (FOADM) while Equipment Platform 2, and Equipment Platform 3 are Reconfigurable OADM (ROADM) based fiber optic systems. OADM/DWDM-based technology allows CenturyLink to transparently transport (see Section 2.2) numerous protocols and support the optical interfaces shown in Table 3-1, which lists the available interfaces on CenturyLink GeoMax service.

Customer interfaces may be 2 or 4 fiber at both ends of the channel and will be delivered to the Network Interface (NI), which will be at a CenturyLink-provided Fiber Distribution Panel (or Fiber Distribution Frame in a Central Office). GeoMax NIs support the delivery of Storage Area Network (SAN), Ethernet, Optical Transport Network (OTN) and SONET protocols; whereas the DWDM (e.g., 88 wavelength) interfaces are internal to the CenturyLink network and not offered to customers.

Carrier Customers have two options at their premises:

- May elect to terminate their cables on the CenturyLink Fiber Distribution Panel in the space provided for CenturyLink's transmission equipment.
- Have CenturyLink terminate CenturyLink cable on the Carrier's Fiber Distribution Panel located in the Carrier's workspace.

The NI to an End User customer will be at a connector receptacle on a CenturyLink-provided Fiber Distribution Panel.

The Network Interface must be located in an accessible, environmentally controlled space. To be accessible, CenturyLink technicians must be able to work and perform tests at the End User or Carrier premises without delay, at any time of day, any day of the year. GeoMax Network Interfaces may be equipped with any one of the available connector types listed in Table 3-1.

Table 3-1 Available Interfaces

Protocol		Bit Rate	Central Wavelength	Fiber Type ¹	Connector	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)								
FICON		1.0625 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Grandfathered ¹¹	Grandfathered ¹¹	Grandfathered ¹¹
			850 nm	Multimode		Grandfathered ¹¹	Grandfathered ¹¹	Grandfathered ¹¹
		2.125 Gbps	1310 nm	Singlemode		Grandfathered ¹¹	Grandfathered ¹¹	Grandfathered ¹¹
			850 nm	Multimode		Grandfathered ¹¹	Grandfathered ¹¹	Grandfathered ¹¹
ISC-3 (Peer Mode)		2.125 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available ³	Where Available ³	Available ³
Fibre Channel	FC-25	266 Mbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Discontinued ⁴	Not Available	Not Available
				Multimode		Discontinued ⁴	Not Available	Not Available
	FC-100	1.0625 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
			850 nm	Multimode		Available	Available	Not Available
	FC-200	2.125 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
			850 nm	Multimode		Available	Available	Not Available
	FC-400	4.25 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available (unprotected only)	Available	Available
			850 nm	Multimode		Available (unprotected only)	Available	Not Available
FC-1200	10.5188 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available	
Video								
D1 Video		270 Mbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Discontinued ⁴	Not Available	Not Available

Table 3-1 Available Interfaces (Continued)

Protocol		Bit Rate	Central Wavelength	Fiber Type ¹	Connector	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Ethernet								
Fast Ethernet	100BASE-LX10	125 Mbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Grandfathered ¹¹	Grandfathered ¹¹	Not Available
	100BASE-FX			Multimode		Grandfathered ¹¹	Not Available	Not Available
Gigabit Ethernet	1000BASE-LX, 1000BASE-LX10	1.25 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
	1000BASE-SX		850 nm	Multimode		Available	Available	Not Available
	1000BASE-ZX		1550 nm	Singlemode		Available	Available	Available
10G WAN PHY	10GBASE-LW	9.953 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
10G LAN PHY	10GBASE-LR	10.3125 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
	10GBASE-SR		850 nm	Multimode		Available (unprotected only)	Available (unprotected only)	Not Available
40 Gigabit Ethernet	40GBASE-LR4	41.25 Gbps	1271 nm 1291 nm 1311 nm 1331 nm	Singlemode	Duplex LC UPC	Not Available	Available (unprotected only)	Available
100 Gigabit Ethernet	100GBASE-LR4	103.125 Gbps	1295.56 nm 1300.05 nm 1304.58 nm 1309.14 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Available	Available

Table 3-1 Available Interfaces (Continued)

Protocol		Bit Rate	Central Wavelength	Fiber Type ¹	Connector	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Optical Transport Network (OTN)								
OTU1	P1L1-1D1/ IR-1	2.666 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Available	Available
	P1L1-1D2/ LR-2		1550 nm			Not Available	Available	Available
OTU2	VSR2000-2R1	10.709 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
	P1S1-2D2/ P1L1-2D2		1550 nm			Not Available	Available	Available
OTU2e	VSR2000-2R1	11.096 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Available	Available
	P1S1-2D2/ P1L1-2D2		1550 nm			Not Available	Available	Available
OTU3	40GBASE-LR4	43.018 Gbps	1271 nm 1291 nm 1311 nm 1331 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Available	Available
	40GBASE-FR/ VSR2000-3R2		1550 nm			Not Available	Available	Available
OTU4	100GBASE-LR4	111.810 Gbps	1295.56 nm 1300.05 nm 1304.58 nm 1309.14 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Available	Available

Table 3-1 Available Interfaces (Continued)

Protocol	Bit Rate	Central Wavelength	Fiber Type ¹	Connector	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
SONET							
OC-3	155.52 Mbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available (unprotected only)	Available
OC-12	622.08 Mbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available (unprotected only)	Available
OC-48	2.488 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
OC-192	9.953 Gbps	1310 nm	Singlemode	Duplex SC, FC or LC UPC ²	Available	Available	Available
		1550 nm			Not Available	Available	Available
OC-768	39.813 Gbps	1550 nm	Singlemode	Duplex SC, FC or LC UPC ²	Not Available	Grandfathered ¹¹	Grandfathered ¹¹

Table 3-1 Notes:

1. Singlemode fiber is 9-10/125 μm and shall meet the requirements in GR-20-CORE, *Generic Requirements for Optical Fiber and Optical Fiber Cable* and ITU-T Recommendation G.652, *Characteristics of a single-mode optical fibre and cable*. Multimode fiber is either 50 or 62.5/125 μm and shall meet the requirements in GR-20-CORE, ANSI/TIA-492AAAB-A-2009, *Detail Specification for 50- μm Core Diameter/125- μm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers* and ANSI/TIA-492AAAA-B-2009, *Detail Specification for 62.5- μm Core Diameter/125- μm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers*. See Table 3-2 for availability along with the maximum supported cable distance.
2. SC/UPC (with Ultra Physical Contact polish) is the CenturyLink default optical connector for new GeoMax Network Interfaces whereas FC and LC are customer-specified options, where available at premises locations only. As there are no (e.g., NCI) codes for ordering, the customer should make the request to their Sales or Account Team, or the connector type would be determined during the field visit and captured on the site survey form.
3. Requests for ISC-3 at 2.125 Gbps will be considered on an Individual Case Basis (and may or may not be available).
4. These protocols have been discontinued and are only available to existing customers with a GeoMax contract as of December 16, 2009. No new orders will be accepted.
5. SC (Subscriber Connector) is a push-pull type of fiber optic connector with a square barrel; standardized in ANSI/TIA/EIA-604-3-B, *FOCIS (Fiber Optic Connector Intermateability Standard) 3, Type SC and SC-APC* and equivalent IEC 61754-4, *Fibre Optic Connector Interfaces - Part 4: Type SC Connector Family*.
6. FC (Fiber Connector) is a keyed, locking type of fiber optic connector with a round barrel and threaded retaining ring; standardized in ANSI/TIA/EIA-604-4-B, *FOCIS (Fiber Optic Connector Intermateability Standard) 4, Type FC and FC-APC* and equivalent IEC 61754-13, *Fibre Optic Connector Interfaces - Part 13: Type FC-PC Connector*.
7. LC (Lucent or Local Connector) is a small form-factor fiber optic connector with a cylindrical ferrule and split sleeve coupler; standardized in ANSI/TIA/EIA-604-10-A, *FOCIS (Fiber Optic Connector Intermateability Standard) 10, Type LC* and equivalent IEC 61754-20, *Fibre Optic Connector Interfaces - Part 20: Type LC Connector Family*.
8. GeoMax Network Interfaces shall meet the optical, mechanical and environmental performance requirements of ISO/IEC 11801: 2002+A1:2008, *Information technology - Generic cabling for customer premises*.
9. Bit rates listed may not correspond to effective channel data rate in a given application due to protocol overheads and other factors.
10. All interfaces will be delivered from CenturyLink-owned OADM/DWDM equipment.
11. Grandfathered services will continue to be supported on existing contracts (to include the Federal Network contracts) until the platform supporting that service has reached end of life or the contract expires. No new orders will be accepted.

CenturyLink Tech Pub 77368, *CUSTOMER PREMISES ENVIRONMENTAL SPECIFICATIONS AND INSTALLATION GUIDE*, describes the environmental and installation requirements as well as the powering and grounding options for CenturyLink telecommunications equipment placed on customer premises.

CenturyLink Tech Pub 77419, *SPECIFICATIONS FOR THE PLACEMENT OF QWEST EQUIPMENT IN CUSTOMER-OWNED OUTDOOR CABINETS*, describes the environmental (including electromagnetic compatibility), power, and grounding requirements for customer-owned outdoor cabinets (if provided) in order to allow the placement of CenturyLink-owned equipment inside these cabinets for the provisioning of GeoMax service to the customer.

3.3 Network Access Channel and Network Interface Distance Limitations

The maximum supported cable distance for Network Access Channels and from the GeoMax OADM/DWDM equipment to the customer's equipment shall be as listed in Table 3-2. See Section 2.4 for information on the GeoMax Network Access Channel (NAC) architecture.

Operating distances are based on a variety of worst-case specifications including:

- Fiber properties regarding attenuation, core diameter, bandwidth length product and chromatic dispersion
- Laser properties regarding launch power, spectral characteristics, jitter and rise/fall times
- Receiver properties regarding sensitivity, cutoff frequency and jitter tolerance
- Link properties regarding connection loss and unallocated link margin

Fiber optic patchcords or duplex jumper cables to connect the Customer Provided Equipment (CPE) to the CenturyLink Fiber Distribution Panel or Network Interface must be provided by the customer. These cables should be at least 3 meters long to facilitate attachment within the OADM/DWDM equipment frame.

To ensure correct server time synchronization, the end-to-end lengths of the transmit and receive fibers within an individual Server Time Protocol link (ISC-3 Peer Mode with STP messaging) must not exceed the equivalent of 900 meters differential delay between transmit and receive paths of the link. This includes all DWDM components, optical amplifiers (OAs), dispersion compensation units (DCUs), dark fiber links, and any time division multiplexing (TDM) based aggregation.

For multimode fiber handoffs, the customer should not mix 50 μm and 62.5 μm core patchcords since the diameter mismatch leads to the area of the 62.5 μm fiber being 56% larger in area than the 50 μm fiber. The mode selective loss created by mixing these fiber types is likely to create a link that does not work or works intermittently.

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹

Protocol Channel	Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
				Tx ⁵		Rx ⁶		
				Min	Max	Min	Max	
Storage Area Network (SAN)								
FICON at 1.0625 Gbps Grandfathered ³³	1310 nm	Singlemode	Unprotected	-13.5	1.0	-16.0	-7.0	10 km
			Protected	-14.4	1.0	-11.4	-7.0	7 km
	850 nm	Multimode 50 μm	Unprotected	-11.5	-3.5	-13.5	1.5	500 m
			Protected	-17.3	-3.5	-9.2	1.5	500 m
		Multimode 62.5 μm	Unprotected	-11.5	-3.5	-13.5	1.5	300 m
			Protected	-17.3	-3.5	-9.2	1.5	300 m
FICON Express at 2.125 Gbps Grandfathered ³³	1310 nm	Singlemode	Unprotected	-11.5	1.0	-16.0	-7.0	10 km
			Protected	-11.5	1.0	-11.4	-7.0	2.6 km
	850 nm	Multimode 50 μm	Unprotected	-11.5	-3.5	-13.0	1.5	300 m
			Protected	-17.3	-3.5	-7.2	1.5	30 m
		Multimode 62.5 μm	Unprotected	-11.5	-3.5	-13.0	1.5	150 m
			Protected	-17.3	-3.5	-7.2	1.5	30 m
ISC-3 at 2.125 Gbps (Peer Mode) ⁸	1310 nm	Singlemode	Unprotected	-11.5	1.0	-16.0	-7.0	10 km
			Protected ⁹	-14.4	1.0	-11.4	-7.0	8 km ¹⁰

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
Storage Area Network (SAN)									
Fibre Channel at 266 Mbps ⁸ Discontinued	25-SM-LL-M	1310 nm	Singlemode	Unprotected	-17.0	-5.0	-18.0	-6.0	10 km ^{10,11}
			Protected	-17.0	-5.0	-18.0	-6.0	10 km ^{10,11}	
	25-M6-LE-I ¹²		Multimode 62.5 µm ¹³	Unprotected	-17.0	-5.0	-18.0	-6.0	1.5 km ¹⁴
				Protected	-17.0	-5.0	-18.0	-6.0	1.5 km ¹⁴
Fibre Channel at 1.0625 Gbps	100-SM-LC-L ¹²	1310 nm	Singlemode	Unprotected	-13.5	1.0	-16.0	-7.0	8 km ⁹
			Protected	-14.4	1.0	-11.4	-7.0	7 km	
	100-M5-SN-I ¹²	850 nm	Multimode 50 µm	Unprotected	-11.5	-3.5	-13.5	1.5	500 m
			Protected	-17.3	-3.5	-9.2	1.5	500 m	
			Multimode 62.5 µm	Unprotected	-11.5	-3.5	-13.5	1.5	300 m
				Protected	-17.3	-3.5	-9.2	1.5	300 m
Fibre Channel at 2.125 Gbps	200-SM-LC-L ¹²	1310 nm	Singlemode	Unprotected	-11.5	1.0	-16.0	-7.0	10 km
			Protected	-11.5	1.0	-11.4	-7.0	2.6 km	
	200-M5-SN-I ¹²	850 nm	Multimode 50 µm	Unprotected	-11.5	-3.5	-13.0	1.5	300 m
			Protected	-17.3	-3.5	-7.2	1.5	30 m	
			Multimode 62.5 µm	Unprotected	-11.5	-3.5	-13.0	1.5	150 m
				Protected	-17.3	-3.5	-7.2	1.5	30 m

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷	
					Tx ⁵		Rx ⁶			
					Min	Max	Min	Max		
Storage Area Network (SAN)										
Fibre Channel at 4.25 Gbps	400-SM-LC-L ¹²	1310 nm	Singlemode	Unprotected	-10.4	-5.0	-15.2/ -11.5 ¹⁵	-1.0	10 km	
				Protected ⁸	-13.3	-5.0	-9.7	-1.0	3 km ⁹	
	400-M5-SN-I ¹²	850 nm	Multimode 50 µm	Unprotected	-11.0	-1.5	-12.0	1.5	150 m	
				Protected ⁸	-9.5	-1.5	-12.5	1.5	150 m	
			400-M6-SN-I ¹²	Multimode 62.5 µm	Unprotected	-11.0	-1.5	-12.0	1.5	70 m
					Protected ⁸	-9.5	-1.5	-12.5	1.5	70 m
Fibre Channel at 10.52 Gbps	1200-SM-LL-M	1310 nm	Singlemode	Unprotected	-10.2	-1.5	-9.0	2.5	8 km ¹⁶	
				Protected	-14.2	-3.0	-5.0	3.0	30 m	
Video										
D1 Video ⁸ Discontinued		1310 nm	Singlemode	Unprotected	-17.0	-5.0	-18.0	-6.0	5.4 km	
				Protected	-17.0	-5.0	-18.0	-6.0	5.4 km	

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
Ethernet									
Fast Ethernet Grandfathered ³³	100BASE-LX10 ¹⁷	1310 nm	Singlemode	Unprotected	-17.0	1.0	-17.0	-7.0	10 km
				Protected	-19.9	1.0	-11.4	-7.0	10 km
	100BASE-FX		Multimode 62.5 μm ¹³	Unprotected	-21.5	-5.0	-19.5	-12.5	300 m ¹⁴
				Protected	-21.5	-5.0	-19.5	-12.5	300 m ¹⁴
Gigabit Ethernet	1000BASE-LX, 1000BASE-LX10	1310 nm	Singlemode	Unprotected	-13.5	1.0	-16.0	-7.0	5/10 ¹⁸ km
				Protected	-14.4	1.0	-11.4	-7.0	4/10 ¹⁸ km
	1000BASE-SX	850 nm	Multimode 50 μm	Unprotected	-11.5	-3.5	-13.5	1.5	550 m
				Protected	-17.3	-3.5	-9.2	1.5	550 m
			Multimode 62.5 μm	Unprotected	-11.5	-3.5	-13.5	1.5	275 m
				Protected	-17.3	-3.5	-9.2	1.5	275 m
	1000BASE-ZX	1550 nm	Singlemode	Unprotected	-4.0	3.0	-19.0	-7.0	80 km
				Protected	-6.9	3.0	-13.4	-7.0	38 km ¹⁹

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
Ethernet									
10G WAN PHY	10GBASE-LW	1310 nm	Singlemode	Unprotected	-10.2	3.0	-9.0	1.0	8 km ¹⁶
				Protected	-14.2	-1.0	-5.0	3.0	30 m
10G LAN PHY	10GBASE-LR	1310 nm	Singlemode	Unprotected	-10.2	3.0	-9.0	1.0	8 km ¹⁶
				Protected	-14.2	-1.0	-5.0	3.0	30 m
	10GBASE-SR	850 nm	Multimode 50 μm	Unprotected	-9.3	-2.5	-7.9	0.5	82/300 m ²⁰
			Multimode 62.5 μm	Unprotected	-9.3	-2.5	-7.9	0.5	33 m
40 Gigabit Ethernet	40GBASE-LR4	1271 nm 1291 nm 1311 nm 1331 nm	Singlemode	Unprotected	-7	2.3	-13.7	2.3	10 km
				Protected	-7	2.3	-13.7	2.3	10 km
100 Gigabit Ethernet	100GBASE-LR4	1295.56 nm 1300.05 nm 1304.58 nm 1309.14 nm	Singlemode	Unprotected	2.0	8.5	-3.0	12.5	10 km
				Protected	-2.0	4.5	1.0	16.5	7 km ²¹

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
Optical Transport Network (OTN)									
OTU1	P1L1-1D1 ²² / IR-1	1310 nm	Singlemode	Unprotected	-7.0	-2.0	-17.0	2.0	30 km ¹⁶
				Protected	-11.0	-6.0	-13.0	6.0	20 km ¹⁶
	P1L1-1D2 ²² / LR-2	1550 nm	Singlemode	Unprotected	-4.0	1.0	-26.0	-7.0	69 km ¹⁹
				Protected	-8.0	-3.0	-22.0	-3.0	57 km ¹⁹
OTU2	VSR2000-2R1 ²³	1310 nm	Singlemode	Unprotected	-10.2	3.0	-9.0	1.0	8 km ¹⁶
				Protected	-14.2	-1.0	-5.0	3.0	30 m
	P1S1-2D2/ P1L1-2D2 ²²	1550 nm	Singlemode	Unprotected	-3.0	2.0	-12.0	-5.0	31/63 km ¹⁹
				Protected	-5.9	-2.9	-6.4	6.6	15/30 km ¹⁹

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
Optical Transport Network (OTN)									
OTU2e	VSR2000-2R1 ²³	1310 nm	Singlemode	Unprotected	-10.2	3.0	-9.0	1.0	8 km ¹⁶
				Protected	-14.2	-1.0	-5.0	3.0	30 m
	P1S1-2D2/ P1L1-2D2 ²²	1550 nm	Singlemode	Unprotected	-3.0	2.0	-12.0	-5.0	31/63 km ¹⁹
				Protected	-5.9	-2.9	-6.4	6.6	15/30 km ¹⁹
OTU3	40GBASE-LR4 ²⁴	1271 nm 1291 nm 1311 nm 1331 nm	Singlemode	Unprotected	–	6.3	See Note 25		10 km
				Protected	–	2.3	See Note 25		
	40GBASE-FR/ VSR2000-3R2 ²³	1550 nm	Singlemode	Unprotected	-2.0	1.0	-4.0	5.0	15 km ²⁶
				Protected	-4.0 ²⁷	-1.0 ²⁷	-2.0 ²⁷	7.0 ²⁷	30 m
OTU4	100GBASE-LR4 ²⁴	1295.56 nm 1300.05 nm 1304.58 nm 1309.14 nm	Singlemode	Unprotected	2.0	8.5	-3.0	12.5	10 km
				Protected	-2.0	4.5	1.0	16.5	7 km ²¹

Table 3-2 Protocol Channel Power Levels and Maximum Reach¹ (Continued)

Protocol Channel		Central Wavelength	Fiber Type ²	Protection ³	Power Level (dBm) at GeoMax NI ⁴				Maximum Reach ⁷
					Tx ⁵		Rx ⁶		
					Min	Max	Min	Max	
SONET									
SONET OC-3	IR-1	1310 nm	Singlemode	Unprotected	-17.0	-2.0	-16.0	-6.0	3 km ²⁸
				Protected	-19.9	-2.0	-11.4	-6.0	30 m
SONET OC-12	IR-1	1310 nm	Singlemode	Unprotected	-17.0	-2.0	-16.0	-6.0	3 km ²⁸
				Protected	-19.9	-2.0	-11.4	-6.0	30 m
SONET OC-48	IR-1	1310 nm	Singlemode	Unprotected	-7.0	-2.0	-16.0	2.0	21 km
				Protected	-11.0	-2.0	-11.4	2.0	14 km ²⁸
SONET OC-192	SR-1	1310 nm	Singlemode	Unprotected	-8.0	3.0	-9.0	1.0	7 km
				Protected	-12.0	-1.0	-5.0	3.0	30 m
	IR-2 ⁸	1550 nm	Singlemode	Unprotected	-3.0	0.0	-12.0	1.0	40 km
				Protected	-7.0	0.0	-6.4	1.0	27 km ²⁹
SONET OC-768 ⁸ Grandfathered	SR-2	1550 nm	Singlemode	Unprotected	-2.0	1.0	-4.0	5.0	14 km
				Protected	-6.0	1.0	1.6	5.0	30 m

Table 3-2 Notes:

1. These protocol channel power levels and maximum reach support multiple Equipment Platforms, Network Interface cards, Small Form-factor Pluggable (SFP) and 10 Gigabit Small Form-factor Pluggable (XFP) hot-swappable, protocol-independent optical transceiver modules and should be used as a planning guide. Other values may be possible including further reach in some cases depending upon the characteristics of the protocol, fiber quality and transceiver specifications. The customer should work jointly with CenturyLink to ensure that power level requirements are appropriately met to guarantee error-free performance and where necessary, optical attenuators must be provided by the customer.
2. Singlemode fiber is 9-10/125 μm and unless indicated otherwise, 50 μm multimode fiber is 500 MHz•km and 62.5 μm multimode fiber is 200 MHz•km modal bandwidth minimum.
3. If protected is not listed as an option for a particular protocol, only unprotected channels are available (see Section 2.7.2).
4. All power levels are based on a valid test pattern at the GeoMax customer Network Interface (NI) and include a maximum 2 dB allocation for CenturyLink singlemode and 1.5 dB for multimode fiber jumpers, connectors and splice loss as well as where applicable; an additional splitter/combiner Tx/Rx insertion loss for protected channels (protocol, fiber type and equipment dependent).
5. Tx represents the Transmit direction from CenturyLink to the customer.
6. Rx represents the Receive direction from the customer to CenturyLink.
7. Maximum reach is the fiber route distance from CenturyLink active OADM equipment to the customer's active equipment and may be optical power, chromatic or Polarization Mode Dispersion (PMD) limited especially with higher bit rate links or usage of standard singlemode dispersion-unshifted (i.e., conventional) fiber in the 1550 nm region. In no case will a further distance be supported than that published in the applicable protocol and/or fiber optic standard, unless explicitly agreed to by CenturyLink and the customer with an understanding of any potential performance impacts.
8. These protocols or interfaces have limited availability and may be equipment or GeoMax contract dependent; customers should consult with their Account Team and CenturyLink Sales/Engineering to determine availability.
9. Without STP messaging only (see Section 2.7.2)
10. The distance is estimated using the assumption of 0.5 dB/km maximum attenuation for 1310 nm singlemode fiber outdoor cable and an allocation of 2 dB total connection and splice loss according to ANSI INCITS 352-2002.
11. The laser transmitter and receiver specifications for this link option are at a higher performance level to support the greater operating distance.
12. These interfaces do not include Open Fiber Control (OFC), which is also not applicable to 10G FC or ISC-3 Peer Mode.
13. With 500 MHz•km modal bandwidth multimode fiber minimum.
14. A mode conditioning patch cord or plug is required to guarantee error-free performance if the subtending customer equipment is more than 30 m (100 ft) away.

Table 3-2 Notes (Continued):

15. With an extinction ratio of 9/3 dB respectively, see ANSI INCITS 404-2006: *Fibre Channel - Physical Interfaces-2 (FC-P1-2)* for further information.
16. The distance is estimated using the assumption of 0.4 dB/km installed fiber loss for the 1310 nm link and 2 dB total connection and splice loss according to ITU-T G.652 or IEEE 802.3-2008 with G.652.B fiber type. Similarly per ANSI INCITS 364, the longwave specification for 10G FC is based on the 10G LAN PHY optical specification for 10GBASE-LR links.
17. 100BASE-LX10 is a newer IEEE 802.3 Physical Layer specification for a 100 Mb/s point-to-point link over two singlemode optical fibers up to at least 10 km and corresponds with the definition change of 100BASE-FX from two optical fibers to two multimode optical fibers, thus this protocol may be referred to as 100BASE-FX over singlemode fiber in some equipment documentation.
18. 10 km may be Network Interface card dependent and must be supported by customer equipment.
19. The distance is estimated using the assumption of 0.35 dB/km installed fiber loss and 2 dB total connection and splice loss according to ITU-T G.652 or IEEE 802.3-2008 with G.652.B fiber type for 1550 nm links (note that extended reach 1000BASE-ZX is considered non-standard).
20. Support at 300 m is with 2000 MHz•km modal bandwidth multimode fiber minimum.
21. The distance is estimated using the assumption of 0.43 dB/km installed fiber loss for the 1310 nm nominal wavelength link and 2 dB total connection and splice loss according to IEEE 802.3ba-2010 and ITU-T G.695.
22. Per ITU-T G.959.1
23. Per ITU-T G.693
24. Physical layer specifications for multi-lane OTU3 and OTU4 interfaces are being added to ITU-T G.695 and G.959.1, including those corresponding to the use of the optical modules developed for IEEE 40GBASE-R and 100GBASE-R signals.
25. The link characteristics are similar to that published for 40GBASE-LR4 in Clause 87 of IEEE 802.3ba-2010 and will require joint engineering/test & turn-up to ensure the appropriate power levels.
26. The distance is estimated using the assumption of 0.275 dB/km installed fiber loss for the 1550 nm link and 2 dB total connection and splice loss according to ITU-T G.695.
27. Excluding cable, connectors and splice loss
28. The distance is estimated using the assumption of 0.55 dB/km installed fiber loss including splices and connectors for 1310 nm links according to GR-253-CORE.
29. The distance is estimated using the assumption of 0.275 dB/km installed fiber loss including splices and connectors for 1550 nm links according to GR-253-CORE.
30. Some D1 Video signals (as defined by SMPTE 259M) may not be carried error-free without using a second level of (proprietary) scrambling.

Table 3-2 Notes (Continued):

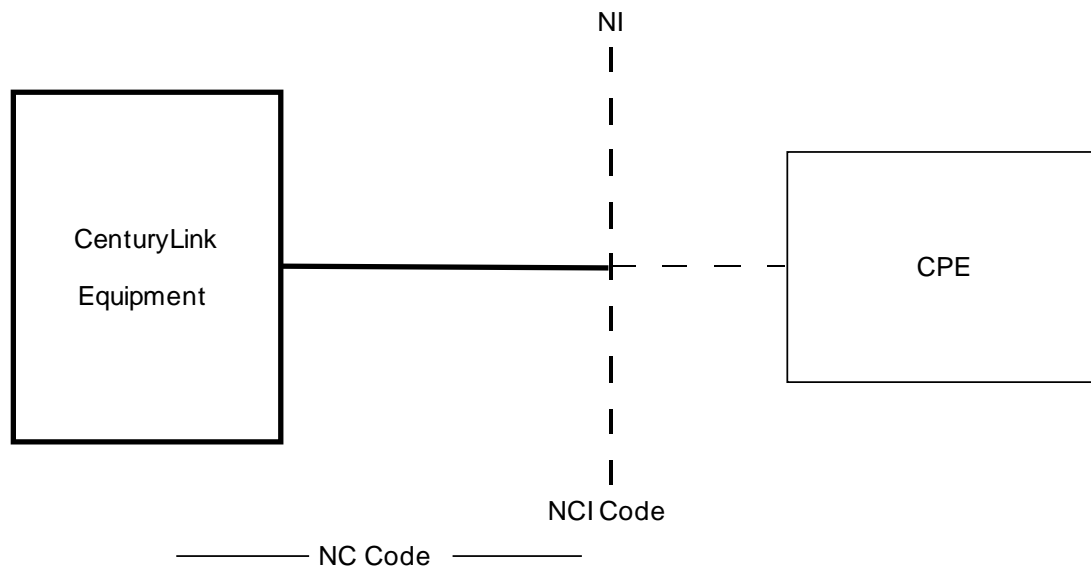
31. For shorter distances, a lower modal bandwidth multimode fiber may be substituted provided the performance requirements are met per the applicable standard.
32. μm = micron
33. Grandfathered services will continue to be supported on existing contracts (to include the Federal Networx contracts) until the platform supporting that service has reached end of life or the contract expires. No new orders will be accepted.

3.4 NC and NCI Codes

Note: CenturyLink may provision GeoMax on more than one type of DWDM-based equipment platform, herein referred to generically as Equipment Platform 1 and Equipment Platform 2. Due to inherent differences in technology and current positioning of the service, some NC and NCI Codes will be different or Not Applicable (or specifically Not Available in some cases) depending upon the specific equipment used by CenturyLink to provide a given customer's GeoMax. The customer will need to identify their service requirements and work with CenturyLink to determine the appropriate NC/NCIs.

Network Channel (NC) and Network Channel Interface (NCI) Codes convey service and technical parameters. The following sections explain the codes in a general manner and also provide specific codes to aid in ordering the CenturyLink Network Interface (NI) for GeoMax service. The NC and NCI Codes are provided by the customer to the CenturyLink Service Representative at the time a request for service is initiated. Figure 3-1 shows where the codes apply.

Figure 3-1 NC and NCI Codes



LEGEND

CPE = Customer Provided Equipment
NC = Network Channel
NCI = Network Channel Interface
NI = Network Interface

Additional information concerning NC/NCI Codes is available in ANSI T1.223-2004, *Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Codes for information exchanges*. See Chapter 7 for ordering information.

In some instances CenturyLink offerings differ from those described by Telcordia Technologies in their published Industry Support Interface: SR- 307, *COMMON LANGUAGE NC/NCI Dictionary*. Furthermore, definitions of NC and NCIs evolve. Therefore, it's important to request CenturyLink GeoMax service as defined in this Publication.

3.5 NC Code Function and Format

Primarily, service considerations are encoded into Network Channel (NC) Codes. Included in this code set are customer options associated with the individual channel services. The NC Code is specified by the customer to advise CenturyLink of the required service connection of the channel.

An NC Code consists of four alpha/numeric characters, which may include a dash (-). There are neither spaces nor delimiters between the characters. The NC Code consists of two data elements:

- The first two characters are the Channel Code, which describes the channel service in an abbreviated form.
- The last two characters are the Optional Feature Code, which represents the option codes available for each Channel Code. Varying combinations of this code allow for further identification of the type of service.

The customer must specify NC Codes for the desired service when ordering GeoMax.

3.6 GeoMax Network Channel Codes

Tables 3-3 and 3-4 list the Network Channel (NC) Codes available with CenturyLink GeoMax service.

Table 3-3 GeoMax System NC Codes

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
OADM/DWDM System				
DTAE	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength ¹ , Point-to-Point, 32 ² wavelengths	√	Not Applicable	Not Applicable
DTCE	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength ¹ , Unidirectional Ring Segment, 32 ² wavelengths	√	Not Applicable	Not Applicable
DUAK	Dense Wave Division Multiplexing (DWDM) system with a maximum of 40 Gbps per wavelength ¹ , Point-to-Point, 44 ² Wavelengths	Not Applicable	√	Not Applicable
DUCK	Dense Wave Division Multiplexing (DWDM) system with a maximum of 40 Gbps per wavelength ¹ , Unidirectional Ring Segment, 44 ² Wavelengths	Not Applicable	√	Not Applicable
DTAJ	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength, Point-to-point, 40 ² wavelengths	Not Applicable	Not Applicable	Not Applicable
DTBJ	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength, Point-to-point Protected, 40 ² wavelengths	Not Applicable	Not Applicable	Not Applicable
DTAG	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength, Point-to-point, 80 ² wavelengths	Not Applicable	Not Applicable	Not Applicable
DTBG	Dense Wave Division Multiplexing (DWDM) system with a maximum of 10 Gbps per wavelength, Point-to-point Protected, 80 ² wavelengths	Not Applicable	Not Applicable	Not Applicable
DVAK	Dense Wave Division Multiplexing (DWDM) system with a maximum of 100 Gbps per wavelength ¹ , Point-to-Point, 44 ² Wavelengths	Not Applicable	√	Not Applicable
DVAM	Dense Wave Division Multiplexing (DWDM) system with a maximum of 100 Gbps per wavelength ¹ , Point-to-Point, 88 ² Wavelengths	Not Applicable	√	√

Table 3-3 GeoMax System NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
OADM/DWDM System				
DVDK	Dense Wave Division Multiplexing (DWDM) system with a maximum of 100 Gbps per wavelength ¹ , Bidirectional Ring Segment, 44 ² Wavelengths	Not Applicable	√	Not Applicable
DVDM	Dense Wave Division Multiplexing (DWDM) system with a maximum of 100 Gbps per wavelength ¹ , Bidirectional Ring Segment, 88 ² Wavelengths	Not Applicable	√	√

Table 3-4 GeoMax Wavelength Channel NC Codes

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Wavelength Channels Riding the OADM/DWDM System				
PID-	Wavelength Channel, Protocol Independent and Bit Rate Variable channel on DWDM, Up to 10 Gbps ¹	√	Not Applicable	Not Applicable
PIDP	Wavelength Channel, Protocol Independent and Bit Rate Variable channel on DWDM, Up to 10 Gbps ¹ , Protected	√	Not Applicable	Not Applicable
Discontinued³ Sub Rate Multiplexed Wavelength Channels Riding the OADM/DWDM System				
PIS-	Wavelength Channel, Protocol Independent and Bit Rate Variable channel on DWDM, Sub-rate Multiplexed ⁴	√	Not Applicable	Not Applicable
PISP	Wavelength Channel, Protocol Independent and Bit Rate Variable channel on DWDM, Sub-rate Multiplexed ⁴ , Protected	√	Not Applicable	Not Applicable

Table 3-5 GeoMax Protocol Channel NC Codes

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)				
OPD-	LAN, Optical Data Transport, Point-To-Point FICON at 1.0625 Gbps	Grandfathered ¹¹	Not Applicable	Not Applicable
OPDP	LAN, Optical Data Transport, Point-to-point FICON™ at 1.0625 Gbps, Protected	Not Applicable	Not Applicable	Not Applicable
OPDH	LAN, Optical Data Transport, Point-To-Point FICON at 1.0625 Gbps, Rate-Adjustable via SONET transport at STS-1-19v, 919.296 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPDA	LAN, Optical Data Transport, Point-To-Point FICON at 1.0625 Gbps, Protected, Rate-Adjustable via SONET transport at STS-1-19v, 919.296 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPE-	LAN, Optical Data Transport, Point-To-Point FICON at 2.125 Gbps	Grandfathered ¹¹	Not Applicable	Not Applicable
OPEP	LAN, Optical Data Transport, Point-to-point FICON™ at 2.125 Gbps, Protected	Not Applicable	Not Applicable	Not Applicable
OPEH	LAN, Optical Data Transport, Point-To-Point FICON at 2.125 Gbps, Rate-Adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPEI	LAN, Optical Data Transport, Point-To-Point FICON at 2.125 Gbps, Protected, Rate-Adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPK-	LAN, Optical Data Transport, ISC-3 – IBM Intersystem Channel at 2.125 Gbps, Point-To-Point	√	Not Applicable	√
OPKP	LAN, Optical Data Transport, ISC-3 – IBM Intersystem Channel at 2.125 Gbps, Point-To-Point, Protected	Not Applicable	Not Applicable	Not Applicable
OPKH	LAN, Optical Data Transport, ISC-3 – IBM Intersystem Channel at 2.125 Gbps, Rate adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√ (Where Available) ⁵	Not Applicable
OPKI	LAN, Optical Data Transport, ISC-3 – IBM Intersystem Channel at 2.125 Gbps, Protected, Rate adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√ (Where Available) ⁵	Not Applicable

Table 3-5 GeoMax Protocol Channel NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)				
OPH-	LAN, Optical Data Transport, Fibre Channel at 266 Mbps	Discontinued ⁶	Not Available	Not Applicable
OPF-	LAN, Optical Data Transport, Fibre Channel at 1.0625 Gbps	√	Not Applicable	√
OPFP	LAN, Optical Data Transport, Fibre Channel at 1.0625 Gbps, Protected	Not Applicable	Not Applicable	Not Applicable
OPFH	LAN, Optical Data Transport, Fibre Channel at 1.0625 Gbps, Rate-Adjustable via SONET transport at STS-1-19v, 919.296 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPFA	LAN, Optical Data Transport, Fibre Channel at 1.0625 Gbps, Protected, Rate-Adjustable via SONET transport at STS-1-19v, 919.296 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPJ-	LAN, Optical Data Transport, Fibre Channel at 2.125 Gbps	√	Not Applicable	√
OPJP	LAN, Optical Data Transport, Fibre Channel at 2.125 Gbps, Protected	Not Applicable	Not Applicable	Not Applicable
OPJH	LAN, Optical Data Transport, Fibre Channel at 2.125 Gbps, Rate-Adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPJI	LAN, Optical Data Transport, Fibre Channel at 2.125 Gbps, Protected, Rate-Adjustable via SONET transport at STS-1-38v, 1838.592 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPL-	LAN, Optical Data Transport, Fibre Channel at 4.25 Gbps	√	Not Applicable	√
OPLP	LAN, Optical Data Transport, Fibre Channel at 4.25 Gbps, Protected	Not Applicable	Not Applicable	Not Applicable
OPLF	LAN, Optical Data Transport, Fibre Channel at 4.25 Gbps, Rate-Adjustable via SONET transport at STS-1-76v, 3677.184 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPLE	LAN, Optical Data Transport, Fibre Channel at 4.25 Gbps, Protected, Rate-Adjustable via SONET transport at STS-1-76v, 3677.184 Mbps Nominal Payload Rate	Not Applicable	√	Not Applicable
OPM-	LAN, Optical Data Transport, Fibre Channel at 10 Gbps	√	√	√
OPMP	LAN, Optical Data Transport, Fibre Channel at 10 Gbps, Requires protected Infrastructure	Not Applicable	√	Not Applicable

Table 3-5 GeoMax Protocol Channel NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Video				
TD--	D1 Video, Component Serial Digital Video – Uncompressed (270 Mbps), Two-Point	Discontinued ⁶	Not Available	Not Applicable
Ethernet				
KEA-	Ethernet at 100 Mbps, Full Duplex LAN	Grandfathered ¹¹	Not Applicable	Not Available
KQFT	Rate-Adjustable 100 Mbps Ethernet, Full Duplex - Rate based on SONET Transport, STS-1-3v, 145.152 Mbps Nominal Payload Rate	Not Applicable	Grandfathered ¹¹	Not Available
KQPT	Rate-Adjustable 100 Mbps Ethernet, Protected Full Duplex - Rate based on SONET transport, STS-1-3v, 145.152 Mbps Nominal Payload Rate	Not Applicable	Grandfathered ¹¹	Not Available
KFL-	Ethernet at 1 Gbps, LAN	√	√	√
KFLP	Ethernet at 1 Gbps, LAN, Protected	Not Applicable	√	√
KRRG	Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on SONET transport with Hi-Order VCAT, STS-3c-7v, 1048.32 Mbps Nominal Payload Rate	Not Applicable	√	Not Available
KRRQ	Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on SONET transport with Hi-Order VCAT, Protected, STS-3c-7v, 1048.32 Mbps Nominal Payload Rate	Not Applicable	√	Not Available
KGW-	Ethernet at 10 Gbps, WAN (9.95328 Gbps)	√	√	√
KGWP	Ethernet at 10 Gbps, WAN (9.95328 Gbps), Protected	Not Applicable	√	√
KGL-	Ethernet at 10 Gbps, LAN PHY at 10.3125 Gbps , Ethernet frames, payload only	√	√	√
KGLP	Ethernet at 10 Gbps, LAN PHY at 10.3125 Gbps, Ethernet frames, payload only, Protected	Not Applicable	√	√
KHL-	Ethernet at 40 Gbps, full duplex LAN	Not Applicable	√	√
KHLP	Ethernet at 40 Gbps, full duplex LAN, Protected	Not Applicable	Not Applicable	√
KJL	Ethernet at 100 Gbps, Full Duplex LAN	Not Available	√	√
KJLP	Ethernet at 100 Gbps, Full Duplex LAN, Protected	Not Available	√	√

Table 3-5 GeoMax Protocol Channel NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Optical Transport Network (OTN)				
OJ--	Optical Transport Network (OTN) per ITU-T G.709 OTU1 (255/238 x 2.488 3202.666057143 Gbps) also referred to as 2.7 Gbps, Point-to-Point	Not Available	√	√
OJT-	Optical Transport Network (OTN) per ITU-T G.709 OTU1 (255/238 x 2.488 3202.666057143 Gbps) also referred to as 2.7 Gbps, Point-to-Point, Requires protected infrastructure	Not Available	√	√
OK--	Optical Transport Network (OTN) OTU2 per ITU-T G.709, Point-to-Point at 10.709 Gbps	√	√	√
OKT-	Optical Transport Network (OTN) OTU2 per ITU-T G.709, Point-to-Point at 10.709 Gbps, Requires protected infrastructure	Not Applicable	√	√
OKD-	Optical Transport Network (OTN) OTU2e per ITU-T G.Sup43 and G.709, Point-to-Point overclocked to 11.0957 Gbps	Not Available	√	√
OKDP	Optical Transport Network (OTN) OTU2e per ITU-T G.Sup43 and G.709, Point-to-Point overclocked to 11.0957 Gbps, Requires protected infrastructure	Not Available	√	√
OL--	Optical Transport Network (OTN) per ITU-T G.709 OTU3 (255/236 x 39.813120 Gbps = 43.018413559 Gbps) also referred to as 43 Gbps, Point-to-Point	Not Available	√	√
OLT-	Optical Transport Network (OTN) per ITU-T G.709 OTU3 (255/236 x 39.813120 Gbps = 43.018413559 Gbps) also referred to as 43 Gbps, Point-to-Point, Requires protected infrastructure	Not Available	√	√
OM--	Optical Transport Network (OTN) per ITU-T G.709 OTU4 also referred to as 111.108 Gbps, Point-to-Point	Not Available	√	√
OMT-	Optical Transport Network (OTN) per ITU-T G.709 OTU4 also referred to as 111.108 Gbps, Point-to-Point, Requires protected infrastructure	Not Available	√	√

Table 3-5 GeoMax Protocol Channel NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
SONET				
OB--	SONET, OC-3, 155.520 Mbps, Point-to-Point channel	√	Not Applicable	√
OB-Z	SONET, OC-3, 155.520 Mbps, Point-to-Point channel, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√
OBTZ	SONET, OC-3, 155.520 Mbps, Point to Point Requiring protected Infrastructure, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable		√
OD--	SONET, OC-12, 622.080 Mbps, Point-to-Point channel	√	Not Applicable	√
OD-Z	SONET, OC-12, 622.080 Mbps, Point-to-Point channel, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√
ODTZ	SONET, OC-12, 622.080 Mbps, Point to Point Requiring protected Infrastructure, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable		√
OF--	SONET, OC-48, 2488.320 Mbps, Point-to-Point channel	√	Not Applicable	√
OF-Z	SONET, OC-48, 2488.320 Mbps, Point-to-Point channel, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√
OFTZ	SONET, OC-48, 2488.320 Mbps, Point to Point Requiring protected Infrastructure, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√

Table 3-5 GeoMax Protocol Channel NC Codes (Continued)

NC Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
SONET				
OG--	SONET, OC-192, 9953.280 Mbps, Point-to-Point channel	Grandfathered ¹¹	Not Applicable	Grandfathered ¹¹
OG-Z	SONET, OC-192, 9953.280 Mbps, Point-to-Point channel, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√
OGTZ	SONET, OC-192, 9953.280 Mbps, Point to Point Requiring protected Infrastructure, This service is transported over non-SONET infrastructure (overhead remains transparent to provider)	Not Applicable	√	√
OH--	SONET, OC-768, 39813.12 Mbps, Point-to-Point channel	Not Available	Grandfathered ¹¹	Grandfathered ¹¹
OHT-	SONET, OC-768, 39813.12 Mbps, Point to Point Requiring protected Infrastructure	Not Available	Grandfathered ¹¹	Grandfathered ¹¹

Tables 3-3 to 3-5 Notes:

1. Maximum bit rate per Wavelength or Protocol Channel.
2. Maximum number of wavelengths per fiber path.
3. These options have been discontinued and if/where available only applies to existing customers.
4. The Sub-rate Multiplexed Wavelength Channel NC Codes are to be used in conjunction with the Sub Rate Mux Wavelength Channel NCIs listed in Table 3-7. The Sub Rate Mux cards allow multiple Protocol Channels to ride a single wavelength. All of the protocols will have the protection specified for that Wavelength Channel. See the Sub Rate Mux NCI Codes for further information including a list of supported protocols.
5. Requests for ISC-3 at 2.125 Gbps will be considered on an Individual Case Basis.
6. These protocols have been discontinued and are only available to existing customers with a GeoMax contract as of December 16, 2009. No new orders will be accepted.
7. See Tables 3-5 to 3-7 for the compatible NCI Codes to use at each node location on the GeoMax network, and at the ends of each Wavelength and Protocol Channel. While the protocol and bit rate (e.g., Gigabit Ethernet) must be the same at both ends of the channel, the wavelength and fiber type may be different (e.g., 1000BASE-LX or 1000BASE-SX) for a given IEEE 802.3 Physical Layer specification (1000BASE-X).
8. As described in Sections 2.7 and 2.8, GeoMax protection options are available on a per (protocol or wavelength) channel basis.
9. FICON = Fiber Connection.
10. ISC = InterSystem Channel.
11. Grandfathered services will continue to be supported on existing contracts (to include the Federal Network contracts) until the platform supporting that service has reached end of life or the contract expires. No new orders will be accepted.

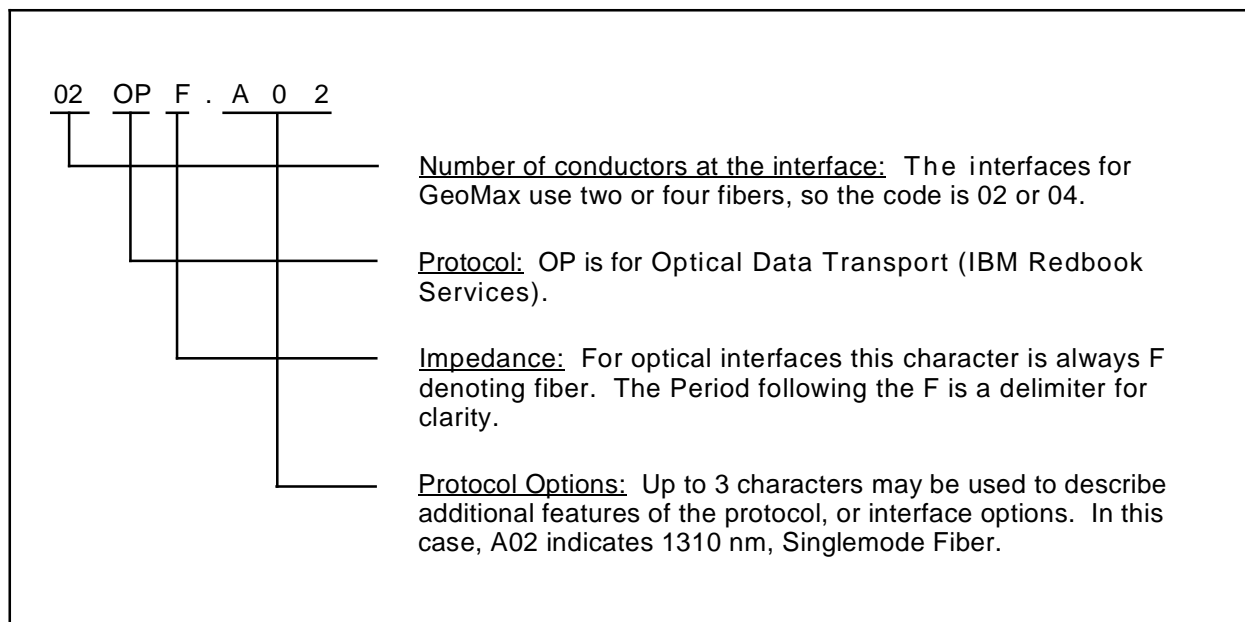
3.7 NCI Code Form and Components

The Network Channel Interface (NCI) Code provides the means to define the Network Interface physical and optical characteristics for the service order, design and circuit provisioning processes. The full NCI Code format has fields not used for optical services. Only those fields relevant to GeoMax interfaces are discussed here.

An NCI Code has the form 02OPF.A02. The period between the characters is a delimiter, which is used for improved clarity. It causes the subsequent Protocol Option Codes to stand out. An NCI Code has no dashes (-).

Figure 3-2 illustrates the components of the GeoMax Network Channel Interface Codes.

Figure 3-2 GeoMax NCI Code Example



3.8 GeoMax Network Channel Interface Codes

Tables 3-6 to 3-9 list the optical NCI Codes available with CenturyLink GeoMax service.

Table 3-6 GeoMax System NCI Codes

NCI Code	Description	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
OADM/DWDM System				
02FMF.004	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 4 ¹ wavelength	√	√	Not Applicable
02FMF.008	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 8 ¹ wavelengths	√	√	Not Applicable
02FMF.012	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 12 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.016	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 16 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.020	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 20 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.024	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 24 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.028	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 28 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.032	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 32 ¹ wavelengths	√	Not Applicable	Not Applicable
02FMF.044	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 44 ¹ wavelengths	Not Applicable	√	Not Applicable
02FMF.088	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Multiplexer with access to 88 ¹ wavelengths	Not Applicable	√	√
02FMF.040	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1) Multiplexer with access to 40 ¹ wavelengths	Not Applicable	Not Applicable	Not Applicable
02FMF.080	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1) Multiplexer with access to 80 ¹ wavelengths	Not Applicable	Not Applicable	Not Applicable

Table 3-7 GeoMax Wavelength Channel NCI Codes

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Wavelength Channels Riding the OADM/DWDM System					
02WLF.A02	Transparent Wavelength Channel, 1310 nm, Singlemode Fiber	FICON at 1.0625 Gbps (Grandfathered ¹⁹) FICON at 2.125 Gbps (Grandfathered ¹⁹) ISC-3 at 2.125 Gbps OC-3 OC-12 OC-48 OC-192 multiplexed only Fast Ethernet (Grandfathered ¹⁹) Gigabit Ethernet 10 Gigabit Ethernet WAN PHY 10 Gigabit Ethernet LAN PHY OTU2 Fibre Channel at 266 Mbps (Discontinued ²) Fibre Channel at 1.0625 Gbps Fibre Channel at 2.125 Gbps Fibre Channel at 4.25 Gbps Fibre Channel at 10.52 Gbps D1 Video (Discontinued ²)	√	Not Applicable	Partially available as indicated in this Tech Pub.
02WLF.A03	Transparent Wavelength Channel, 1550 nm, Singlemode Fiber	Gigabit Ethernet	√	Not Applicable	√

Table 3-7 GeoMax Wavelength Channel NCI Codes (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Wavelength Channels Riding the OADM/DWDM System					
02WLF.A04	Transparent Wavelength Channel, 850 nm, 50 micron Multimode Fiber	FICON at 1.0625 Gbps FICON at 2.125 Gbps Gigabit Ethernet 10 Gigabit Ethernet LAN PHY Fibre Channel at 1.0625 Gbps Fibre Channel at 2.125 Gbps Fibre Channel at 4.25 Gbps	Grandfathered ¹⁹	Not Applicable	Not Applicable
02WLF.A05	Transparent Wavelength Channel, 1310 nm, 50 micron Multimode Fiber	Fibre Channel at 266 Mbps (Discontinued ²)	Discontinued ²	Not Applicable	Not Applicable
02WLF.A07	Transparent Wavelength Channel, 850 nm, 62.5 micron Multimode Fiber	FICON at 1.0625 Gbps FICON at 2.125 Gbps Gigabit Ethernet 10 Gigabit Ethernet LAN PHY Fibre Channel at 1.0625 Gbps Fibre Channel at 2.125 Gbps Fibre Channel at 4.25 Gbps	Grandfathered ¹⁹	Not Applicable	Not Applicable
02WLF.A08	Transparent Wavelength Channel, 1310 nm, 62.5 micron Multimode Fiber	Fast Ethernet Fibre Channel at 266 Mbps (Discontinued ²)	Grandfathered ¹⁹	Not Applicable	Not Applicable

Table 3-7 GeoMax Wavelength Channel NCI Codes (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Discontinued³ Sub Rate Multiplexed Wavelength Channels Riding the OADM/DWDM System⁴					
02FMF.S 04FMF.S ⁵	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Sub Rate Mux, 4 ports @ 50-270 Mbps each	1310 nm, Singlemode and/or 50/62.5 micron Multimode Fiber: OC-3 ⁶ SMF Fast Ethernet SMF (Grandfathered ¹⁹) Fast Ethernet MMF (Grandfathered ¹⁹) Fibre Channel at 266 Mbps MMF (Discontinued ²) D1 Video SMF (Discontinued ²)	FastE – Grandfathered ¹⁹ 266 Mbps Fibre Channel and D1 Video SMF – Discontinued ²	Not Applicable	Not Applicable
02FMF.S3 04FMF.S3 ⁵	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Sub Rate Mux, 2 ports @ up to 1.25 Gbps each (GigE, Fibre Channel, FICON)	1310 nm, Singlemode Fiber: Gigabit Ethernet Fibre Channel at 1.0625 Gbps FICON at 1.0625 Gbps	√	Not Applicable	Not Applicable
02FMF.S5 04FMF.S5 ⁵	Wavelength Division Multiplexing Interface (DWDM per ITU-694.1), Sub Rate Mux, 4 ports of SONET/SDH OC-3 and/or OC-12 (UPSR only)	1310 nm, Singlemode Fiber: OC-3 OC-12	√	Not Applicable	Not Applicable

Table 3-8 GeoMax Protocol Channel NCI Codes at Access Carrier and End User
Customer Premises

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)					
02OPF.A02	Optical Data Transport (IBM Redbook Services), 1310 nm, Singlemode Fiber	FICON at 1.0625 Gbps	Grandfathered ¹⁹	√	Not Available
		FICON at 2.125 Gbps	Grandfathered ¹⁹	√	Not Available
		ISC-3 at 2.125 Gbps	√	√ (Where Available) ⁷	√
		Fibre Channel at 266 Mbps	Discontinued ²	Not Available	Not Available
		Fibre Channel at 1.0625 Gbps	√	√	√
		Fibre Channel at 2.125 Gbps	√	√	√
		Fibre Channel at 4.25 Gbps	√	√	√
		Fibre Channel at 10.52 Gbps	√	√	√
02OPF.A04	Optical Data Transport (IBM Redbook Services), 850 nm, 50 micron Multimode Fiber	FICON at 1.0625 Gbps	Grandfathered ¹⁹	√	Not Available
		FICON at 2.125 Gbps	Grandfathered ¹⁹	√	Not Available
		Fibre Channel at 1.0625 Gbps	√	√	Not Available
		Fibre Channel at 2.125 Gbps	√	√	Not Available
		Fibre Channel at 4.25 Gbps	√	√	Not Available

Table 3-8 GeoMax Protocol Channel NCI Codes at Access Carrier and End User
Customer Premises (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)					
02OPF.A05	Optical Data Transport (IBM Redbook Services), 1310 nm, 50 micron Multimode Fiber	Fibre Channel at 266 Mbps	Discontinued ²	Not Available	Not Available
02OPF.A07	Optical Data Transport (IBM Redbook Services), 850 nm, 62.5 micron Multimode Fiber	FICON at 1.0625 Gbps	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		FICON at 2.125 Gbps	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		Fibre Channel at 1.0625 Gbps	√	√	Not Available
		Fibre Channel at 2.125 Gbps	√	√	Not Available
		Fibre Channel at 4.25 Gbps	√	√	Not Available
02OPF.A08	Optical Data Transport (IBM Redbook Services), 1310 nm, 62.5 micron Multimode Fiber	Fibre Channel at 266 Mbps	Discontinued ²	Not Available	Not Available
Video					
02TDF.E	Component Digital D1 Video	D1 Video	Discontinued ²	Not Available	Not Available

Table 3-8 GeoMax Protocol Channel NCI Codes at Access Carrier and End User
Customer Premises (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Ethernet					
02LNF.A02	Local Area Network Interface, 1310 nm, Singlemode Fiber	Fast Ethernet	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		Gigabit Ethernet	√	√	√
		10 Gigabit Ethernet WAN PHY	√	√	√
		10 Gigabit Ethernet LAN PHY	√	√	√
02LNF.A03	Local Area Network Interface, 1550 nm, Singlemode Fiber	Gigabit Ethernet	√	√	√
02LNF.A04	Local Area Network Interface, 850 nm, 50 micron Multimode Fiber	Gigabit Ethernet	√	√	Not Available
		10 Gigabit Ethernet LAN PHY	√	√	Not Available
02LNF.A07	Local Area Network Interface, 850 nm, 62.5 micron Multimode Fiber	Gigabit Ethernet	√	√	Not Available
		10 Gigabit Ethernet LAN PHY	√	√	Not Available
02LNF.A08	Local Area Network Interface, 1310 nm, 62.5 micron Multimode Fiber	Fast Ethernet	Grandfathered ¹⁹	Not Available	Not Available
02LNF.4LL	40GBASE-LR4 with 1310 nm 40 Gbps PHY using 40GBASE-R encoding over four WDM lanes on single-mode fiber, with reach up to at least 10 km per IEEE 802.3ba with Provider optical loopback/monitoring device.	40 Gigabit Ethernet	Not Available	√	√
02LNF.CL4	Local Area Network (LAN) Interface, 100GBASE-LR4, 100 Gbps PHY using 100GBASE-R encoding over four WDM lanes via two single-mode fibers, with reach up to at least 10 km per IEEE 802.3ba-2010	100 Gigabit Ethernet	Not Available	√	√

Table 3-8 GeoMax Protocol Channel NCI Codes at Access Carrier and End User
Customer Premises (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Optical Transport Network (OTN)					
02OTF.102	Optical Transport Network (OTN) Optical Interface, OTU1 with 1310 nm, Single-mode Fiber	OTU1	Not Available	√	√
02OTF.103	Optical Transport Network (OTN) Optical Interface, OTU1 with 1550 nm, Single-mode Fiber	OTU1	Not Available	√	√
02OTF.202	OTN Interface, OTU2 with 1310 nm, Single-mode Fiber	OTU2	√	√	√
02OTF.203	OTN Interface, OTU2 with 1550 nm, Single-mode Fiber	OTU2	Not Available	√	√
02OTF.2E2	OTN Interface, OTU2e with 1310 nm, Single-mode Fiber	OTU2e	Not Available	√	√
02OTF.2E3	OTN Interface, OTU2e with 1550 nm, Single-mode Fiber	OTU2e	Not Available	√	√
02OTF.302	Optical Transport Network (OTN) Optical Interface, OTU3 with 1310 ⁹ nm, Single-mode Fiber	OTU3	Not Available	√	√
02OTF.303	Optical Transport Network (OTN) Optical Interface, OTU3 with 1550 nm, Single-mode Fiber	OTU3	Not Available	√	√
02OTF.402	Optical Transport Network (OTN) Optical Interface, OTU4 with 1310 ⁹ nm, Single-mode Fiber	OTU4	Not Available	√	√

Table 3-8 GeoMax Protocol Channel NCI Codes at Access Carrier and End User
Customer Premises (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
SONET					
02SOF.D 04SOF.D ⁸	SONET/SDH Optical Interface, ANSI: Intermediate Reach – 1, Single Longitudinal Mode Laser, 1310 nm (ITU- T: S-16.1 & SLM) ¹⁰	OC-3	√	√	√
		OC-12	√	√	√
		OC-48	√	√	√
		OC-192	√	Not Available	√
02SOF.M 04SOF.M	SONET/SDH Optical Interface, ANSI: Short Reach – 1, Single Longitudinal Mode Laser, 1310 nm (ITU-T: I-64.1 or VSR2000-3R1 & SLM)	OC-192	Not Available	√	√
02SOF.L 04SOF.L	SONET/SDH Optical Interface, ANSI: Intermediate Reach – 2, Single Longitudinal Mode Laser, 1550 nm (ITU- T: S-1.2 or S-4.2 or S-16.2 or S-64.2 & SLM)	OC-192	Not Available	√	√
02SOF.N 04SOF.N	SONET/SDH Optical Interface, Short Reach – 2, Single Longitudinal Mode Laser, 1550 nm (ITU-T: I-64.2 or VSR2000- 3R2/VSR2000-3R3/VSR2000-3R5 & SLM)	OC-768	Not Available	Grandfathered ¹⁹	Grandfathered ¹⁹

Table 3-9 GeoMax Protocol Channel NCI Codes at CenturyLink COs

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Storage Area Network (SAN)					
02QBF.P02	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, IBM Redbook Optical, 1310 nm, Single-mode Fiber	FICON at 1.0625 Gbps	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		FICON at 2.125 Gbps	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		ISC-3 at 2.125 Gbps	√	√ (Where Available) ⁷	√
		Fibre Channel at 1.0625 Gbps	√	√	√
		Fibre Channel at 2.125 Gbps	√	√	√
		Fibre Channel at 4.25 Gbps	√	√	√
		Fibre Channel at 10.52 Gbps	√	√	√

Table 3-9 GeoMax Protocol Channel NCI Codes at CenturyLink COs (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Ethernet					
02QBF.K02	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, Ethernet, 1310 nm, Single-mode Fiber	Fast Ethernet	Grandfathered ¹⁹	Grandfathered ¹⁹	Not Available
		Gigabit Ethernet	√	√	√
		10 Gigabit Ethernet WAN PHY	√	√	√
		10 Gigabit Ethernet LAN PHY	√	√	√
02QBF.K03	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, Ethernet, 1550 nm, Single-mode Fiber	Gigabit Ethernet	√	√	√
02QBF.4L4	40GBASE-LR4, 40 Gbps PHY using 40GBASE-R encoding over four WDM lanes on 1310 nm single-mode fiber, with reach up to at least 10 km per IEEE 802.3ba-2010.	40 Gigabit Ethernet	Not Available	√	√
02QBF.CL4	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, 100GBASE-LR4, 100 Gbps PHY using 100GBASE-R encoding over four WDM lanes via two single-mode fibers, with reach up to at least 10 km per IEEE 802.3ba-2010	100 Gigabit Ethernet	Not Available	√	√

Table 3-9 GeoMax Protocol Channel NCI Codes at CenturyLink COs (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Optical Transport Network (OTN)					
02QBF.102	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU1 with 1310 nm, Single-mode Fiber	OTU1	Not Available	√	√
02QBF.103	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU1 with 1550 nm, Single-mode Fiber	OTU1	Not Available	√	√
02QBF.202	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU2 with 1310 nm, Single-mode Fiber	OTU2	√	√	√
02QBF.203	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU2 with 1550 nm, Single-mode Fiber	OTU2	Not Available	√	√
02QBF.2E2	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU2e with 1310 nm, Single-mode Fiber	OTU2e	Not Available	√	√

Table 3-9 GeoMax Protocol Channel NCI Codes at CenturyLink COs (Continued)

NCI Code	Description	Available Protocols	Equipment Platform 1	Equipment Platform 2	Equipment Platform 3
Optical Transport Network (OTN)					
02QBF.2E3	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU2e with 1550 nm, Single-mode Fiber	OTU2e	Not Available	√	√
02QBF.302	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU3 with 1310 ⁹ nm, Single-mode Fiber	OTU3	Not Available	√	√
02QBF.303	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU3 with 1550 nm, Single-mode Fiber	OTU3	Not Available	√	√
02QBF.402	Central Office Manual cross-connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, OTU4 with 1310 ⁹ nm, Single-mode Fiber	OTU4	Not Available	√	√
SONET					
02QBF.LL 04QBF.LL ⁸	Central Office Manual Cross Connect Termination With No Sub-Rating Capability For Non-Multiplexed Facilities Only, SONET/SDH Optical on a fiber distribution bay	OC-3	√	√	√
		OC-12	√	√	√
		OC-48	√	√	√
		OC-192	Grandfathered ¹⁹	Grandfathered ¹⁹	Grandfathered ¹⁹
		OC-768	Not Available	Grandfathered ¹⁹	Grandfathered ¹⁹

Tables 3-6 to 3-9 Notes:

1. The system-level NCI Code at a given GeoMax Node site on the OADM/DWDM network identifies the requirement to add/drop up to # wavelengths, 8, 44 or 88 for example with CenturyLink Equipment Platform 2 (ROADM).
2. These protocols have been discontinued and are only available to existing customers with a GeoMax contract as of December 16, 2009.
3. These previously customer-orderable options have been discontinued and if/where available limited to existing customer contracts. Note that some of the Sub Rate Multiplexer cards have been discontinued or are no longer supported on GeoMax. Based on customer requirements, CenturyLink Engineering will determine the appropriate equipment to deliver the service including Network Interface cards.
4. There can only be one source and destination location for the signals on a Sub-rate Multiplexed Wavelength Channel.
5. Each port requires the ordering of 2 similar protocol channels (for those listed with a 2 fiber NCI Code only).
6. With this Sub Rate Mux circuit pack, multiple OC-3 source signals must come from a single SONET/SDH transport product that can be configured for either BITS synchronization or line timing. You cannot connect the OC-3 signals to the SRM card from a source that cannot function as a SONET/SDH transport product. Multiple OC-3 source traffic signals that are to be connected to the SRM card must be frequency synchronous to a single internal clock source as the H1, H2 & H3 STS Payload Pointer and Action bytes are not processed.
7. Requests for ISC-3 at 2.125 Gbps will be considered on an Individual Case Basis.
8. Requires the ordering of two similar wavelength channels (with Equipment Platform 1).
9. See Table 3-2 for the WDM lane (wavelength) assignments.
10. While the indication is that of an SLM laser, an MLM transmitter may be used to provide OC-3 and OC-12 singlemode fiber interfaces.
11. An OADM/DWDM System NCI Code is required for both the "east" and "west" fiber paths at each node location.
12. See Sections 2.7 and 2.8 for a description of the 2 and 4 fiber channel protection options.
13. 4 fiber Network Interfaces for non-SONET protocols associated with the customer-specified option of two unprotected channels with CenturyLink-provided diverse OADM network transport will require two similar 2 fiber NCI – NC – 2 fiber SEC NCI orders.
14. Specific protocol or bit rate information is specified by the corresponding Protocol Channel NC Code from Table 3-5.
15. ISC and FICON interfaces present a symmetric, fiber optic signal at a nominal rate using an IBM open optical interface. Full details of these IBM protocols and physical requirements are available from IBM in their Redbook series. IBM's Redbook web site is at <http://www.redbooks.ibm.com/>.
16. MLM = Multi Longitudinal Mode

Tables 3-6 to 3-9 Notes (Continued):

17. NRZ = Non-Return-to-Zero, a DC balanced signals intent is the elimination of long strings of ones and zeros resulting in an equal number of each. It improves clock recovery effectiveness.
18. D1 Video is a serial digital video based on SMPTE 259M and CCIR601 that is transmitted at 270 Mbps.
19. Grandfathered services will continue to be supported on existing contracts (to include the Federal Network contracts) until the platform supporting that service has reached end of life or the contract expires. No new orders will be accepted.

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4. Performance Specifications

4.1 General

The GeoMax network primarily operates at the lower SONET and/or Optical Transport Network (OTN) physical layers in support of providing transparency for the incoming customer protocols. As such, CenturyLink's performance responsibilities will be limited to the transport integrity of the underlying wavelength and protocol channel support layers only and not the customer end-to-end higher layer protocols being carried over the GeoMax Fixed or Reconfigurable OADM/DWDM network.

Objectives given in this section are for all one-way system options, designed consistent with standard Optical Transport Network architectures. These performance objectives apply in a normal operating environment and only for the GeoMax provided portion of a service. For services where GeoMax provides only a segment of the entire path, performance of the service is dictated by the segment with the lowest objectives.

Loopback tests should be made using the one-way limits because one direction is likely to be controlling. If these tests fail, the failed direction should be sectionalized and appropriate one-way tests made.

4.2 Service Availability

The service is available when it's in a state where it's fully useable. A service is assumed to be in the available state unless a transition to the unavailable state is observed without a subsequent transition to the available state.

Transitions between the available and unavailable states are:

- Transition to the Unavailable state occurs at the beginning of 10 consecutive Loss of Signal Seconds (LOSS) or Severely Errored Seconds (SEs).
- Transition to the Available state occurs at the beginning of 10 consecutive seconds none of which consists of a LOSS or SES condition.

LOSS and SES conditions will be as determined by the CenturyLink Network Operations Center (NOC) monitoring of the GeoMax network, including the evaluation of available Performance Monitoring (PM) registers, alarms, Threshold Crossing Alerts (TCAs), and events generated and logged by the CenturyLink OADM/DWDM equipment and Operations System Support (OSS).

Each direction of the service is assumed to be in the available state unless a transition to the unavailable state is observed without a subsequent transition to the available state.

Availability objectives are stated in terms of the channel protection option ordered as shown in Table 4-1. GeoMax protection configurations and channel protection options are described in Chapter 2.

Table 4-1 Availability Objectives

All channels/ bit rates	% Service Availability (Monthly)
Unprotected	99.9
Protected	99.999

Note: Excludes planned outages/
maintenance windows,
malfunction of Customer
Provided Equipment and
power at the premises.

4.3 Bit Error Ratio (BER)

BER is defined as the ratio of the number of bit errors to the total number of bits transmitted in a given time interval.

The BER for GeoMax will be 10^{-10} or better for all channels on the service and may be monitored or derived via the BIP-8 overhead bytes for error detection at the applicable OTN (OTUk or ODUk) or SONET Section, Line and/or Path layers depending upon the protocol ordered and visibility along with that used for encapsulation and Digital Wrapper.

4.4 Throughput

Throughput is defined as the total capability of equipment to process or transmit data during a specified time period. The GeoMax network and each network component are designed and sized to deliver the full throughput that the native protocol can achieve. However, performance may be affected by the inherent delay caused by signals traveling over long distances, which is a characteristic of the protocol architecture, rather than that of the GeoMax OADM network.

Storage Area Network (SAN) protocols such as FICON and Fibre Channel are distance sensitive whereas the actual data throughput will depend upon the customer packet size and available buffer credits in conjunction with the end-to-end transport distance. See the ANSI and IBM references in Chapter 7 for detailed SAN requirements.

4.5 Delay (Latency)

Delay is defined as the time interval between the transmission of a signal at one point and the reception or detection of the same signal at another point. The end-to-end one-way delay across the GeoMax Layer 1 transport network, measured from Network Interface to Network Interface will be no more than 8.4 us/mi (5.2 us/km) for each channel. This includes the GeoMax fiber optic propagation delay as well as that attributable to other components in the signal path for channel add-drop, regeneration or amplification per GR-499-CORE, *Transport Systems Generic Requirements (TSGR): Common Requirements* and also applies to the alternate fiber path for protected channels. GeoMax point-to-point channels do not include oversubscription or traffic flow congestion mechanisms for data protocols.

4.6 Reflectance

Reflectance is defined as the ratio in decibels (dB) of reflected power to incident power. If not controlled, reflections can degrade DWDM system performance. In general, reflection-induced degradation increases with system bit-rate, optical source coherence, and fiber dispersion. By enforcing reflectance requirements on individual components placed in the fiber optic transmission span, and by requiring system performance to have a tolerance to specified reflectance values from these components, the effects of fiber optic system reflection noise can be minimized.

Individual channel reflectance objectives are stated in terms of the two parameters listed in Table 4-2. Optical Return Loss (ORL) is defined as the ratio of the optical power arriving downstream at a DWDM system interface to the optical power reflected back upstream to the same interface. Additionally, receiver reflectance criteria are enforced in order to prevent multi-path interference between two or more reflections.

Table 4-2 Reflectance Objectives

Parameter	All channels
ORL (minimum)	24 dB
Receiver Reflectance (maximum)	-27 dB

Note: Includes patchcords, attenuators, connectors, splices, fiber, couplers, Fiber Distribution Panels, OADM/DWDM equipment components, Passive Dispersion Compensation devices and Optical Fiber Amplifiers.

4.7 Jitter

Timing jitter is defined as the short-term variations of the significant instants of a digital signal from their ideal positions in time (where short-term implies that these variations are of frequency greater than or equal to 10 Hz).

Jitter performance and supporting characteristics of the eye mask will follow the requirements as indicated in GR-499-CORE, GR-253-CORE, *Synchronous Optical Network (SONET) Transport Systems: Common Criteria* including the Category II jitter transfer and tolerance criteria along with ANSI T1.105.03-2003, *Synchronous Optical Network (SONET) – Jitter and Wander at Network and Equipment Interfaces*; ITU-T G.825, *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)* and ITU-T G.8251, *The control of jitter and wander within the optical transport network (OTN)* at the OTUk layer as utilized within the GeoMax OADM/DWDM equipment including client mappers, 3R regenerators, and client demappers.

4.8 Protection Switching

Automatic Protection Switching (APS) improves the availability and reliability performance of CenturyLink GeoMax service by substituting backup equipment or an alternate fiber or signal path when failure occurs on a protected channel.

The APS function will operate and switch the affected protocol channel to the OTN or SONET protected system when a signal degradation (such as a BER threshold crossing at the ODU layer), Loss of Signal (LOS), Loss of Frame (LOF) or circuit card failure for example is detected on the working channel depending upon CenturyLink equipment platform.

Once a decision is made to switch to the protection system, the additional time required to complete the switch (i.e., switch completion time) will not exceed 50 milliseconds.

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5. Maintenance

5.1 CenturyLink Responsibilities

CenturyLink's maintenance responsibilities will be limited to the transport integrity of the underlying wavelength and protocol channel physical layers only and not the customer end-to-end higher layer protocols being carried over the GeoMax OADM/DWDM network.

CenturyLink is responsible for all equipment and cable on their side of the Network Interface at the customer locations and for maintaining the transmission facility between customer locations.

CenturyLink will notify the customer within 20 minutes of a service affecting trouble alarm received via the CenturyLink Network Operations Center (NOC).

CenturyLink will also furnish the customer a trouble reporting telephone number. The Customer Service Center will be available 24 hours a day, 7 days a week.

Upon receipt of a trouble alarm or customer report, CenturyLink will initiate action within 20 minutes to clear the trouble and will commit to a 4 hour maximum service restorable time in the event of a service interruption due to an electronic component failure. If the trouble is caused by a cable failure, the maximum service restorable time will be 8 hours.

The CenturyLink NOC will update the customer as needed during the repair phase of trouble isolation and upon resolution.

5.2 Customer Responsibilities

The customer is responsible for all equipment and cable on the customer side of the Network Interface at their locations.

The customer is responsible for power feeds at their locations.

The customer or their agent must sectionalize the trouble and verify that the trouble is not in the customer owned equipment or cable before calling the CenturyLink Customer Service Center.

If the trouble is isolated to the customer owned equipment or cable, the customer is responsible for clearing the trouble and restoring the service to normal.

Joint testing between the customer locations may sometimes be necessary to isolate the trouble.

Model numbers and technical specifications of the Customer Provided Equipment (CPE) attached to the GeoMax network may be helpful in resolving the problem.

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6. Definitions

6.1 Acronyms

3R	Reamplification, Reshaping and Retiming
ANSI	American National Standards Institute
APS	Automatic Protection Switching
AWC	Alternate Wire Center
BER	Bit Error Ratio
BIP-8	Bit Interleaved Parity 8
BITS	Building Integrated Timing Supply
BLSR	Bidirectional Line Switched Ring
CO	Central Office
CPE	Customer Provided Equipment
CPU	Central Processing Unit
DASD	Direct Access Storage Device
dB	Decibel
dBm	Decibel reference to one milliwatt
DCC	Data Communications Channel
DIX	Digital, Intel and Xerox
DWDM	Dense WDM
FC	Fiber Connector
FDP	Fiber Distribution Panel
FEC	Forward Error Correction
FOADM	Fixed OADM
Gbps	Gigabits per second
GDPS	Geographically Dispersed Parallel Sysplex
GFP	Generic Framing Procedure
GFP-F	Frame-mapped GFP
Hz	Hertz
I/O	Input/Output
IBM	International Business Machines

IEEE	Institute of Electrical and Electronic Engineers
IOF	Interoffice Facilities
IR	Intermediate Reach
ISC	InterSystem Channel
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
km	Kilometer
LAN	Local Area Network
LC	Lucent or Local Connector
LOS	Loss of Signal
LOSS	Loss of Signal Seconds
LR	Long Reach
MAC	Media Access Control
MAN	Metropolitan Area Network
MB/s	Mega Bytes per second
Mbps	Megabits per second
mi	Mile
MLM	Multi Longitudinal Mode
MMF	Multi-Mode Fiber
NC	Network Channel
NCI	Network Channel Interface
NI	Network Interface
nm	Nanometer
NRZ	Non-Return-to-Zero
OADM	Optical Add-Drop Multiplexer
OC-N	Optical Carrier - level N
ODUk	Optical channel Data Unit - level k
OPUk	Optical channel Payload Unit - level k
ORL	Optical Return Loss

OTN	Optical Transport Network
OTUk	Optical channel Transport Unit - level k
OWD	One-Way Delay
PHY	Physical Layer entity
ppm	parts per million
PPRC	Peer-to-Peer Remote Copy
ROADM	Reconfigurable OADM
Rx	Receive
S/390	System 390
SC	Subscriber Connector
SES	Severely Errored Second
SLM	Single Longitudinal Mode
SMF	Single-Mode Fiber
SONET	Synchronous Optical Network
SPE	Synchronous Payload Envelope
SR	Short Reach
STS	Synchronous Transport Signal
STS-N	STS level N (e.g., N = 3, 12, 48, 192 or 768)
SWC	Serving Wire Center
TIA/EIA	Telecommunications Industry Association/Electronic Industries Alliance
TOD	Time-Of-Day
Tx	Transmit
μm	Micron
UPC	Ultra Physical Contact
us	Microseconds
VCG	Virtual Concatenated Group
WAN	Wide Area Network
WDM	Wavelength Division Multiplexer, or Wavelength Division Multiplexing
zSeries	Zero downtime Series

6.2 Glossary

Alternate Route

Places part of a customer's services over one route and the remainder of the services over a second route.

American National Standards Institute (ANSI)

An organization supported by the telecommunications industry to establish performance and interface standards.

Attenuator

A device inserted into the electrical or optical path to lessen or weaken the signal.

Automatic Protection Switch (APS)

A device which monitors a channel and automatically switches the channel to another facility whenever the channel fails or when specified parameters go beyond a specified threshold.

Availability

The relative amount of time that a service is "usable" by a customer, represented as a percentage over any calendar month.

Bidirectional

Optical signal transmission in both directions.

Bidirectional Line-Switched Ring (BLSR)

A bidirectional ring that uses the line level status and performance parameters to initiate Automatic Protection Switching (APS).

Bit

A binary unit of information. It is represented by one of two possible conditions, such as the value 0 or 1, on or off, high potential or low potential, conducting or not conducting, magnetized or demagnetized. A bit is the smallest unit of information, by definition.

Bit Error Ratio (BER)

The ratio of the number of bit errors to the total number of bits transmitted in a given time interval.

Bit Interleaved Parity 8 (BIP-8)

A method of error monitoring. If “even parity” is used, the transmitting equipment generates an 8-bit code over a specified portion of the signal in such a manner that the first bit of the code provides even parity over the first bit of all 8-bit sequences in the covered portion of the signal, the second bit provides even parity over the second bits of all 8-bit sequences within the specified portion, etc. Even parity is generated by setting the BIP-8 bits so that there is an even number of ones in each of all 8-bit sequences, including the BIP-8.

Bit Rate

The total number of bits per second.

Building Integrated Timing Supply (BITS)

Used for intraoffice synchronization distribution. The BITS is a master clock that distributes timing to equipment within a Central Office.

Byte

A consecutive number of bits usually constituting a complete character or symbol. If the length of the byte is not specified, it is conventionally assumed to have a length of 8-bits. In the Digital Data System, a byte refers to an arbitrary group of 8 consecutive bits; it does not correspond to a byte of customer data.

Carrier

An organization whose function is to provide telecommunications services. Examples are: Local Exchange Carriers, Interexchange Carriers, Cellular Carriers, etc.

Central Office (CO)

A local switching system (or a portion thereof) and its associated equipment located at a Wire Center.

Central Wavelength

The average of two optical wavelengths at which the spectral radiant intensity is 50% of the maximum value.

Channel

An electrical or photonic (in the case of fiber optic based transmission systems) communications path between two or more points of termination.

Connection

A path between two points operating at the same layer in a network.

Connector

A mechanical device used to align and join two optical fibers. The connector provides a means for coupling and decoupling fiber to a transmitter, receiver, or another fiber.

Customer Premises

Denotes a building or portion(s) of a building occupied by a single customer or End User either as a place of business or residence. Adjacent buildings and the buildings on the same continuous property occupied by the customer and not separated by a public thoroughfare, are also considered the customer's premises.

Customer Provided Equipment (CPE)

Equipment owned and maintained by the customer and located on their side of the End User Point of Termination (EU-POT) Network Interface.

Customers

Denotes any individual, partnership or corporation who subscribes to the services provided by CenturyLink customers are divided into two distinct and separate categories: (1) Carriers, who provide interexchange services for hire for others, and (2) End Users, who request services only for their own use.

Data Rate

The maximum number of bits of information that can be transmitted per second, as in a data transmission link.

Decibel (dB)

A unit measurement of transmission loss, gain, or relative level. It's the logarithmic unit of signal power ratio most commonly used in telephony. It's used to express the relationship between two signal powers, usually between two acoustical, electrical, or optical signals; it's equal to ten times the common logarithm of the ratio of the two signal powers.

Degree

The number of WDM Carrier links that a WDM Network Element supports.

Dense Wavelength Division Multiplexer or Multiplexing (DWDM)

A system that merges many optical signals onto one optical fiber. Each optical signal is transmitted over a single wavelength in the 1550 nm region, and it can be spaced only 50 GHz to 200 GHz apart from another optical signal on the same fiber.

Digital Wrapper

The digital overhead and Forward Error Correction (FEC) bytes that are added to the client signal for Operations, Administration and Maintenance (OAM) functions and reliable transport over the Optical Transport Network.

Dispersion

The broadening of input pulses as they travel the length of an optical fiber. There are three major types of dispersion, as follows:

- Modal dispersion, which is caused by the many optical path lengths in a multimode fiber
- Chromatic dispersion, which is caused by the differential delay at various wavelengths in the optical fiber
- Waveguide dispersion, which is caused by light traveling through both the core and cladding materials in singlemode fibers

Diversity

Routing of customer circuits or access lines over physically separated facilities.

Duplex

Pertaining to communication in which data can be sent and received at the same time.

End User

The term "End User" denotes any customer of telecommunications service that is not a Carrier, except that a Carrier shall be deemed to be an "End User" to the extent that such Carrier uses a telecommunications service for administrative purposes without making such service available to others, directly or indirectly. The term is frequently used to denote the difference between a Carrier interface and an interface subject to unique regulatory requirements at non-Carrier customer premises (FCC Part 68, etc.).

Ethernet

A packet-switched local network design (by Xerox Corp.) employing Carrier Sense Multiple Access with Collision Detection (CSMA/CD) as access control mechanism.

Eye Mask

A graphic presentation formed by the superimposition of the waveforms of all possible pulse sequences.

Facilities

Facilities are the transmission paths between the demarcation points serving customer locations, a demarcation point serving a customer location and a CenturyLink Central Office, or two CenturyLink offices.

Fiber

A thin filament of glass that consists of a core and a cladding that is capable of carrying information in the form of light.

Fixed OADM (FOADM)

An Optical Network Element that provides for the termination of a fixed set of Optical Tributaries at each node. DWDM systems were commonly implemented using Fixed filter OADMs in what is known as a “banded” architecture. A typical banded DWDM system provided 32 wavelength channels in eight groups with four wavelength channels in each group.

Frame-mapped GFP (GFP-F)

A type of GFP mapping in which a client signal frame is received and mapped in its entirety into one GFP frame.

Full Duplex

Simultaneous transmission in both directions between two points.

Gigabits per Second (Gbps)

One billion (1,000,000,000) bits per second.

Input/Output (I/O)

I/O describes any operation, program, or device that transfers data to or from a computer.

Intermediate Reach (IR)

Optical interfaces referring to optical sections with system loss budgets from 0, 3 or 6 dB to 11 or 12 dB (depending on the bit rate).

Jumper

An optical fiber cable with connectors on both ends.

Kilometer (km)

One thousand (1,000) meters.

Laser

Light Amplification through Stimulated Emission Radiation. A silicon chip technology used for optical signal generation at higher bit rates and/or longer distances. Differs from a Light Emitting Diode (LED) in that the emitted light is in phase.

Layer 1

Physical Layer of the OSI model which allows the protocol to provide the transmission of information on the transmission facility. It is concerned with the physical and electrical characteristics of the interface.

Link

The physical connection and transmission medium used between a transmitter and a receiver

Local Area Network (LAN)

A network permitting the interconnection and intercommunication of a group of computers, primarily for the sharing of resources such as data storage devices and printers.

Local Loop

The facility which connects the Serving (or other adjacent) Wire Center to the customer's location.

Long Reach (LR)

Optical interfaces referring to optical sections with system loss budgets from 10, 11 or 16 dB to 22, 24 or 28 dB (depending on the bit rate).

Loopback

An out-of-service test procedure applied to a full duplex channel that causes a received signal to be returned to the source.

Loss of Signal (LOS)

A physical layer alarm sent by the receiver to indicate a cessation in signal transmission. For example, LOS is declared if a fiber optic cable is cut and the receiving end no longer detects any signal transmissions.

Loss of Signal Seconds (LOSS)

This parameter is a count of 1-second intervals containing one or more LOS defects.

Maximum Link Loss

The maximum amount of link attenuation (loss), expressed in decibels, that can exist without causing a possible failure condition.

Maximum Reach

The maximum reach of a link, expressed in kilometers that can exist without causing a possible signal degrade or failure condition.

Megabits per Second (Mbps)

One million (1,000,000) bits per second.

Mesh

A network topology in which there are at least two nodes with two or more paths between them.

Metropolitan Area Network (MAN)

A Metropolitan Area Network (MAN) is a data communications system which allows a number of independent data devices to communicate with each other.

Micron (μm)

One millionth (10^{-6}) of a meter and commonly used to express the geometric dimensions of optical fiber.

Microsecond (μs)

One millionth (10^{-6}) of a second.

Millisecond (ms)

One thousandth (10^{-3}) of a second.

Mode

An independent light path through an optical fiber.

Multi-Mode Fiber (MMF)

A fiber optic medium in which light travels in multiple modes. Typical core/cladding sizes (measured in microns) include 62.5/125 and 50/125.

Multiplexer

An equipment unit to multiplex, or do multiplexing: Multiplexing is a technique of modulating (analog) or interleaving (digital) multiple, relatively narrow bandwidth channels into a single channel having a wider bandwidth (analog) or higher bit-rate (digital). The term Multiplexer implies the demultiplexing function is present to reverse the process so it is not usually stated.

Multiplexing

The sending of multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end.

Nanometer (nm)

One billionth (10^{-9}) of a meter and a unit of measure commonly used to express the wavelengths of light.

Network

The interconnected telecommunications equipment and facilities.

Network Channel (NC) Code

The Network Channel (NC) Code is an encoded representation used to identify both switched and non-switched channel services. Included in this code set are customer options associated with individual channel services, or feature groups and other switched services.

Network Channel Interface (NCI) Code

The Network Channel Interface (NCI) Code is an encoded representation used to identify five (5) interface elements located at a Point of Termination (POT) at a Central Office or at the Network Interface at a customer location. The Interface code elements are: Total Conductors, Protocol, Impedances, Protocol Options, and Transmission Level Points (TLP). (At a digital interface, the TLP element of the NCI Code is not used.)

Network Element (NE)

A hardware only or combined hardware/software-based system that is primarily designed to directly perform a telecommunications function. For digital transmission surveillance, an NE is the part of network equipment where a transport entity (e.g., line or path) is terminated and monitored.

Network Interface (NI)

The point of demarcation on the customer's premises at which CenturyLink's responsibility for the provisioning and maintenance of service ends.

Optical Add-Drop Multiplexer (OADM)

An optical networking NE that allows for the all-optical adding and dropping of wavelength channels in a multiwavelength signal.

Optical Carrier - level N (OC-N)

The optical signal that results from an optical conversion of an STS-N signal

Optical channel Data Unit - level k (ODUk)

The ODUk is an information structure consisting of the information payload (OPUk) and ODUk related overhead. ODUk capacities for $k = 1$, $k = 2$, $k = 3$ are defined.

Optical channel Payload Unit - level k (OPUk)

The OPUk is the information structure used to adapt client information for transport over an optical channel. It comprises client information together with any overhead needed to perform rate adaptation between the client signal rate and the OPUk payload rate and other OPUk overhead supporting the client signal transport. This overhead is adaptation specific. OPUk capacities for $k=1$, $k=2$, $k=3$ are defined.

Optical channel Transport Unit - level k (OTUk)

The OTUk is the information structure used for transport of an ODUk over one or more optical channel connections. It consists of the optical channel data unit and OTUk related overhead (FEC and overhead for management of an optical channel connection). It is characterized by its frame structure, bit rate, and bandwidth. OTUk capacities for $k = 1$, $k = 2$, $k = 3$ are defined.

Optical Interface

The optical interface is the transmit point wherein light waves move away from the interface toward an optical receiver.

Optical Transport Network (OTN)

The transport network defined by the ITU-T consisting of the OPU/ODU, OTU, OCh, OMS, and OTS layers which is composed of a set of optical network elements connected by optical fiber links, able to provide functionality of transport, multiplexing, routing, management, supervision and survivability of optical channels carrying client signals.

Path

The sequence of segments and repeaters providing the connectivity between two points in a network.

Physical Layer entity (PHY)

The Physical Layer entity contains the functions that transmit, receive, and manage the encoded signals that are impressed on and recovered from the physical medium.

Point of Termination (POT)

The physical telecommunications interface that establishes the technical interface, the test point(s), and the point(s) of operational responsibility. (See Network Interface).

Point-to-Point

A link connecting two (and only two) points.

Port

The physical point at which energy or signals enter or leave a device, circuit, etc.

Power Budget

The minimum optical power available to overcome the sum of attenuation plus power penalties of the optical path between the transmitter and receiver calculated as the difference between the transmitter launch power (min) and the receive power (min).

Primary Reference Source (PRS)

Equipment that provides a timing signal whose long-term accuracy is maintained as 1×10^{-11} ; or better, as verified by Universal Coordinated Time, and whose timing signal is used as the basis of reference for the control of other clocks within a network.

Protocol

The rules for communication system operation which must be followed if communication is to be effected; the complete interaction of all possible series of messages across an interface. Protocols may govern portions of a network, types of service, or administrative procedures.

Protocol Code

The Protocol (character positions 3 and 4 or the Network Channel Interface [NCI] Code) is a two-character alpha code that defines requirements for the interface regarding signaling and transmission.

Receiver

A card or circuit that includes a photodetector and converts an incoming signal into an electrical signal.

Redundant Route

Places the same customer services over two separate routes.

Reflection

The abrupt change in direction of a light beam at an interface between two dissimilar media so the light beam returns into the media from which it originated.

Regenerator

A unidirectional device that can receive a digital signal and retransmit it in a form in which the amplitude, waveforms, and timing characteristics of the signal are constrained within specified limits.

Route

The physical path established through a network for a particular circuit.

Section

The portion of a transmission facility, including terminating points, between (1) a terminal network element and a regenerator, or (2) two regenerators. A terminating point is the point after signal regeneration at which performance monitoring is (or may be) done.

Serving Wire Center (SWC)

The Wire Center which normally provides service to a customer.

Severely Errored Second (SES)

A second in which the BER is greater than 10^{-3} (note more specific definitions apply to SONET, see GR-253-CORE for further information).

Short Reach (SR)

Optical interfaces referring to optical sections having system loss budgets from 0 dB to 4 or 7 dB (depending on the bit rate).

Single-Mode Fiber (SMF)

An optical fiber that supports only one mode of light propagation above the cutoff wavelength. Core diameters are usually between 5 and 10 microns and claddings are usually ten times the core diameter.

Splice

The point where two fibers are joined together to make a continuous optical path, or the device or means used to align two fiber ends to create a continuous optical path.

STS Envelope Capacity

Bandwidth within, and aligned to, the STS Frame that carries the STS Synchronous Payload Envelope (SPE). The bandwidth from N STS-1s can be combined to carry an STS-Nc SPE.

STS Synchronous Payload Envelope (SPE)

A 125-microsecond frame structure composed of STS Path Overhead and bandwidth for payload. The term generically refers to STS-1 SPEs and STS-Nc SPEs.

Super-Rate Payload

A payload signal that has to be carried by a Contiguous Concatenated Synchronous Transport Signal level N (STS-Nc), STS-1-Xv or STS-3c-Xv Virtual Concatenated Group.

Synchronous

The essential characteristic of time scales or signals such that their corresponding significant instants occur (and are defined to occur) at precisely the same, or multiples of the same, average rate.

Synchronous Optical Network (SONET)

A standard providing electrical and optical specifications for the physical and higher layers, the first stage of which is at 51.84 Mbps, the Optical Channel - level 1 (OC-1). Other rates defined as OC-N where N=3 through a number not yet firm are possible.

Synchronous Payload

A payload derivable from a network transmission signal by removing integral numbers of bits in every frame (i.e., there are no variable bit stuffing rate adjustments required to fit the payload in the transmission signal).

Synchronous Transport Signal - level N (STS-N)

A (functional) module used to build SONET signals. An STS-N has a bit rate of N x 51.84 Mbps, and may be converted to an OC-N or STS-N electrical interface signal, or multiplexed with other modules to form a higher rate signal (in which case it is referred to as an STS-N).

Terminal

In the loop, predetermined points of access designed to facilitate connection of the Customer Entrance Cable to the Outside Plant Facility.

Threshold Crossing Alert (TCA)

A message generated by a NE and sent to the appropriate OS if, at any time during the accumulation cycle, the current value of a performance monitoring parameter reaches or exceeds its corresponding (settable) threshold value.

Throughput

The total capability of equipment to process or transmit data during a specified time period.

Transmitter

Either a card or a circuit that includes a laser or LED, and that transmits an optical signal onto a fiber.

Transparent

In communication systems, that property which allows transmission of signals without changing the electrical characteristics or coding beyond the specified limits of the system design.

Transponder cards

The input wavelength converting cards on a DWDM system. Accepts 1310 nm band or 1550 nm band signals, and converts them to one of the 1550 nm band signals used by the DWDM system (ITU-T G.694.1 grid standard wavelengths) for transmission.

Undefined bits/bytes

Those locations within the signal that do not have a function or value assigned to them. The receiver is required to ignore the value of these bits/bytes (except for BIP-8 calculation/verification).

Virtual Concatenation

Virtual concatenation breaks the integral payload into individual SPEs, separately transports each SPE and then recombines them into a contiguous bandwidth at the end point of the transmission. This type of concatenation requires concatenation functionality only at the Path Terminating Equipment.

Wavelength

The distance an electromagnetic wave travels in the time it takes to oscillate through a complete cycle. Wavelengths of light are measured in nanometers or microns.

Wavelength Division Multiplexer (WDM)

Passive fiber optic branching components that combine or separate optical channels on the basis of wavelength.

Wavelength Division Multiplexing (WDM)

A technology that allows two or more optical signals with different wavelengths to be simultaneously transmitted in the same direction over one fiber, and then separated by wavelength at the distant end.

Wavelength Selective Switch (WSS)

A WDM component that can take in all wavelengths from a WDM Carrier into its Line side port and send any combination of the input wavelengths to any outgoing WSS drop port on the component. Functionally an outgoing port can serve as a Wavelength Cross-Connects (WXC) port that allows interconnections between WDM links.

Wire Center (WC)

A building in which one or more Central Offices, used for the provision of local exchange services, are located.

zSeries

IBM's newest generation of 64-bit mainframe computers.

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7. References

7.1 American National Standards Institute Documents

ANSI INCITS 326-1999	<i>Information Technology - Fibre Channel - Low-Cost 10-km Optical 1063-MBaud Interface (100-SM-LC-L)</i>
ANSI INCITS 349-2001	<i>Information Technology - Fibre Channel - Single-Byte-2 (FC-SB-2)</i>
ANSI INCITS 352-2002	<i>American National Standard for Information Technology - Fibre Channel - Physical Interfaces (FC-PI)</i>
ANSI INCITS 364-2003	<i>Information Technology - Fibre Channel 10 Gigabit (10GFC)</i>
ANSI INCITS 373-2003	<i>Information Technology - Fibre Channel - Framing and Signaling (FC-FS)</i>
ANSI INCITS 374-2003	<i>Information technology - Fibre Channel - Single-Byte Command Code Sets Mapping Protocol - 3 (FC-SB-3)</i>
ANSI INCITS 404-2006	<i>American National Standard for Information Technology - Fibre Channel - Physical Interfaces-2 (FC-PI-2)</i>
ANSI INCITS 424-2007	<i>Fibre Channel - Framing and Signaling-2 (FC-FS-2)</i>
ANSI T1.105-2001	<i>Synchronous Optical Network (SONET) - Basic Description including Multiplex Structure, Rates, and Formats</i>
ANSI T1.105.03-2003(R2008)	<i>Synchronous Optical Network (SONET) – Jitter and Wander at Network and Equipment Interfaces</i>
ANSI T1.105.06-2002(R2007)	<i>Telecommunications - Synchronous Optical Network (SONET): Physical Layer Specifications</i>
ANSI T1.223-2004	<i>Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Codes for information exchanges</i>
ANSI T1.231-2003(R2007)	<i>Layer 1 In-Service Digital Transmission Performance Monitoring</i>
ANSI/TIA-492AAAA-B-2009	<i>Detail Specification for 62.5-μm Core Diameter/125-μm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers</i>
ANSI/TIA-492AAAB-A-2009	<i>Detail Specification for 50-μm Core Diameter/125-μm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers</i>

ANSI/TIA-526-7-2008	<i>OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant</i>
ANSI/TIA-526-14-2010	<i>OFSTP-14 Measurement of Optical Power Loss of Installed Multimode Fiber Cable Plant</i>
ANSI/TIA/EIA-570-B-2010	<i>Residential Telecommunications Cabling Standard</i>
ANSI/TIA/EIA-604-3-B-2004	<i>FOCIS (Fiber Optic Connector Intermateability Standard) 3, Type SC and SC-APC</i>
ANSI/TIA/EIA-604-4-B-2004	<i>FOCIS (Fiber Optic Connector Intermateability Standard) 4, Type FC and FC-APC</i>
ANSI/TIA/EIA-604-10-A-2002	<i>FOCIS (Fiber Optic Connector Intermateability Standard) 10, Type LC</i>
ANSI/TIA/EIA-758-A-2004	<i>Customer-Owned Outside Plant Telecommunications Cabling Standard</i>
ATIS-0900.105.02-2007	<i>Synchronous Optical Network (SONET) -- Payload Mappings</i>

7.2 Telcordia Documents

GR-20-CORE	<i>Generic Requirements for Optical Fiber and Fiber Optical Cable</i>
GR-253-CORE	<i>Synchronous Optical Network (SONET) Transport Systems: Common Criteria</i>
GR-499-CORE	<i>Transport Systems Generic Requirements (TSGR): Common Requirements</i>
GR-1377-CORE	<i>SONET OC-192 Transport System Generic Criteria</i>
GR-2918-CORE	<i>DWDM Network Transport Systems with Digital Tributaries for Use in Metropolitan Area Applications: Common Generic Criteria</i>
GR-2979-CORE	<i>Common Generic Requirements for Optical Add-Drop Multiplexers (OADMs) and Optical Terminal Multiplexers (OTMs)</i>
GR-3009-CORE	<i>Optical Cross-Connect Generic Requirements</i>
SR-307	<i>COMMON LANGUAGE NC/NCI Dictionary</i>

7.3 International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) Recommendations

G.652	<i>Characteristics of a single-mode optical fibre and cable</i>
G.693	<i>Optical interfaces for intra-office systems</i>
G.694.1	<i>Spectral grids for WDM applications: DWDM frequency grid</i>
G.695	<i>Optical interfaces for coarse wavelength division multiplexing applications</i>

- G.709 *Interfaces for the Optical Transport Network (OTN)*
- G.825 *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*
- G.959.1 *Optical transport network physical layer interfaces*
- G.7041 *Generic framing procedure (GFP)*
- G.8251 *The control of jitter and wander within the optical transport network (OTN)*
- G.Sup43 *Transport of IEEE 10GBASE-R in optical transport networks (OTN)*

7.4 CenturyLink Technical Publications

- PUB 77346 *Synchronous Service Transport (SST), Issue U, November 2012*
- PUB 77368 *CUSTOMER PREMISES ENVIRONMENTAL SPECIFICATIONS AND INSTALLATION GUIDE, Issue F, July 2009*
- PUB 77386 *Interconnection and Collocation for Transport and Switched Unbundled Network Elements and Finished Services, Issue N, February 2011*
- PUB 77419 *SPECIFICATIONS FOR THE PLACEMENT OF QWEST EQUIPMENT IN CUSTOMER-OWNED OUTDOOR CABINETS, Issue B, June 2011*

7.5 IBM Redbooks

SA23-0395	<i>System z Coupling Links I/O Interface Physical Layer</i>
SA24-7172	<i>System z Fiber Channel Connection (FICON) I/O Interface Physical Layer</i>
SG24-5444	<i>IBM System z Connectivity Handbook</i>
SG24-5445	<i>FICON (FCV Mode) Planning Guide</i>
SG24-6266	<i>FICON Native Implementation and Reference Guide</i>
SG24-6374	<i>GDPS Family - An Introduction to Concepts and Capabilities</i>
SG24-6485	<i>z/OS Parallel Sysplex Configuration Overview</i>
SG24-7280	<i>Server Time Protocol Planning Guide</i>
SG24-7281	<i>Server Time Protocol Implementation Guide</i>

7.6 Institute of Electrical and Electronics Engineers Documents

IEEE 802.3-2008	<i>IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications</i>
IEEE 802.3ba-2010	<i>Amendment 4: Media Access Control Parameters, Physical Layers, and Management Parameters for 40 Gb/s and 100 Gb/s Operation</i>

7.7 International Organization for Standardization/International Electrotechnical Commission Publications

ISO/IEC 11801: 2002+A1:2008	<i>Information technology – Generic cabling for customer premises</i>
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7.8 Other

PMC-Sierra, Inc.	<i>ROADMs and the Evolution of the Metro Optical Core</i>
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7.9 Ordering Information

All documents are subject to change and their citation in this document reflects the most current information available at the time of printing. Readers are advised to check status and availability of all documents.

Those who are not CenturyLink employees may obtain;

- ANSI documents and ISO/IEC publications from:

American National Standards Institute
Attn: Customer Service
11 West 42nd Street
New York, NY 10036
Phone: (212) 642-4900
Fax: (212) 302-1286
Web: <http://www.ansi.org/>

ANSI has a catalog available which describes their publications.

More detailed information about the Fibre Channel standards including FICON can be obtained from the following Web sites:

<http://www.t10.org>
<http://www.t11.org/index.html>

- Telcordia documents from:

Telcordia Customer Relations
8 Corporate Place, PYA 3A-184
Piscataway, NJ 08854-4156
Fax: (732) 699-2559
Phone: (800) 521-CORE (2673) (U.S. and Canada)
Phone: (908) 699-5800 (Others)
Web: <http://www.telcordia.com>

- ITU-T Recommendations from:

International Telecommunications Union
General Secretariat
Place des Nations, CH-1211
Geneva 20, Switzerland
Web: <http://www.itu.int/home/>

- CenturyLink Technical Publications from:
<http://www.qwest.com/techpub/>
- IBM Redbooks from:
International Business Machines
Phone: (800) 879-2755
Fax: (800) 445-9269
Web: <http://www.redbooks.ibm.com>
- IEEE documents from:
Institute of Electrical and Electronics Engineers
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855
Web: <http://www.ieee.org/portal/site>

7.10 Trademarks

AQCB	Registered Trademark of CenturyLink, Inc.
GeoMax	Registered Trademark of CenturyLink, Inc.
IEEE	Registered Trademark of the Institute of Electrical and Electronics Engineers, Inc.
FICON	Registered Trademark of International Business Machines Corporation
GDPS	Registered Trademark of International Business Machines Corporation
Geographically Dispersed Parallel Sysplex	Trademark of International Business Machines Corporation
IBM	Registered Trademark of International Business Machines Corporation
Parallel Sysplex	Registered Trademark of International Business Machines Corporation
S/390	Registered Trademark of International Business Machines Corporation
System z	Trademark of International Business Machines Corporation
z/OS	Registered Trademark of International Business Machines Corporation
zSeries	Registered Trademark of International Business Machines Corporation