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A YANG Data Model for WDM Tunnels
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Abstract

This document defines a YANG data model for the provisioning and management of Traffic Engineering (TE) tunnels and Label Switched Paths (LSPs) in Optical Networks (Wavelength Switched Optical Networks (WSON) and Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks).

The YANG data model defined in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Transport networks have evolved from traditional fixed-grid Wavelength Switched Optical Networks (WSON) [RFC6163] to more scalable and flexible elastic optical networks. These utilize flexi-grid Dense Wavelength Division Multiplexing (DWDM) technologies [RFC7698] to optimize bandwidth usage. Current DWDM Optical Network deployments may include fixed-grid WSON, flexi-grid DWDM, or a combination of both.

In the optical domain, a WDM tunnel typically originates and concludes at a pair of transponders using one or more transceivers dependent upon the data rate and encoding type of the transceivers. These transponders are then connected to an intermediate line system composed of optical switches and multiplexers, including Reconfigurable Optical Add-Drop Multiplexers (ROADMs) and add-drop multiplexers, complemented by optical amplifiers to boost the transmission distance. The optical wavelength can be routed from the transponder or an incoming fiber, through multiplexing, to various outgoing fibers in the DWDM network. At optical nodes, wavelengths

may undergo conversion via optical-electrical-optical (OEO) regenerators, depending on the switching setup and fiber configuration.

Optical services, transmitted via analog signals, require careful provisioning across the network to maintain signal quality and prevent interference between different wavelength channels. The technology within optical nodes, like tunable transceivers or Colorless, Directionless and Contentionless Flexi-grid (CDC-F) ROADMs, introduces specific constraints that can limit WDM tunnel path options. These constraints must be factored into WDM tunnel provisioning and pre-computation. Additionally, assessing the end-to-end optical performance metrics like Generalized Signal-to-noise Ratio (G-SNR), Bit Error Rate (BER), and Q-factor is crucial to ensure transmission quality and receiver signal integrity.

This draft introduces a YANG [RFC7950] data model for setting up and managing TE tunnels and LSPs in DWDM Optical Networks. It aims to provide an intent-based interface used by a control entity such as a Software-defined Network (SDN) controller at its northbound to establish services between endpoints, typically optical transponders. Clients can utilize this model to either partially or fully delegate service provisioning to the SDN controller, while still capable to express additional constraints to guide its operation. Service provisioning can be as simple as identifying the source and destination transponders and delegate the rest of determination to the SDN controller, or as explicit as specifying a complete detailed path complete with tuned wavelengths and transceiver details.

This document identifies the WDM tunnel components, parameters and their values, and characterizes the features and the performances of the WDM elements. An application example is provided towards the end of the document to understand their utility better.

2. Conventions and Definitions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The terminology for describing YANG data models is found in [RFC7950].

Refer to [RFC7446] and [RFC7699] for the key terms used in this document.

The following terms are defined in [RFC7950] and are not redefined here: - client

* server

* augment

* data model

* data node

The following terms are defined in [RFC6241] and are not redefined here: - configuration data

* state data

3. Overview

The YANG data model in this draft builds upon the generic TE tunnel model from [I-D.ietf-teas-yang-te]. This base model is suitable for all TE-enabled networks and includes universal TE tunnel elements like node addresses, tunnel termination points (TTPs), and path-level constraints such as explicit path hops, label restrictions, and path diversity. The current model enhances [I-D.ietf-teas-yang-te] by incorporating WDM-specific attributes and constraints relevant to WDM tunnels, including definitions for:

* Network-scope optical transceiver configuration constraints, e.g., operational modes, transceiver tuning constraints

* Network-scope WDM path routing policies for influencing WDM TE path selection. For exmaple, whether or not using regenerator or wavelength conversion is allowed, whether or not wavelength retuing is allowed for tunable transceivers, etc.

* Network-scope optical performance constraints, e.g. the generalized Signal-to-noise (G-SNR) margin and delta power of a feasible optical path

* Path-scope WDM layer constraints and transceiver configurations for working and protection path within a WDM tunnel

* List of WDM nodes, links, and optical wavelength that constitute an end-to-end WDM path

* Other relevant optical attributes which characterize the optical signal

The attributes described above are optional, allowing the model to support both simplified and fully-explicit WDM tunnel provisioning to meet diverse client requirements.

Additionally, the YANG model provides the status of a WDM tunnel, which includes:

* Computed paths for various roles such as working, protection, and restoration, indicating potential optical paths confirmed by the SDN controller via pre-computation.

* Actual LSPs for each tunnel path, representing the optical paths currently established in the network.

3.1. Integrated vs. External Optical Transponder

In optical networks built with traditional chassis-based DWDM optical equipment, optical transponder (OTs) are typically inserted into the chassis installed as cards. WDM tunnels are established between pairs of OTs, with the SDN controller serving as the central entity for provisioning and managing these tunnels.

In scenarios like data center interconnects (DCI), optical transponders may be externally mounted on a ’pizza box’ and linked via dedicated fiber or wavelength multiplexer/demultiplexer to the optical line system. These external OTs could be managed by the same SDN controller or a different entity, such as an orchestrator. Consequently, a WDM tunnel might be composed of several segments joined to create a continuous end-to-end tunnel.

The YANG data model offers a cohesive interface for managing WDM tunnels and tunnel segments, irrespective of transponder location.

4. Example of Use

To illustrate the model’s application, consider an optical network with various transponders, switches, and links. A depicted topology outlines two WDM tunnel scenarios. In the first, an end-to-end WDM tunnel (WDM Tunnel 1) comprises two physical paths (WDM Primary Path 1 and 2) linking two integrated optical transponders, Transponder A and E, through WSON and Flexi-grid nodes. The second scenario describes three WDM tunnel segments (WDM Tunnel Segment 2a to 2c) connecting two external OTs, External OT node X and Y, via the same nodes and links.

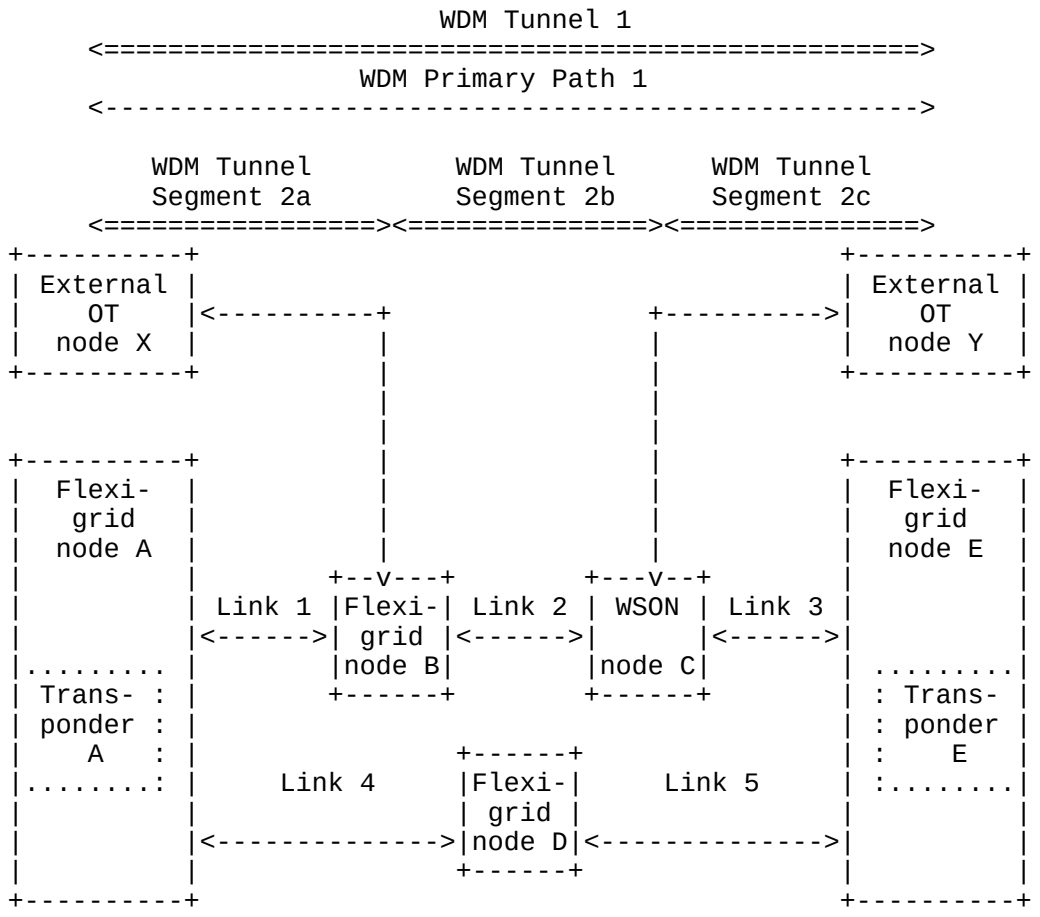

Figure 1: Topology Example

To configure an end-to-end WDM tunnel to interconnect transponders A and E, first of all we have to populate the flexi-grid topology YANG model with all elements in the network:

* We define the transponders within nodes A and E as tunnel termination points (TTPs) and provide their internal local link connectivity towards the node interfaces. We also provide nodes A and E identifiers, addresses and interfaces.

* We do the same for the nodes B, C and D, providing their identifiers, addresses and interfaces, as well as the internal connectivity matrix between interfaces.

* Then, we also define the links 1 to 5 that interconnect nodes, indicating which WSON or flexi-grid labels are available.

* Other information, such as the slot frequency and granularity are also provided.

After the nodes, links and transponders have been defined using [I-D.ietf-ccamp-flexigrid-yang] and [RFC9094] we can configure the tunnel from the information we have stored in the flexi-grid topology, by querying which elements are available, and planning the resources that have to be provided on each situation, taking into account the global and path-specific WDM tunnel constraints. Note that every element in the flexi-grid topology has a reference, and this is the way in which they are called in the tunnel.

* Depending on the case, it is possible to define either the source and destination node ports, or the source and destination node and transponder. In our case, we would define a network tunnel, with source transponder A and source node B, and destination transponder E and destination node C. Thus, we are going to follow path x.

* Then, for each link in the path x, we indicate which channel we are going to use, providing information about the slots, and what nodes are connected.

* Finally, the flexi-grid topology has to be updated with each element usage status each time a tunnel is created or torn down.

5. YANG Model for WDM Tunnel

5.1. YANG Tree

module: ietf-wdm-tunnel

```
  augment /te:te/te:tunnels/te:tunnel:
    +--rw wdm-constraint
       +--rw transceiver-constraint
       |  +--rw operational-modes*            string
       |  +--rw otsi-carrier-frequency?       l0-types:frequency-thz
       |  +--rw tx-tune-constraints
       |  |  +--rw min-central-frequency?
       |  |  |       frequency-thz
       |  |  +--rw max-central-frequency?
```

```
          |  |  |       frequency-thz
          |  |  +--rw transceiver-tunability-granularity?
          |  |          frequency-ghz
          |  +--rw line-coding-bitrate*          identityref
          |  +--rw tx-channel-power?             l0-types:power-dbm
          |  +--rw preferred-rx-channel-power?   l0-types:power-dbm
          |  +--rw gsnr-extra-margin?            snr
          +--rw use-regen?                     boolean
          +--rw wavelength-conversion?         boolean
          +--rw wavelength-assignment?         identityref
          +--rw guard-band-size?               l0-types:frequency-thz
          +--rw matching-fwd-rev-wavelength?   boolean
          +--rw allow-retuning?                boolean
          +--rw delta-power?                   l0-types:power-ratio
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:explicit-route-objects
               /te:route-object-exclude-always/te:type
               /te:numbered-node-hop/te:numbered-node-hop:
       +--rw (node-position)?
          +--:(source)
          |  +--rw source-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(destination)
          |  +--rw destination-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
```

```
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(transit)
             +--rw regen-transceivers
                +--rw regen-group-id?         uint32
                +--rw incoming-transceiver
                |  +--rw transponder-id?   uint32
                |  +--rw transceivers* [transceiver-id]
                |     +--rw transceiver-id                uint32
                |     +--rw otsi-carrier-id?              uint16
                |     +--rw operational-modes*            string
                |     +--rw otsi-carrier-frequency?
                |     |       l0-types:frequency-thz
                |     +--rw tx-tune-constraints
                |     |  +--rw min-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw max-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw transceiver-tunability-granularity?
                |     |          frequency-ghz
                |     +--rw line-coding-bitrate*          identityref
                |     +--rw tx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw preferred-rx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw gsnr-extra-margin?            snr
                +--rw outgoing-transceiver
                   +--rw transponder-id?   uint32
                   +--rw transceivers* [transceiver-id]
                      +--rw transceiver-id                uint32
                      +--rw otsi-carrier-id?              uint16
                      +--rw operational-modes*            string
                      +--rw otsi-carrier-frequency?
                      |       l0-types:frequency-thz
                      +--rw tx-tune-constraints
```

```
                    |  +--rw min-central-frequency?
                    |  |       frequency-thz
                    |  +--rw max-central-frequency?
                    |  |       frequency-thz
                    |  +--rw transceiver-tunability-granularity?
                    |          frequency-ghz
                    +--rw line-coding-bitrate*          identityref
                    +--rw tx-channel-power?
                    |       l0-types:power-dbm
                    +--rw preferred-rx-channel-power?
                    |       l0-types:power-dbm
                    +--rw gsnr-extra-margin?            snr
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path
               /te:explicit-route-objects/te:route-object-exclude-always
               /te:type/te:numbered-node-hop/te:numbered-node-hop:
       +--rw (node-position)?
          +--:(source)
          |  +--rw source-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id               uint32
          |        +--rw otsi-carrier-id?             uint16
          |        +--rw operational-modes*           string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(destination)
          |  +--rw destination-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id               uint32
          |        +--rw otsi-carrier-id?             uint16
          |        +--rw operational-modes*           string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
```

```
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(transit)
             +--rw regen-transceivers
                +--rw regen-group-id?         uint32
                +--rw incoming-transceiver
                |  +--rw transponder-id?   uint32
                |  +--rw transceivers* [transceiver-id]
                |     +--rw transceiver-id                uint32
                |     +--rw otsi-carrier-id?              uint16
                |     +--rw operational-modes*            string
                |     +--rw otsi-carrier-frequency?
                |     |       l0-types:frequency-thz
                |     +--rw tx-tune-constraints
                |     |  +--rw min-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw max-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw transceiver-tunability-granularity?
                |     |          frequency-ghz
                |     +--rw line-coding-bitrate*          identityref
                |     +--rw tx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw preferred-rx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw gsnr-extra-margin?            snr
                +--rw outgoing-transceiver
                   +--rw transponder-id?   uint32
                   +--rw transceivers* [transceiver-id]
                      +--rw transceiver-id                uint32
                      +--rw otsi-carrier-id?              uint16
                      +--rw operational-modes*            string
                      +--rw otsi-carrier-frequency?
                      |       l0-types:frequency-thz
                      +--rw tx-tune-constraints
                      |  +--rw min-central-frequency?
                      |  |       frequency-thz
```

```
                    |  +--rw max-central-frequency?
                    |  |       frequency-thz
                    |  +--rw transceiver-tunability-granularity?
                    |          frequency-ghz
                    +--rw line-coding-bitrate*          identityref
                    +--rw tx-channel-power?
                    |       l0-types:power-dbm
                    +--rw preferred-rx-channel-power?
                    |       l0-types:power-dbm
                    +--rw gsnr-extra-margin?            snr
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:explicit-route-objects
               /te:route-object-exclude-always/te:type
               /te:numbered-node-hop/te:numbered-node-hop:
       +--rw (node-position)?
          +--:(source)
          |  +--rw source-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(destination)
          |  +--rw destination-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
```

```
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(transit)
             +--rw regen-transceivers
                +--rw regen-group-id?         uint32
                +--rw incoming-transceiver
                |  +--rw transponder-id?   uint32
                |  +--rw transceivers* [transceiver-id]
                |     +--rw transceiver-id                uint32
                |     +--rw otsi-carrier-id?              uint16
                |     +--rw operational-modes*            string
                |     +--rw otsi-carrier-frequency?
                |     |       l0-types:frequency-thz
                |     +--rw tx-tune-constraints
                |     |  +--rw min-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw max-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw transceiver-tunability-granularity?
                |     |          frequency-ghz
                |     +--rw line-coding-bitrate*          identityref
                |     +--rw tx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw preferred-rx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw gsnr-extra-margin?            snr
                +--rw outgoing-transceiver
                   +--rw transponder-id?   uint32
                   +--rw transceivers* [transceiver-id]
                      +--rw transceiver-id                uint32
                      +--rw otsi-carrier-id?              uint16
                      +--rw operational-modes*            string
                      +--rw otsi-carrier-frequency?
                      |       l0-types:frequency-thz
                      +--rw tx-tune-constraints
                      |  +--rw min-central-frequency?
                      |  |       frequency-thz
                      |  +--rw max-central-frequency?
                      |  |       frequency-thz
```

```
                    |  +--rw transceiver-tunability-granularity?
                    |          frequency-ghz
                    +--rw line-coding-bitrate*          identityref
                    +--rw tx-channel-power?
                    |       l0-types:power-dbm
                    +--rw preferred-rx-channel-power?
                    |       l0-types:power-dbm
                    +--rw gsnr-extra-margin?            snr
     augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
               /te:secondary-reverse-path/te:explicit-route-objects
               /te:route-object-exclude-always/te:type
               /te:numbered-node-hop/te:numbered-node-hop:
       +--rw (node-position)?
          +--:(source)
          |  +--rw source-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(destination)
          |  +--rw destination-transceiver
          |     +--rw transponder-id?   uint32
          |     +--rw transceivers* [transceiver-id]
          |        +--rw transceiver-id                uint32
          |        +--rw otsi-carrier-id?              uint16
          |        +--rw operational-modes*            string
          |        +--rw otsi-carrier-frequency?
          |        |       l0-types:frequency-thz
          |        +--rw tx-tune-constraints
          |        |  +--rw min-central-frequency?
          |        |  |       frequency-thz
          |        |  +--rw max-central-frequency?
```

```
          |        |  |       frequency-thz
          |        |  +--rw transceiver-tunability-granularity?
          |        |          frequency-ghz
          |        +--rw line-coding-bitrate*          identityref
          |        +--rw tx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw preferred-rx-channel-power?
          |        |       l0-types:power-dbm
          |        +--rw gsnr-extra-margin?            snr
          +--:(transit)
             +--rw regen-transceivers
                +--rw regen-group-id?         uint32
                +--rw incoming-transceiver
                |  +--rw transponder-id?   uint32
                |  +--rw transceivers* [transceiver-id]
                |     +--rw transceiver-id                uint32
                |     +--rw otsi-carrier-id?              uint16
                |     +--rw operational-modes*            string
                |     +--rw otsi-carrier-frequency?
                |     |       l0-types:frequency-thz
                |     +--rw tx-tune-constraints
                |     |  +--rw min-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw max-central-frequency?
                |     |  |       frequency-thz
                |     |  +--rw transceiver-tunability-granularity?
                |     |          frequency-ghz
                |     +--rw line-coding-bitrate*          identityref
                |     +--rw tx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw preferred-rx-channel-power?
                |     |       l0-types:power-dbm
                |     +--rw gsnr-extra-margin?            snr
                +--rw outgoing-transceiver
                   +--rw transponder-id?   uint32
                   +--rw transceivers* [transceiver-id]
                      +--rw transceiver-id                uint32
                      +--rw otsi-carrier-id?              uint16
                      +--rw operational-modes*            string
                      +--rw otsi-carrier-frequency?
                      |       l0-types:frequency-thz
                      +--rw tx-tune-constraints
                      |  +--rw min-central-frequency?
                      |  |       frequency-thz
                      |  +--rw max-central-frequency?
                      |  |       frequency-thz
                      |  +--rw transceiver-tunability-granularity?
                      |          frequency-ghz
```

```
                    +--rw line-coding-bitrate*          identityref
                    +--rw tx-channel-power?
                    |       l0-types:power-dbm
                    +--rw preferred-rx-channel-power?
                    |       l0-types:power-dbm
                    +--rw gsnr-extra-margin?            snr
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:computed-paths-properties
               /te:computed-path-properties/te:path-properties
               /te:path-route-objects/te:path-route-object/te:type
               /te:numbered-node-hop/te:numbered-node-hop:
       +--ro (node-position)?
          +--:(source)
          |  +--ro source-transceiver
          |     +--ro transponder-id?   uint32
          |     +--ro transceivers* [transceiver-id]
          |        +--ro otsi-carrier-id?          uint16
          |        +--ro transceiver-id            uint32
          |        +--ro otsi-carrier-frequency?   union
          |        +--ro rx-channel-power?         power-dbm-or-null
          |        +--ro rx-total-power?           power-dbm-or-null
          |        +--ro estimated-gsnr?           snr
          |        +--ro estimated-eol-gsnr?       snr
          |        +--ro estimated-lowest-gsnr?    snr
          +--:(destination)
          |  +--ro destination-transceiver
          |     +--ro transponder-id?   uint32
          |     +--ro transceivers* [transceiver-id]
          |        +--ro otsi-carrier-id?          uint16
          |        +--ro transceiver-id            uint32
          |        +--ro otsi-carrier-frequency?   union
          |        +--ro rx-channel-power?         power-dbm-or-null
          |        +--ro rx-total-power?           power-dbm-or-null
          |        +--ro estimated-gsnr?           snr
          |        +--ro estimated-eol-gsnr?       snr
          |        +--ro estimated-lowest-gsnr?    snr
          +--:(transit)
             +--ro regen-transceivers
                +--ro regen-group-id?         uint32
                +--ro incoming-transceiver
                |  +--ro transponder-id?   uint32
                |  +--ro transceivers* [transceiver-id]
                |     +--ro otsi-carrier-id?          uint16
                |     +--ro transceiver-id            uint32
                |     +--ro otsi-carrier-frequency?   union
                |     +--ro rx-channel-power?         power-dbm-or-null
                |     +--ro rx-total-power?           power-dbm-or-null
                |     +--ro estimated-gsnr?           snr
```

```
               |     +--ro estimated-eol-gsnr?       snr
               |     +--ro estimated-lowest-gsnr?    snr
               +--ro outgoing-transceiver
                  +--ro transponder-id?   uint32
                  +--ro transceivers* [transceiver-id]
                     +--ro otsi-carrier-id?          uint16
                     +--ro transceiver-id            uint32
                     +--ro otsi-carrier-frequency?   union
                     +--ro rx-channel-power?         power-dbm-or-null
                     +--ro rx-total-power?           power-dbm-or-null
                     +--ro estimated-gsnr?           snr
                     +--ro estimated-eol-gsnr?       snr
                     +--ro estimated-lowest-gsnr?    snr
    augment /te:te/te:tunnels/te:tunnel/te:primary-paths
              /te:primary-path/te:primary-reverse-path
              /te:computed-paths-properties/te:computed-path-properties
              /te:path-properties/te:path-route-objects
              /te:path-route-object/te:type/te:numbered-node-hop
              /te:numbered-node-hop:
      +--ro (node-position)?
         +--:(source)
         |  +--ro source-transceiver
         |     +--ro transponder-id?   uint32
         |     +--ro transceivers* [transceiver-id]
         |        +--ro otsi-carrier-id?          uint16
         |        +--ro transceiver-id            uint32
         |        +--ro otsi-carrier-frequency?   union
         |        +--ro rx-channel-power?         power-dbm-or-null
         |        +--ro rx-total-power?           power-dbm-or-null
         |        +--ro estimated-gsnr?           snr
         |        +--ro estimated-eol-gsnr?       snr
         |        +--ro estimated-lowest-gsnr?    snr
         +--:(destination)
         |  +--ro destination-transceiver
         |     +--ro transponder-id?   uint32
         |     +--ro transceivers* [transceiver-id]
         |        +--ro otsi-carrier-id?          uint16
         |        +--ro transceiver-id            uint32
         |        +--ro otsi-carrier-frequency?   union
         |        +--ro rx-channel-power?         power-dbm-or-null
         |        +--ro rx-total-power?           power-dbm-or-null
         |        +--ro estimated-gsnr?           snr
         |        +--ro estimated-eol-gsnr?       snr
         |        +--ro estimated-lowest-gsnr?    snr
         +--:(transit)
            +--ro regen-transceivers
               +--ro regen-group-id?         uint32
               +--ro incoming-transceiver
```

```
               |  +--ro transponder-id?   uint32
               |  +--ro transceivers* [transceiver-id]
               |     +--ro otsi-carrier-id?          uint16
               |     +--ro transceiver-id            uint32
               |     +--ro otsi-carrier-frequency?   union
               |     +--ro rx-channel-power?         power-dbm-or-null
               |     +--ro rx-total-power?           power-dbm-or-null
               |     +--ro estimated-gsnr?           snr
               |     +--ro estimated-eol-gsnr?       snr
               |     +--ro estimated-lowest-gsnr?    snr
               +--ro outgoing-transceiver
                  +--ro transponder-id?   uint32
                  +--ro transceivers* [transceiver-id]
                     +--ro otsi-carrier-id?          uint16
                     +--ro transceiver-id            uint32
                     +--ro otsi-carrier-frequency?   union
                     +--ro rx-channel-power?         power-dbm-or-null
                     +--ro rx-total-power?           power-dbm-or-null
                     +--ro estimated-gsnr?           snr
                     +--ro estimated-eol-gsnr?       snr
                     +--ro estimated-lowest-gsnr?    snr
    augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
              /te:secondary-path/te:computed-paths-properties
              /te:computed-path-properties/te:path-properties
              /te:path-route-objects/te:path-route-object/te:type
              /te:numbered-node-hop/te:numbered-node-hop:
      +--ro (node-position)?
         +--:(source)
         |  +--ro source-transceiver
         |     +--ro transponder-id?   uint32
         |     +--ro transceivers* [transceiver-id]
         |        +--ro otsi-carrier-id?          uint16
         |        +--ro transceiver-id            uint32
         |        +--ro otsi-carrier-frequency?   union
         |        +--ro rx-channel-power?         power-dbm-or-null
         |        +--ro rx-total-power?           power-dbm-or-null
         |        +--ro estimated-gsnr?           snr
         |        +--ro estimated-eol-gsnr?       snr
         |        +--ro estimated-lowest-gsnr?    snr
         +--:(destination)
         |  +--ro destination-transceiver
         |     +--ro transponder-id?   uint32
         |     +--ro transceivers* [transceiver-id]
         |        +--ro otsi-carrier-id?          uint16
         |        +--ro transceiver-id            uint32
         |        +--ro otsi-carrier-frequency?   union
         |        +--ro rx-channel-power?         power-dbm-or-null
         |        +--ro rx-total-power?           power-dbm-or-null
```

```
          |        +--ro estimated-gsnr?           snr
          |        +--ro estimated-eol-gsnr?       snr
          |        +--ro estimated-lowest-gsnr?    snr
          +--:(transit)
             +--ro regen-transceivers
                +--ro regen-group-id?         uint32
                +--ro incoming-transceiver
                |  +--ro transponder-id?   uint32
                |  +--ro transceivers* [transceiver-id]
                |     +--ro otsi-carrier-id?          uint16
                |     +--ro transceiver-id            uint32
                |     +--ro otsi-carrier-frequency?   union
                |     +--ro rx-channel-power?         power-dbm-or-null
                |     +--ro rx-total-power?           power-dbm-or-null
                |     +--ro estimated-gsnr?           snr
                |     +--ro estimated-eol-gsnr?       snr
                |     +--ro estimated-lowest-gsnr?    snr
                +--ro outgoing-transceiver
                   +--ro transponder-id?   uint32
                   +--ro transceivers* [transceiver-id]
                      +--ro otsi-carrier-id?          uint16
                      +--ro transceiver-id            uint32
                      +--ro otsi-carrier-frequency?   union
                      +--ro rx-channel-power?         power-dbm-or-null
                      +--ro rx-total-power?           power-dbm-or-null
                      +--ro estimated-gsnr?           snr
                      +--ro estimated-eol-gsnr?       snr
                      +--ro estimated-lowest-gsnr?    snr
     augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
               /te:secondary-reverse-path/te:computed-paths-properties
               /te:computed-path-properties/te:path-properties
               /te:path-route-objects/te:path-route-object/te:type
               /te:numbered-node-hop/te:numbered-node-hop:
       +--ro (node-position)?
          +--:(source)
          |  +--ro source-transceiver
          |     +--ro transponder-id?   uint32
          |     +--ro transceivers* [transceiver-id]
          |        +--ro otsi-carrier-id?          uint16
          |        +--ro transceiver-id            uint32
          |        +--ro otsi-carrier-frequency?   union
          |        +--ro rx-channel-power?         power-dbm-or-null
          |        +--ro rx-total-power?           power-dbm-or-null
          |        +--ro estimated-gsnr?           snr
          |        +--ro estimated-eol-gsnr?       snr
          |        +--ro estimated-lowest-gsnr?    snr
          +--:(destination)
          |  +--ro destination-transceiver
```

```
          |     +--ro transponder-id?   uint32
          |     +--ro transceivers* [transceiver-id]
          |        +--ro otsi-carrier-id?          uint16
          |        +--ro transceiver-id            uint32
          |        +--ro otsi-carrier-frequency?   union
          |        +--ro rx-channel-power?         power-dbm-or-null
          |        +--ro rx-total-power?           power-dbm-or-null
          |        +--ro estimated-gsnr?           snr
          |        +--ro estimated-eol-gsnr?       snr
          |        +--ro estimated-lowest-gsnr?    snr
          +--:(transit)
             +--ro regen-transceivers
                +--ro regen-group-id?         uint32
                +--ro incoming-transceiver
                |  +--ro transponder-id?   uint32
                |  +--ro transceivers* [transceiver-id]
                |     +--ro otsi-carrier-id?          uint16
                |     +--ro transceiver-id            uint32
                |     +--ro otsi-carrier-frequency?   union
                |     +--ro rx-channel-power?         power-dbm-or-null
                |     +--ro rx-total-power?           power-dbm-or-null
                |     +--ro estimated-gsnr?           snr
                |     +--ro estimated-eol-gsnr?       snr
                |     +--ro estimated-lowest-gsnr?    snr
                +--ro outgoing-transceiver
                   +--ro transponder-id?   uint32
                   +--ro transceivers* [transceiver-id]
                      +--ro otsi-carrier-id?          uint16
                      +--ro transceiver-id            uint32
                      +--ro otsi-carrier-frequency?   union
                      +--ro rx-channel-power?         power-dbm-or-null
                      +--ro rx-total-power?           power-dbm-or-null
                      +--ro estimated-gsnr?           snr
                      +--ro estimated-eol-gsnr?       snr
                      +--ro estimated-lowest-gsnr?    snr
    augment /te:te/te:lsps/te:lsp/te:lsp-actual-route-information
              /te:lsp-actual-route-information/te:type
              /te:numbered-node-hop/te:numbered-node-hop:
      +--ro (node-position)?
         +--:(source)
         |  +--ro source-transceiver
         |     +--ro transponder-id?   uint32
         |     +--ro transceivers* [transceiver-id]
         |        +--ro otsi-carrier-id?          uint16
         |        +--ro transceiver-id            uint32
         |        +--ro otsi-carrier-frequency?   union
         |        +--ro rx-channel-power?         power-dbm-or-null
         |        +--ro rx-total-power?           power-dbm-or-null
```

```
|        +--ro pre-fec-ber
|        |  +--ro timestamp?   yang:timestamp
|        |  +--ro value?       decimal64
|        +--ro q-factor
|           +--ro timestamp?   yang:timestamp
|           +--ro value?       l0-types:decimal-2-or-null
+--:(destination)
|  +--ro destination-transceiver
|     +--ro transponder-id?   uint32
|     +--ro transceivers* [transceiver-id]
|        +--ro otsi-carrier-id?          uint16
|        +--ro transceiver-id            uint32
|        +--ro otsi-carrier-frequency?   union
|        +--ro rx-channel-power?         power-dbm-or-null
|        +--ro rx-total-power?           power-dbm-or-null
|        +--ro pre-fec-ber
|        |  +--ro timestamp?   yang:timestamp
|        |  +--ro value?       decimal64
|        +--ro q-factor
|           +--ro timestamp?   yang:timestamp
|           +--ro value?       l0-types:decimal-2-or-null
+--:(transit)
   +--ro regen-transceivers
      +--ro regen-group-id?         uint32
      +--ro incoming-transceiver
      |  +--ro transponder-id?   uint32
      |  +--ro transceivers* [transceiver-id]
      |     +--ro otsi-carrier-id?          uint16
      |     +--ro transceiver-id            uint32
      |     +--ro otsi-carrier-frequency?   union
      |     +--ro rx-channel-power?         power-dbm-or-null
      |     +--ro rx-total-power?           power-dbm-or-null
      |     +--ro pre-fec-ber
      |     |  +--ro timestamp?   yang:timestamp
      |     |  +--ro value?       decimal64
      |     +--ro q-factor
      |        +--ro timestamp?   yang:timestamp
      |        +--ro value?       l0-types:decimal-2-or-null
      +--ro outgoing-transceiver
         +--ro transponder-id?   uint32
         +--ro transceivers* [transceiver-id]
            +--ro otsi-carrier-id?          uint16
            +--ro transceiver-id            uint32
            +--ro otsi-carrier-frequency?   union
            +--ro rx-channel-power?         power-dbm-or-null
            +--ro rx-total-power?           power-dbm-or-null
            +--ro pre-fec-ber
            |  +--ro timestamp?   yang:timestamp
```

```
                    |  +--ro value?       decimal64
                    +--ro q-factor
                       +--ro timestamp?   yang:timestamp
                       +--ro value?       l0-types:decimal-2-or-null
     augment /te:te/te:lsps/te:lsp/te:lsp-actual-route-information
               /te:lsp-actual-route-information/te:type
               /te:numbered-link-hop/te:numbered-link-hop:
       +--ro e2e-mc-path-id*   uint16
     augment /te:te/te:lsps/te:lsp/te:lsp-actual-route-information
               /te:lsp-actual-route-information/te:type
               /te:unnumbered-link-hop/te:unnumbered-link-hop:
       +--ro e2e-mc-path-id*   uint16
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-in-segment
               /te:label-restrictions/te:label-restriction:
       +--rw grid-type?    identityref
       +--rw priority?     uint8
       +--rw flexi-grid
          +--rw slot-width-granularity?   identityref
          +--rw min-slot-width-factor?    uint16
          +--rw max-slot-width-factor?    uint16
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-out-segment
               /te:label-restrictions/te:label-restriction:
       +--rw grid-type?    identityref
       +--rw priority?     uint8
       +--rw flexi-grid
          +--rw slot-width-granularity?   identityref
          +--rw min-slot-width-factor?    uint16
          +--rw max-slot-width-factor?    uint16
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-in-segment/te:label-restrictions
               /te:label-restriction:
       +--rw grid-type?    identityref
       +--rw priority?     uint8
       +--rw flexi-grid
          +--rw slot-width-granularity?   identityref
          +--rw min-slot-width-factor?    uint16
          +--rw max-slot-width-factor?    uint16
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction:
       +--rw grid-type?    identityref
       +--rw priority?     uint8
       +--rw flexi-grid
          +--rw slot-width-granularity?   identityref
          +--rw min-slot-width-factor?    uint16
          +--rw max-slot-width-factor?    uint16
```

```
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
          /te:primary-path/te:primary-reverse-path
          /te:path-in-segment/te:label-restrictions
          /te:label-restriction:
  +--rw grid-type?    identityref
  +--rw priority?     uint8
  +--rw flexi-grid
     +--rw slot-width-granularity?   identityref
     +--rw min-slot-width-factor?    uint16
     +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
          /te:primary-path/te:primary-reverse-path
          /te:path-out-segment/te:label-restrictions
          /te:label-restriction:
  +--rw grid-type?    identityref
  +--rw priority?     uint8
  +--rw flexi-grid
     +--rw slot-width-granularity?   identityref
     +--rw min-slot-width-factor?    uint16
     +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
          /te:secondary-path/te:path-in-segment
          /te:label-restrictions/te:label-restriction:
  +--rw grid-type?    identityref
  +--rw priority?     uint8
  +--rw flexi-grid
     +--rw slot-width-granularity?   identityref
     +--rw min-slot-width-factor?    uint16
     +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
          /te:secondary-path/te:path-out-segment
          /te:label-restrictions/te:label-restriction:
  +--rw grid-type?    identityref
  +--rw priority?     uint8
  +--rw flexi-grid
     +--rw slot-width-granularity?   identityref
     +--rw min-slot-width-factor?    uint16
     +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-in-segment
          /te:label-restrictions/te:label-restriction:
  +--rw grid-type?    identityref
  +--rw priority?     uint8
  +--rw flexi-grid
     +--rw slot-width-granularity?   identityref
     +--rw min-slot-width-factor?    uint16
     +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
```

```
            /te:secondary-reverse-path/te:path-out-segment
            /te:label-restrictions/te:label-restriction:
      +--rw grid-type?    identityref
      +--rw priority?     uint8
      +--rw flexi-grid
         +--rw slot-width-granularity?   identityref
         +--rw min-slot-width-factor?    uint16
         +--rw max-slot-width-factor?    uint16
    augment /te:te/te:globals/te:named-path-constraints
            /te:named-path-constraint/te:explicit-route-objects
            /te:route-object-exclude-always/te:type/te:label
            /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
    augment /te:te/te:globals/te:named-path-constraints
            /te:named-path-constraint/te:explicit-route-objects
            /te:route-object-include-exclude/te:type/te:label
            /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
```

```
            +--:(cwdm)
            |  +--rw cwdm-n?                    cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?             flexi-n
                  |  +--rw flexi-m?             flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-in-segment
               /te:label-restrictions/te:label-restriction
               /te:label-start/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-in-segment
               /te:label-restrictions/te:label-restriction/te:label-end
               /te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-in-segment
               /te:label-restrictions/te:label-restriction/te:label-step
               /te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
```

```
           +--:(cwdm)
           |  +--rw wson-cwdm-channel-spacing?    identityref
           +--:(flexi-grid)
              x--rw flexi-grid-channel-spacing?   identityref
              +--rw flexi-ncfg?                   identityref
              +--rw flexi-n-step?                 uint8
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-out-segment
               /te:label-restrictions/te:label-restriction
               /te:label-start/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-end
               /te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:globals/te:named-path-constraints
               /te:named-path-constraint/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-step
               /te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
                x--rw flexi-grid-channel-spacing?   identityref
                +--rw flexi-ncfg?                   identityref
                +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:optimizations/te:algorithm/te:metric
               /te:optimization-metric/te:explicit-route-exclude-objects
               /te:route-object-exclude-object/te:type/te:label
```

```
              /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:optimizations/te:algorithm/te:metric
               /te:optimization-metric/te:explicit-route-include-objects
               /te:route-object-include-object/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
```

```
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:explicit-route-objects
               /te:route-object-exclude-always/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:explicit-route-objects
               /te:route-object-include-exclude/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
```

```
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-in-segment/te:label-restrictions
               /te:label-restriction/te:label-start/te:te-label
               /te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-in-segment/te:label-restrictions
               /te:label-restriction/te:label-end/te:te-label
               /te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-in-segment/te:label-restrictions
               /te:label-restriction/te:label-step/te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
```

```
              x--rw flexi-grid-channel-spacing?   identityref
              +--rw flexi-ncfg?                   identityref
              +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction
               /te:label-start/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-end
               /te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-step
               /te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
                x--rw flexi-grid-channel-spacing?   identityref
                +--rw flexi-ncfg?                   identityref
                +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:computed-paths-properties
               /te:computed-path-properties/te:path-properties
               /te:path-route-objects/te:path-route-object/te:type
               /te:label/te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--ro (grid-type)?
```

```
            +--:(fixed-dwdm)
            |  +--ro (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--ro dwdm-n?              dwdm-n
            |     +--:(multi)
            |        +--ro subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--ro cwdm-n?                    cwdm-n
            +--:(flexi-grid)
               +--ro (single-or-super-channel)?
                  +--:(single)
                  |  +--ro flexi-n?             flexi-n
                  |  +--ro flexi-m?             flexi-m
                  x--:(super)
                  |  x--ro subcarrier-flexi-n* [flexi-n]
                  |     +--ro flexi-n    flexi-n
                  |     +--ro flexi-m?   flexi-m
                  +--:(multi)
                     +--ro frequency-slots
                        +--ro frequency-slot* [flexi-n]
                           +--ro flexi-n    flexi-n
                           +--ro flexi-m?   flexi-m
    augment /te:te/te:tunnels/te:tunnel/te:primary-paths
              /te:primary-path/te:primary-reverse-path/te:optimizations
              /te:algorithm/te:metric/te:optimization-metric
              /te:explicit-route-exclude-objects
              /te:route-object-exclude-object/te:type/te:label
              /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?              dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                    cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?             flexi-n
                  |  +--rw flexi-m?             flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
```

```
                    +--rw frequency-slots
                       +--rw frequency-slot* [flexi-n]
                          +--rw flexi-n    flexi-n
                          +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path/te:optimizations
               /te:algorithm/te:metric/te:optimization-metric
               /te:explicit-route-include-objects
               /te:route-object-include-object/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path
               /te:explicit-route-objects/te:route-object-exclude-always
               /te:type/te:label/te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
```

```
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?             flexi-n
                  |  +--rw flexi-m?             flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
    augment /te:te/te:tunnels/te:tunnel/te:primary-paths
              /te:primary-path/te:primary-reverse-path
              /te:explicit-route-objects
              /te:route-object-include-exclude/te:type/te:label
              /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?              dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                    cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?             flexi-n
                  |  +--rw flexi-m?             flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
    augment /te:te/te:tunnels/te:tunnel/te:primary-paths
              /te:primary-path/te:primary-reverse-path
              /te:path-in-segment/te:label-restrictions
              /te:label-restriction/te:label-start/te:te-label
              /te:technology:
```

```
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path
               /te:path-in-segment/te:label-restrictions
               /te:label-restriction/te:label-end/te:te-label
               /te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path
               /te:path-in-segment/te:label-restrictions
               /te:label-restriction/te:label-step/te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
                x--rw flexi-grid-channel-spacing?   identityref
                +--rw flexi-ncfg?                   identityref
                +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:primary-paths
               /te:primary-path/te:primary-reverse-path
               /te:path-out-segment/te:label-restrictions
               /te:label-restriction/te:label-start/te:te-label
               /te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
```

```
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
          /te:primary-path/te:primary-reverse-path
          /te:path-out-segment/te:label-restrictions
          /te:label-restriction/te:label-end/te:te-label
          /te:technology:
  +--:(wdm)
     +--rw (grid-type)?
        +--:(fixed-dwdm)
        |  +--rw dwdm-n?    dwdm-n
        +--:(cwdm)
        |  +--rw cwdm-n?    cwdm-n
        +--:(flexi-grid)
           +--rw flexi-n?   flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
          /te:primary-path/te:primary-reverse-path
          /te:path-out-segment/te:label-restrictions
          /te:label-restriction/te:label-step/te:technology:
  +--:(wdm)
     +--rw (l0-grid-type)?
        +--:(fixed-dwdm)
        |  +--rw wson-dwdm-channel-spacing?    identityref
        +--:(cwdm)
        |  +--rw wson-cwdm-channel-spacing?    identityref
        +--:(flexi-grid)
           x--rw flexi-grid-channel-spacing?   identityref
           +--rw flexi-ncfg?                   identityref
           +--rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
          /te:primary-path/te:primary-reverse-path
          /te:computed-paths-properties/te:computed-path-properties
          /te:path-properties/te:path-route-objects
          /te:path-route-object/te:type/te:label/te:label-hop
          /te:te-label/te:technology:
  +--:(wdm)
     +--ro (grid-type)?
        +--:(fixed-dwdm)
        |  +--ro (fixed-single-or-super-channel)?
        |     +--:(single)
        |     |  +--ro dwdm-n?               dwdm-n
        |     +--:(multi)
        |        +--ro subcarrier-dwdm-n*    dwdm-n
        +--:(cwdm)
        |  +--ro cwdm-n?                     cwdm-n
        +--:(flexi-grid)
           +--ro (single-or-super-channel)?
              +--:(single)
              |  +--ro flexi-n?              flexi-n
              |  +--ro flexi-m?              flexi-m
```

```
                  x--:(super)
                  |  x--ro subcarrier-flexi-n* [flexi-n]
                  |     +--ro flexi-n    flexi-n
                  |     +--ro flexi-m?   flexi-m
                  +--:(multi)
                     +--ro frequency-slots
                        +--ro frequency-slot* [flexi-n]
                           +--ro flexi-n    flexi-n
                           +--ro flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:optimizations/te:algorithm
               /te:metric/te:optimization-metric
               /te:explicit-route-exclude-objects
               /te:route-object-exclude-object/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?              dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                    cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?             flexi-n
                   |  +--rw flexi-m?             flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:optimizations/te:algorithm
               /te:metric/te:optimization-metric
               /te:explicit-route-include-objects
               /te:route-object-include-object/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
```

```
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
    augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
              /te:secondary-path/te:explicit-route-objects
              /te:route-object-exclude-always/te:type/te:label
              /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
```

```
                          +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:explicit-route-objects
               /te:route-object-include-exclude/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-in-segment
               /te:label-restrictions/te:label-restriction
               /te:label-start/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-in-segment
               /te:label-restrictions/te:label-restriction/te:label-end
               /te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
```

```
            |  +--rw dwdm-n?    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?    cwdm-n
            +--:(flexi-grid)
               +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-in-segment
               /te:label-restrictions/te:label-restriction/te:label-step
               /te:technology:
       +--:(wdm)
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
                x--rw flexi-grid-channel-spacing?   identityref
                +--rw flexi-ncfg?                   identityref
                +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction
               /te:label-start/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-end
               /te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw dwdm-n?    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?    cwdm-n
             +--:(flexi-grid)
                +--rw flexi-n?   flexi-n
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:path-out-segment
               /te:label-restrictions/te:label-restriction/te:label-step
               /te:technology:
       +--:(wdm)
```

```
          +--rw (l0-grid-type)?
             +--:(fixed-dwdm)
             |  +--rw wson-dwdm-channel-spacing?    identityref
             +--:(cwdm)
             |  +--rw wson-cwdm-channel-spacing?    identityref
             +--:(flexi-grid)
                x--rw flexi-grid-channel-spacing?   identityref
                +--rw flexi-ncfg?                   identityref
                +--rw flexi-n-step?                 uint8
     augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
               /te:secondary-path/te:computed-paths-properties
               /te:computed-path-properties/te:path-properties
               /te:path-route-objects/te:path-route-object/te:type
               /te:label/te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--ro (grid-type)?
             +--:(fixed-dwdm)
             |  +--ro (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--ro dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--ro subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--ro cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--ro (single-or-super-channel)?
                   +--:(single)
                   |  +--ro flexi-n?             flexi-n
                   |  +--ro flexi-m?             flexi-m
                   x--:(super)
                   |  x--ro subcarrier-flexi-n* [flexi-n]
                   |     +--ro flexi-n    flexi-n
                   |     +--ro flexi-m?   flexi-m
                   +--:(multi)
                      +--ro frequency-slots
                         +--ro frequency-slot* [flexi-n]
                            +--ro flexi-n    flexi-n
                            +--ro flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
               /te:secondary-reverse-path/te:optimizations/te:algorithm
               /te:metric/te:optimization-metric
               /te:explicit-route-exclude-objects
               /te:route-object-exclude-object/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
```

```
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
                           +--rw flexi-n    flexi-n
                           +--rw flexi-m?   flexi-m
    augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
              /te:secondary-reverse-path/te:optimizations/te:algorithm
              /te:metric/te:optimization-metric
              /te:explicit-route-include-objects
              /te:route-object-include-object/te:type/te:label
              /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--rw (grid-type)?
            +--:(fixed-dwdm)
            |  +--rw (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--rw dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--rw subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--rw cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--rw (single-or-super-channel)?
                  +--:(single)
                  |  +--rw flexi-n?              flexi-n
                  |  +--rw flexi-m?              flexi-m
                  x--:(super)
                  |  x--rw subcarrier-flexi-n* [flexi-n]
                  |     +--rw flexi-n    flexi-n
                  |     +--rw flexi-m?   flexi-m
                  +--:(multi)
                     +--rw frequency-slots
                        +--rw frequency-slot* [flexi-n]
```

```
                          +--rw flexi-n    flexi-n
                          +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
               /te:secondary-reverse-path/te:explicit-route-objects
               /te:route-object-exclude-always/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
                   |  +--rw flexi-m?              flexi-m
                   x--:(super)
                   |  x--rw subcarrier-flexi-n* [flexi-n]
                   |     +--rw flexi-n    flexi-n
                   |     +--rw flexi-m?   flexi-m
                   +--:(multi)
                      +--rw frequency-slots
                         +--rw frequency-slot* [flexi-n]
                            +--rw flexi-n    flexi-n
                            +--rw flexi-m?   flexi-m
     augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
               /te:secondary-reverse-path/te:explicit-route-objects
               /te:route-object-include-exclude/te:type/te:label
               /te:label-hop/te:te-label/te:technology:
       +--:(wdm)
          +--rw (grid-type)?
             +--:(fixed-dwdm)
             |  +--rw (fixed-single-or-super-channel)?
             |     +--:(single)
             |     |  +--rw dwdm-n?               dwdm-n
             |     +--:(multi)
             |        +--rw subcarrier-dwdm-n*    dwdm-n
             +--:(cwdm)
             |  +--rw cwdm-n?                     cwdm-n
             +--:(flexi-grid)
                +--rw (single-or-super-channel)?
                   +--:(single)
                   |  +--rw flexi-n?              flexi-n
```

```
                |  +--rw flexi-m?              flexi-m
                x--:(super)
                |  x--rw subcarrier-flexi-n* [flexi-n]
                |     +--rw flexi-n    flexi-n
                |     +--rw flexi-m?   flexi-m
                +--:(multi)
                   +--rw frequency-slots
                      +--rw frequency-slot* [flexi-n]
                         +--rw flexi-n    flexi-n
                         +--rw flexi-m?   flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-in-segment
          /te:label-restrictions/te:label-restriction
          /te:label-start/te:te-label/te:technology:
  +--:(wdm)
     +--rw (grid-type)?
        +--:(fixed-dwdm)
        |  +--rw dwdm-n?    dwdm-n
        +--:(cwdm)
        |  +--rw cwdm-n?    cwdm-n
        +--:(flexi-grid)
           +--rw flexi-n?   flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-in-segment
          /te:label-restrictions/te:label-restriction/te:label-end
          /te:te-label/te:technology:
  +--:(wdm)
     +--rw (grid-type)?
        +--:(fixed-dwdm)
        |  +--rw dwdm-n?    dwdm-n
        +--:(cwdm)
        |  +--rw cwdm-n?    cwdm-n
        +--:(flexi-grid)
           +--rw flexi-n?   flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-in-segment
          /te:label-restrictions/te:label-restriction/te:label-step
          /te:technology:
  +--:(wdm)
     +--rw (l0-grid-type)?
        +--:(fixed-dwdm)
        |  +--rw wson-dwdm-channel-spacing?    identityref
        +--:(cwdm)
        |  +--rw wson-cwdm-channel-spacing?    identityref
        +--:(flexi-grid)
           x--rw flexi-grid-channel-spacing?   identityref
           +--rw flexi-ncfg?                   identityref
           +--rw flexi-n-step?                 uint8
```

```
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-out-segment
          /te:label-restrictions/te:label-restriction
          /te:label-start/te:te-label/te:technology:
  +--:(wdm)
     +--rw (grid-type)?
        +--:(fixed-dwdm)
        |  +--rw dwdm-n?    dwdm-n
        +--:(cwdm)
        |  +--rw cwdm-n?    cwdm-n
        +--:(flexi-grid)
           +--rw flexi-n?   flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-out-segment
          /te:label-restrictions/te:label-restriction/te:label-end
          /te:te-label/te:technology:
  +--:(wdm)
     +--rw (grid-type)?
        +--:(fixed-dwdm)
        |  +--rw dwdm-n?    dwdm-n
        +--:(cwdm)
        |  +--rw cwdm-n?    cwdm-n
        +--:(flexi-grid)
           +--rw flexi-n?   flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:path-out-segment
          /te:label-restrictions/te:label-restriction/te:label-step
          /te:technology:
  +--:(wdm)
     +--rw (l0-grid-type)?
        +--:(fixed-dwdm)
        |  +--rw wson-dwdm-channel-spacing?    identityref
        +--:(cwdm)
        |  +--rw wson-cwdm-channel-spacing?    identityref
        +--:(flexi-grid)
           x--rw flexi-grid-channel-spacing?   identityref
           +--rw flexi-ncfg?                   identityref
           +--rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
          /te:secondary-reverse-path/te:computed-paths-properties
          /te:computed-path-properties/te:path-properties
          /te:path-route-objects/te:path-route-object/te:type
          /te:label/te:label-hop/te:te-label/te:technology:
  +--:(wdm)
     +--ro (grid-type)?
        +--:(fixed-dwdm)
        |  +--ro (fixed-single-or-super-channel)?
        |     +--:(single)
```

```
            |     |  +--ro dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--ro subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--ro cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--ro (single-or-super-channel)?
                  +--:(single)
                  |  +--ro flexi-n?              flexi-n
                  |  +--ro flexi-m?              flexi-m
                  x--:(super)
                  |  x--ro subcarrier-flexi-n* [flexi-n]
                  |     +--ro flexi-n    flexi-n
                  |     +--ro flexi-m?   flexi-m
                  +--:(multi)
                     +--ro frequency-slots
                        +--ro frequency-slot* [flexi-n]
                           +--ro flexi-n    flexi-n
                           +--ro flexi-m?   flexi-m
    augment /te:te/te:lsps/te:lsp/te:lsp-actual-route-information
              /te:lsp-actual-route-information/te:type/te:label
              /te:label-hop/te:te-label/te:technology:
      +--:(wdm)
         +--ro (grid-type)?
            +--:(fixed-dwdm)
            |  +--ro (fixed-single-or-super-channel)?
            |     +--:(single)
            |     |  +--ro dwdm-n?               dwdm-n
            |     +--:(multi)
            |        +--ro subcarrier-dwdm-n*    dwdm-n
            +--:(cwdm)
            |  +--ro cwdm-n?                     cwdm-n
            +--:(flexi-grid)
               +--ro (single-or-super-channel)?
                  +--:(single)
                  |  +--ro flexi-n?              flexi-n
                  |  +--ro flexi-m?              flexi-m
                  x--:(super)
                  |  x--ro subcarrier-flexi-n* [flexi-n]
                  |     +--ro flexi-n    flexi-n
                  |     +--ro flexi-m?   flexi-m
                  +--:(multi)
                     +--ro frequency-slots
                        +--ro frequency-slot* [flexi-n]
                           +--ro flexi-n    flexi-n
                           +--ro flexi-m?   flexi-m
```

Figure 2: WDM Tunnel YANG tree

5.2. YANG Code

```
<CODE BEGINS> file "ietf-wdm-tunnel@2024-07-02.yang"
module ietf-wdm-tunnel {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-wdm-tunnel";
  prefix "wdm-tnl";

  import ietf-te {
    prefix "te";
    reference
      "RFC YYYY: A YANG Data Model for Traffic Engineering Tunnels,
      Label Switched Paths and Interfaces.";
  }
  /* RFC Ed.: replace YYYY with the number assigned
     to the RFC once draft-ietf-teas-yang-te becomes an RFC.*/

  import ietf-layer0-types {
    prefix "l0-types";
  }

  import ietf-yang-types {
    prefix "yang";
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web:   <http://tools.ietf.org/wg/ccamp/>
     WG List:  <mailto:ccamp@ietf.org>

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               <italo.busi@nokia.com>

     Editor:   Aihua Guo
               <aihuaguo.ietf@gmail.com>";

  description
```

```
       "This module defines a YANG data model for configuring
        and managing Wavelength-Division Multiplexing (WDM) switched
        optical tunnels.

       The model fully conforms to the Network Management
       Datastore Architecture (NMDA).

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       set forth in Section 4.c of the IETF Trust's Legal Provisions
       Relating to IETF Documents
       (https://trustee.ietf.org/license-info).

       This version of this YANG module is part of RFC XXXX; see
       the RFC itself for full legal notices.";

     revision "2024-07-02" {
       description
         "Updated revision with combined WSON and Flexi-grid tunnel
          YANG model";

       reference
         "RFC XXXX: YANG data model for WDM tunnels";
       // RFC Ed.: replace XXXX with actual RFC number, update date
       // information and remove this note
     }

     /*
      * Groupings
      */
     grouping additional-transceiver-configuration-constraints {
       description
         "This grouping defines additional optional constraints for
          transceiver configurations related to tunnel selection.
          These constraints further limit the resources available
          to the tunnel. All constraints operate inclusively, using
          an AND logic. For example, if a specific frequency range
          is selected, the tunnel must also be constrained to match
          only that range.

          When these constraints are combined with the operational
          mode, the list of operational modes should exclude any
          modes that cannot satisfy the additional constraints.
          For instance, if the frequency is restricted to the C-band,
```

```
           the list of operational modes should not include any modes
           applicable only to the L-band.";

        leaf otsi-carrier-frequency {
            type l0-types:frequency-thz;
            description
              "OTSi carrier frequency, i.e. configured transmitter
               frequency.";
        }

        container tx-tune-constraints {
          description
            "The permissible tuning frequency range for the
             transmitter.";

          uses l0-types:transceiver-tuning-range;
        }

        leaf-list line-coding-bitrate {
          type identityref {
            base l0-types:line-coding;
          }
          description
            "The list of the bit rate/line coding of the optical
            tributary signal that constrains the configuration of
            the transceiver.";
          reference
            "ITU-T G.698.2 section 7.1.2";
        }

        leaf tx-channel-power {
          type l0-types:power-dbm;
          description
            "The preferred channel transmit power.";
        }

        leaf preferred-rx-channel-power {
          type l0-types:power-dbm;
          description
            "The preferred channel received power.";
        }

        /*
        leaf inverse-multiplexing-mode {
          //type l0-types:inverse-multiplexing-mode;
          type string;
          description
            "The inverse multiplexing mode.";
```

```
      }
      */

      uses l0-types:path-constraints;
    }

    grouping transceiver-constraints {
      description
        "This grouping defines constraints for transceiver
         configurations";

      leaf-list operational-modes {
        type string {
          length "1..255";
        }
        description
          "List of operational mode ids of the transceiver.";
      }

      uses additional-transceiver-configuration-constraints;
    }

    grouping transceiver-config {
      description
        "This grouping defines explicit transceiver
         configurations.";

      leaf transponder-id {
        type uint32;
        description "transponder identifier";
      }

      list transceivers {
        key "transceiver-id";
        description
          "List of transceivers used within the transponder.";

        leaf transceiver-id {
          type uint32;
          description
          "transceiver identifier";
        }
        leaf otsi-carrier-id {
          type uint16;
          description
            "OTSi carrier identifier associated with the
             transceiver.";
        }
```

```
        uses transceiver-constraints;
      }
    }

    grouping path-transceiver-config {
      description
        "This grouping defines a set of transceivers on a node,
         serving as either source transceivers, destination
         transceivers, or regenerators.";

      choice node-position {
        description
          "The relative position of the node within the path.";
        case source {
          container source-transceiver {
            description
              "Constraints for transceiver configurations at the
               source node";

            uses transceiver-config;
          }
        }
        case destination {
          container destination-transceiver {
            description
              "Constraints for transceiver configurations at the
               destination node";

            uses transceiver-config;
          }
        }
        case transit {
          container regen-transceivers {
            description
              "Constraints for transceiver configurations at the
               transit node equipped with regenerators";

            leaf regen-group-id {
              type uint32;
              description
                "3R regen group identifier.";
            }

            /*
            leaf regen-level {
              //type l0-types:regen-level;
              type string;
              description
```

```
                "Indicate the chosen level of 3R regeneration.";
            }
            */

            container incoming-transceiver {
              description
                "Constraints for transceiver configurations at the
                 incoming direction of the regenerator";

              uses transceiver-config;
            }

            container outgoing-transceiver {
              description
                "Constraints for transceiver configurations at the
                 outgoing direction of the regenerator";

              uses transceiver-config;
            }
          }
        }
      }
    }

    grouping transceiver-measured-parameters {
      description
        "Measured transceiver parameters.";

      container pre-fec-ber {
        description
          "Timestamp and value of the Pre-FEC Bit Error Rate (BER)
           of the received signal.";

        leaf timestamp {
          type yang:timestamp;
          description
            "Timestamp associated with the Pre-FEC BER.";
        }

        leaf value {
          type decimal64 {
            fraction-digits 18;
          }
          description
            "Pre-FEC BER of the received signal.";
        }
      }
```

```
        container q-factor {
          description
            "Timestamp and value of the estimated Q-factor based on
             the pre-FEC BER.";

          leaf timestamp {
            type yang:timestamp;
            description
              "Timestamp associated with the Q-factor.";
          }

          leaf value {
            type l0-types:decimal-2-or-null;
            units "dB";
            description
              "Estimated Q-factor based on the pre-FEC BER.";
          }
        }
      }

      grouping transceiver-state {
        description
          "This grouping includes common transceiver state
           information.";

        leaf transponder-id {
          type uint32;
          description "transponder identifier";
        }

        list transceivers {
          key "transceiver-id";
          description
            "List of transceivers used within the transponder.";

          leaf otsi-carrier-id {
            type uint16;
            description
              "OTSi carrier identifier associated with the
               transceiver.";
          }
          leaf transceiver-id {
            type uint32;
            description
            "transceiver identifier";
          }

          leaf otsi-carrier-frequency {
```

```
          type union {
            type l0-types:frequency-thz;
            type empty;
          }
          description
            "OTSi carrier frequency, equivalent to the
            actual configured transmitter frequency, when known, or
            an empty value when unknown.";
        }

        uses l0-types:common-transceiver-readonly-param;
      }
    }

    grouping e2e-media-channel-info {
      description
        "This grouping includes end-to-end media channel path id
         information.";

      leaf-list e2e-mc-path-id {
        type uint16;
        description
          "The list of the possible end-to-end Media Channel
          (e2e-MC) paths associated with the OTSi which have
          different optical impairments.

          This list is meaningful in case the OTSi can be associated
          with multiple end-to-end Media Channel (e2e-MC) paths
          (e.g., when OPS protection is configured).

          The list can be empty when the OTSi has only one
          e2e-MC path.";
      }
    }

    grouping path-transceiver-state {
      description
        "This grouping defines the state of transceivers on a
         node functioning as starting, terminating transceivers,
         or regenerators.";

      choice node-position {
        description
          "The relative position of the node within the path.";
        case source {
          container source-transceiver {
            description
              "Transceiver state at the source node.";
```

```
            uses transceiver-state;
          }
        }
        case destination {
          container destination-transceiver {
            description
              "Transceiver state at the destination node.";

            uses transceiver-state;
          }
        }
        case transit {
          container regen-transceivers {
            description
              "Transceiver state at the transit node equipped
               with regenerators.";

            leaf regen-group-id {
              type uint32;
              description
                "3R regen group identifier.";
            }

            /*
            leaf regen-level {
              //type l0-types:regen-level;
              type string;
              description
                "Indicate the chosen level of 3R regeneration.";
            }
            */

            container incoming-transceiver {
              description
                "Transceiver state on the incoming direction of
                 the regenerator.";

              uses transceiver-state;
            }

            container outgoing-transceiver {
              description
                "Transceiver state on the outgoing direction of
                 the regenerator.";

              uses transceiver-state;
            }
          }
```

```
        }
      }
    }

    grouping global-transceiver-constraint {
      description
        "This grouping defines the constraints for transceiver
         configurations.";

      container transceiver-constraint {
        description
          "Constraints for transceiver configurations";

        uses transceiver-constraints;
      }
    }

    grouping wdm-constraint {
      description
        "Grouping for WDM tunnel constraints";

      container wdm-constraint {
        description
          "WDM tunnel constraints.";

        uses global-transceiver-constraint;

        leaf use-regen {
          type boolean;
          default false;
          description
            "Indicate whether or not regenerators (e.g. 3R) should be
             considered. When this parameter is set to true, the
             tunnel path may include a regen when the path is not
             feasible for direct optical reach.";
        }

        /*
        leaf-list regen-levels {
          when '../use-regen = "true"' {
            description
              "Regenerator must be enabled for the regen levels
               to be considered.";
          }
          //type l0-types:regen-level;
          type string;
          description
            "Indicate the levels of 3R regeration permitted by
```

```
           the tunnel.";
        }
        */

        leaf wavelength-conversion {
          when '../use-regen = "true"' {
            description
              "Regenerator must be enabled for wavelength conversion
               to be considered.";
          }
          type boolean;
          default false;
          description
            "Indicate whether or not wavelength conversion is allowed
             along the tunnel path. Applicable only when 3R
             regeneration is enabled.";
        }

        uses l0-types:tunnel-attributes;

        leaf guard-band-size {
          type l0-types:frequency-thz;
          description
            "Guard band size in THz.";
        }

        leaf matching-fwd-rev-wavelength {
          type boolean;
          default true;
          description
            "Indicate whether or not the assigned channels for
             forward and reverse wavelength path must be the same.";
        }

        leaf allow-retuning {
          type boolean;
          default false;
          description
            "Indicate whether or not re-tuning is allowed when one or
             more paths of a WDM tunnel is being restored. Typically,
             wavelength retuning is not preferred for wavelength
             planning considerations.";
        }
        leaf delta-power {
          type l0-types:power-ratio;
          description
            "Delta power in dB indicating the per-channel power
             deviation from the nominal power per channel at the
```

```
            output of an OMS.";
        }
      }
    }

    /*
    grouping digital-layer-constraint {
      description
        "Grouping for digital layer constraints";

      container digital-constraint {
        description
          "Digital layer constraints.";

        leaf digital-termination {
          //type l0-types:digital-termination-type;
          type string;
          description
            "Identifies how digital signal is terminated.";
        }

        leaf multiplexing-label-type {
          //type l0-types:multiplexing-label-type;
          type string;
          description
            "Identifies the type of multiplexing technology
             used (e.g. ODUj,k).";
        }
      }
    }
    */

    /*
     * Data nodes
     */

    /*
     * Global constraints for WDM tunnel
     */
    augment "/te:te/te:tunnels/te:tunnel" {
      description
        "Augment with additional parameters required for WDM
         tunnel configurations.";
      uses wdm-constraint;
      //uses digital-layer-constraint;
    }

    /*
```

```
       * Transceiver constraints for primary path
       * Applicable to starting, terminating and regenerator
       * transceivers.
       */
      augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
            + "te:primary-path/te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/"
            + "te:numbered-node-hop/te:numbered-node-hop" {
        description
          "Augment TE primary path with transceiver configurations.";

        uses path-transceiver-config;
      }

      /*
       * Transceiver constraints for primary reverse path
       * Applicable to starting, terminating and regenerator
       * transceivers.
       */
      augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
            + "te:primary-path/te:primary-reverse-path/"
            + "te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/"
            + "te:numbered-node-hop/te:numbered-node-hop" {
        description
          "Augment TE primary reverse path with transceiver
           configurations.";

        uses path-transceiver-config;
      }

      /*
       * Transceiver constraints for secondary path
       * Applicable to starting, terminating and regenerator
       * transceivers.
       */
      augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
            + "te:secondary-path/te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/"
            + "te:numbered-node-hop/te:numbered-node-hop" {
        description
          "Augment TE secondary path with transceiver configurations.";

        uses path-transceiver-config;
      }

      /*
       * Transceiver constraints for secondary reverse path
```

```
      * Applicable to starting, terminating and regenerator
      * transceivers.
      */
     augment "/te:te/te:tunnels/te:tunnel/"
           + "te:secondary-reverse-paths/"
           + "te:secondary-reverse-path/"
           + "te:explicit-route-objects/"
           + "te:route-object-exclude-always/te:type/"
           + "te:numbered-node-hop/te:numbered-node-hop" {
       description
         "Augment TE secondary reverse path with transceiver
          configurations.";

       uses path-transceiver-config;
     }

     /*
      * Computed transceiver properties for primary path.
      */
     augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
           + "te:primary-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop" {
       description
         "Augment TE computed primary path with transceiver
          properties.";

       uses path-transceiver-state;
     }

     augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
           + "te:primary-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
           + "wdm-tnl:node-position/wdm-tnl:source/"
           + "wdm-tnl:source-transceiver/wdm-tnl:transceivers" {
       description
         "Augment source transceiver with additional estimated
          parameters.";

       uses l0-types:path-properties;
     }

     augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
           + "te:primary-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
```

```
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:destination/"
          + "wdm-tnl:destination-transceiver/wdm-tnl:transceivers" {
      description
        "Augment destination transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:incoming-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen incoming transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:outgoing-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen outgoing transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    /*
     * Computed transceiver properties for primary reverse path.
     */
    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:primary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
```

```
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop" {
      description
        "Augment TE computed primary path with transceiver
         properties.";

      uses path-transceiver-state;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:primary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:source/"
          + "wdm-tnl:source-transceiver/wdm-tnl:transceivers" {
      description
        "Augment source transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:primary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:destination/"
          + "wdm-tnl:destination-transceiver/wdm-tnl:transceivers" {
      description
        "Augment destination transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:primary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:incoming-transceiver/wdm-tnl:transceivers" {
```

```
      description
        "Augment regen incoming transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:primary-paths/"
          + "te:primary-path/te:primary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:outgoing-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen outgoing transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    /*
     * Computed transceiver properties for secondary path.
     */
    augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
          + "te:secondary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop" {
      description
        "Augment TE computed primary path with transceiver
         properties.";

      uses path-transceiver-state;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
          + "te:secondary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:source/"
          + "wdm-tnl:source-transceiver/wdm-tnl:transceivers" {
      description
        "Augment source transceiver with additional estimated
         parameters.";
```

```
      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
          + "te:secondary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:destination/"
          + "wdm-tnl:destination-transceiver/wdm-tnl:transceivers" {
      description
        "Augment destination transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
          + "te:secondary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:incoming-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen incoming transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    augment "/te:te/te:tunnels/te:tunnel/te:secondary-paths/"
          + "te:secondary-path/te:computed-paths-properties/"
          + "te:computed-path-properties/te:path-properties/"
          + "te:path-route-objects/te:path-route-object/"
          + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:outgoing-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen outgoing transceiver with additional estimated
         parameters.";

      uses l0-types:path-properties;
    }

    /*
```

```
      * Computed transceiver properties for secondary reverse path.
      */
     augment "/te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths/"
           + "te:secondary-reverse-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop" {
       description
         "Augment TE computed primary path with transceiver
          properties.";

       uses path-transceiver-state;
     }

     augment "/te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths/"
           + "te:secondary-reverse-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
           + "wdm-tnl:node-position/wdm-tnl:source/"
           + "wdm-tnl:source-transceiver/wdm-tnl:transceivers" {
       description
         "Augment source transceiver with additional estimated
          parameters.";

       uses l0-types:path-properties;
     }

     augment "/te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths/"
           + "te:secondary-reverse-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
           + "wdm-tnl:node-position/wdm-tnl:destination/"
           + "wdm-tnl:destination-transceiver/wdm-tnl:transceivers" {
       description
         "Augment destination transceiver with additional estimated
          parameters.";

       uses l0-types:path-properties;
     }

     augment "/te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths/"
           + "te:secondary-reverse-path/te:computed-paths-properties/"
           + "te:computed-path-properties/te:path-properties/"
           + "te:path-route-objects/te:path-route-object/"
           + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
           + "wdm-tnl:node-position/wdm-tnl:transit/"
```

```
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:incoming-transceiver/wdm-tnl:transceivers" {
        description
          "Augment regen incoming transceiver with additional estimated
           parameters.";

        uses l0-types:path-properties;
      }

      augment "/te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths/"
            + "te:secondary-reverse-path/te:computed-paths-properties/"
            + "te:computed-path-properties/te:path-properties/"
            + "te:path-route-objects/te:path-route-object/"
            + "te:type/te:numbered-node-hop/te:numbered-node-hop/"
            + "wdm-tnl:node-position/wdm-tnl:transit/"
            + "wdm-tnl:regen-transceivers/"
            + "wdm-tnl:outgoing-transceiver/wdm-tnl:transceivers" {
        description
          "Augment regen outgoing transceiver with additional estimated
           parameters.";

        uses l0-types:path-properties;
      }

      /*
       * Actual transceiver state.
       */
      augment "/te:te/te:lsps/te:lsp/"
            + "te:lsp-actual-route-information/"
            + "te:lsp-actual-route-information/te:type/"
            + "te:numbered-node-hop/te:numbered-node-hop" {
        description
          "Augment TE LSP with WDM path state.";

        uses path-transceiver-state;
      }

      augment "/te:te/te:lsps/te:lsp/"
            + "te:lsp-actual-route-information/"
            + "te:lsp-actual-route-information/te:type/"
            + "te:numbered-node-hop/te:numbered-node-hop/"
            + "wdm-tnl:node-position/wdm-tnl:source/"
            + "wdm-tnl:source-transceiver/wdm-tnl:transceivers" {
        description
          "Augment source transceiver with additional measured
           parameters.";

        uses transceiver-measured-parameters;
```

```
    }

    augment "/te:te/te:lsps/te:lsp/"
          + "te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/"
          + "te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:destination/"
          + "wdm-tnl:destination-transceiver/wdm-tnl:transceivers" {
      description
        "Augment destination transceiver with additional measured
         parameters.";

      uses transceiver-measured-parameters;
    }

    augment "/te:te/te:lsps/te:lsp/"
          + "te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/"
          + "te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:incoming-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen incoming transceiver with additional measured
         parameters.";

      uses transceiver-measured-parameters;
    }

    augment "/te:te/te:lsps/te:lsp/"
          + "te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/"
          + "te:numbered-node-hop/te:numbered-node-hop/"
          + "wdm-tnl:node-position/wdm-tnl:transit/"
          + "wdm-tnl:regen-transceivers/"
          + "wdm-tnl:outgoing-transceiver/wdm-tnl:transceivers" {
      description
        "Augment regen outgoing transceiver with additional measured
         parameters.";

      uses transceiver-measured-parameters;
    }

    augment "/te:te/te:lsps/te:lsp/"
          + "te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/"
          + "te:numbered-link-hop/te:numbered-link-hop" {
      description
```

```
        "Augment TE LSP with end-to-end media channel
         information.";

      uses e2e-media-channel-info;
    }

    augment "/te:te/te:lsps/te:lsp/"
          + "te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/"
          + "te:unnumbered-link-hop/te:unnumbered-link-hop" {
      description
        "Augment TE LSP with end-to-end media channel
         information.";

      uses e2e-media-channel-info;
    }

    /*
     * Augment TE label range information
     */

    augment "/te:te/te:globals/te:named-path-constraints/"
          + "te:named-path-constraint/te:path-in-segment/"
          + "te:label-restrictions/te:label-restriction" {
      description
        "Augment TE label range information for the ingress segment
        of the named path constraint.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:globals/te:named-path-constraints/"
          + "te:named-path-constraint/te:path-out-segment/"
          + "te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the egress segment
        of the named path constraint.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the ingress segment
        of the primay path.";
      uses l0-types:wdm-label-range-info;
```

```
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the egress segment
        of the primay path.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the ingress segment
        of the primay reverse path.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the egress segment
        of the primay reverse path.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction" {
      description
        "Augment TE label range information for the ingress segment
        of the secondary path.";
      uses l0-types:wdm-label-range-info;
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction" {
```

```
        description
          "Augment TE label range information for the egress segment
          of the secondary path.";
        uses l0-types:wdm-label-range-info;
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-reverse-paths/te:secondary-reverse-path/"
            + "te:path-in-segment/te:label-restrictions/"
            + "te:label-restriction" {
        description
          "Augment TE label range information for the ingress segment
          of the secondary reverse path.";
        uses l0-types:wdm-label-range-info;
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-reverse-paths/te:secondary-reverse-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction" {
        description
          "Augment TE label range information for the egress segment
          of the secondary reverse path.";
        uses l0-types:wdm-label-range-info;
      }

      /*
       * Augment TE label.
       */
      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/"
            + "te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the explicit route objects always
          excluded by the path computation with the named path
          constraint.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/"
            + "te:explicit-route-objects/"
            + "te:route-object-include-exclude/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
```

```
        description
          "Augment TE label hop for the explicit route objects included
          or excluded by the path computation with the named path
          constraint.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }
      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-in-segment/"
            + "te:label-restrictions/"
            + "te:label-restriction/te:label-start/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the ingress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-in-segment/"
            + "te:label-restrictions/"
            + "te:label-restriction/te:label-end/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the ingress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-in-segment/"
            + "te:label-restrictions/te:label-restriction/"
            + "te:label-step/te:technology" {
        description
          "Augment TE label range step for the ingress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-out-segment/"
```

```
          + "te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the egress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-out-segment/"
            + "te:label-restrictions/"
            + "te:label-restriction/te:label-end/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the egress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:globals/te:named-path-constraints/"
            + "te:named-path-constraint/te:path-out-segment/"
            + "te:label-restrictions/te:label-restriction/"
            + "te:label-step/te:technology" {
        description
          "Augment TE label range step for the egress segment
          of the named path constraint.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-exclude-objects/"
            + "te:route-object-exclude-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
          route objects excluded by the path computation of the primary
          path.";
        case wdm {
          uses l0-types:wdm-label-hop;
```

```
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:optimizations/te:algorithm/te:metric/"
          + "te:optimization-metric/te:explicit-route-include-objects/"
          + "te:route-object-include-object/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the optimization of the explicit
        route objects included by the path computation of the primary
        path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-exclude-always/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects always
        excluded by the path computation of the primary path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-include-exclude/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects included
        or excluded by the path computation of the primary path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
```

```
          + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the ingress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:path-in-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-end/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the ingress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:path-in-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-step/te:technology" {
        description
          "Augment TE label range step for the ingress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-start/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the egress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
```

```
          + "te:primary-paths/te:primary-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the egress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-step/te:technology" {
        description
          "Augment TE label range end for the egress segment
          of the primay path.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:computed-paths-properties/"
            + "te:computed-path-properties/te:path-properties/"
            + "te:path-route-objects/te:path-route-object/"
            + "te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the route object of the computed
          primary path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:primary-paths/te:primary-path/"
            + "te:primary-reverse-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-exclude-objects/"
            + "te:route-object-exclude-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
```

```
        route objects excluded by the path computation of the primary
        reverse path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:optimizations/te:algorithm/te:metric/"
          + "te:optimization-metric/te:explicit-route-include-objects/"
          + "te:route-object-include-object/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the optimization of the explicit
        route objects included by the path computation of the primary
        reverse path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-exclude-always/"
          + "te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects always
        excluded by the path computation of the primary reverse
        path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-include-exclude/"
          + "te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects included
```

```
        or excluded by the path computation of the primary reverse
        path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range start for the ingress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range end for the ingress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-step/te:technology" {
      description
        "Augment TE label range step for the ingress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-step;
      }
    }
```

```
    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range start for the egress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range end for the egress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-step/te:technology" {
      description
        "Augment TE label range step for the egress segment
        of the primay reverse path.";
      case wdm {
        uses l0-types:wdm-label-step;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:primary-paths/te:primary-path/"
          + "te:primary-reverse-path/"
          + "te:computed-paths-properties/te:computed-path-properties/"
          + "te:path-properties/te:path-route-objects/"
          + "te:path-route-object/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
```

```
        description
          "Augment TE label hop for the route object of the computed
          primary reverse path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-exclude-objects/"
            + "te:route-object-exclude-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
          route objects excluded by the path computation of the
          secondary path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-include-objects/"
            + "te:route-object-include-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
          route objects included by the path computation of the
          secondary path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the explicit route objects always
          excluded by the path computation of the secondary path.";
        case wdm {
          uses l0-types:wdm-label-hop;
```

```
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-include-exclude/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects included
        or excluded by the path computation of the secondary path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range start for the ingress segment
        of the secondary path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range end for the ingress segment
        of the secondary path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }
    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-paths/te:secondary-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-step/te:technology" {
      description
        "Augment TE label range step for the ingress segment
        of the secondary path.";
```

```
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-start/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the egress segment
          of the secondary path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-end/"
            + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the egress segment
          of the secondary path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:path-out-segment/te:label-restrictions/"
            + "te:label-restriction/te:label-step/te:technology" {
        description
          "Augment TE label range step for the egress segment
          of the secondary path.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-paths/te:secondary-path/"
            + "te:computed-paths-properties/"
            + "te:computed-path-properties/"
            + "te:path-properties/te:path-route-objects/"
```

```
          + "te:path-route-object/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the route object of the computed
          secondary path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-reverse-paths/te:secondary-reverse-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-exclude-objects/"
            + "te:route-object-exclude-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
          route objects excluded by the path computation of the
          secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-reverse-paths/te:secondary-reverse-path/"
            + "te:optimizations/te:algorithm/te:metric/"
            + "te:optimization-metric/te:explicit-route-include-objects/"
            + "te:route-object-include-object/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the optimization of the explicit
          route objects included by the path computation of the
          secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-hop;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
            + "te:secondary-reverse-paths/te:secondary-reverse-path/"
            + "te:explicit-route-objects/"
            + "te:route-object-exclude-always/te:type/te:label/"
            + "te:label-hop/te:te-label/te:technology" {
        description
          "Augment TE label hop for the explicit route objects always
          excluded by the path computation of the secondary reverse
```

```
        path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:explicit-route-objects/"
          + "te:route-object-include-exclude/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the explicit route objects included
        or excluded by the path computation of the secondary reverse
        path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range start for the ingress segment
        of the secondary reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
      description
        "Augment TE label range end for the ingress segment
        of the secondary reverse path.";
      case wdm {
        uses l0-types:wdm-label-start-end;
      }
    }

    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
```

```
          + "te:path-in-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-step/te:technology" {
        description
          "Augment TE label range step for the ingress segment
          of the secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-start/"
          + "te:te-label/te:technology" {
        description
          "Augment TE label range start for the egress segment
          of the secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-end/"
          + "te:te-label/te:technology" {
        description
          "Augment TE label range end for the egress segment
          of the secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-start-end;
        }
      }

      augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:path-out-segment/te:label-restrictions/"
          + "te:label-restriction/te:label-step/te:technology" {
        description
          "Augment TE label range step for the egress segment
          of the secondary reverse path.";
        case wdm {
          uses l0-types:wdm-label-step;
        }
      }
```

```
    augment "/te:te/te:tunnels/te:tunnel/"
          + "te:secondary-reverse-paths/te:secondary-reverse-path/"
          + "te:computed-paths-properties/"
          + "te:computed-path-properties/"
          + "te:path-properties/te:path-route-objects/"
          + "te:path-route-object/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the route object of the computed
        secondary reverse path.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }

    augment "/te:te/te:lsps/"
          + "te:lsp/te:lsp-actual-route-information/"
          + "te:lsp-actual-route-information/te:type/te:label/"
          + "te:label-hop/te:te-label/te:technology" {
      description
        "Augment TE label hop for the actual route of the LSP.";
      case wdm {
        uses l0-types:wdm-label-hop;
      }
    }
  }
  <CODE ENDS>
```

Figure 3: WDM Tunnel YANG module

6. Security Considerations

The configuration, state, and action data defined in this document are designed to be accessed via a management protocol with a secure transport layer, such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

* /te:te/te:tunnels/te:tunnel

* /te:te/.../te:te-bandwidth/te:technology

* /te:te/.../te:type/te:label/te:label-hop/te:te-label/te:technology

* /te:te/.../te:label-restrictions/te:label-restriction/te:label-start/te:te-label/te:technology

* /te:te/.../te:label-restrictions/te:label-restriction/te:label-end/te:te-label/te:technology

* /te:te/.../te:label-restrictions/te:label-restriction/

Editors note: we are using simplified description by folding similar branches to avoid repetition.

7. IANA Considerations

This document requests IANA to register the following URIs in the "ns" subregistry within the "IETF XML Registry" [RFC3688]. Following the format in [RFC3688], the following registrations are requested.

```
URI: urn:ietf:params:xml:ns:yang:ietf-wdm-tunnel
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.
```

This document requests IANA to register the following YANG modules in the "IANA Module Names" [RFC6020]. Following the format in [RFC6020], the following registrations are requested:

```
name: ietf-wdm-tunnel
namespace: urn:ietf:params:xml:ns:yang:ietf-wdm-tunnel
prefix: wdm-tnl
reference: RFC XXXX
```

RFC Editor: Please replace XXXX with the RFC number assigned to this document.

8. References

8.1. Normative References

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8.2. Informative References

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