

CCAMP Working Group  
Internet Draft  
Intended Status: Standard Track

Expires: August 27, 2019

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February 28, 2019

A Yang Data Model for Optical Impairment-aware Topology

draft-lee-ccamp-optical-impairment-topology-yang-01

## Abstract

In order to provision an optical connection through optical networks, a combination of path continuity, resource availability, and impairment constraints must be met to determine viable and optimal paths through the network. The determination of appropriate paths is known as Impairment-Aware Routing and Wavelength Assignment (IA-RWA) for WSON, while it is known as Impairment-Aware Routing and Spectrum Assigment (IA-RSA) for SSON.

This document provides a YANG data model for the impairment-aware TE topology in optical networks.

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## 1. Introduction

In order to provision an optical connection (an optical path) through a wavelength switched optical networks (WSONs) or spectrum switched optical networks (SSONs), a combination of path continuity, resource availability, and impairment constraints must be met to determine viable and optimal paths through the network. The determination of appropriate paths is known as Impairment-Aware Routing and Wavelength Assignment (IA-RWA) [RFC6566] for WSON, while it is known as IA-Routing and Spectrum Assignment (IA-RSA) for SSON.

This document provides a YANG data model for the impairment-aware Traffic Engineering (TE) topology in WSONs and SSONs. The YANG model described in this document is a WSON/SSON technology-specific Yang model based on the information model developed in [RFC7446] and the two encoding documents [RFC7581] and [RFC7579] that developed protocol independent encodings based on [RFC7446].

The intent of this document is to provide a Yang data model, which can be utilized by a Multi-Domain Service Coordinator (MDSC) to collect states of WSON impairment data from the Transport PNCs to enable impairment-aware optical path computation according to the

ACTN Architecture [RFC8453]. The communication between controllers is done via a NETCONF [RFC8341]. Similarly, this model can also be exported by the MDSC to a Customer Network Controller (CNC), which can run an offline planning process to map latter the services in the network.

This document augments the generic TE topology draft [TE-TOPO] where possible.

This document defines one YANG module: ietf-optical-impairment-topology (Section 3) according to the new Network Management Datastore Architecture [RFC8342].

### 1.1. Terminology

Refer to [RFC4847] and [RFC5253] for the key terms used in this document.

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

- o client
- o server
- o augment
- o data model
- o data node

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

- o configuration data
- o state data

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

### 1.2. Tree diagram

A simplified graphical representation of the data model is used in Section 2 of this this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

### 1.3. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in Table 1.

Prefix	YANG module	Reference
optical-imp-topo	ietf-optical-impairment-topology	[RFC XXXX]
layer0-types	ietf-layer0-types	[WSON-topo]
nw	ietf-network	[RFC8345]
nt	ietf-network-topology	[RFC8345]
tet	ietf-te-topology	[TE-TOPO]

Table 1: Prefixes and corresponding YANG modules

Note: The RFC Editor will replace XXXX with the number assigned to the RFC once this draft becomes an RFC.

## 2. Reference Architecture

### 2.1. Control Plane Architecture

Figure 1 shows the control plane architecture.

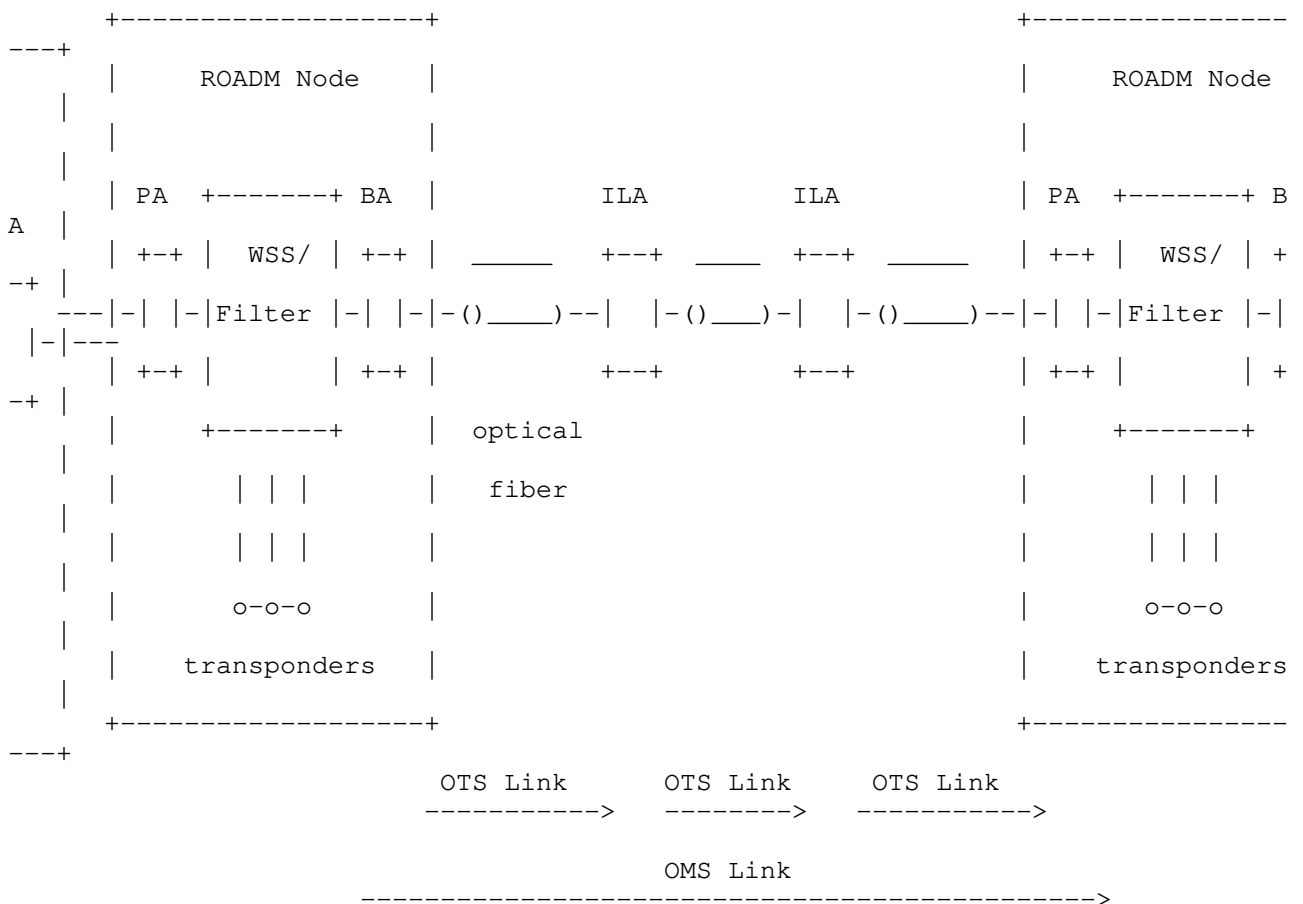
Figure 1. Control Plane Architecture

The models developed in this document is an abstracted Yang model that may be used in the interfaces colored in yellow in Figure 1. It is not intended to support detailed device configuration model. Device configuration model is supported by the models presented in [draft-ietf-ccamp-dwdm-if-parameter-yang].

## 2.2. Transport Data Plane

This section provides the description of the reference optical network architecture and its relevant components to support optical impairment-aware path computation.

Figure 2 shows the reference architecture.



PA: Pre-Amplifier  
 BA: Booster Amplifier  
 ILA: In-Line Amplifier

Figure 2. Reference Architecture for Optical Transport Network

BA (on the left side ROADM) is the ingress Amplifier and PA (on the right side ROADM) is the egress amplifier for the OMS link shown in the Figure.

## 2.3. OMS Media Links

According to [G.872], OMS Media Link represents a media link between two ROADM. Specifically, it originates at the ROADM's Filter in the source ROADM and terminates at the ROADM's Filter in the destination ROADM.

OTS Media Link represents a media link:





- (i)    between ROADM's BA and ILA;
- (ii)   between a pair of ILAs;
- (iii) between ILA and ROADM's PA.

OMS Media link can be decomposed of a number of elements, which are basically OTS links type (i), (ii), and (iii) as discussed above. OMS Media link would give an abstracted view of impairment data (e.g., power, OSNR, etc.) to the network controller.

#### 2.3.1. Optical Tributary Signal Group (OTSiG)

The Media Channel and Network Media Channel are well modelled by the RFC7698, RFC7699 and RFC7792 reflecting the ITU-T Recommendations G.694.1 and G.698.2.

Some work is in progress in ITU-T SG15/Q12 to define Network Media Channel (group) that is capable of accommodating the optical tributary signals (OTSi) belonging to optical tributary signal group (OTSiG). ( see new ITU-T Draft Recommendation G.807)).

Currently, no models exist (in the IETF nor ITU-T SG15) that define how the optical tributary signals are described inside the Network Media Channel Group in terms of OTSi identifier, OTSi carrier frequency and OTSi signal width.

There are several options how the mentioned parameters can be described. One option is to use the description defined in draft-ggalimbe-ccamp-flexigrid-carrier-label.

A second option is to describe the OTSi carrier frequency relative to the anchor frequency 193.1THz based on a well-defined granularity (e.g. OTSi carrier frequency = 193100 (GHz) + K \* granularity (GHz) where K is a signed integer value).

A third option is to explicitly describe the OTSi carrier frequency and the OTSi signal width in GHz with a certain accuracy.

It is proposed to use the third option which is independent of the n, m values already define in ITU-T Recommendation G.694.1.

The OTSi carrier frequency is described in GHz with 3 fractional digits (decimal 64 fraction digits 3).

The OTSi signal width is described in GHz with 3 fractional digits (decimal 64 fraction digits 3) and includes the signal roll off as well as some guard band.

The accuracy of 0.001 GHz does not impose a requirement on the optical transceiver components (optical transmitter) in terms of carrier frequency tuneability precision. Today's components typically provide a tunability precision in the range of 1..1.5GHz (carrier frequency offset compared to the configured nominal carrier frequency). Future components may provide a better precision as technology evolves.

If needed, a controller may retrieve the transceiver properties in terms of carrier frequency tuneability precision in order to be capable of properly configuring the underlying transceiver.

[Note from the Editor]:

As this description is arbitrarily proposed by the authors to cover a lack of information in IETF and ITU-T, a liaison request to ITU-T is needed.

The authors are willing to contribute to Liaison editing and to consider any feedback and proposal from ITU-T.

## 2.4. Amplifiers

There are three basic types of amplifiers. ILA is In-Line Amplifier which is a separate node type while Pre-Amplifier and Booster Amplifier are integral elements of ROADM node. From a data modeling perspective, Pre-Amplifier and Booster Amplifier are internal functions of a ROADM node and as such these elements are hidden within ROADM node. In this document, we would avoid internal node details, but attempt to abstract as much as possible.

One modeling consideration of the ROADM internal is to model power parameter through the ROADM, factoring the output power from the Pre-Amplifier minus the ROADM power loss would give the input power to the Booster Amplifier. In other words, Power\_in (@ ROADM Booster)

= Power\_out (@ ROADM Pre-Amplifier) - Power\_loss (@ ROADM WSS/Filter).

#### 2.4.1. In-Line Amplifier

(Need to explain details including VOA)

#### 2.5. Transponders

A Transponder is the element that sends and receives the optical signal from a fiber. A transponder is typically characterized by its data rate and the maximum distance the signal can travel. Channel frequency, per channel input power, FEC and Modulation are also associated with a transponder. From a path computation point of view, the selection of the compatible source and destination transponders is an important factor for optical signal to traverse through the fiber. There are three main approaches to determine optical signal compatibility. Application Code based on G.682.2 is one approach that only checks the code at both ends of the interface. Another approach is organization codes that are specific to an organization or a vendor. The third approach is specify all the relevant parameters explicitly, e.g., FEC type, Modulation type, etc.

#### 2.6. WSS/Filter

WSS separates the incoming light input spectrally as well as spatially, then chooses the wavelength that is of interest by deflecting it from the original optical path and then couple it to another optical fibre port. WSS/Filter is internal to ROADM. So this document does not model the inside of ROADM.

#### 2.7. Optical Fiber

There are various optical fiber types defined by ITU-T. There are several fiber-level parameters that need to be factored in, such as, fiber-type, length, loss coefficient, pmd, connectors (in/out).

ITU-T G.652 defines Standard Singlemode Fiber; G.654 Cutoff Shifted Fiber; G.655 Non-Zero Dispersion Shifted Fiber; G.656 Non-Zero Dispersion for Wideband Optical Transport; G.657 Bend-Insensitive Fiber. There may be other fiber-types that need to be considered.

## 3. YANG Model (Tree Structure)

```

module: ietf-optical-impairment-topology
  augment /nw:networks/nw:network/nw:network-types/tet:te-topology:
    +--rw optical-impairment-topology!
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes:
    +--ro OMS-attributes
      +--ro generalized-snr? decimal64
      +--ro equalization-mode identityref
      +--ro (power-param)?
        +--:(channel-power)
          | +--ro nominal-channel-power? decimal64
          +--:(power-spectral-density)
            +--ro nominal-power-spectral-density? decimal64
      +--ro network-media-channel-group* [i]
        +--ro i int16
        +--ro current-channels* [flex-n]
          | +--ro flex-n uint16
          | +--ro flex-m? uint16
          +--ro OTSiG-container* [carrier-id]
            +--ro carrier-id int16
            +--ro OTSi-carrier-frequency? decimal64
            +--ro OTSi-signal-width? decimal64
            +--ro channel-delta-power? decimal64
      +--ro OMS-elements* [elt-index]
        +--ro elt-index uint16
        +--ro uid? string
        +--ro type identityref
        +--ro element
          +--ro (element)?
            +--:(amplifier)
              +--ro amplifier
                +--ro type_variety string
                +--ro operational
                  +--ro actual-gain decimal64
                  +--ro tilt-target decimal64
                  +--ro out-voa decimal64
                  +--ro in-voa decimal64
                  +--ro (power-param)?
                    +--:(channel-power)
                      | +--ro nominal-channel-power? decimal6
                      |
                      +--:(power-spectral-density)
                        +--ro nominal-power-spectral-density? decimal6
                +--:(fiber)
                  +--ro fiber

```

```

        |      +--ro type_variety      string
        |      +--ro length            decimal64
        |      +--ro loss_coef         decimal64
        |      +--ro total_loss        decimal64
        |      +--ro pmd?              decimal64
        |      +--ro conn_in?          decimal64
        |      +--ro conn_out?         decimal64
        +---:(concentratedloss)
            +--ro concentratedloss
            +--ro loss? decimal64
augment /nw:networks/nw:network/nw:node/tet:te/tet:tunnel-termination-point
:
    +--ro transponders-list* [transponder-id]
        +--ro transponder-id          uint32
        +--ro (mode)?
            +---:(G.692.2)
            |   +--ro G.692.2?          layer0-types:standard-mode
            +---:(organizational_mode)
            |   +--ro operational-mode?  layer0-types:operational-mode
            |   +--ro organization-identifier? layer0-types:vendor-identifier
            +---:(explicit_mode)
            |   +--ro available-modulation* identityref
            |   +--ro modulation-type?    identityref
            |   +--ro available-baud-rates* uint32
            |   +--ro configured-baud-rate? uint32
            |   +--ro available-FEC*       identityref
            |   +--ro FEC-type?            identityref
            |   +--ro FEC-code-rate?       decimal64
            |   +--ro FEC-threshold?       decimal64
            +--ro power?                   int32
            +--ro power-min?               int32
            +--ro power-max?               int32
augment /nw:networks/nw:network/nw:node/tet:te/tet:tunnel-termination-point
:
    +--ro transponder-list* [carrier-id]
        +--ro carrier-id      uint32

```

#### 4. Optical Impairment Topology YANG Model

<CODE BEGINS> file ietf-optical-impairment-topology@2018-02-27.yang

```

module ietf-optical-impairment-topology {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-optical-impairment-topology";

  prefix "optical-imp-topo";

```

```
import ietf-network {
  prefix "nw";
}

import ietf-network-topology {
  prefix "nt";
}

import ietf-te-topology {
  prefix "tet";
}

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

organization
  "IETF CCAMP Working Group";

contact
  "Editor:   Young Lee   <leeyoung@huawei.com>
   Editor:   Haomian Zheng <zhenghaomian@huawei.com>
   Editor:   Nicola Sambo <nicosambo@gmail.com>
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   Editor:   Julien Meuric <julien.meuric@orange.com>
   Editor:   Italo Busi <Italo.Busi@huawei.com>";

description
  "This module contains a collection of YANG definitions for
   impairment-aware optical networks.

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   Provisions Relating to IETF Documents
   (http://trustee.ietf.org/license-info).";

revision 2019-02-27 {
  description
    "Initial Version";
  reference
```

```
    "RFC XXXX: A Yang Data Model for Impairment-aware
      Optical Networks";
  }

  identity modulation {
    description "base identity for modulation type";
  }

  identity QPSK {
    base modulation;
    description
      "QPSK (Quadrature Phase Shift Keying) modulation";
  }

  identity DP_QPSK {
    base modulation;
    description
      "DP-QPSK (Dual Polarization Quadrature
        Phase Shift Keying) modulation";
  }

  identity QAM8 {
    base modulation;
    description
      "8QAM (8-State Quadrature Amplitude Modulation) modulation";
  }

  identity QAM16 {
    base modulation;
    description
      "QAM16 (Quadrature Amplitude Modulation)";
  }

  identity DP_QAM8 {
    base modulation;
    description
      "DP-QAM8 (Dual Polarization Quadrature Amplitude Modulation)";
  }

  identity DC_DP_QAM8 {
    base modulation;
    description
      "DC DP-QAM8 (Dual Polarization Quadrature Amplitude Modulation)";
  }

  identity DP_QAM16 {
    base modulation;
    description
      "DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation)";
  }

  identity DC_DP_QAM16 {
    base modulation;
    description
      "DC DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation)";
  }
```

```
}

identity FEC {
  description
    "Enumeration that defines the type of
    Forward Error Correction";
}
identity reed-solomon {
  base FEC;
  description
    "Reed-Solomon error correction";
}
identity hamming-code {
  base FEC;
  description
    "Hamming Code error correction";
}
identity golay {
  base FEC;
  description "Golay error correction";
}

typedef fiber-type {
  type enumeration {
    enum G.652 {
      description "G.652 Standard Singlemode Fiber";
    }
    enum G.654 {
      description "G.654 Cutoff Shifted Fiber";
    }
    enum G.653 {
      description "G.653 Dispersion Shifted Fiber";
    }
    enum G.655 {
      description "G.655 Non-Zero Dispersion Shifted Fiber";
    }
    enum G.656 {
      description "G.656 Non-Zero Dispersion for Wideband
        Optical Transport";
    }
    enum G.657 {
      description "G.657 Bend-Insensitive Fiber";
    }
  }
  description
    "ITU-T based fiber-types";
}
```



```
grouping transponder-attributes {
  description "Configuration of an optical transponder";

  leaf-list available-modulation {
    type identityref {
      base modulation;
    }
    config false;
    description
      "List determining all the available modulations";
  }

  leaf modulation-type {
    type identityref {
      base modulation;
    }
    config false;
    description
      "Modulation configured for the transponder";
  }

  leaf-list available-baud-rates {
    type uint32;
    units Bd;
    config false;
    description
      "list of available baud-rates. Baud-rate is the unit for
      symbol rate or modulation rate in symbols per second or
      pulses per second. It is the number of distinct symbol
      changes (signaling events) made to the transmission medium
      per second in a digitally modulated signal or a line code";
  }

  leaf configured-baud-rate {
    type uint32;
    units Bd;
    config false;
    description "configured baud-rate";
  }

  leaf-list available-FEC {
    type identityref {
      base FEC;
    }
    config false;
    description "List determining all the available FEC";
  }

  leaf FEC-type {
```

```
    type identityref {
      base FEC;
    }
    config false;
    description
      "FEC type configured for the transponder";
  }

  leaf FEC-code-rate {
    type decimal64 {
      fraction-digits 8;
      range "0..max";
    }
    config false;
    description "FEC-code-rate";
  }

  leaf FEC-threshold {
    type decimal64 {
      fraction-digits 8;
      range "0..max";
    }
    config false;
    description
      "Threshold on the BER, for which FEC is able to correct errors";
  }
}

grouping sliceable-transponder-attributes {
  description
    "Configuration of a sliceable transponder.";
  list transponder-list {
    key "carrier-id";
    config false;
    description "List of carriers";
    leaf carrier-id {
      type uint32;
      config false;
      description "Identifier of the carrier";
    }
  }
}

grouping optical-fiber-data {
  description
    "optical link (fiber) attributes with impairment data";
  leaf fiber-type {
    type fiber-type;
  }
}
```

```
    config false;
    description "fiber-type";
}

leaf span-length {
    type decimal64 {
        fraction-digits 2;
    }
    units "km";
    config false;
    description "the lenght of the fiber span in km";
}

leaf input-power {
    type decimal64 {
        fraction-digits 2;
    }
    units "dBm";
    config false;
    description
        "Average input power level estimated at the receiver
        of the link";
}

leaf output-power {
    type decimal64 {
        fraction-digits 2;
    }
    units "dBm";
    description
        "Mean launched power at the transmitter of the link";
}

leaf pmd {
    type decimal64 {
        fraction-digits 8;
        range "0..max";
    }
    units "ps/(km)^0.5";
    config false;
    description
        "Polarization Mode Dispersion";
}

leaf cd {
    type decimal64 {
        fraction-digits 5;
    }
    units "ps/nm/km";
}
```

```
    config false;
    description
      "Cromatic Dispersion";
  }

  leaf osnr {
    type decimal64 {
      fraction-digits 5;
    }
    units "dB";
    config false;
    description
      "Optical Signal-to-Noise Ratio (OSNR) estimated
       at the receiver";
  }

  leaf sigma {
    type decimal64 {
      fraction-digits 5;
    }
    units "dB";
    config false;
    description
      "sigma in the Gaussian Noise Model";
  }
}

grouping optical-channel-data {
  description
    "optical impairment data per channel/wavelength";
  leaf bit-rate {
    type decimal64 {
      fraction-digits 8;
      range "0..max";
    }
    units "Gbit/s";
    config false;
    description
      "Gross bit rate";
  }

  leaf BER {
    type decimal64 {
      fraction-digits 18;
      range "0..max";
    }
    config false;
    description
      "BER (Bit Error Rate)";
  }
}
```

```
}

leaf ch-input-power {
    type decimal64 {
        fraction-digits 2;
    }
    units "dBm";
    config false;
    description
        "Per channel average input power level
         estimated at the receiver of the link";
}

leaf ch-pmd {
    type decimal64 {
        fraction-digits 8;
        range "0..max";
    }
    units "ps/(km)^0.5";
    config false;
    description
        "per channel Polarization Mode Dispersion";
}

leaf ch-cd {
    type decimal64 {
        fraction-digits 5;
    }
    units "ps/nm/km";
    config false;
    description
        "per channel Chromatic Dispersion";
}

leaf ch-osnr {
    type decimal64 {
        fraction-digits 5;
    }
    units "dB";
    config false;
    description
        "per channel Optical Signal-to-Noise Ratio
         (OSNR) estimated at the receiver";
}

leaf q-factor {
    type decimal64 {
        fraction-digits 5;
    }
}
```

```
    units "dB";
    config false;
    description
        "q-factor estimated at the receiver";
}
}

grouping standard_mode {
    description
        "ITU-T G.698.2 standard mode that guarantees interoperability.
        It must be an string with the following format:
        B-DScW-ytz(v) where all these attributes are conformant
        to the ITU-T recomendation";

    leaf standard_mode {
        type layer0-types:standard-mode;
        config false;
        description
            "G.698.2 standard mode";
    }
}

grouping organizational_mode {
    description
        "Transponder operational mode supported by organizations or
        vendor";

    leaf operational-mode {
        type layer0-types:operational-mode;
        config false;
        description
            "configured organization- or vendor-specific
            application identifiers (AI) supported by the transponder";
    }

    leaf organization-identifier {
        type layer0-types:vendor-identifier;
        config false;
        description
            "organization identifier that uses organizational
            mode";
    }
}

/*
* Identities
*/
identity type-element {
```

```
    description
      "Base identity for element type";
  }

  identity Fiber {
    base type-element;
    description
      "Fiber element";
  }

  identity Roadm {
    base type-element;
    description
      "Roadm element";
  }

  identity Edfa {
    base type-element;
    description
      "Edfa element";
  }

  identity Concentratedloss {
    base type-element;
    description
      "Concentratedloss element";
  }

  identity type-power-mode {
    description
      "power equalization mode used within the OMS and its elements";
  }

  identity power-spectral-density {
    base type-power-mode;
    description
      "all elements must use power spectral density (W/Hz)";
  }

  identity channel-power {
    base type-power-mode;
    description
      "all elements must use power (dBm)";
  }

  /*
   * Groupings
   */
  grouping amplifier-params {
```

```
description "describes parameters for an amplifier";
container amplifier{
  description "amplifier type, operational parameters are described";
  leaf type_variety {
    type string ;
    mandatory true ;
    description
      "String identifier of amplifier type referencing
       a specification in a separate equipment catalog";
  }
  container operational {
    description "amplifier operational parameters";
    leaf actual-gain {
      type decimal64 {
        fraction-digits 2;
      }
      units dB ;
      mandatory true ;
      description "..";
    }
    leaf tilt-target {
      type decimal64 {
        fraction-digits 2;
      }
      mandatory true ;
      description "..";
    }
    leaf out-voa {
      type decimal64 {
        fraction-digits 2;
      }
      units dB;
      mandatory true;
      description "..";
    }
    leaf in-voa {
      type decimal64 {
        fraction-digits 2;
      }
      units dB;
      mandatory true;
      description "..";
    }
    uses power-param;
  }
}

grouping fiber-params {
```



```
description "String identifier of fiber type referencing a specification in
a
separate equipment catalog";
container fiber {
  description "fiber characteristics";
  leaf type_variety {
    type string ;
    mandatory true ;
    description "fiber type";
  }
  leaf length {
    type decimal64 {
      fraction-digits 2;
    }
    units km;
    mandatory true ;
    description "length of fiber";
  }
  leaf loss_coef {
    type decimal64 {
      fraction-digits 2;
    }
    units dB/km;
    mandatory true ;
    description "loss coefficient of the fiber";
  }
  leaf total_loss {
    type decimal64 {
      fraction-digits 2;
    }
    units dB;
    mandatory true ;
    description
      "includes all losses: fiber loss and conn_in and conn_out losses";
  }
  leaf pmd{
    type decimal64 {
      fraction-digits 2;
    }
    units sqrt(ps);
    description "pmd of the fiber";
  }
  leaf conn_in{
    type decimal64 {
      fraction-digits 2;
    }
    units dB;
    description "connector-in";
  }
  leaf conn_out{
```

```
        type decimal64 {
            fraction-digits 2;
        }
        units dB;
        description "connector-out";
    }
}

grouping roadm-params{
    description "roadm parameters description";
    container roadm{
        description "roadm parameters";
        leaf type_variety {
            type string ;
            mandatory true ;
            description "String identifier of roadm type referencing a specification
in a
separate equipment catalog";
        }
        leaf loss {
            type decimal64 {
                fraction-digits 2;
            }
            units dB ;
            description "..";
        }
    }
}

grouping concentratedloss-params{
    description "concentrated loss";
    container concentratedloss{
        description "concentrated loss";
        leaf loss {
            type decimal64 {
                fraction-digits 2;
            }
            units dB ;
            description "..";
        }
    }
}

grouping power-param{
    description
        "optical power or PSD after the ROADM or after the out-voa";
    choice power-param {
        description
            "select the mode: channel power or power spectral density";
    }
}
```

```

    case channel-power {
/*      when "../..//equalization-mode='channel-power'"; */
      leaf nominal-channel-power{
        type decimal64 {
          fraction-digits 1;
        }
        units dBm ;
        description
          " Reference channel power after the ROADM or after the out-voa. ";
      }
    }
    case power-spectral-density{
/*      when "../..//equalization-mode='power-spectral-density'"; */
      leaf nominal-power-spectral-density{
        type decimal64 {
          fraction-digits 16;
        }
        units W/Hz ;
        description
          " Reference power spectral density after the ROADM or after the out-voa.
          Typical value : 3.9 E-14, resolution 0.1nW/MHz";
      }
    }
  }
}

grouping oms-general-optical-params {
  description "OMS link optical parameters";
  leaf generalized-snr {
    type decimal64 {
      fraction-digits 5;
    }
    units "dB@0.1nm";
    description "generalized snr";
  }
  leaf equalization-mode{
    type identityref {
      base type-power-mode;
    }
    mandatory true;
    description "equalization mode";
  }
  uses power-param;
}

grouping network-media-channel-group {
  description "network media channel group";
  list network-media-channel-group {
    key "i";
  }
}
```

```
description
  "list of network media channel group's member";
leaf i {
  type int16;
  description "index of network media channel group member";
}

list current-channels {
  key "flex-n";
  description
    "list of media channels in the OMS";

  uses layer0-types:flex-grid-channel;
}

list OTSiG-container {
  key "carrier-id";
  description
    "list of OTSi under OTSi-G";
  leaf carrier-id {
    type int16;
    description "carrier-id under OTSi-G";
  }
  leaf OTSi-carrier-frequency {
    type decimal64 {
      fraction-digits 3;
    }
    units GHz;
    config false;
    description
      "OTSi carrier frequency";
  }
  leaf OTSi-signal-width {
    type decimal64 {
      fraction-digits 3;
    }
    units GHz;
    config false;
    description
      "OTSi signal width";
  }
  leaf channel-delta-power {
    type decimal64 {
      fraction-digits 2;
    }
    units dB;
    config false;
    description
```

```

        "optional ; delta power to ref channel input-power applied to this
channel";
    }
}
}

grouping oms-element {
    description "OMS description";
    list OMS-elements {
        key "elt-index";
        description
            "defines the spans and the amplifier blocks of the amplified lines";
        leaf elt-index {
            type uint16;
            description
                "ordered list of Index of OMS element (whether it's a Fiber, an EDFA
or a
Concentratedloss)";
        }
        leaf uid {
            type string;
            description
                "unique id of the element if it exists";
        }
        leaf type {
            type identityref {
                base type-element;
            }
        }
        mandatory true;
        description "element type";
    }

    container element {
        description "element of the list of elements of the OMS";
        choice element {
            description "OMS element type";
            case amplifier {
                /*
                when "../..type = 'Edfa'"; */
                uses amplifier-params ;
            }
            case fiber {
                /*
                when "../..type = 'Fiber'"; */
                uses fiber-params ;
            }
            case concentratedloss {
                /*
                when "../..type = 'Concentratedloss'"; */
                uses concentratedloss-params ;
            }
        }
    }
}

```

```
    }
  }
}

/* Data nodes */

augment "/nw:networks/nw:network/nw:network-types"
+ "/tet:te-topology" {
  description "optical-impairment topology augmented";
  container optical-impairment-topology {
    presence "indicates an impairment-aware topology of optical networks";
    description
      "Container to identify impairment-aware topology type";
  }
}

augment "/nw:networks/nw:network/nt:link/tet:te"
+ "/tet:te-link-attributes" {
  when "/nw:networks/nw:network/nw:network-types"
  + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
    description
      "This augment is only valid for Optical Impairment.";
  }
  description "Optical Link augmentation for impairment data.";
  container OMS-attributes {
    config false;
    description "OMS attributes";
    uses oms-general-optical-params;
    uses network-media-channel-group;
    uses oms-element;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:tunnel-termination-point" {
  when "/nw:networks/nw:network/nw:network-types"
  + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
    description
      "This augment is only valid for Impairment with non-sliceable
      transponder model";
  }
  description
    "Tunnel termination point augmentation for non-sliceable
    transponder model.";
  list transponders-list {
    key "transponder-id";
    config false;
    description "list of transponders";
    leaf transponder-id {
```

```
type uint32;
description "transponder identifier";
}

choice mode {
  description "standard mode, organizational mode or explicit mode";

  case G.692.2 {
    uses standard_mode;
  }

  case organizational_mode {
    uses organizational_mode;
  }

  case explicit_mode {
    uses transponder-attributes;
  }
}

leaf power {
  type int32;
  units "dBm";
  config false;
  description "per channel power";
}

leaf power-min {
  type int32;
  units "dBm";
  config false;
  description "minimum power of the transponder";
}

leaf power-max {
  type int32;
  units "dBm";
  config false;
  description "maximum power of the transponder";
}
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:tunnel-termination-point" {
  when "/nw:networks/nw:network/nw:network-types"
  + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
    description
      "This augment is only valid for optical impairment with sliceable
```

```
        transponder model";
    }
    description
        "Tunnel termination point augmentation for sliceable transponder model.";
    uses sliceable-transponder-attributes;
}
}
<CODE ENDS>
```

## 5. 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]. The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content.

A number of configuration data nodes defined in this document are read-only; however, these data nodes may be considered sensitive or vulnerable in some network environments (TBD).

## 6. IANA Considerations

This document registers the following namespace URIs in the IETF XML registry [RFC3688]:

```
-----
URI: urn:ietf:params:xml:ns:yang:ietf-optical-impairment-topology
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.
-----
```

This document registers the following YANG modules in the YANG Module Names registry [RFC7950]:

```
-----
name:      ietf-optical-impairment-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-optical-impairment-
topology
-----
```



reference: RFC XXXX (TDB)

---

## 7. Acknowledgments

We thank Dieter Bella and Sergio Belotti for useful discussions and motivation for this work.

## 8. References

### 8.1. Normative References

### 8.2. Informative References

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