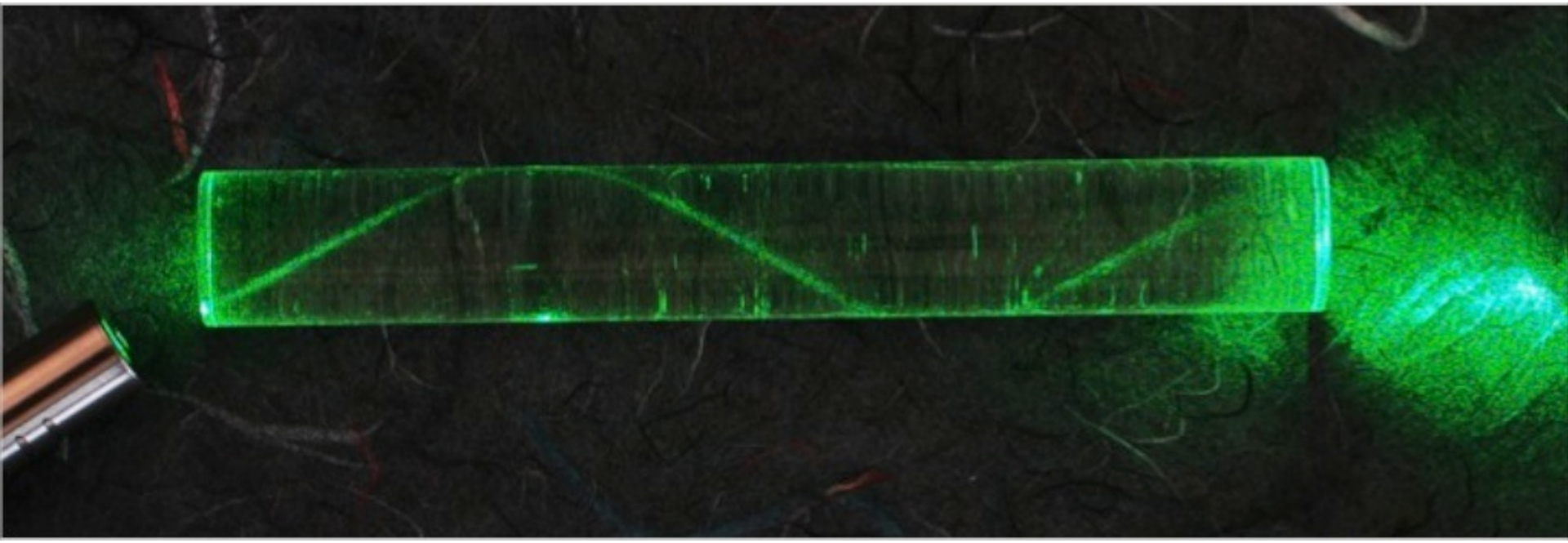

Optical Wavelength Considerations for NG EPON

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Topics

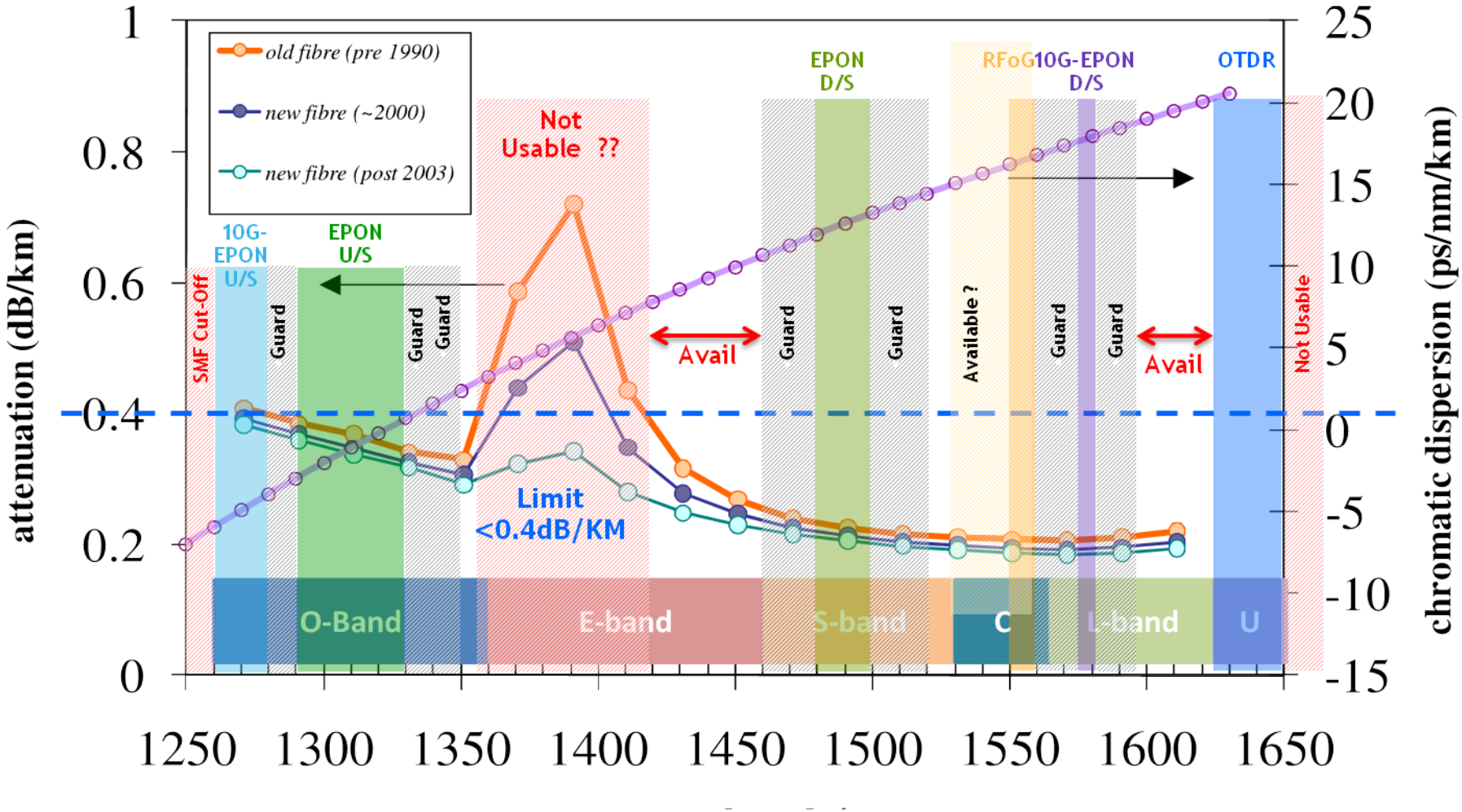
- Wavelength technology discussion
- Technology types and wavelengths used
- Co-existence
- Summary

TOPICS:

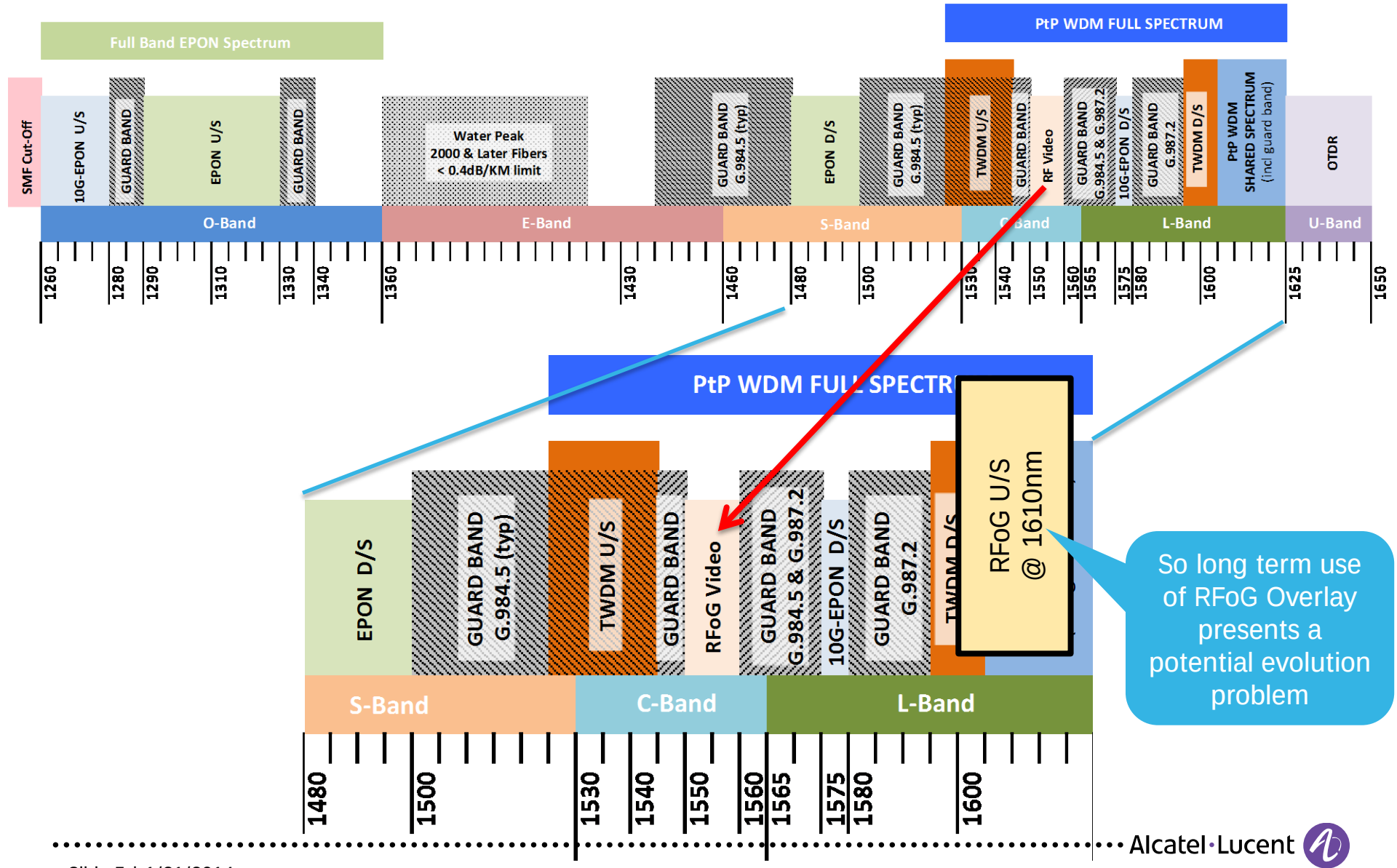
- **Wavelength Discussion**

Today's Spectrum Usage

- The figure below attempts to show the reality of taking ALL of today's coexistence characteristics into account, assuming use of Pre-1990 fibers



View of Optical Spectrum (considering RFoG)



So long term use of RFoG Overlay presents a potential evolution problem

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TOPICS:

- Technology types and wavelengths used

Standards: EPON and 10G EPON

- The Rates of EPON and 10G EPON are shown below:

Classes "x" =	Application	Down-Stream	Up-Stream
PX	EPON	1G	1G
PRX	10GEPON Asymmetric	10G	1G
PR	10GEPON Symmetric	10G	10G

- The Link Classes of EPON and 10G EPON are shown below:

Classes	Application	Budget (dB)
x10	10 km, 1:16	20
x20	20 km, 1:16 10km, 1:32	24
x30	20 km, 1:32	29
x40	20 km, 1:64	33

Standards: EPON, 10G EPON, NGPON2, GPON

- IEEE 802.3 Rev 2012 details for EPON & 10GEPON
  - EPON 1G down: 1480-1500 nm
  - EPON 1G up: 1260-1360 (although in N.A. this is normally 1290-1330 nm)
  - 10GEPON 10G down: 1575-1580 nm
  - 10GEPON 10G up: 1260-1280 nm

- ITU SG15/Q2 NGPON2 details
  - NGPON2 down: 1596-1603 nm (TWDM PON)
  - NGPON2 up: 1524-1544 nm (TWDM PON)
  - NGPON2 up/down: 1524-1625 nm (Full Spectrum PtP WDM)

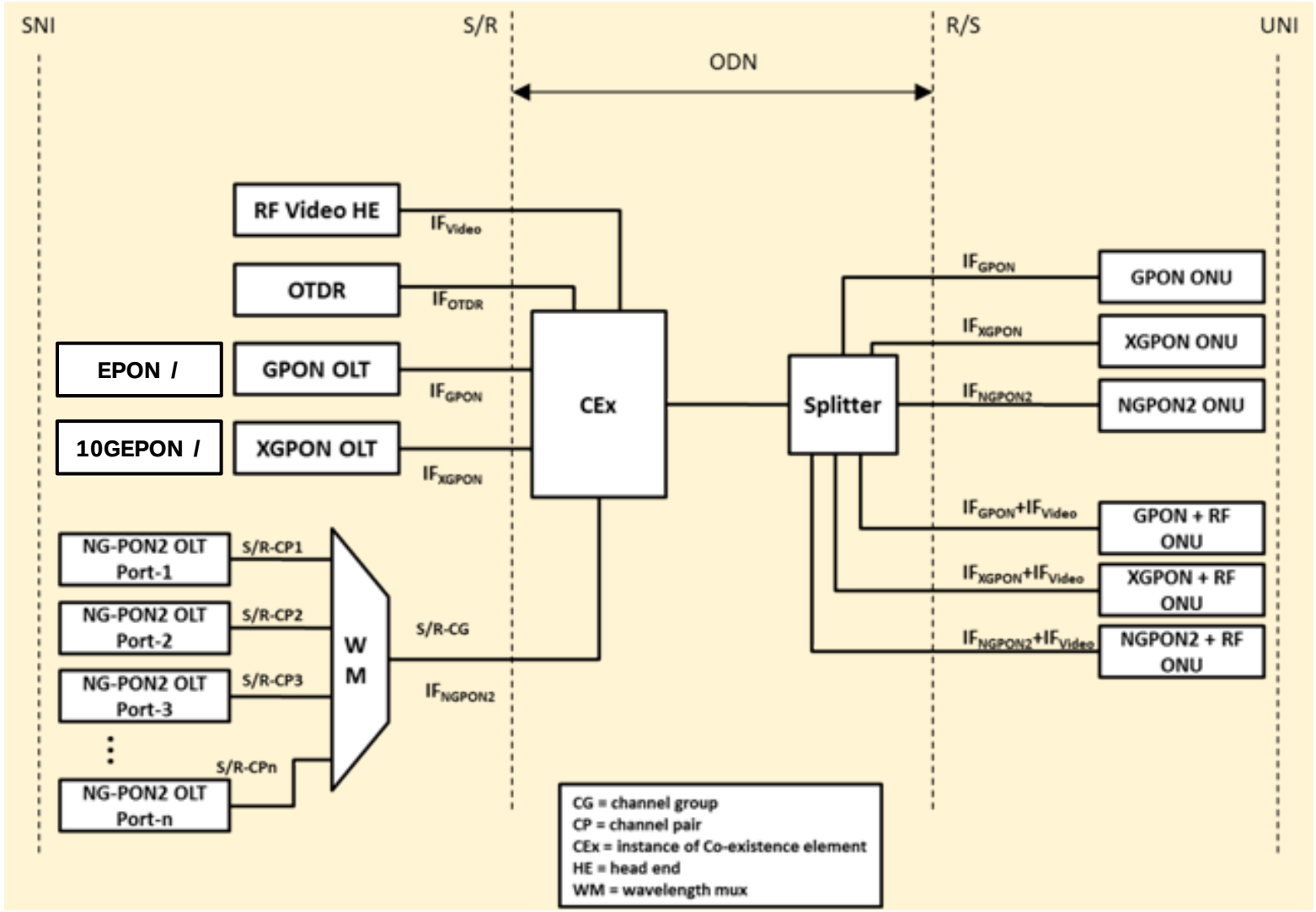
- ITU G.984.5/Table 1 GPON 1310 nm Upstream wavelength range options
  - Regular 100 nm 1260-1360 nm
  - Reduced 40 nm 1290-1330 nm
  - Narrow 20 nm 1300-1320 nm

PON Optical PMD comparison

EPON, 10G-EPON (Px10,20,30,40), GPON, NGPON2

Link Budget (dB)	System	Class
20	IEEE	Px10
24	IEEE	Px20
28	GPON	B+
29	IEEE / XG-PON1 / NG-PON2	Px30 / N1
31	XG-PON1 / NG-PON2	N2
32	GPON	C+
33	IEEE / XG-PON1 / NG-PON2	Px40 / E1
35	XG-PON1 / NG-PON2	E2

Reference ODN Architecture



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Standards Evolution – NG-PON2

- FSAN/ITU is developing 40/80G PON standards now

- Based on a multi-wavelength scheme (similar to 100GbE)
  - Primary Solution is a Time & Wavelength Division Multiplexing (TWDM) scheme
  - Optional Solution is a Point-to-Point Wavelength Division Multiplexing (PtP WDM) scheme
  - Both schemes use colorless Power Splitters in the ODN, and “Colorless” ONUs

- Consists of a series of standards:
  - G.989.1 (Operational Requirements – Operators) Already available
  - G.989.2 (PMD or Optical Requirements) Out for vote
  - G.989.3 (TC or MAC Layer) Anticipated mid-2014
  - G.multi (the multi-wavelength control) Still under discussion/standardization

Standards Evolution – NG-PON2

TWDM

- This is hybrid PON approach, taking aspects of traditional TDM/TDMA PON and WDM PON.
- In TWDM PON, ONUs share individual wavelengths in a TDMA scheme

PtP WDM

- This is a pure wavelength per user PON approach
- In PtP WDM PON, ONUs have dedicated wavelengths per ONU/User

In both schemes, colorless power splitters are still used (re-use of ODN)

TOPICS:

- **Co-existence**

Discussion

- EPON ONUs need to have Wavelength Blocking Filters (WBF) to block future PON wavelengths (10G EPON, TWDM, etc).
  - If considering CWDM on the same fiber, need CWDM type Band-pass filters (BPF)
  - CWDM also has ramifications on the RFoG ONU, needing appropriate BPFs

- The FSAN & ITU groups did not consider RFoG as a coexistence requirement and therefore there is a wavelength conflict between future (Beyond 10G) xGPON and RFoG solutions

- One additional observation
  - RFoG and NG PON technologies both have high power optical levels
  - This results in RAMAN associated interactions and degradations
    - RFoG ONU video can be impacted due to RAMAN depletion of the RFoG 1550nm carrier
    - 10GEPON impact is limited, especially for lower power budget classes, but should be evaluated
    - Multi-wavelength (NG EPON) type solutions would need mitigation mechanisms

Summary

- Presented for information only
- No specific proposals being made at this time
- This information is being presented to help aid the NG EPON group to PON in considering fiber wavelength conflicts, service coexistence, and potential optical component economies of scale