10G EPON
Backward Compatibility

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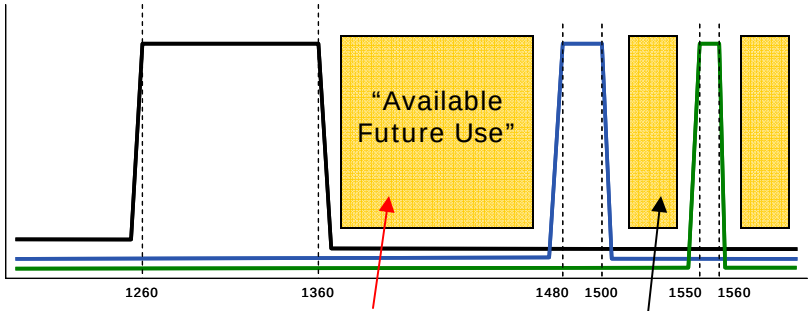
10G EPON – Summary Wish List

- 10G EPON is a wavelength overlay which permits legacy 1G EPON services including analog video to operate for existing customer base.
- Support 10G symmetric capacity (both downstream and upstream).
- Must support Class A & B PONs. Prefer to support Class C too. BONUS to support Class D.
  - Class A supports 10km w/16 ONUs (20dB of loss)
  - Class B supports 10km w/32 ONUs or 20km w/16 ONUs (24-25dB of loss)
  - Class C supports 10km w/64 ONUs or 20km w/32 ONUs (28-30dB of loss)
  - Class D supports 10km w/128 ONUs …to… 40km w/16 ONUs (32-35dB of loss)
- Achieve attractive economic targets. e.g. 3x Price for 10x BW
  - This is somewhat amusing since technical feasibility was illustrated in the CFI neglecting link budget for TDP and WDM filters while still using EMLs, APDs, FEC, & EDFAs which are likely to cost ~30x Price for 10x BW.

All are challenging requirements.
These tend to work against each other.

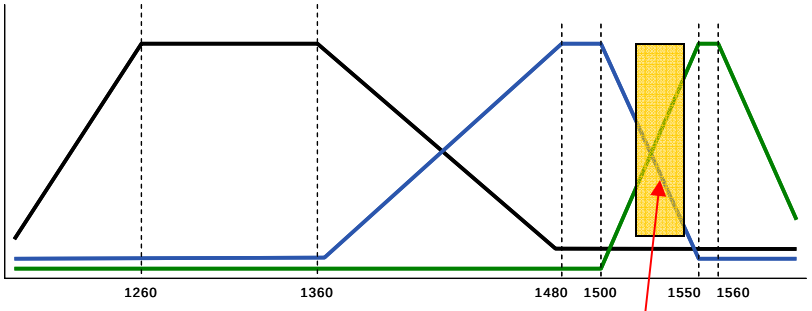
10G EPON – Legacy Overlay

- Adding 10G services on a PON which has 1G EPON services in operation is more difficult than simply selecting wavelengths not presently being used.
- The WDM filter response of the legacy transceivers may couple light from these new 10G wavelengths into the legacy receivers. The degree to which this happens may vary greatly for different legacy transceiver designs.
- Will be extra WDM filter losses if 10G Tx & Rx in different bands.
- Benefit to Link Budget if 10G Up/Down stream operate in 15XXnm with loss <3.6dB/10km rather than >=6.0dB/10km 1360-1460nm.



CONCERNs: Availability of lasers, fiber water peak, splitter loss optimized for 2-windows

For future digital services. 1530-1550nm available. Room for full-duplex 10G if use semi-stabilized sources.



CONCERN: 1G EPON filter guard-band & roll-off of legacy transceivers may affect use.

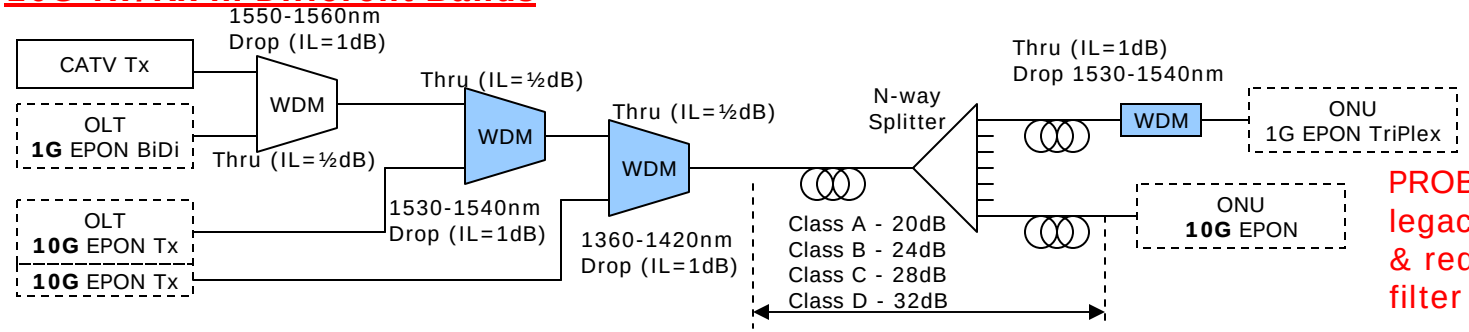
RECOMMENDATION:

Upstream 1G 1260-1360nm	Downstream 1G 1480-1500nm	Downstream 10G 1532-1538nm	Upstream 10G 1542-1548nm	Analog Video 1550-1560nm

10G EPON – Legacy Overlay

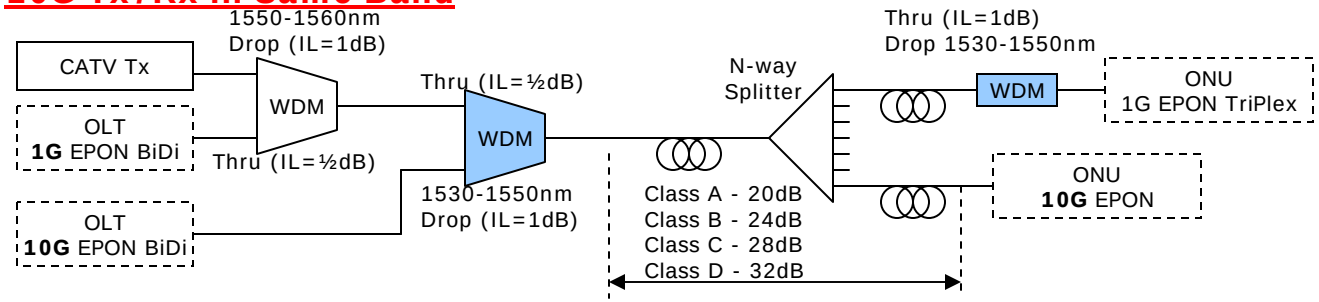
- If such wavelength crosstalk occurs (it will), there are two possible solutions
  - Add a filter at the ONU
    - defeats the benefit of an overlay & adds to the cost of the legacy service
    - increases loss budget on legacy (which will "break" some links)
  - Choose a modulation format that won't cross-talk
    - Use some form of PSK for 10G which won't

10G Tx/Rx in Different Bands



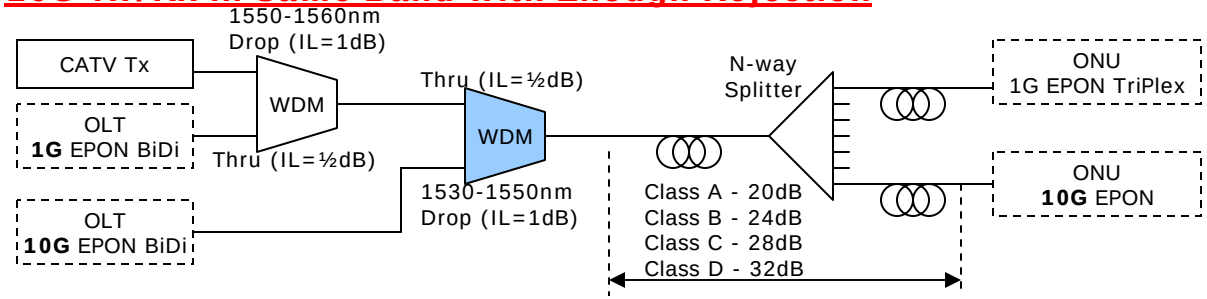
PROBLEM: **ADDs** ~2.0dB to legacy 1G EPON loss budget & requires deployment of a filter at every 1G ONU / home.

10G Tx/Rx in Same Band



PROBLEM: **ADDs** ~1.5dB to legacy 1G EPON loss budget & requires deployment of a filter at every 1G ONU / home.

10G Tx/Rx in Same Band with Enough Rejection

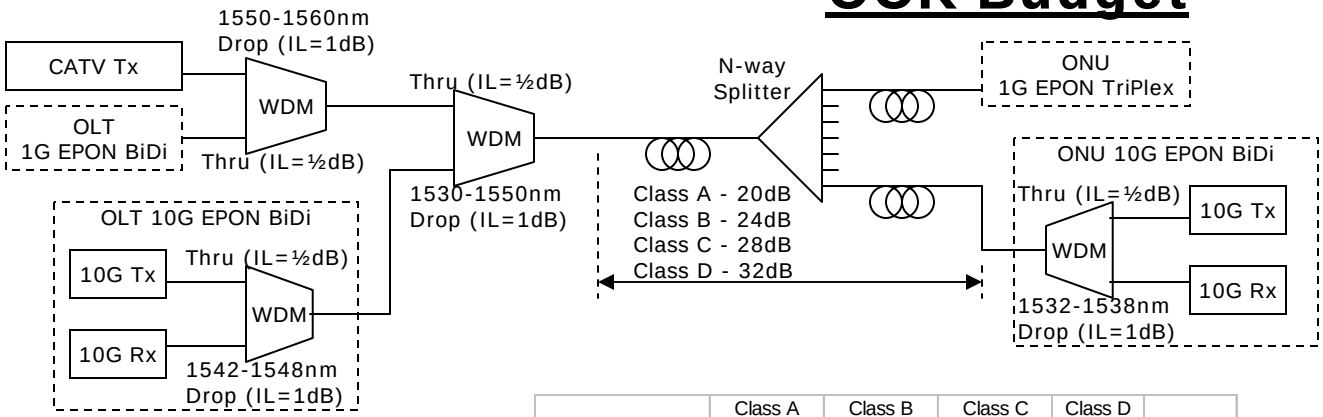


DESIRED but not sure how to accomplish. Penalty is only ~0.5dB if 10G signal is -12dB WRT 1G signal. Still represents ~1dB to legacy 1G EPON.

10G EPON – Loss Budget

- Legacy PON wavelength plans and technology selections date back to early 1990s.
- Sticking with these choices can prevent new technologies from being applied and limit the standard to use more costly discrete and/or hybrid technologies but preclude monolithically integrated technologies where Tx and Rx are on the same chip.

OOK Budget



EML can not arbitrarily be replaced with DML as the transmitter penalties will be worse.

Most economical OOK solution uses SR-2 EML with APD and FEC.

	Class A	Class B	Class C	Class D	
10G EML	-4.0	-1.0	1.0	1.0	dBm
OLT WDM BiDi	-0.5	-0.5	-0.5	-0.5	dB
Ext WDM	-1.0	-1.0	-1.0	-1.0	dB
Path & Connector	-20.0	-24.0	-28.0	-32.0	dB
ONU WDM BiDi	-1.0	-1.0	-1.0	-1.0	dB
	-26.5	-27.5	-29.5	-33.5	dBm
10G Rx	-26.0	-26.0	-26.0	-26.0	dBm
Tx Penalty	2.0	2.0	2.0	2.0	dB
FEC	-4.5	-4.5	-4.5	-4.5	dB
	-28.5	-28.5	-28.5	-28.5	dBm
Margin / Shortage	2.0	1.0	-1.0	-5.0	dB
Optics used	SR-2+APD	IR-2+APD	LR-2	LR-2	
FEC used	BCH	BCH	BCH	BCH	

10G EPON – Conclusions

- Backward compatibility overlays will likely require filters deployed near legacy ONUs which will make the overlay undesirable and costly to deploy.
- Regardless of legacy support, 10G EPON best uses 15XX up & down for easiest budget.
- All classes will require FEC and APDs in their most cost effective implementations.
- Class C & D requires optical gain for a working link. For downstream 10G, this might be economically viable; but not for 10G upstream. Maybe this means that asymmetric 10G/1G can be offered for Class A/B/C but symmetric 10G may be only be offered for Class A/B