Discussion of Simplified Plan EO

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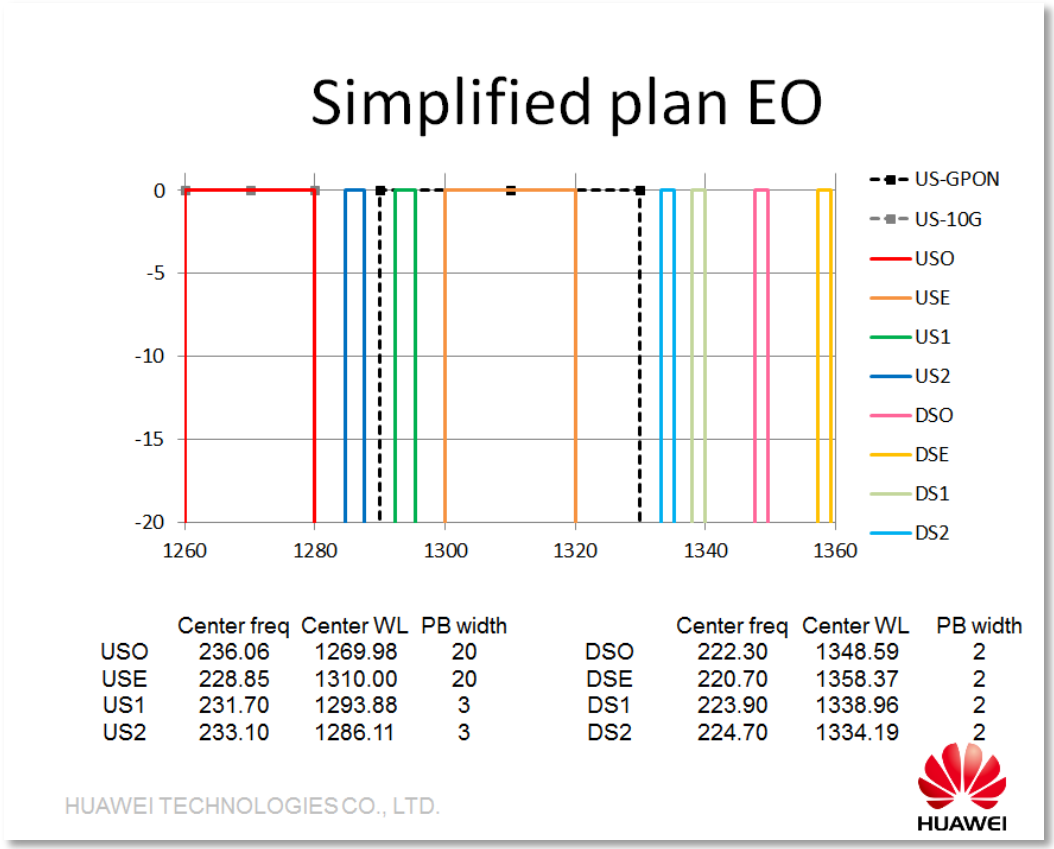
Two-Option Wavelength Plans

- Consensus in 802.3ca is that TDM coexistence with legacy PON systems is difficult to implement in silicon and not desirable from an operational standpoint – WDM coexistence is required.
- Although not an 802.3ca objective, WDM coexistence of 25G-EPON with 1G-EPON/GPON is an important goal.
  - GPON and 1G-EPON are the most widely deployed PON systems worldwide, so it represents a major market opportunity.
  - It's likely that a sizeable fraction of GPON systems will not be upgraded to 10G PON by the time 25G-EPON is ready to deploy.
  - Maintaining WDM coexistence with GPON is a step in the direction of NG-PON convergence with ITU-T.
- Consensus is emerging that a "two-option" wavelength plan is a viable way to meet the conflicting objectives of WDM coexistence with 10G-EPON and GPON.
  - Two markets exist with different needs, requiring two solutions.
  - Common wavelengths can be shared between the two options, allowing sharing of optical components.
  - This is not ideal from the component viewpoint, but is a workable solution.

Simplified Plan EO



	Center freq	Center WL	PB width
USO	236.06	1269.98	20
USE	228.85	1310.00	20
US1	231.70	1293.88	3
US2	233.10	1286.11	3

	Center freq	Center WL	PB width
DSO	222.30	1348.59	2
DSE	220.70	1358.37	2
DS1	223.90	1338.96	2
DS2	224.70	1334.19	2

F. Effenberger, "Wavelength Plan Options", presented on 6/22/17 802.3ca consensus call.

- Simplified Plan EO has 4 US wavelengths deployed in different order in two plans
- Enables low cost uncooled lasers for 25/25G ONUs in both plans.
  - "Plan E" for 10G-EPON WDM CE deploys uncooled USE first.
  - "Plan O" for GPON WDM CE deploys uncooled USO first.
- US1-US2 are used for 50/50G ONUs in both plans.
- 100/100G ONUs would add the other 20nm wide channel.

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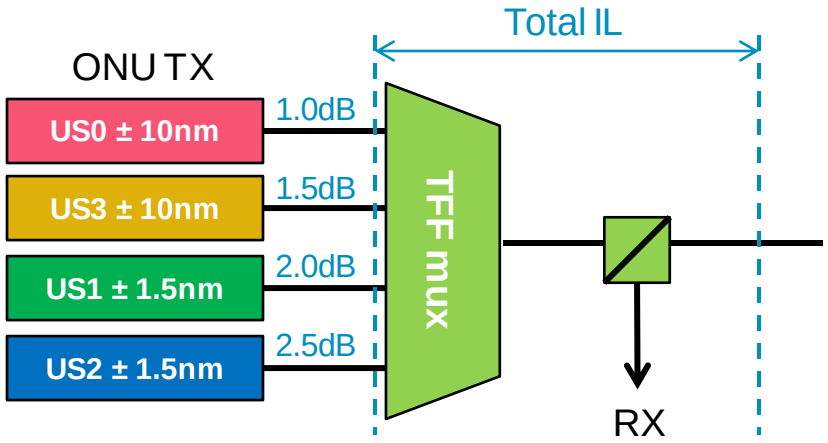
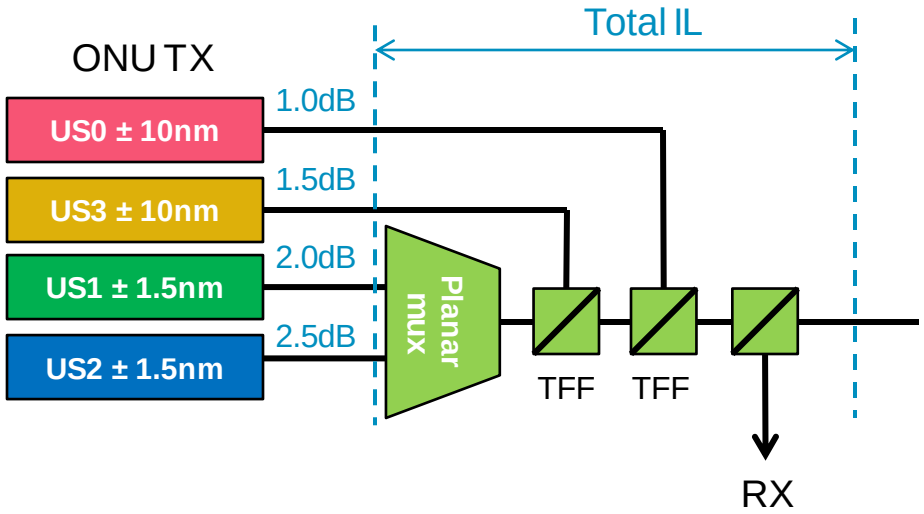
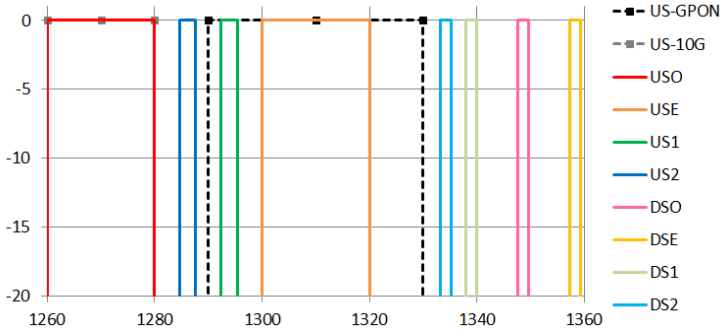
Discussion of Simplified Plan EO

- Simplified Plan EO addresses the requirements of the heterogeneous PON market: Upgrade of 1G/2.5G PON, Upgrade of 10G PON and Greenfield deployments.
  - A two option plan that preserves WDM coexistence between GPON and 25G-EPON serves as the framework for PON convergence with ITU-T.
  - Allowing for uncooled 25/25G ONUs in both options significantly reduces the cost of deployment for 25G-EPON networks.
  - WDM coexistence with 10G PON enables low cost 25/10G ONUs operating with 802.3ca protocol which can be implemented in 25G-EPON SoC ICs.
  - Using the same set of four US and four DS wavelengths in both options reduces the number of laser codes that need to be developed and manufactured, reducing ONU cost.
- There are minor issues with Simplified Plan EO that warrant discussion:
  - DS passband width is only 2nm. Should be ≤ 3nm for lower cost.
  - Having more than one wide US channel adds complexity and penalties.
    - 100G ONU Tx are unlikely to use uncooled lasers due to high mux/demux insertion losses.
    - 20nm wide channels have increased SOA noise penalty in pre-amplified 100G OLT RX.
    - The solution is to define both cooled and uncooled channels at 1270 and 1310nm.
  - Having two different downstream 25G wavelengths could enable proprietary implementation of two independent 25G PONs on the same ODN, but…
    - Multiple 25G pairs on the same PON is not in scope. See Motion #3, March 2016 meeting.
    - Increased operational complexity of deploying two different versions of 25/25G ONUs.
    - Increased manufacturing cost of supporting two different versions of 25G OLT optics.
    - A single downstream wavelength plan is preferred for both coexistence options.

100G ONU TX with two wide channels







- TFF mux enables lowest IL on US0, but US1 has increased loss – difficult to implement with uncooled laser.
- Planar mux can handle non-uniform channel spacing, but can't do non-uniform passband width easily – must demux wide channels separately with TFF.
- Implementation with planar mux of 50G channels is complicated.
- OLT demux configurations are similar to ONU mux.

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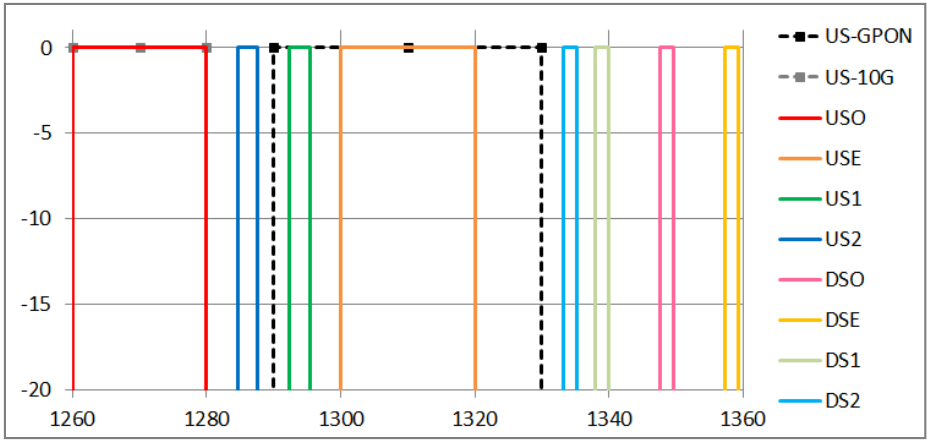
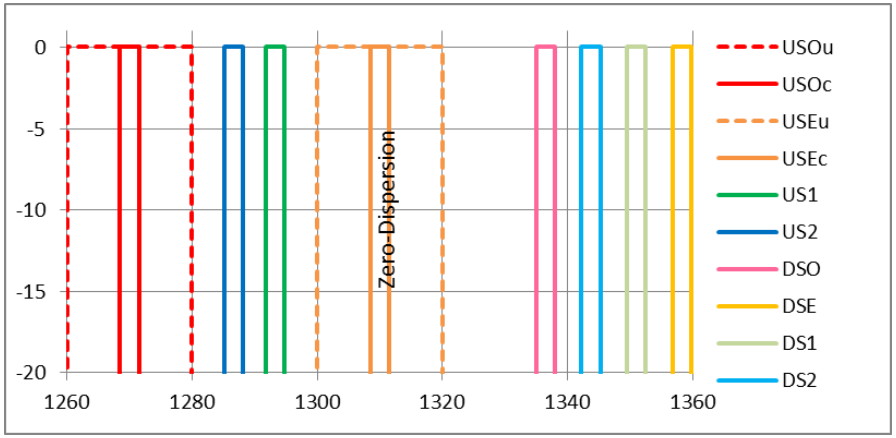
Solution: Define narrow US0/3 for 100G

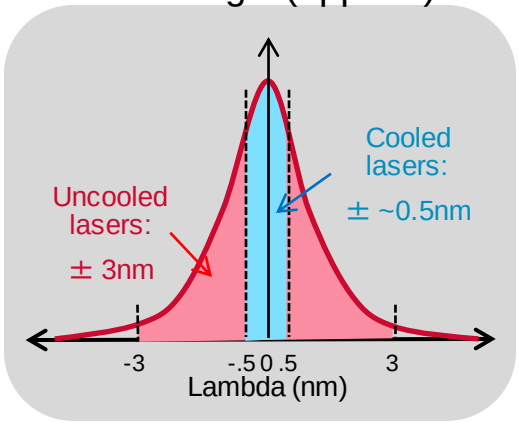
Original Simplified Plan EO



Modified Plan EO



Distribution of DFB center wavelength (approx.)



- For 100G ONU TX, cooled lasers will be used to overcome mux and demux losses totaling ~5dB.
- Define cooled laser wavelengths at center of uncooled channel for use by 100G TX.
- Cooled channel passband width = 3nm
- Uncooled 25G and cooled 100G TX use the same laser chip – no yield loss for cooled version, reducing cost of 100G TX.
- 100G OLT RX must still have first channel passband 20nm wide for 25G ONUs.

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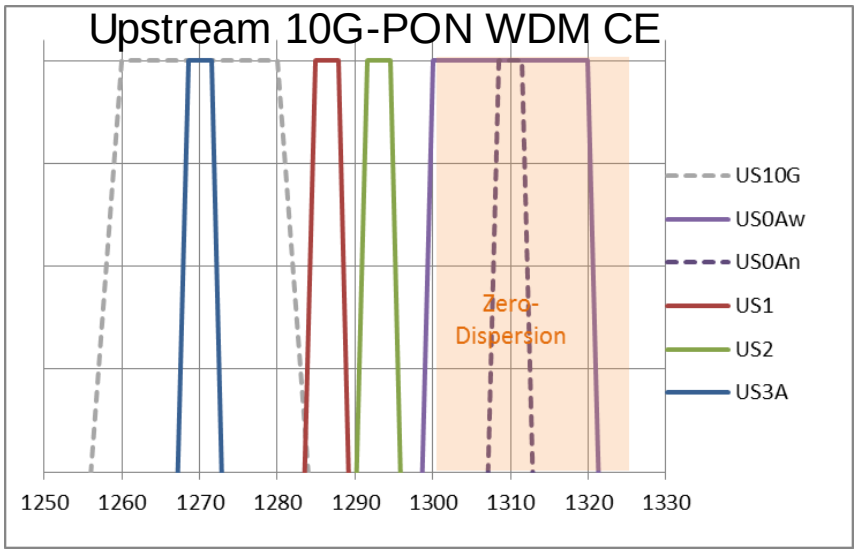
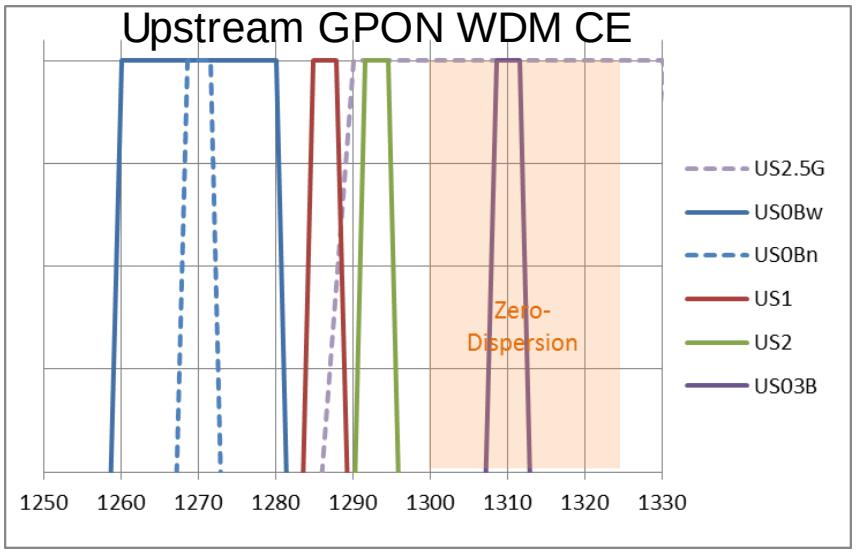
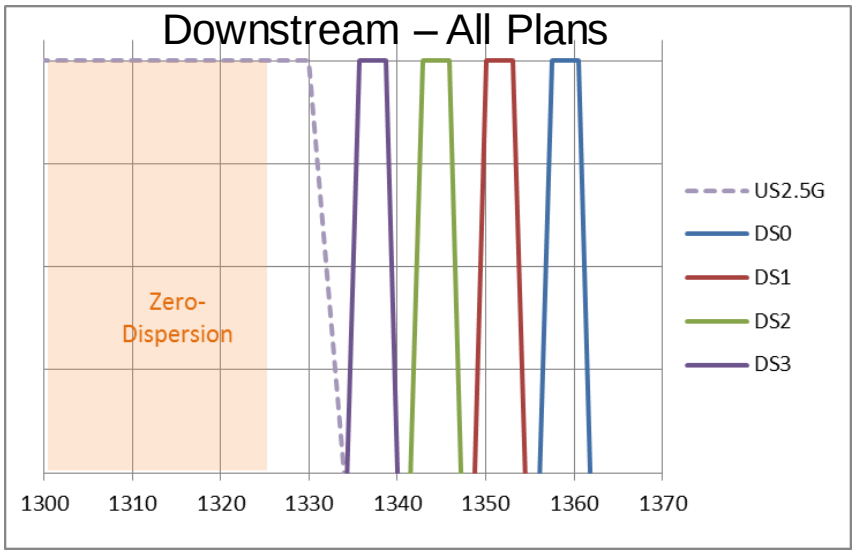
Modified Plan EO wavelengths







Channel	Center Freq. (THz)	Center WL (nm)	PB width (nm)
US0Aw	228.85	1310.00	20
US0Bw	236.05	1270.04	20
US1	233.05	1286.39	3
US2	231.85	1293.04	3
US3A/0Bn	236.05	1270.04	3
US3B/0An	228.85	1310.00	3
DS0	220.60	1358.99	3
DS1	221.80	1351.63	3
DS2	223.00	1344.36	3
DS3	224.20	1337.17	3

3.0THz
1.2THz
3.0THz
1.2THz
1.2THz
1.2THz

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Conclusions

- Simplified Plan EO has many benefits among the two-option plans that have been presented.
  - Options for WDM coexistence with GPON or 10G-PON.
  - Only four wavelengths are defined in upstream and downstream plans – maximum re-use of optical components.
  - Wide passbands for 25/25G ONUs with uncooled DML for low cost.
  - Support for 25/10G ONUs using 802.3ca protocols for low cost.
- The minor modifications proposed in this contribution additionally provide:
  - A single downstream wavelength plan for both coexistence options for fewer OLT optics versions.
  - Increased downstream passband to 3nm for reduced laser wavelength accuracy and lower cost.
  - Only one 20nm wide channel in 100G upstream for reduced mux/demux complexity and reduced 100G OLT RX amplifier noise penalty.
  - Sharing of laser wavelengths between cooled and uncooled transmitters for cost reduction of 100G ONU TX.
- The proposed modifications should be considered if the Simplified Plan EO becomes the baseline wavelength plan.