The story of the NG-PON2 TWDM PON wavelength plan

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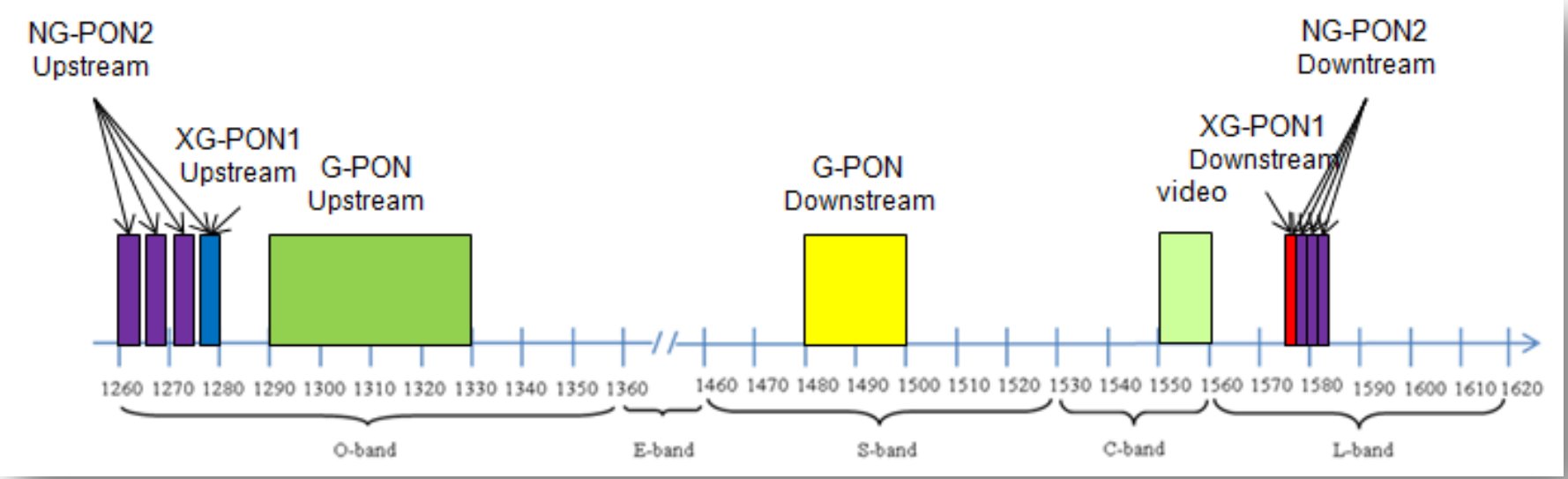
Re-use of XG-PON wavelengths was considered



Source: Orange

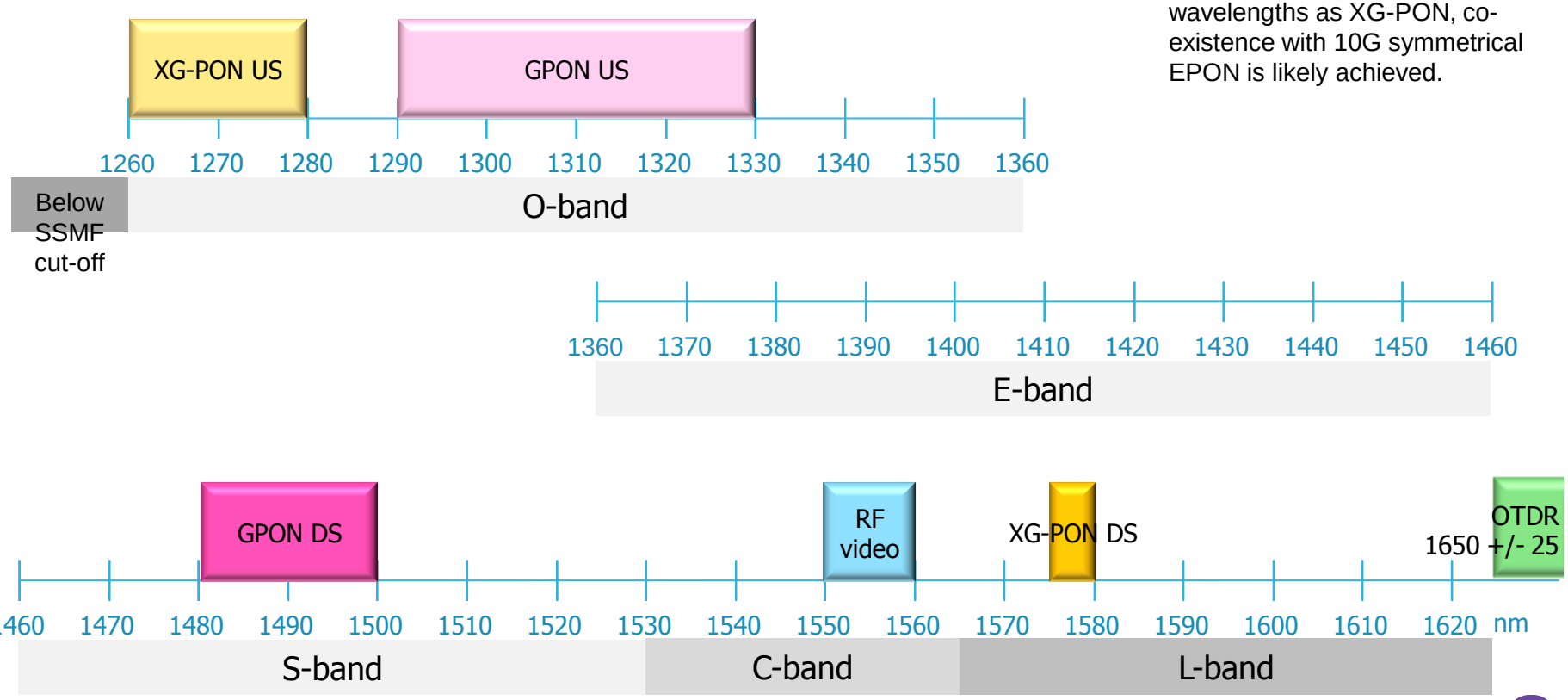
Conclusion: No, because

- It would have prevented co-existence with XG-PON and undermined XG-PON viability
- Some APAC operators protested, having plans for XG-PON deployment
- Some optical component vendors protested, having invested in XG-PON
- Feasible alternatives existed

NG-PON2 headline requirements

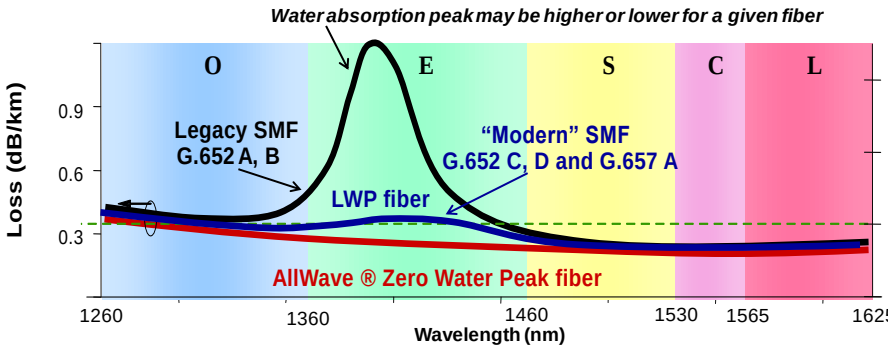
1. 40 Gb/s down, 10/40 Gb/s up
2. 40 km reach
3. Reuse of ODN
4. Coexistence with G-PON, XG-PON*, RF-video and OTDR:

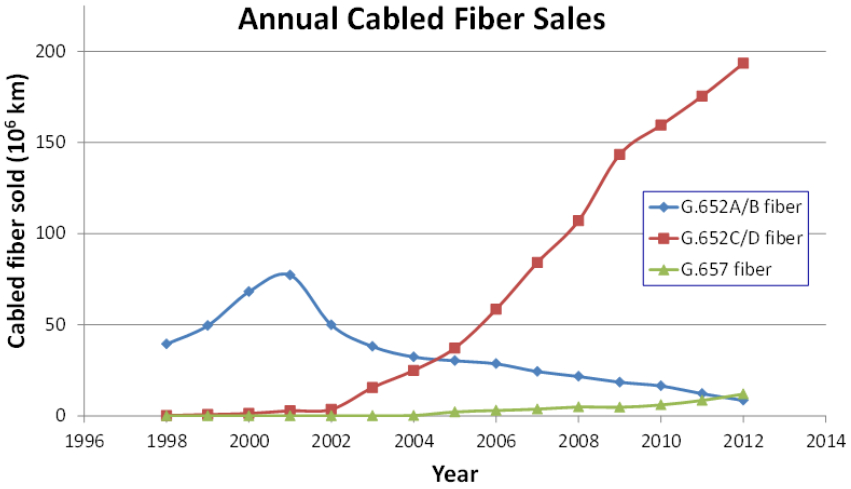
* Although co-existence with 10G symmetrical EPON was not a requirement, since it uses the same wavelengths as XG-PON, co-existence with 10G symmetrical EPON is likely achieved.



E-band was considered, rejected

- The case for E-band (OFS-Fitel)
  1. 100 nm open spectrum
  2. Of the fiber sold since 2003 (significant share in access), 82% is full spectrum





Data courtesy of Patrick Fay of CRU, April 2012.

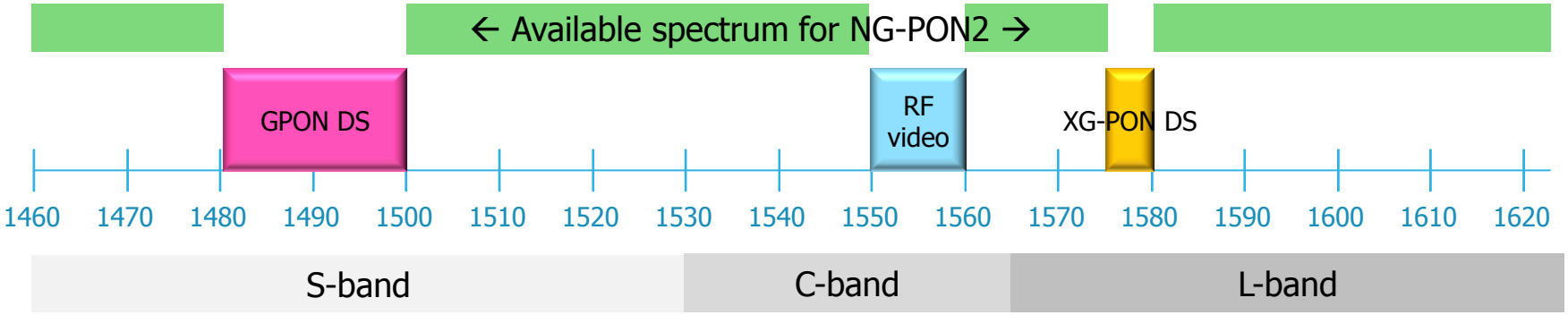
- ITU-T : G.671 specifies performance for PON splitters for 1260-1360, 1480-1625nm, but E-band performance is not specified.

Conclusion: Reject due to some risk of installed fiber and splitters

Why not O-band

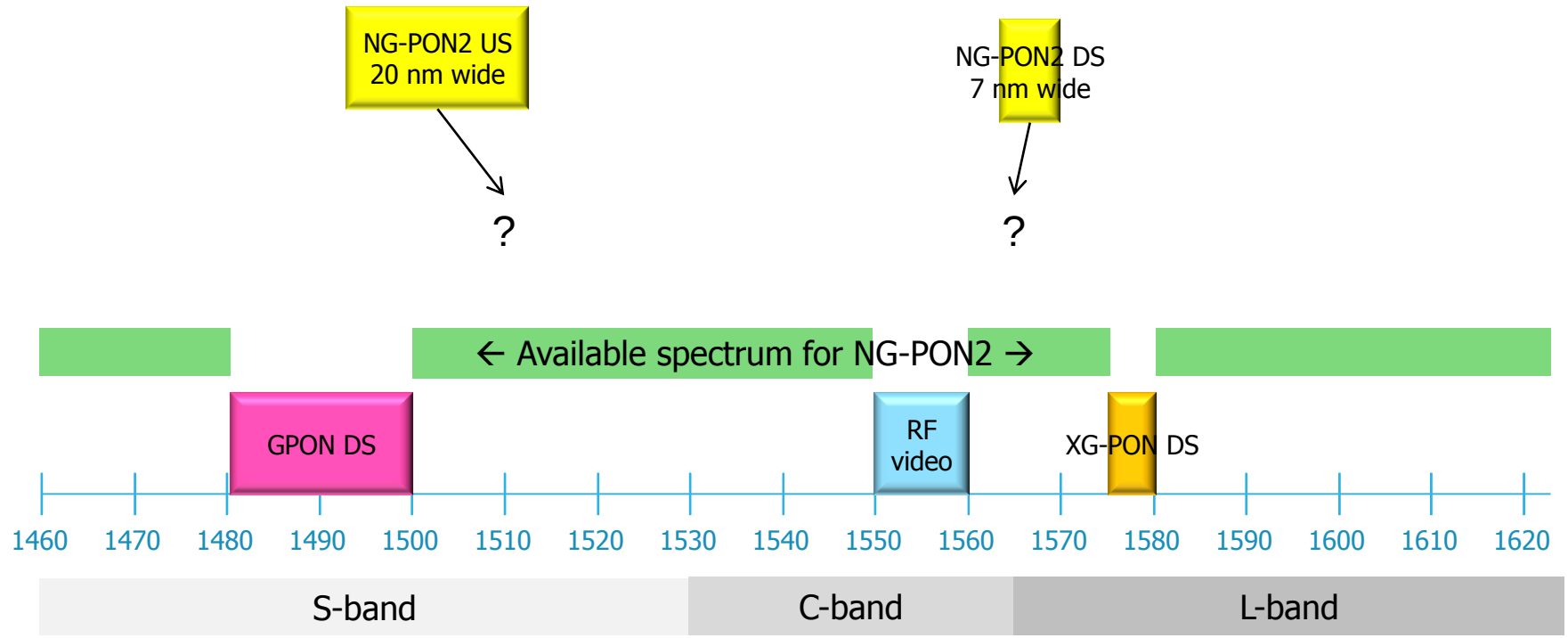
1. 40 km reach requirement: longer loss-limited reach if both upstream and downstream wavelengths in S/C/L bands.
   - ITU-T G.sup39 specifies 0.55 dB/km for 1310-nm cables and 0.275 dB/km for 1550-nm cables (incl. splices). Over 40 km, the difference is 11 dB of fiber loss.
2. To facilitate multiple optical amplification approaches, O-band would prevent EDFA use.
3. A cyclic AWG can be used as a WDM mux/demux for both upstream and downstream if in same band.

What's left: S, C and L bands, except where overlap with legacy signals



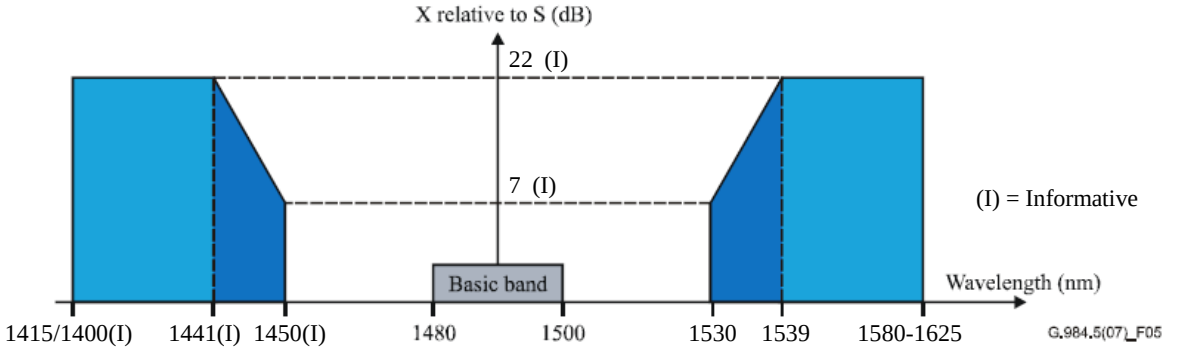
NG-PON2 wavelength operating ranges

- Downstream: support 8x100GHz: 7 nm
- Upstream: 20 nm “wide band” option. Accommodates low cost “uncalibrated” tunable lasers
  - Laser wavelength change over -40/+85C =~ 12.5-13.0nm
  - Laser wavelength range for manufacture =~ +/- 2nm, or 4nm range
  - For TWDM thermal tuning = 3.0nm



Co-existence requirement #1: with GPON

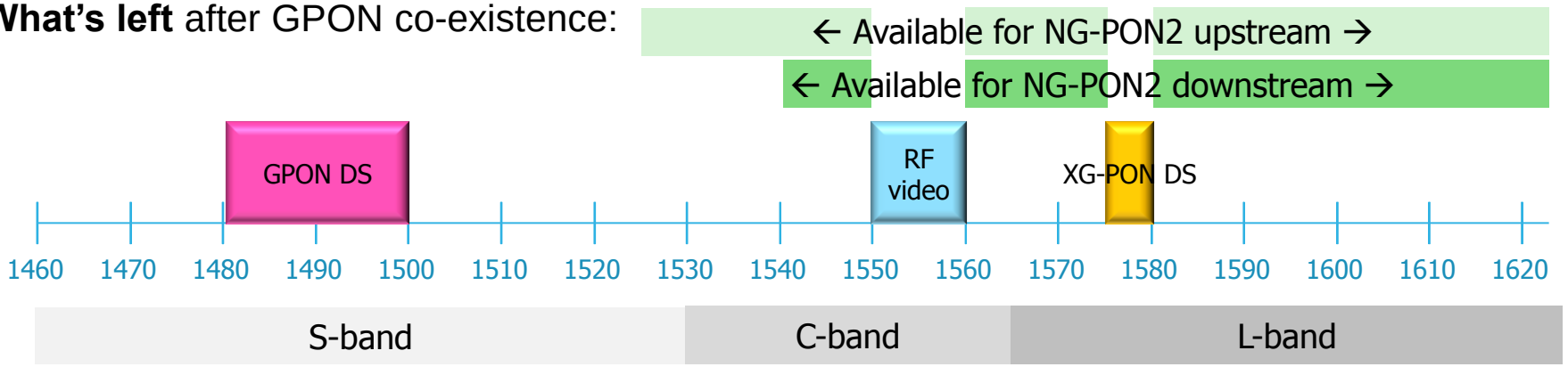
- NG-PON2 downstream: GPON ONU tolerance to interferers constrains to ≥ 1539 nm.



S Received power of basic band.
X Maximum total power of NGA and video received in the blocking wavelength range.
X/S in the mask (hatching area) should not cause the sensitivity of the basic band receiver to fail to meet the specified limit.
NOTE – λ3 value of 1400 *(Informative)* may be applicable for low-water-peak fibre only.

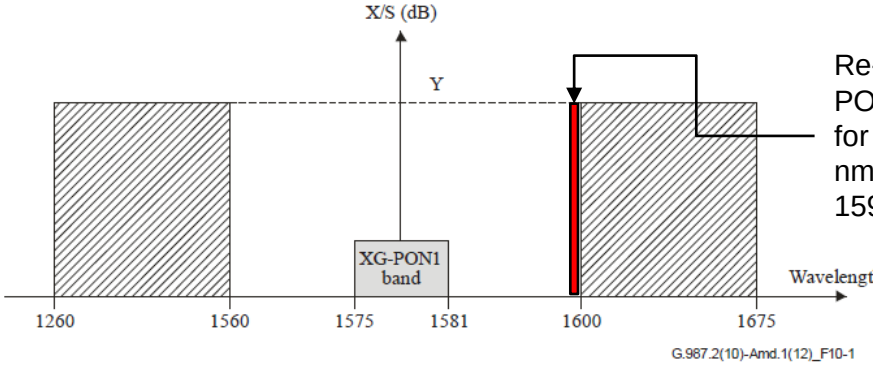
- NG-PON2 upstream: In G.984.5 Amd1 (10/2009), in specification of "WDM1r" co-existence element, "NGA" defined to be: 1524-1625nm (effectively a 24 nm filter guard band).

What's left after GPON co-existence:



Co-existence requirement #2: XG-PON

- NG-PON2 downstream: XG-PON ONU tolerance to interferers constrains to ≤ 1560 nm and ≥1596 nm.



Re-specify the XG-PON1 ONU X/S mask for symmetrical +15 nm dead zone (i.e. to 1596 nm)

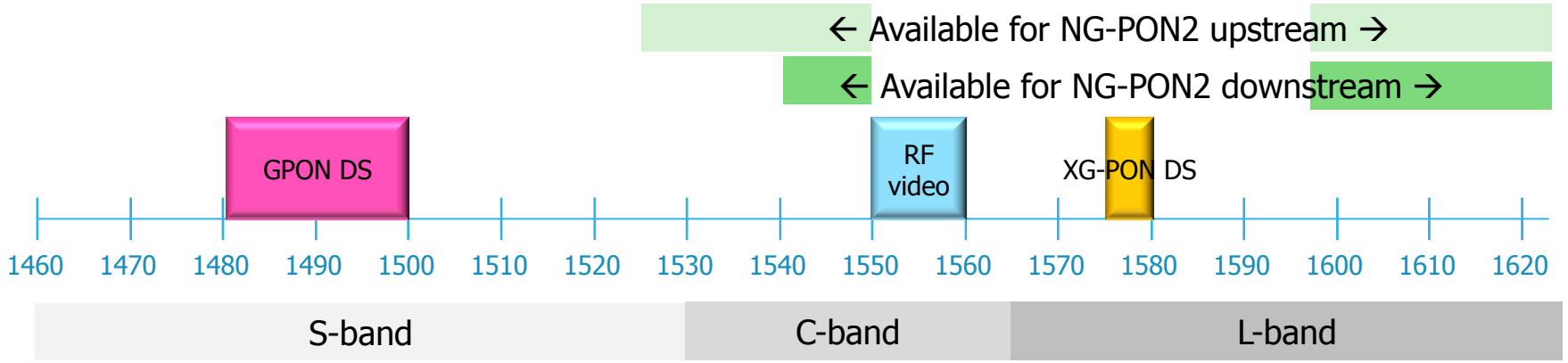
Class	Y (dB)
N1, E1, N2a, E2a	21.5
N2b, E2b	15

G.987.2 Amd 1

S: Received power of basic band.
X: Maximum total power of additional services received in the blocking wavelength range.
X/S: In the mask (hatching area) should not cause the XG-PON receiver to fail to meet its sensitivity requirements.

- NG-PON2 upstream: assume nominal 15 nm guard band with XG-PON (becomes irrelevant)

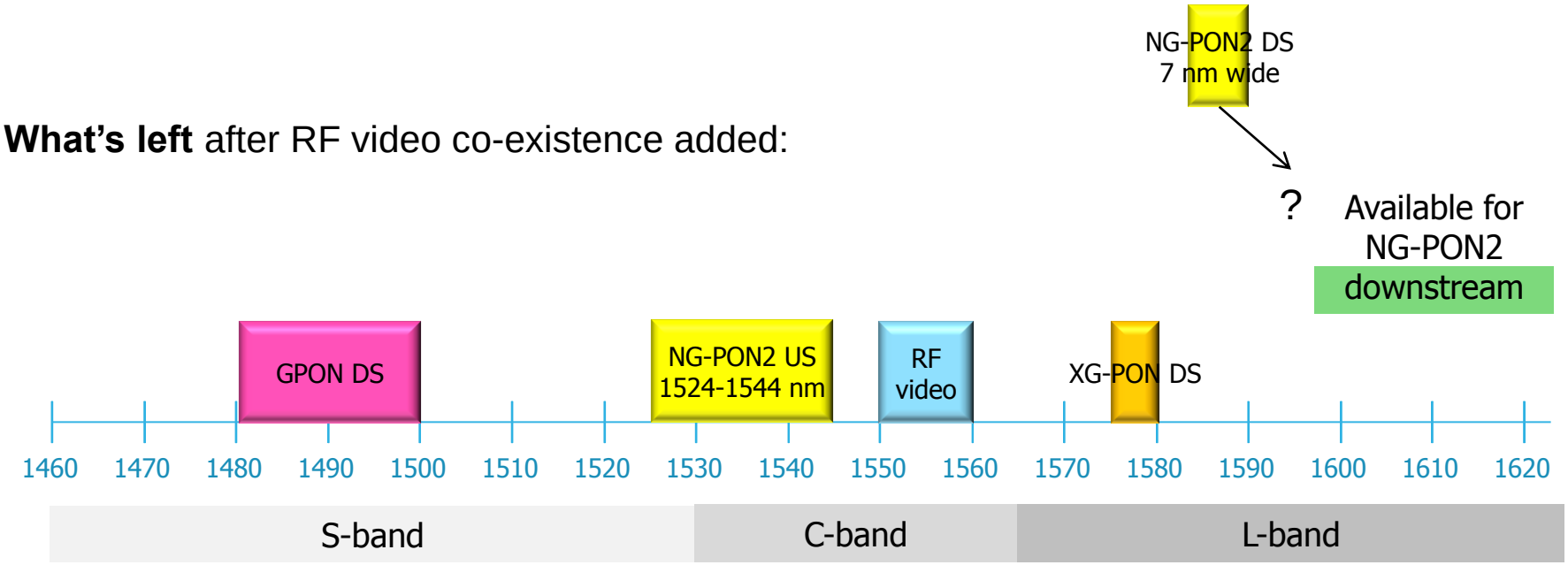
What's left after XGPON co-existence added:



Coexistence requirement #3: RF video

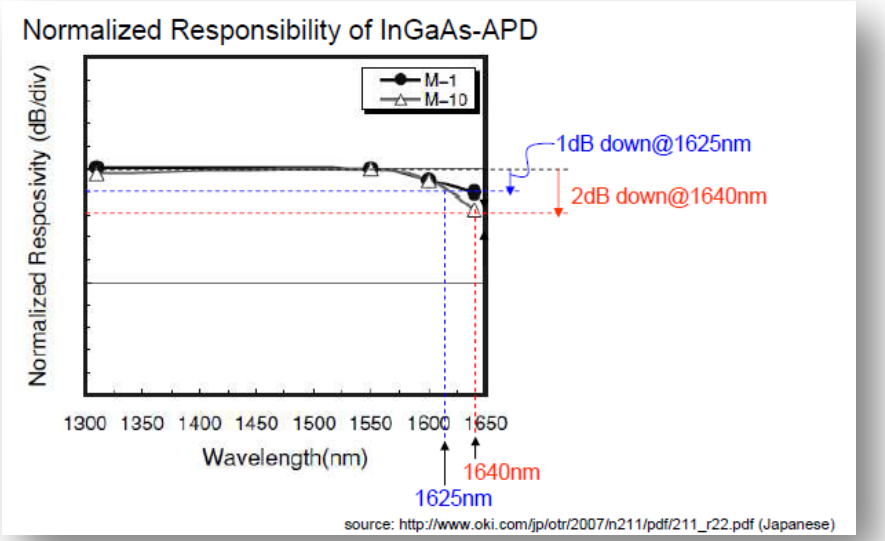
- RF video receiver filter will not protect against adjacent downstream interferers.
- Therefore, NG-PON2 downstream must use the available band ≥1596 nm
- and NGPON-2 upstream must use the band ≤ 1550 nm.
- Crosstalk analysis showed that the RF video signal is sufficiently isolated from adjacent NG-PON2 upstream signals.
- Within available 1524-1550 nm, 20 nm of NGPON-2 upstream was placed at 1524-1544 nm.

What's left after RF video co-existence added:

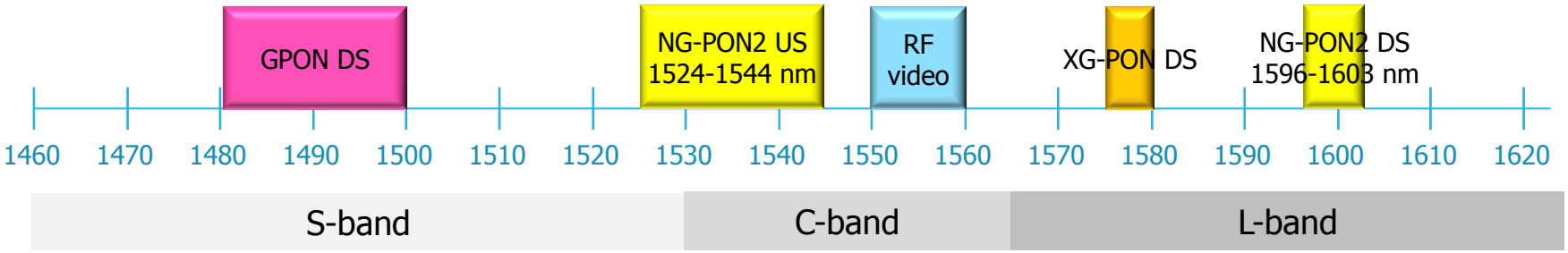


Where to put NGPON-2 downstream in 1596 – 1625 nm?

- Based on reviewing a number of EDFA vendor's feedback, it is was advisable to limit the upper end wavelength to 1605nm (ALU)
- There are higher fiber attenuation and bending losses at longer wavelengths.
- Ensure a guard band with OTDR receiver filter.
- APD sensitivity rolls off at the long end of the L-band.

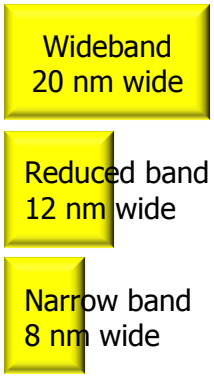


Conclusion: Use the shortest possible wavelengths, i.e. start at 1596 nm.



Narrower NG-PON2 upstream operating ranges

- “Reduced” and “Narrow” band wavelength operating ranges created for upstream “calibrated” lasers



NG-PON2 TWDM PON final plan, ITU-T G.989.2