



F6G for access network : the future 50G PON

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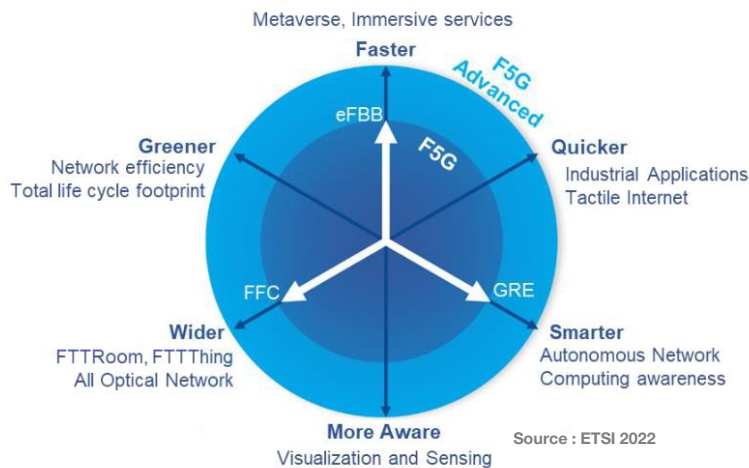
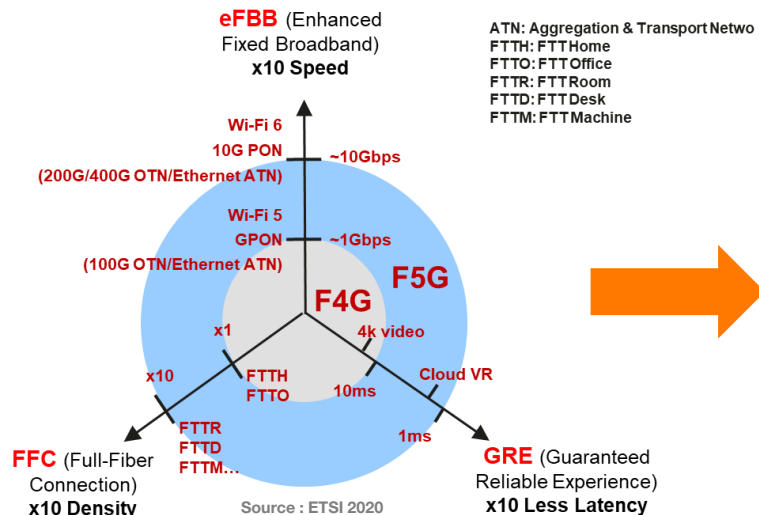
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From 5th to 6th fixed network generation : F5G to F6G



Gigabit services

10 Gigabit everywhere

10-100 Gigabit everywhere ?

F5G

F5G advanced

F6G

2020

2025

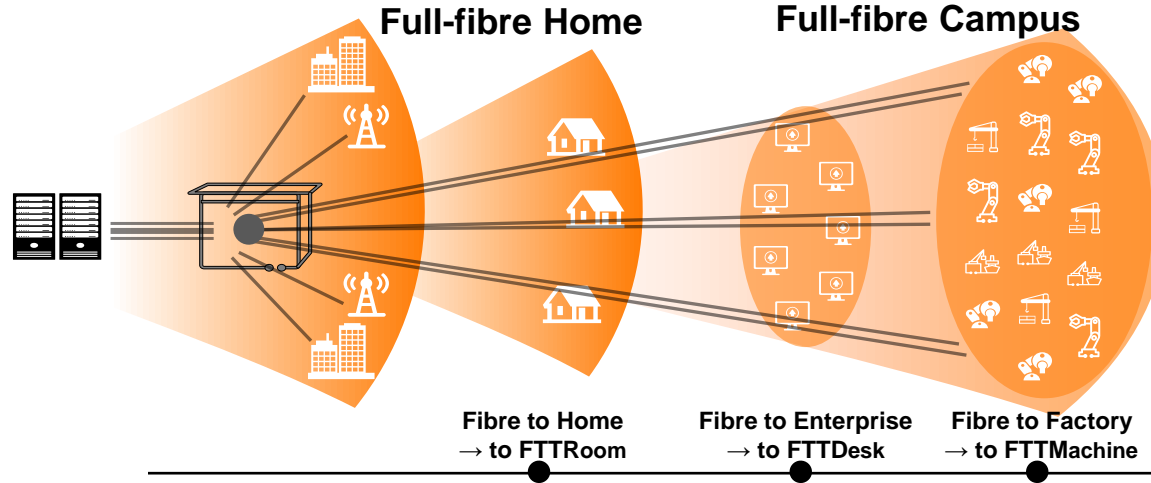
2030

ETSI White Paper No. #41
"The Fifth Generation Fixed Network (F5G):
Bringing Fibre to Everywhere and Everything"
September 2020

ETSI White Paper No. #50
"Fixed 5th Generation Advanced and Beyond"
September 2022

Fibre to Everywhere for Unlimited Future

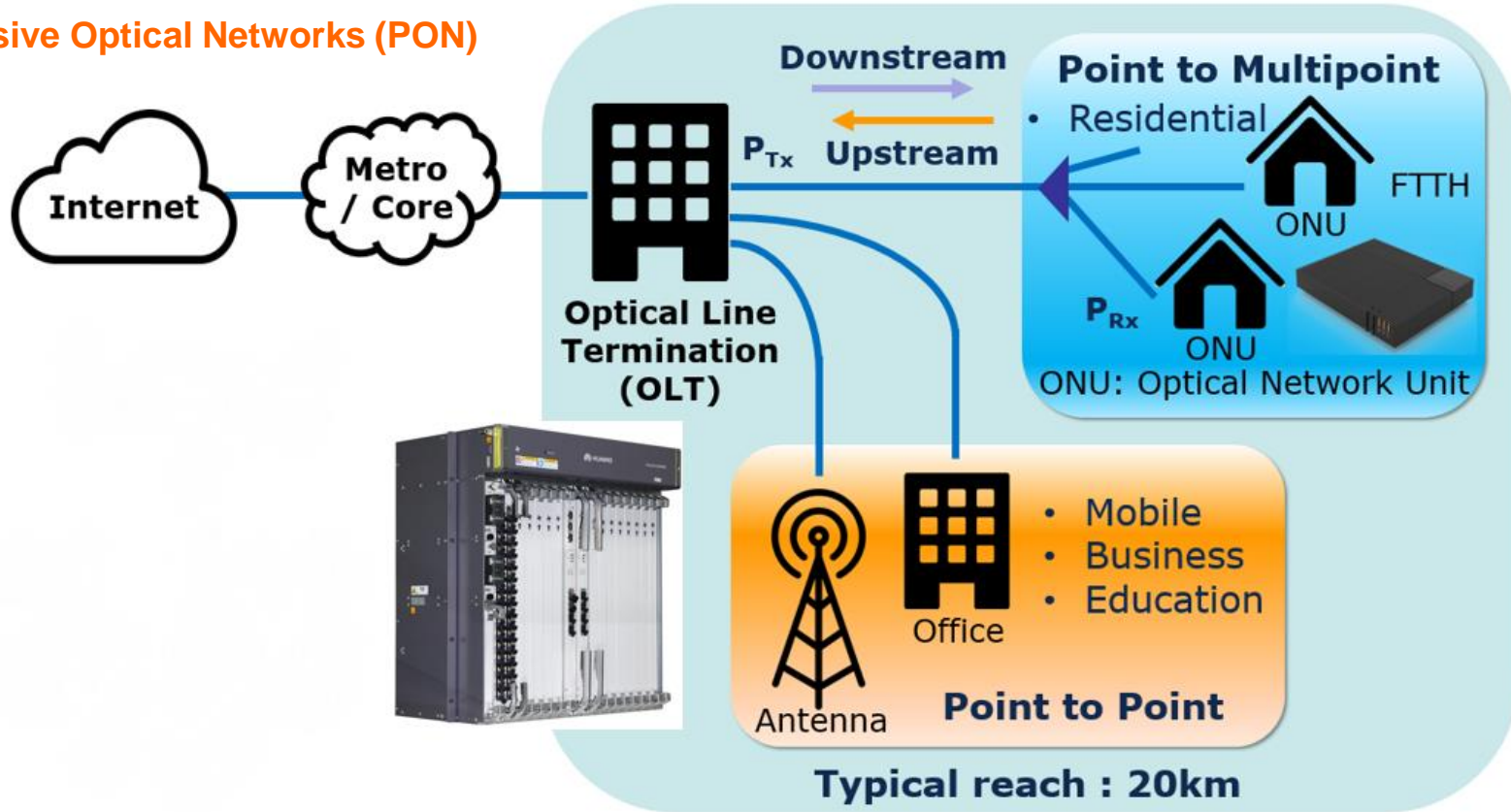
To make fixed access future proof



- Extending to **more end-user** : Home, Room, Business, Mobile, Device, Machine, etc.
- Reducing everywhere the **fibre-to-end user distance**: Km → 100m → 10m → 1m
- **Number of connections** expanding: X3 (Room), X10 (Desk), X30 (Machine), X100 (Smart city)

Focus on Optical Access Networks

Passive Optical Networks (PON)



F1G to F6G Fixed access technology evolution : ETSI and our estimations

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Reference Upstream Bandwidth per User	1/2Mbps	10-100 Mbps	15-100 Mbps	50-500 Mbps	1-10Gbps
Reference Services	Voice ,Dial Internet	High Speed Internet, SD-Video	HD Video	UHD 4K, video	VR video Cloud Gaming Smart City
Reference Architecture	CO LE	CO DSLAM	FFTC / FTTB	FTTH / FTTdp	FTTH / FTTR
Access Network Technology Reference	PSTN / ISDN	ADSL / ADSL2+	VDSL2 SDSL	GPON/G.Fast GE PtP	XGS-PON 10GE / 10G-PtP
Technical Specifications Reference	I.100-I.699	G.992.x	G.993.x	G.984.x G.9701 G.986	G.9807.x G.9806
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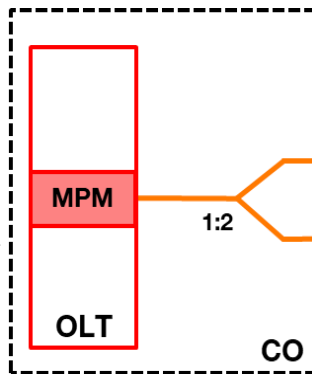
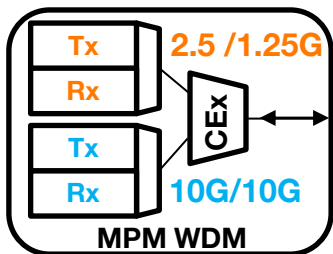
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Optical Access Network evolution

In June 2022, Orange reached 60.6 million households connectable to FTTH worldwide (up 16.1% year on year growth), including 31.2 million in France (+19.5%)

GPON (2.5Gbit/s), XGS-PON (10Gbit/s symmetric), and then 50G-PON

Multi-PON Module :
Dual-techno Optical Pluggable
Emitters /Receivers



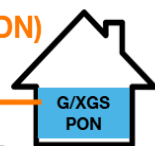
OLT : Optical Line Terminal
MPM : Multi-PON Module
CO : Central Office

Optical Distribution Network (ODN)

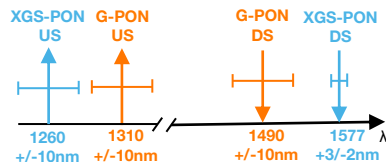
< 20km

1:32

1:32



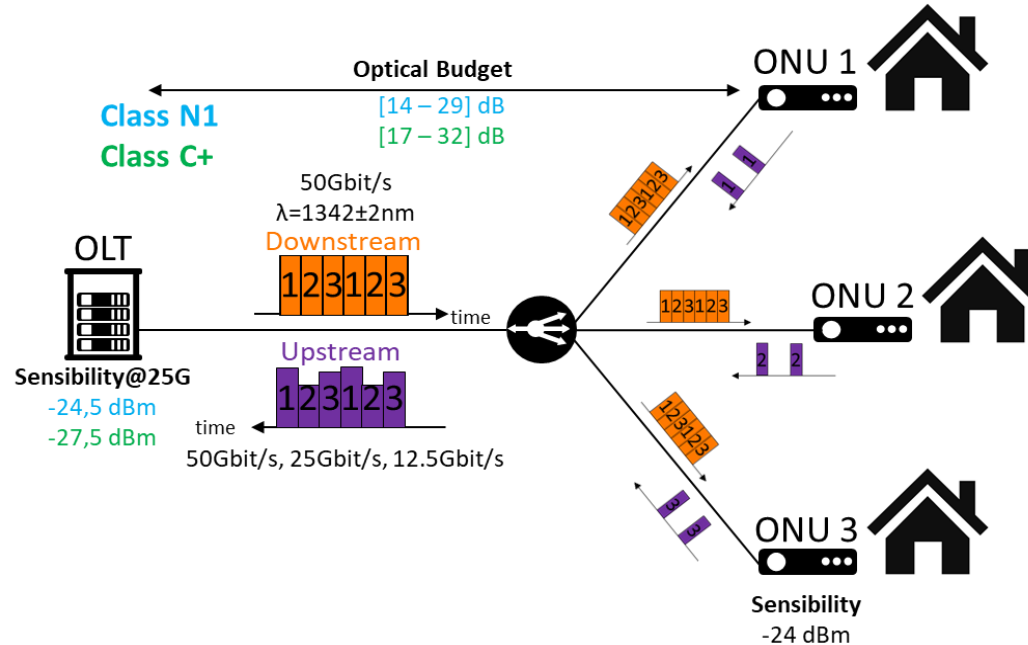
GPON and XGS-PON coexist (wavelength overlay) on the same ODN with MPM module in OLT



50G- PON standard

ITU-T **G.9804** first recommendation on PHY layer in 2021

Standard Amendment in 2023 for **50Gbit/s US** specifications



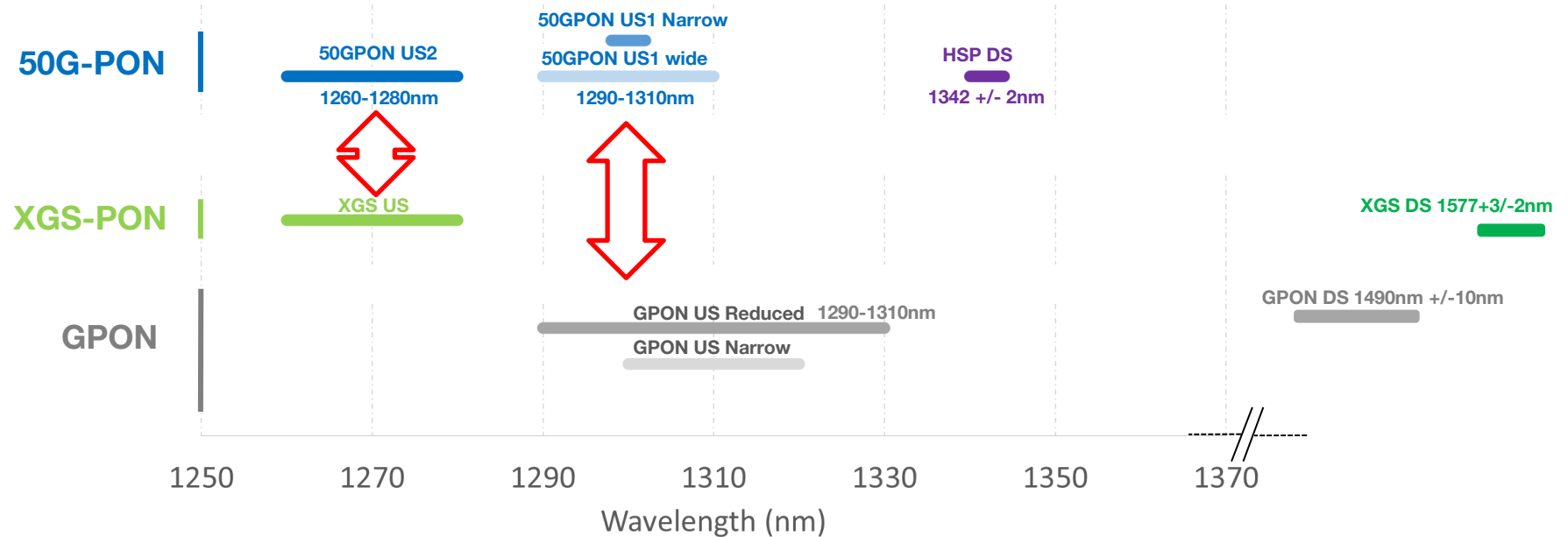
→ Challenge : develop 50Gbit/s TDM/TDMA PON systems **at low cost**

First prototypes (50G/25G) evaluated in 2023 but 50G-PON coexistence only with XGS-PON

50G-PON Wavelength Plan

Upstream and Downstream wavelengths' windows for PON technologies

For 50G-PON, all in O-band to limit chromatic dispersion impairments



Wavelength plan not in favor of triple co-existence

4 choices for operators :

1 - Deploy 50G-PON alone on specific ODNs

→ require new investments in Fibre plants

2 - Replace all XGS-PON with 50G-PON to coexist with GPON only

→ not likely to give up the most recently deployed technology

3 - Replace all GPON by 50G-PON to coexist with XGS-PON only

→ choice of Asian Operators that will bring volume for this option

4 - Allow a new wavelength option to provide triple co-existence

→ smooth migration preferred by Orange :

As long as XGS-PON ONUs cost > GPON ones, **no overall replacement foreseen by operators**

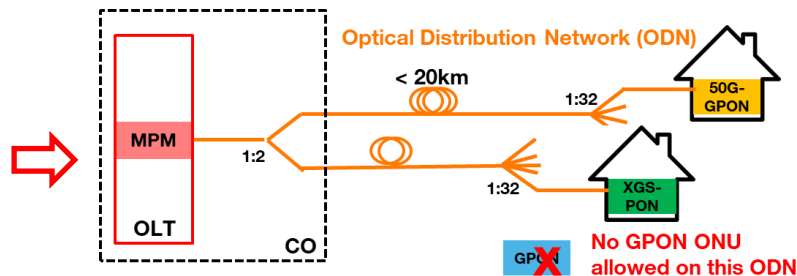
Current trend is to increase the life cycle of deployed technologies

50G-PON needed to answer to specific demands in the next 5 (10?) years

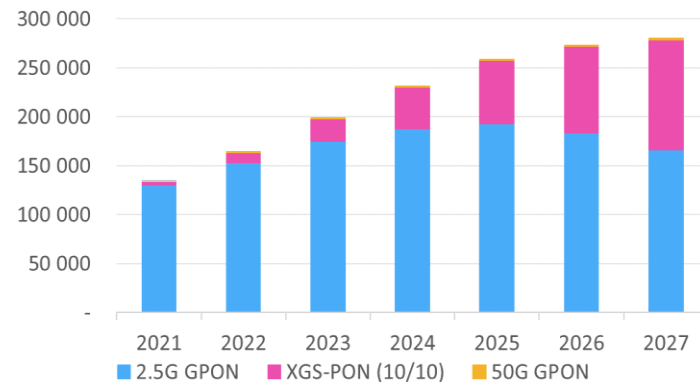
No high volume expected on 50G-PON ONUs yet

→ **Triple coexistence is a needed now !**

3rd Choice preferred in Asia



PON ONT/ONU optical component forecast - PON family



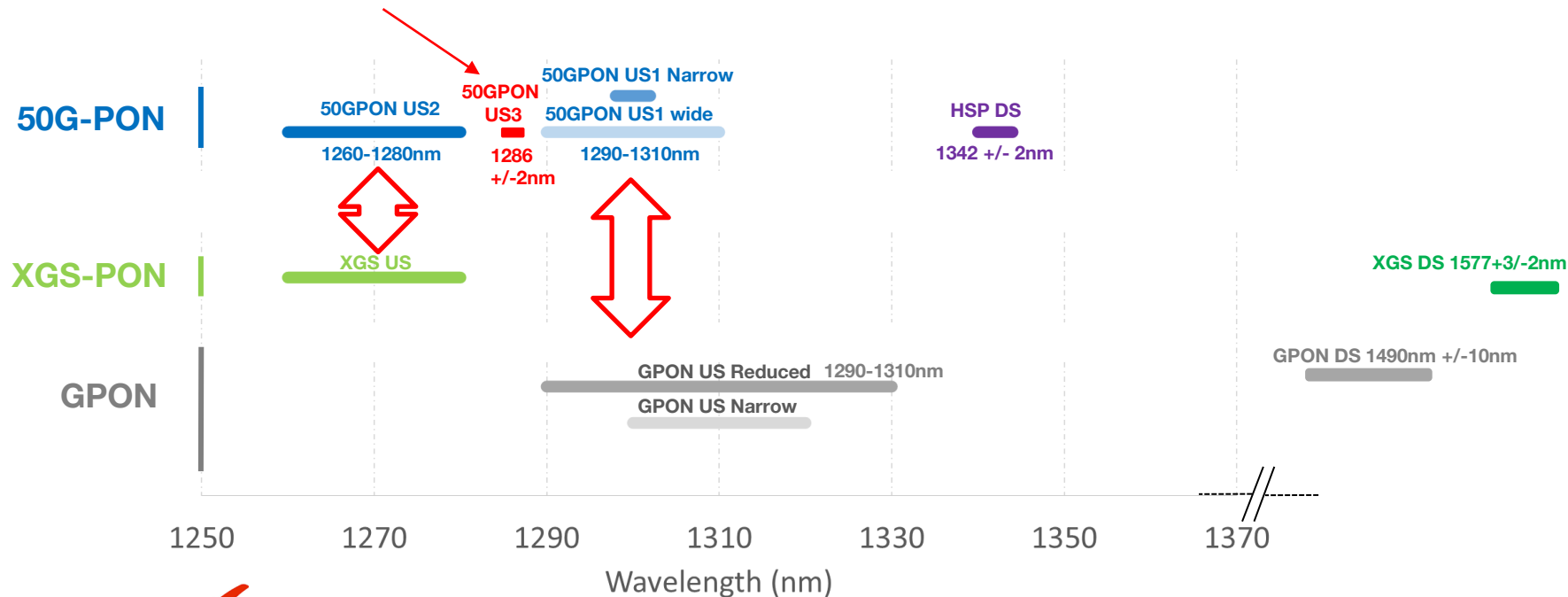
Source: OMDIA Sept 2022

50G-PON Wavelength Plan

Upstream and Downstream wavelengths' windows for PON technologies

For **50G-PON**, all in **O-band** to limit chromatic dispersion impairments

New US option for triple co-existence (requires T°C regulation at ONUs ?)



MPM with triple coexistence included in PON vendors roadmap

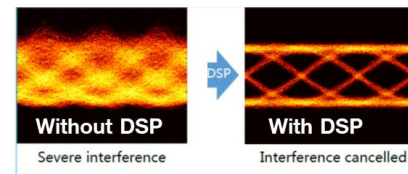
Current challenges for 50G-PON

50Gbit/s transmissions with low-cost components

→ **Low-cost optics** (Tx/Rx) from the DATACOM market preferred but limited performances, to be adapted for PONs

→ Require **additional Digital Signal Processing** : extra cost, power consumption, complexity, imposes new metrics (TDEC)

→ Upstream burst mode implementation difficult at 50Gbit/s



50G-PON **needs to reach high optical budgets** as G-PON, XGS-PON:

Class N1 : 14-29dB

Class C+ : 17-32dB

Class D : 20-35dB

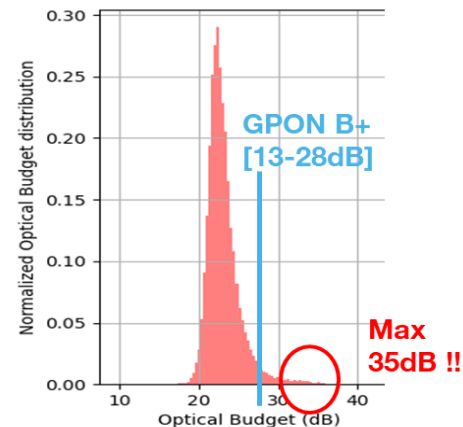
Requires optical amplification ?

Same performances expected for 0km reach and 20km reach :

Dynamic range of 15dB required

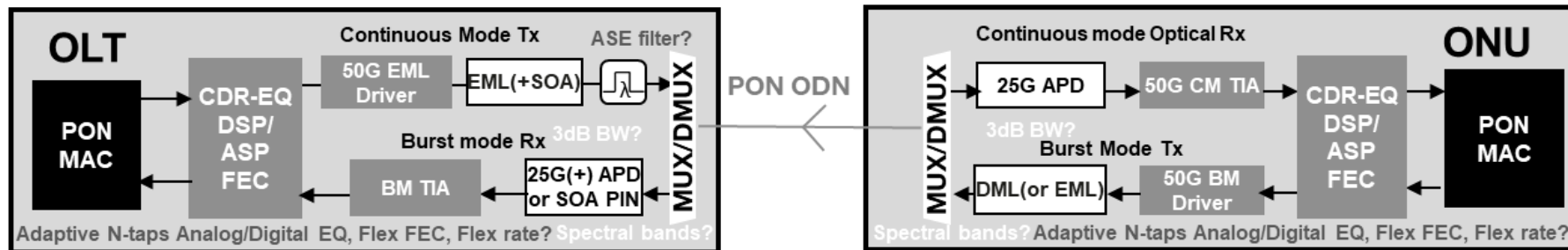
Fast adaptation of the DSP between bursts

Avoid flex FEC or flex rate



GPON Data Mining
France Area - 2020

50G-PON : many possible physical layer implementations



In the standard, **many parameters** left open to vendor's implementations :

choice of **emitters** : EML or DML w/ or w/o integrated SOA

choice of **receivers** : PIN or SOA-PIN or APD

choice of **spectral** filters : which US option ? ASE filter width ?

with different EO/OE bandwidth,
spectral ranges

choice of **DSP** : Analog or Digital, Number of taps, adaptive or fixed equalization, FFE/DFE or both ?, reduced complexity ?

... etc...

→ **Physical Layer Interop is challenged**

Not ready to operate 50G-PON on the field yet (requires new test plans with new metrics, 50G-PON power meters, triple coexistence...)

→ **Ongoing studies**

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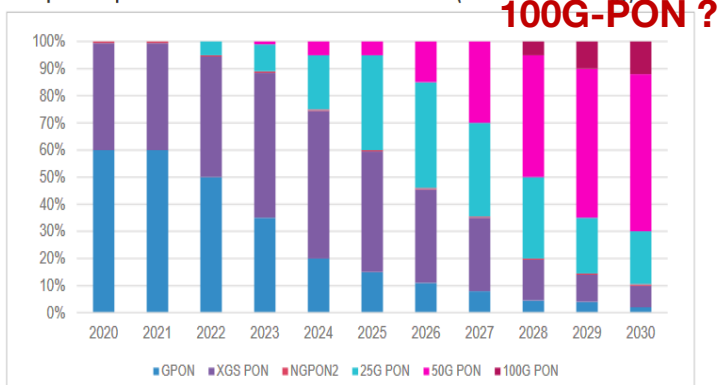
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Future technologies for F6G

Very High-Speed PONs

Discussions launched at ITU-T (FSAN)

OLT ports shipment from GPON to 100G PON 2020 - 2030 (% of each technology)



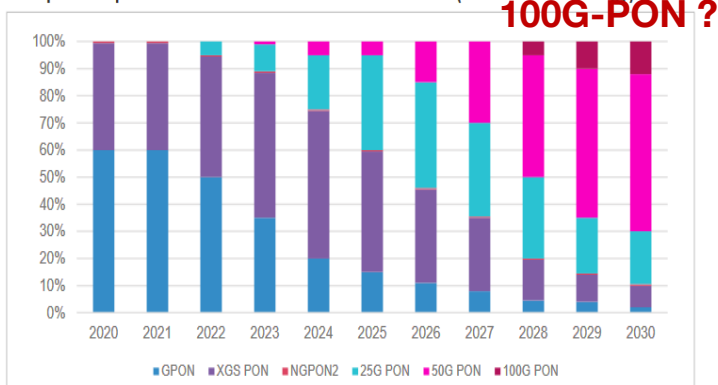
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 - redundancy
 - low energy network features
 - higher split ratio & longer reach
- New Fibres for Fiber to everywhere
 - Hollow Core fibre for ultra low latency services
- All- Photonic Networks
 - Photonic switching in OLT
 - Optical bypass
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OCTAPUS



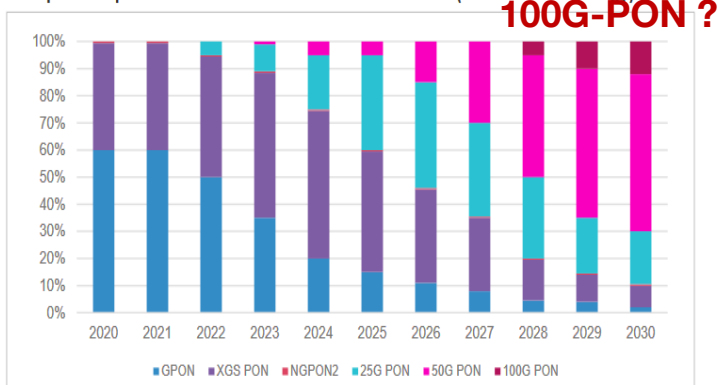
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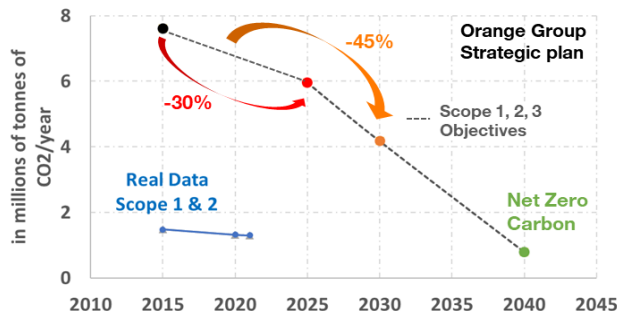
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Future networks and services must decrease their CO2 impact



Net Zero Carbon in 2040 for many Operators

Future photonic technologies and networks must demonstrate global CO₂ reduction in all scope (1,2,3)

Energy savings, avoid CO₂ emissions, LCA & upcycling

**Orange
Innovation**

Merci !



Fabienne Saliou
Philippe Chanclou
Jérémy Potet
Gaël Simon
Georges Gaillard
Dylan Chevalier

fabienne.saliou@orange.com

Thank you !

