

Aligning MOPA Blueprints with Industry Standards

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And thanks to my colleagues in the group (Nokia, Ericsson, Coherent, Lumentum)

Introduction & Background

- **5G mobile systems (and soon 6G)** require significant growth in network capability resulting in an urgent and critical need for high-capacity, cost-effective *optical solutions*.
- Currently, *lack* of a shared, common view of the optical soln's needed, which results in:
 - A plethora of different architectures and technologies.
 - Challenging choices for operators, system vendors and optical pluggable suppliers to focus on the most relevant device solns.
 - The right soln *may not* be commercially available at the right time and at the right cost.
- ➔ The purpose of MOPA is to form an improved common understanding by defining *blueprints*, or network solution descriptions which document a use-case utilizing optical pluggables and passive optical components including high-level requirements.
- Existing standards and MSA specs can help form a broad description of useful optical soln's for mobile network use-cases.
- The initial release of the MOPA whitepaper (**Rev. 1.0, June 2021**), described **19 blueprints**
- **Rev 2.0 (Sept 2022)** added appendices and annexes
 - Presents a new framework and classes for optical pluggables with respect to their impact on *tight transport synchronization*
 - *Remote management* of optical modules, including *remote tuning*.
 - Presents various MOPA Blueprints along with industry specification(s) that are closely aligned or nearly aligned.
 - Proposes a *50Gb/s 48 ch DWDM system in O-band* after making a general analysis of the options.
- **Rev 2.1 (March 2023)** adds additional detail to these annexes and appendices
- This presentation will show by way of examples how some industry specs are close enough to the MOPA blueprint req'ts to enable suppliers to leverage other high-volume products and provide cost-effective solns for these mobile networks.

IL (Insertion Loss) Budgets



Distance	Fiber attenuation @ 1.3 μm	Fiber attenuation @ 1.55 μm	Connectors Insertion Loss	Maintenance Margin	Total Loss budget - P2P fiber @ 1.3 μm	Total Loss budget - P2P fiber @ 1.55 μm
≤ 2 km	0.8 dB	0.5 dB	2 dB (4x)	0 dB	2.8 dB	2.5 dB
10 km	4 dB	2.5 dB	2 dB (4x)	1 dB	7.0 dB	5.5 dB
15 km	6 dB	3.8 dB	2 dB (4x)	1 dB	9.0 dB	6.8 dB
20 km	8 dB	5 dB	2 dB (4x)	1 dB	11.0 dB	8.0 dB
40 km	16 dB	10 dB	3 dB (6x)	2 dB	21.0 dB	15.0 dB

Summary of **P2P** pluggables needed for each Blueprint

Pluggables vs Blueprints		10G-2km-O-G-1-2-SFP+	10G-2km-O-B2-2-1-SFP+	10G-10km-O-G-1-2-SFP+	10G-10km-O-B2-2-1-SFP+	10G-15km-O-G-1-2-SFP+	10G-15km-O-B2-2-1-SFP+	10G-40km-C-G-1-2-SFP+	10G-40km-O-B2-2-1-SFP+	25G-2km-O-G-1-2-SFP28	25G-2km-O-B2-2-1-SFP28	25G-10km-O-G-1-2-SFP28	25G-10km-O-B2-2-1-SFP28	25G-15km-O-G-1-2-SFP28	25G-15km-O-B2-2-1-SFP28	25G-40km-O-G-1-2-SFP28	25G-40km-O-B2-2-1-SFP28	100G-2km-O-G-1-2-QSFP28	100G-2km-O-B2-2-1-QSFP28	100G-10km-O-G-1-2-QSFP28	100G-10km-O-B2-2-1-QSFP28	100G-15km-O-G-1-2-QSFP28	100G-15km-O-B2-2-1-QSFP28	100G-40km-O-G-1-2-QSFP28	100G-40km-O-B2-2-1-QSFP28	
DRAN	7.2.1	o	o							o	o															
	7.2.2			o	o							o	o													
CRAN	8.2.1					o	o							o	o											
	8.2.5	o										o														
	8.2.6	o								o	o							o	o							
	8.2.7	o								o				o	o								o	o		
Backhaul	9.2.1	o								o								o								
	9.2.2	o		o	o					o		o								o	o					
	9.2.3	o						o	o	o						o	o							o	o	
	9.2.4	o								o																
	9.2.5	o								o								o								
	9.2.6	o		o	o					o		o								o	o					
	9.2.7	o						o	o	o						o	o							o	o	
	9.2.8	o								o																

➔ Covered by existing IEEE, ITU-T standards or MSAs. In some cases, the corresponding standard (spec) is over-engineered for the intended Blueprint. Added cost?

Example Blueprint Description

10 km RU DU Direct parallel fibers Blueprint			
Typical UC	DRAN DU to RU. 2-10 km		
Distance	Typ Min 2 km; Typ. Max: 10 km		
Channel IL	7.0 dB @1.3 um (For Typ. Max Distance)		
Mode, Nr ch., WL	Dual fiber: O-band 1310 nm. BiDi O-band 1270nm/1330 nm.		
Temp. Range/Class	I-temp		
Lifespan	15 years		
Data rates	10 Gb/s	25 Gb/s	50 Gb/s
Formfactor	SFP+	SFP28	SFP56
FEC, Mod format	No, NRZ	Yes, NRZ	Yes, PAM4
Power Class	PC2 (1.5 W)	PC2 (1.5 W)	PC2 (1.5 W)
Pluggables codes	10G-10km-O-G-1-2-SFP+ 10G-10km-O-B2-2-1-SFP+	25G-10km-O-G-1-2-SFP28 25G-10km-O-B2-2-1-SFP28	50G-10km-O-G-1-2-SFP56 50G-10km-O-B2-2-1-SFP56
Key technologies	-	Low-cost 25G DFB	TBD
Standards	IEEE 802.3, Clauses 52 & 158 ITU-T G.9806 (Amend 2) See Appendix A Tables 5,6,7	IEEE 802.3, Clause 114 & 159 ITU-T G.9806 (Amend 2) See Appendix A Tables 5,6,7	IEEE 802.3, Clauses 139 & 160 ITU-T G.9806 (Amend 2) See Appendix A Tables 5,6,7
Market status and outlook	Mature	Ramping, complement to 10G	Introduced, complement to 25G

Table 7: 10 km RU-DU direct parallel fibers Blueprint. (*) For DRAN, distances between 2 and 10 km are expected to be much fewer than those ≤ 2 km.

Aligning Point-Point Standards *(IEEE, 10-km example)*

10 km, 10/25/50G, dual-fiber Parameter	10 Gb/s		25 Gb/s		50 Gb/s		10 km, 10/25/50G, BiDi Parameter	10 Gb/s		25 Gb/s		50 Gb/s	
	10G-10 km-O-G-1-2-SFP+		25G-10km-O-G-1-2-SFP28		50G-10km-O-G-1-2-SFP56			10G-10km-O-B2-2-1-SFP+		25G-10km-O-B2-2-1-SFP28		50G-10km-O-B2-2-1-SFP56	
	IEEE 802.3 Cl. 52 (10GBASE-LR)	MOPA Blueprint	IEEE 802.3 Cl. 114 (25GBASE-LR)	MOPA Blueprint	IEEE802.3 Cl. 139 (50GBASE-LR)	MOPA Blueprint		IEEE 802.3 Cl. 158 (10GBASE-BR10)	MOPA Blueprint	IEEE 802.3 Cl. 159 (25GBASE-BR10)	MOPA Blueprint	IEEE 802.3 Cl. 160 (50GBASE-BR10)	MOPA Blueprint
Wavelength	1260–1355 nm	1260–1355 nm	1295–1325 nm	1295–1325 nm	1304.5 - 1317.5 nm	1304.5–1317.5 nm	Wavelength	1270/1330 nm (±10 nm)	1270/1330 nm (±10 nm)	1270/1330 nm (±10 nm)	1270/1330 nm (±10 nm)	1270/1330 nm (±10 nm)	1270/1330 nm (±10 nm)
Launch power (min) in OMA minus TDP	-6.2 dBm	-5.4 dBm	-5.0 dBm	-4.3 dBm	-2.9 dBm	-2.2 dBm	Launch power (min) in OMA minus TDP	-6.2 dBm	-5.4 dBm	-5.0 dBm	-4.3 dBm	-2.9 dBm	-2.2 dBm
Optical Modulation Amplitude (min)	-5.2 dBm	-4.4 dBm	-4.0 dBm	-3.3 dBm	-1.5 dBm	-0.8 dBm	Optical Modulation Amplitude (min)	-5.2 dBm	-4.4 dBm	-4.0 dBm	-3.3 dBm	-1.5 dBm	-0.8 dBm

- Wavelength ranges explicitly stated
- Tx launch power increased to accommodate IL budget -- 6.3dB (IEEE) vs. 7dB (Blueprint)

Aligning Point-Point Standards (*IEEE, 40-km example*)

40 km, 10/25/100G Dual-fiber	10Gb/s		25Gb/s		100Gb/s		40 km, 10/25/100G BiDi	10Gb/s		25Gb/s		100Gb/s	
	10G-40 km-C-G-1-2-SFP+		25G-40 km-O-G-1-2-SFP28		100G-40 km-O-L-4-2-QSFP28 or 100G-40 km-O-G-1-2-QSFP28			10G-40 km-O-B2-2-1-SFP+		25G-40 km-O-B2-2-1-SFP28		100G-40 km-O-B2-2-1-QSFP28	
Parameter	IEEE 802.3 Cl 52 (10GBASE-ER)	MOPA Blueprint	IEEE 802.3 Cl 114 (25GBASE-ER)	MOPA Blueprint	IEEE 802.3 Cl. 88 (100GBASE-ER4) Or 100G Lambda MSA (100G-ER1-40)	MOPA Blueprint	IEEE 802.3 Cl. 158 (10GBASE-BR40)	MOPA Blueprint	IEEE 802.3 Cl. 159 (25GBASE-BR40)	MOPA Blueprint	IEEE 802.3 ^t or ITU-T G.9806 (Amend. 3 ^{tt})	MOPA Blueprint	
Wavelength	1530 to 1565 nm	-	1295 to 1310 nm	-	1294.53 to 1310.19 nm or 1308.09-1310.19 nm	-		No exceptions	1314/1289nm	1314/1289nm		TBD	
Launch power (min) in OMA minus TDP	-2.1 dBm	+2.0 dBm*	-1.0 dBm	+2.0 dBm*	+0.1 dBm or +3.3 dBm	+3.1 dBm* Or +6.3 dBm*		-1.0 dBm	+2.0 dBm*	-1.0 dBm	+2.0 dBm*	TBD	
Optical Modulation Amplitude (min)	-1.7 dBm	+2.4 dBm*	0.0 dBm	+3.0 dBm*	NA or +4.7 dBm	NA or +7.7 dBm*		0.0 dBm	+3.0 dBm*	0.0 dBm	+3.0 dBm*	TBD	

**Such high optical modulation amplitude may not be achievable with available cost-effective technology.*

- Tx launch power increased to accommodate IL budget
 - 25/100Gb/s, 18 dB (IEEE) vs. 21 dB (Blueprint) => 3dB Tx launch increase
 - 10G (dual-fiber), 10.9 (IEEE) vs. 15 dB (Blueprint) => 4.1 dB Tx launch increase

Summary of **TDM PON** pluggables needed for each Blueprint

Pluggables vs. Blueprints	GPON-20km-OS-B3-1-SFP - OLT	GPON-20km-OS-B3-1-SFP-ONU	GPON-20km-OS-B3-1-SFP-iONU	XGSPON-20km-OL-B3-1-SFP+-OLT	GSPON-20km-OL-B3-1-SFP+-ONU	XGSPON-20km-OL-B3-1-SFP+-iONU	25GSPON-20km-O-B3-1-SFP28-OLT	25GSPON-20km-O-B3-1-SFP28-ONU	25GSPON-20km-O-B3-1-SFP28-iONU
9.2.9	○	○		○	○		○	○	
9.2.10	○		○	○		○	○		○

➔ Covered by TDM-PON & 25GS-PON MSA specifications

Aligning PON Standards *(GPON, XGS-PON, 25GS-PON)*

TDM-PON	2.5/1.25 Gb/s		10/10 Gb/s		25 / 10 Gb/s or 25 Gb/s	
		GPON-20 km-OS-B3-1-SFP-OLT GPON-20 km-OS-B3-1-SFP-ONU		XGS-PON-20 km-OL-B3-1-SFP+-OLT XGS-PON-20 km-OL-B3-1-SFP+-ONU		25GS-PON-20 km-O-B3-1-SFP28-OLT 25GS-PON-20 km-O-B3-1-SFP28-ONU
Parameter	ITU-T G.984.2	MOPA Blueprint	IEEE 802.3 Clause 75 (10GBASE-PR-D/U3) or ITU-T G.9807.1(Amend 2) (Annex B)	MOPA Blueprint	IEEE 802.3 Clause 141 (25/10-PQ30X) (25/25-PQ30X) or 25GS-PON MSA V2.0	MOPA Blueprint
IL Budget	28dB	No exceptions	33 dB or up to 35 dB	No exceptions	29 dB or 31 dB	No exceptions

- Standards describe multiple IL Classes
- If Use-Case (Blueprint) is deployed in a comparable ODN (IL class) then No Exceptions

Summary of **WDM line** pluggables needed for each Blueprint

Pluggables vs. Blueprints	10G-10km-*C-6-2-SFP+	10G-15km-C-D-48-2-SFP+	25G-15km-C-D-48-2-SFP28
8.2.2	○		
8.2.3		○	○
8.2.4		○	○
8.2.5		○	○
9.2.4		○	○
9.2.8		○	○

- 10Gb/s: de-facto standards
 - Fixed WDM mature, cost effective
 - Tunable (self-tuning) available.....(for 10Gb/s & 25Gb/s)
- 25Gb/s: no ITU or IEEE standards (however O-RAN, WG9 exists)

Aligning WDM Standards

15 km, 10/25G CWDM	10Gb/s		25Gb/s	
	10G-10km-*-C-6-2-SFP+			
Parameter	ITU-T G.695 (07/2018)	MOPA Blueprint	O-RAN WG9 WDM 0-v02.00 Table 5	MOPA Blueprint
		Use Table 8-15 as starting point for a 6-wavelength interface		Under Consideration

Table APA.12: 10 km, CWDM Blueprint. IL loss budget = 11.5 dB.

Mature & shipping

15 km, 10/25G DWDM	10Gb/s		25Gb/s	
	10G-15km-C-D-48-2-SFP+		25G-15km-C-D-48-2-SFP28	
Parameter	ITU-T G.698.1 (11/2009) Table 8-3	MOPA Blueprint	O-RAN WG9 WDM 0-v02.00 Table 10	MOPA Blueprint
		No exceptions*		Under Consideration

Table APA.13: 15 km, DWDM Blueprint. IL budget = 17.8 dB in C-band. *ITU-T specification supports 1000 ps/nm of chromatic dispersion which is more than the 270 ps/nm assumed for 15 km of standard G.652 SMF.

50G xWDM line pluggable option

Pluggables vs. Blueprints	10G-10km*-C-6-2-SFP+	10G-15km-C-D-48-2-SFP+	25G-15km-C-D-48-2-SFP28
8.2.2	○		
8.2.3		○	○
8.2.4		○	○
8.2.5		○	○
9.2.4		○	○
9.2.8		○	○

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Annex A	50G-15km-O-D-48-2-SFP56
	○

- LLS (fronthaul) use-case
- O-band wavelength range
- SFP56 form-factor
- I-temp operating range
- 18 dB IL
- Low power dissipation using analog EQ (?)

- No TRx standards for higher data-rates exist---de-facto standards
- Fixed WDM mature, cost effective (for 10Gb/s)
 - Tunable (self-tuning) emerging.....(for 10Gb/s & 25Gb/s)

Summary

- **Many standards are aligned, or nearly aligned with MOPA Blueprints**
 - Enables low-cost, high-volume transceiver solutions to be utilized
 - MOPA Blueprints have some special req'ts that can result in higher costs
 - Higher IL budgets
 - I-temp (-40C to +85C)
- **100G BiDi Standards are in progress**
 - LLS (fronthaul) & Backhaul use-cases
 - SFP112 form-factor preferred with 2.5W envelope, LLS
 - QSFP112 ok for backhaul
 - ITU-T G.9806 Amend 3
 - IEEE 802.3dk "Greater than 50Gb/s BiDi" Task Force
- **WDM Blueprints (25Gb/s) lack ITU (or ITU-like) standard**
 - O-RAN WG9 has released a relevant specification (*this may be good enough*)
 - ITU-T SG15 are good starting points



Thank You!



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