smartoptics

Evolution of transceivers in optical networks

01 October 2026

Transceivers as an optical transport option

Transport the service you need

- 100G LR
- 100G SR
- 100G ZR

Open/flexible interfaces



Is Grey = TRUE
(actually DWDM)

interchangeable lasers





One transceiver = one DWDM service mode/option

100GBASE-ZR (IEEE 802.3ct)

Target application
100GbE over DWDM, metro and edge DCI

Target reach
Amplified: ≥80 km DWDM

Baud rate
~27.95 GBd

Modulation
DP-DQPSK

OIF 400ZR

Target application
400GbE point-to-point data center interconnect

Target reach
Amplified: ≤120 km, single span
Unamplified: ~40 km (11 dB loss budget)

Baud rate
~59.84 GBd

Modulation
DP-16QAM

OIF 800ZR

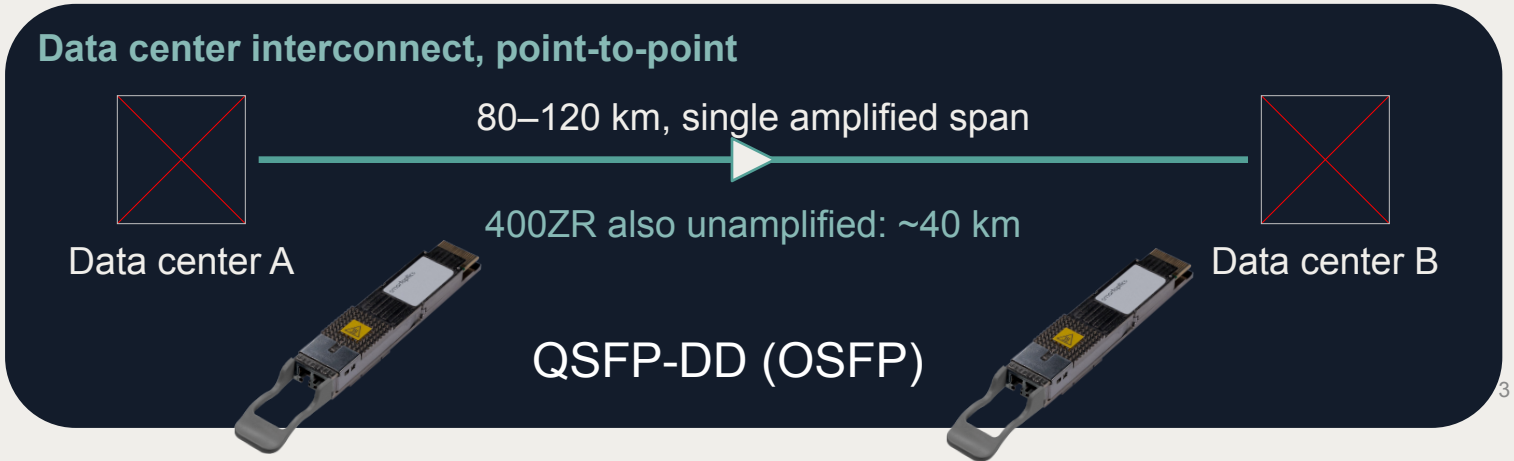
Target application
800G point-to-point data center interconnect (100GbE–800GbE clients)

Target reach
Amplified: 80–120 km, single span

Baud rate
~118.2 GBd

Modulation
DP-16QAM





What? STANDARDS are evolving!



100ZR







100ZR (Proprietery)
RS-FEC reducing latency



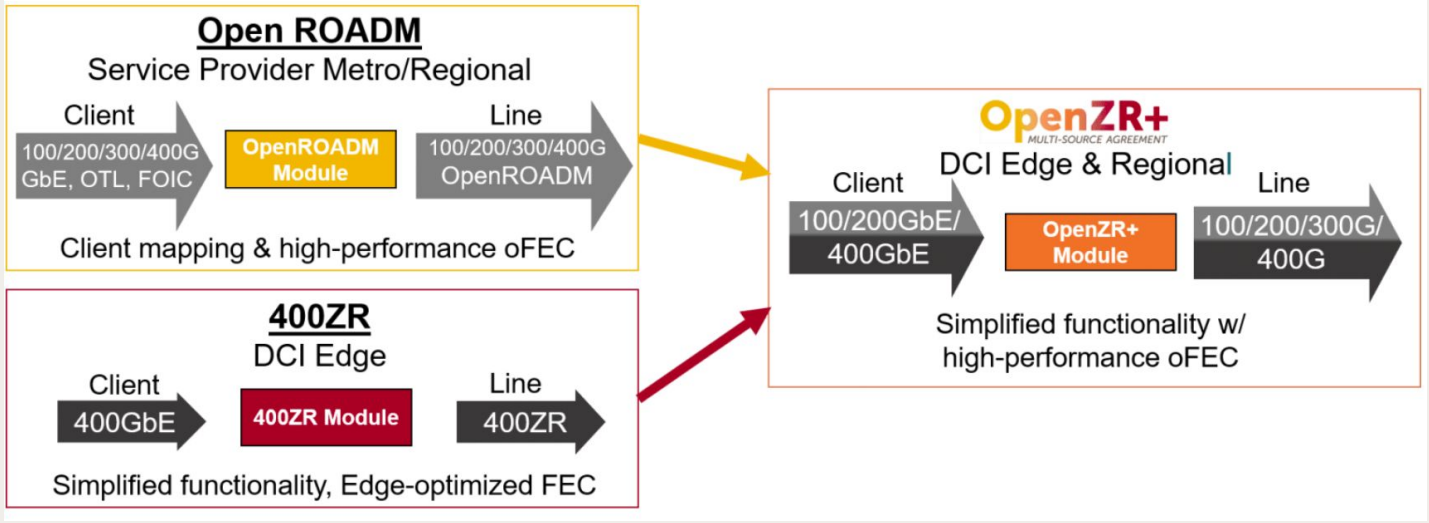


STANDARDS evolved into "+" modes

Data Classification: Confidential

Transceivers as a multi-tool of operational modes (400G)

OpenZR+ MULTI-SOURCE AGREEMENT



Host Side	Datapath					Media Side
Host Interface	Host Map/Demap	MUX/DMUX	Media Framing	FEC Encode/Decode	Modulation	Media Interface
1 x 400GBASE-R	1 x 400ZR.ts		400ZR	OFEC	16QAM	ZR400-OFEC-16QAM
2 x 200GBASE-R	2 x 200ZR.ts					
4 x 100GBASE-R	4 x 100ZR.ts					
1 x 400GBASE-R	1 x 400ZR.ts		400ZR	OFEC	8QAM	ZR400-OFEC-8QAM
2 x 200GBASE-R	2 x 200ZR.ts					
4 x 100GBASE-R	4 x 100ZR.ts					
3 x 100GBASE-R	3 x 100ZR.ts		ZR300	OFEC	8QAM	ZR300-OFEC-8QAM
1 x 200GBASE-R	1 x 200ZR.ts		ZR200	OFEC	QPSK	ZR200-OFEC-QPSK
2 x 100GBASE-R	2 x 100ZR.ts					
1 x 100GBASE-R	1 x 100ZR.ts		ZR100	OFEC	QPSK	ZR100-OFEC-QPSK

Higher performance of 400G, from 120km to ~700km

Simple mapping of 100G Ethernet clients

15 applications (OpenZR+)
2 applications OIF400ZR
3 applications OpenROADM
? applications “proprietary”

1) https://openzrplus.org/

Transceivers as a multi-tool of operational modes (800G)

	OIF 800G COHERENT	Open ROADM
Target application	Edge DCI/Campus	Metro/Regional DCI
Reach (amplified)	80 – 120km	>120km
Line capacity	800G	400/600/800G (118-131GBd)
Client formats	100GE/200GE/400GE/800GE*	100GE-800GE + OTN
FEC	oFEC	oFEC
Line modulation	16QAM	QPSK/8QAM/16QAM/PCS-16QAM
Line frame	FlexO-8e over FlexO-8e-DO-16QAM	FlexO-4/6/8(e) over FlexO-x(e)-D[P]O

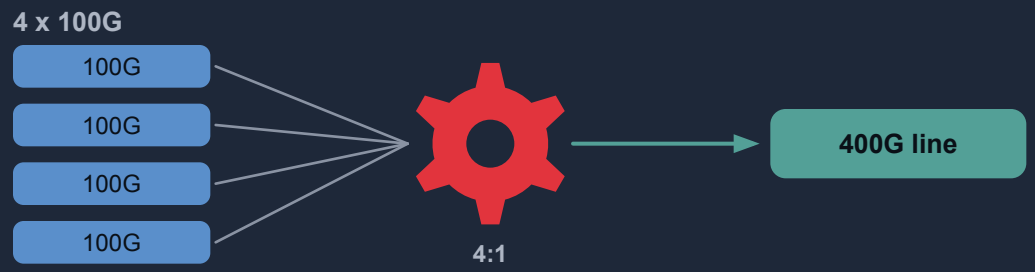
8 new line modes defined for “800G technology” (118-131GBd)

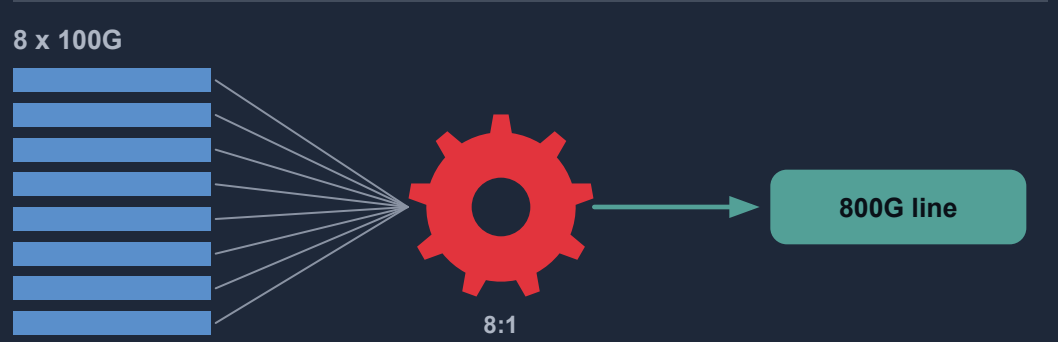
x Proprietery PCS modes introduced

BW optimization – aggregation of 100G clients

Aggregation

100G lanes muxed to a single line port

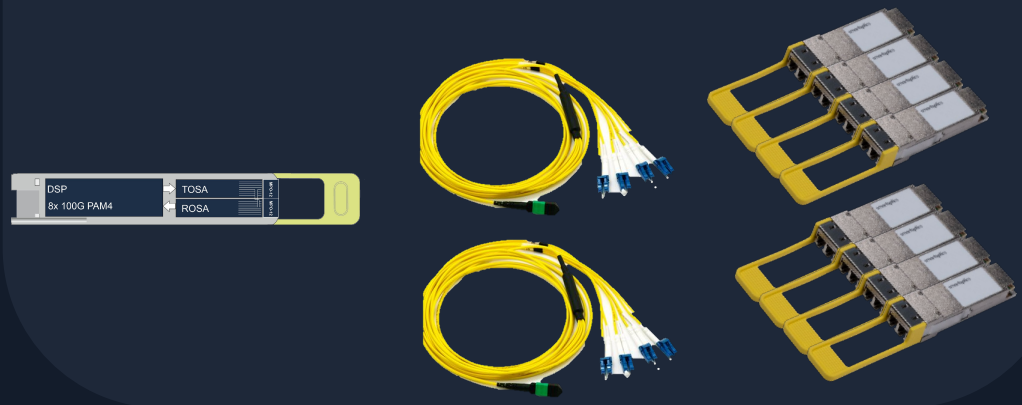




Aggregation clients (100G DR1)

Client 100G lanes muxed to a single line port





Transceivers as a multi-tool of operational modes

QSFP-DD 400G ZR+

Mode	Modulation	Baud	FEC	Typical use
400ZR	DP-16QAM	~60 GBd	C-FEC	DCI ≤120 km
400G ZR+	DP-16QAM	~60 GBd	oFEC	Metro/regional
300G	DP-8QAM	~60 GBd	oFEC	Regional
200G	DP-16QAM	~30GBd	oFEC	Regional
200G	DP-QPSK	~60 GBd	oFEC	Long haul
100G	DP-QPSK	~30 GBd	oFEC	Very long haul

QSFP-DD 800G ZR+

Mode	Modulation	Baud	FEC	Typical use
800ZR	DP-16QAM	~120 GBd	C-FEC	DCI ≤120 km
800G ZR+	DP-16QAM/PCS	~120-130 GBd	oFEC	Metro/regional
600G	PCS	~130 GBd	oFEC	Regional
400G	DP-QPSK	~120GBd	oFEC	Regional
400G OpenZR+	DP-16QAM	~60 GBd	oFEC	Metro/regional
400G	DP-QPSK	~120 GBd	oFEC	Very long haul

Selectable features

1

Bit rate

100 / 200 / 300 / 400G per wavelength
400 / 600 / 800G per wavelength

2

Channel width

Baud rate & grid to fit the filter

3

Encryption (yes/no)

MACsec / layer-1 encryption on the line

4

Client mapping

1×400GE, 2×200GE, 4×100GE
1x 800GE, 2x 400GE, 4x200GE

One transceiver, many purposes: application codes

1 Module advertises

List of supported Applications (host + media interface)

2 Host selects

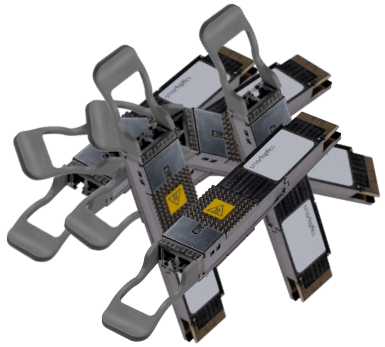
AppSel code written via CMIS

3 Module reconfigures

Rate, modulation, FEC, grid – **no hardware swap**

240

Up to 240 application codes in CMIS today



400ZR
400ZR+
400ZR++
800ZR
800ZR+

A viable choice?

?



All-in-1 module

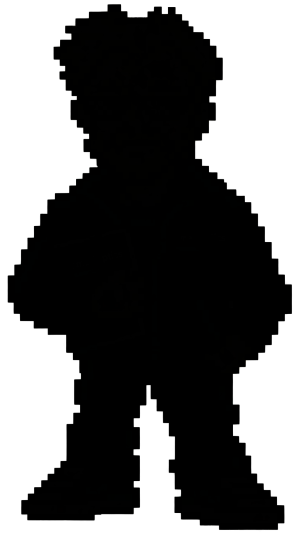
How DWDM transceiver bit-rate evolution works

	~32 GBd ~2015	~60 GBd 2020	~120 GBd 2024	~240 GBd 2028+
DP-16QAM Capacity	200G	400G	800G	1.6T
DP-QPSK reach “++” modes	100G	200G	400G	800G

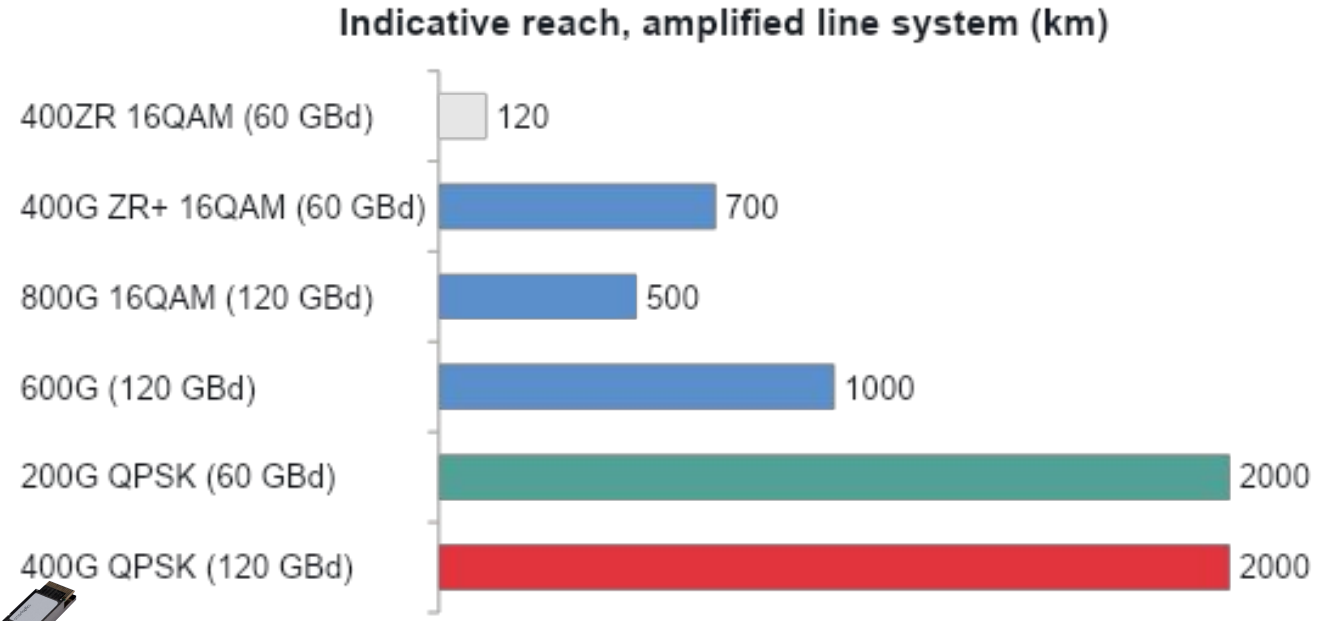
Capacity ≈ baud × bits/symbol × 2 pol.

New generation → higher baud. Keep the baud, reduce constellation complexity → previous rate, much longer reach.

Huh? Coherent DWDM standards reaching further!



Reaching further with the “++” modes

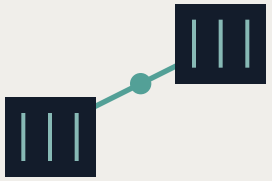
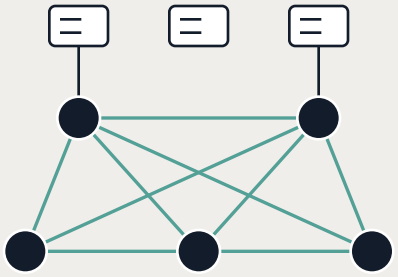
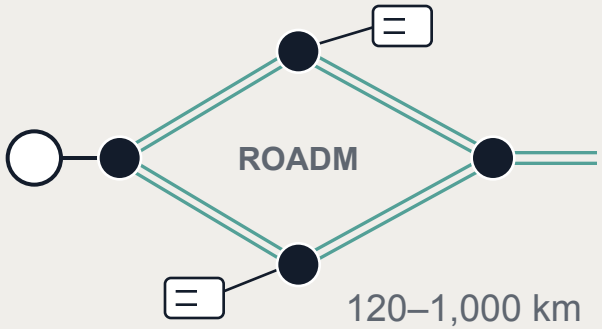
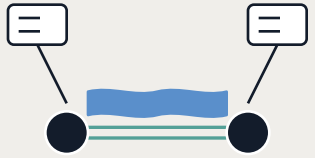


400G QPSK on an 800G module

- ~120 GBd, DP-QPSK
- Same bits/symbol as 200G QPSK → similar reach
- 400G in one 150 GHz wavelength
- ≈ 2000 km class

Increase baud rate, reduce constellation complexity → reach.



Around the DC	Metro/Regional		Core	
Campus DCI	DCI	Multi-span ROADM	Long haul	Subsea
				
2–20 km	<120 km	120–1,000 km	1,000–4,000 km	Up to 10,000+ km

How far can a 400G ULH (++) transceiver reach?

Assumptions:

- 34D ROADMs in every node
- Variable Gain PreAmps
- Average span loss per column.
- QSFP-DD Tx power = 0dBm
- TX OSNR = 42dB

Traffic Format	OSNR limit (dB)
400ZR 16QAM	26,0dB
400G ZR+ 16QAM	23,4dB
400G QPSK	17,9dB
300G 8QAM	20,3dB
200G QPSK	15,0dB
100G QPSK	11,8dB

Number of channels	48ch						
Amp Output power	3,2dBm/ch						
span loss	0,25dB/km						
	52km	60km	68km	76km	84km	92km	100km
	13dB	15dB	17dB	19dB	21dB	23dB	25dB

Spans	OSNR (dB)						
1	33,4	32,9	32,3	31,4	30,1	28,8	27,1
2	30,7	30,1	29,5	28,5	27,3	25,8	24,2
3	29,0	28,5	27,8	26,8	25,6	24,1	22,5
4	27,8	27,3	26,6	25,6	24,3	22,9	21,2
5	26,9	26,3	25,7	24,7	23,4	21,9	20,3
6	26,1	25,5	24,9	23,9	22,6	21,1	19,5
7	25,4	24,9	24,2	23,2	21,9	20,5	18,8
8	24,9	24,3	23,7	22,7	21,4	19,9	18,2
9	24,4	23,8	23,2	22,2	20,9	19,4	17,7
10	23,9	23,4	22,7	21,7	20,4	18,9	17,3
11	23,5	23,0	22,3	21,3	20,0	18,5	16,8
12	23,1	22,6	21,9	20,9	19,6	18,2	16,5
13	22,8	22,2	21,6	20,6	19,3	17,8	16,1
14	22,5	21,9	21,3	20,3	19,0	17,5	15,8
15	22,2	21,6	21,0	20,0	18,7	17,2	15,5

* Estimated average OSNR. Gain ripple/tilt and fiber tilt will create some variation between channels

Reaching further with the “++” modes



SIMULATION RESULTS

Service is feasible (Min required OSNR: 18 dB)

Start Point → End Point margin: 1.1 dB

End Point → Start Point margin: 1.1 dB

START POINT → END POINT

Total Length: 2740 km

GSNR: 19.6 dB

OSNR: 20 dB

Rx Power: -3.9 dBm

Chromatic Dispersion: 45758 ps/nm

PMD: 2.1 ps

PDL: 0 dB

Penalties:

- **Rx Power:** 0.0 dB
- **Chromatic Dispersion:** 0.5 dB

END POINT → START POINT

Total Length: 2740 km

GSNR: 19.6 dB

OSNR: 20 dB

Rx Power: -3.4 dBm

Chromatic Dispersion: 45758 ps/nm

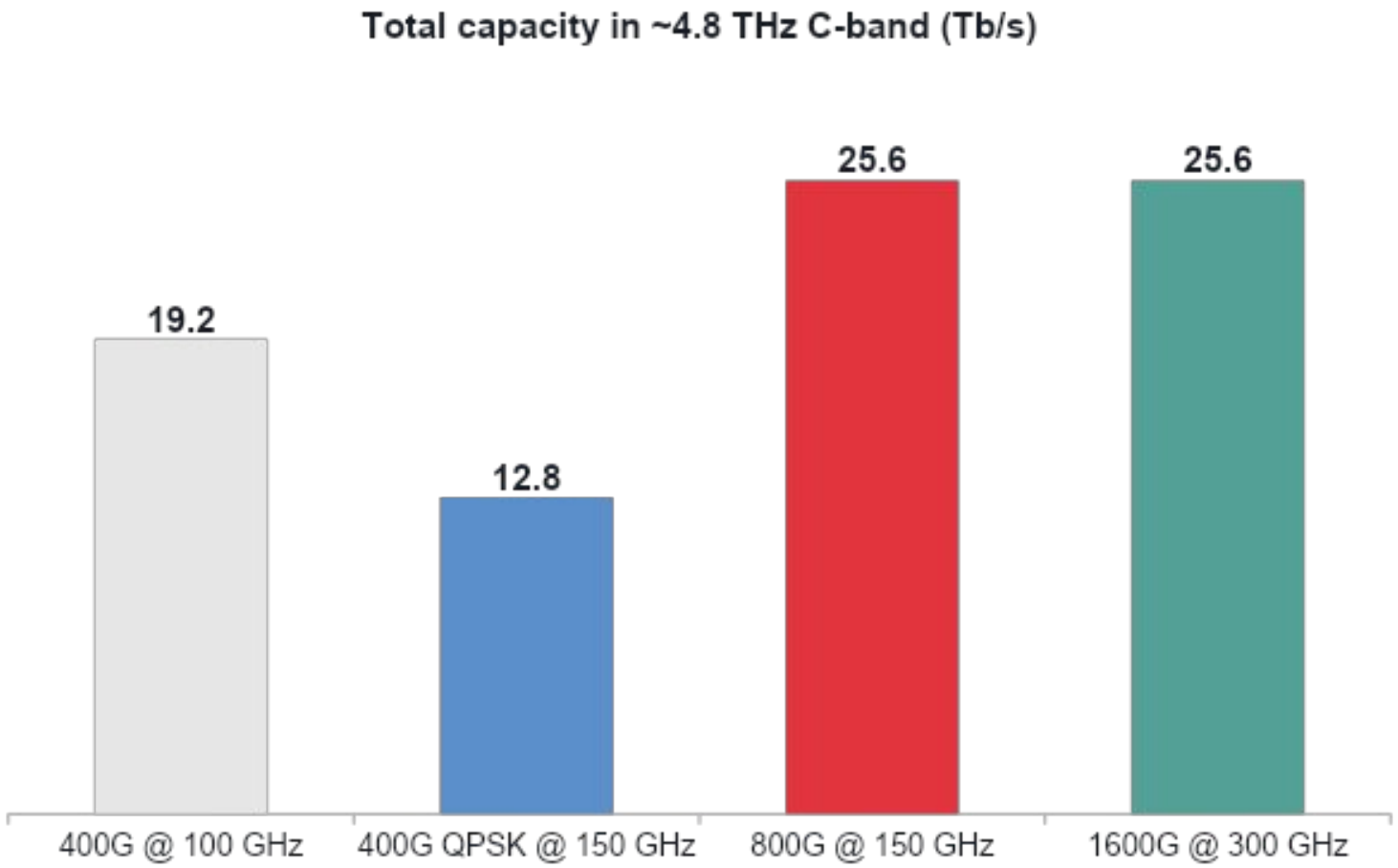
PMD: 2.1 ps

PDL: 0 dB

Penalties:

- **Rx Power:** 0.0 dB
- **Chromatic Dispersion:** 0.5 dB

Maximising spectral efficiency across the C-band



How do we increase capacity from 25.6Tbps?

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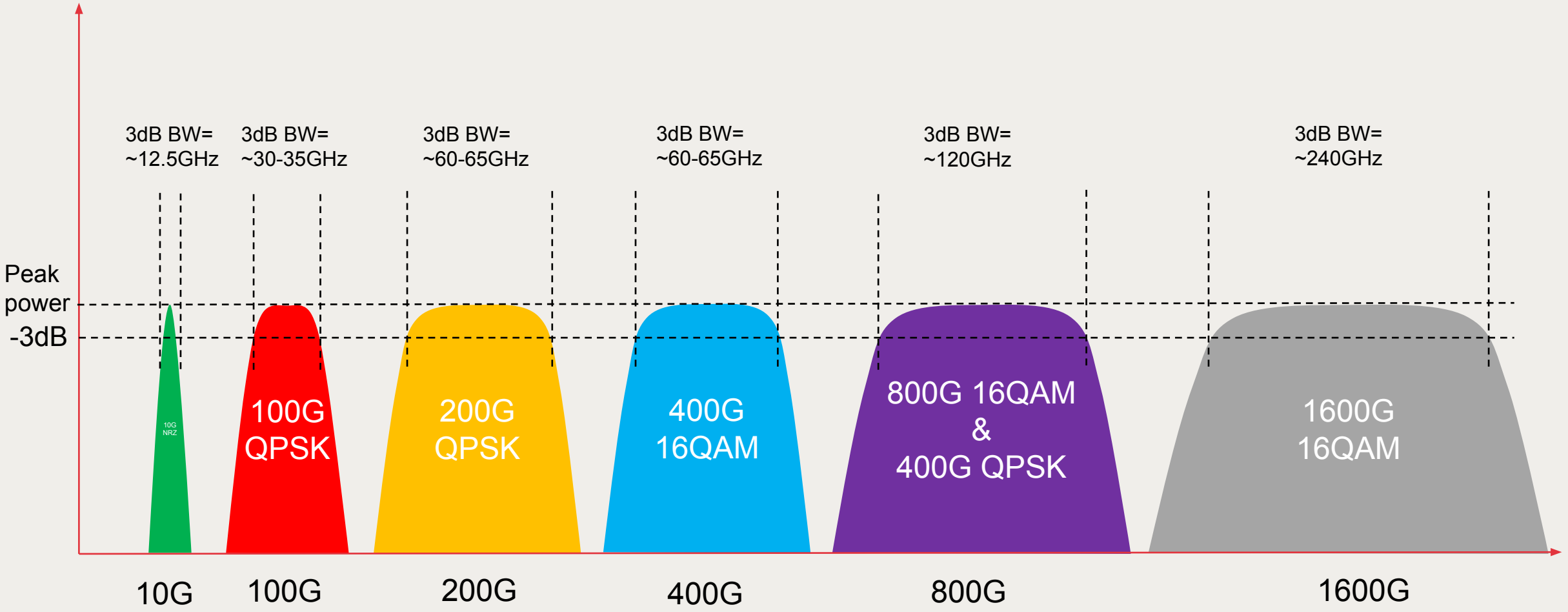
DWDM Signal Bandwidth Overview



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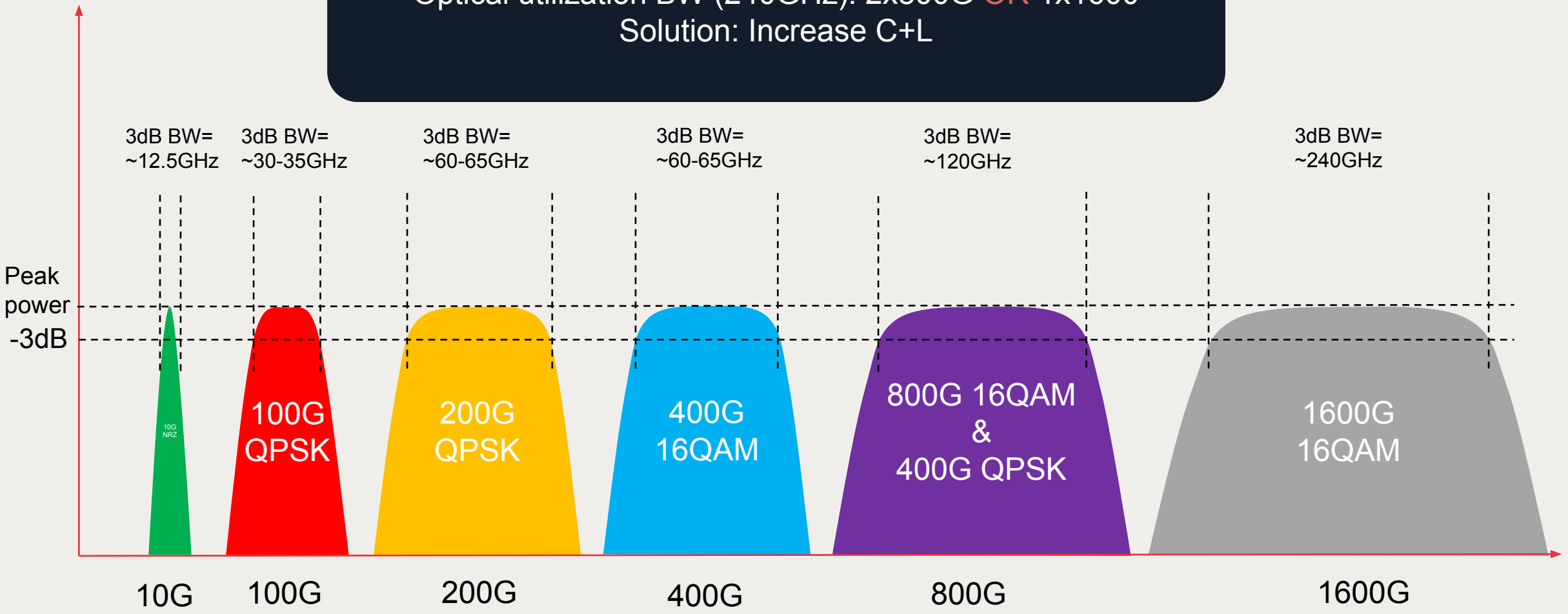
DWDM Signal Bandwidth Overview

Optical utilization BW (240GHz): 2x800G OR 1x1600
Solution: Increase C+L



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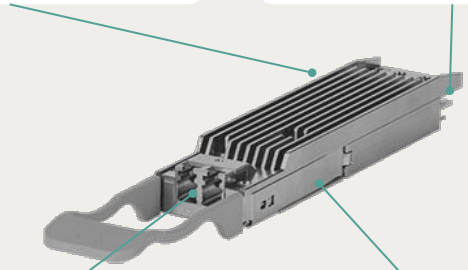
Introduction to C+L band

- C-band frequency and wavelength range: 191.35–196.15 THz (1528.38–1566.72 nm) – 4800 GHz
- L-band frequency and wavelength range: 186.07–190.87 THz (1570.68–1611.20 nm) – 4800 GHz
- Guard band: ~482 GHz (3.96 nm) between C and L, reserved for the band-splitting filter/interleaver
- Standards: ITU-T G.694.1 (DWDM frequency grid), G.652.D (standard single-mode fiber), G.671/G.807 (optical interfaces and amplifiers)
- 400G and 800G modules GA



Coherent DSP
Modulation, FEC and dispersion compensation

Host interface
Electrical lanes to the router; CMIS selects the mode



Tunable laser
Narrow-linewidth source, tunable across the ~~C-band~~ L-Band

Coherent optics
IQ modulator and coherent receiver (silicon photonics)

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Thank you

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Layouts

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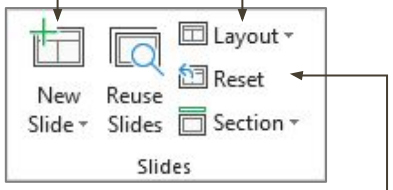
2. Layout, changes the appearance of the current slide.



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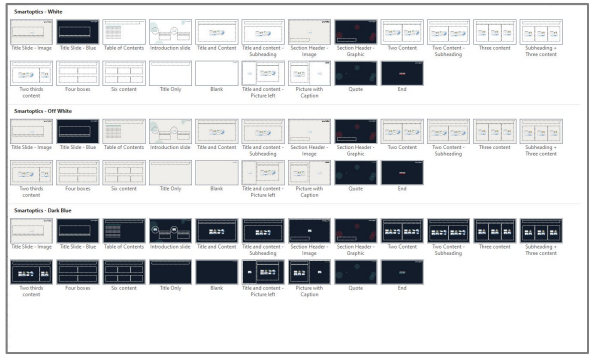
Current layouts in the template



Theme colors

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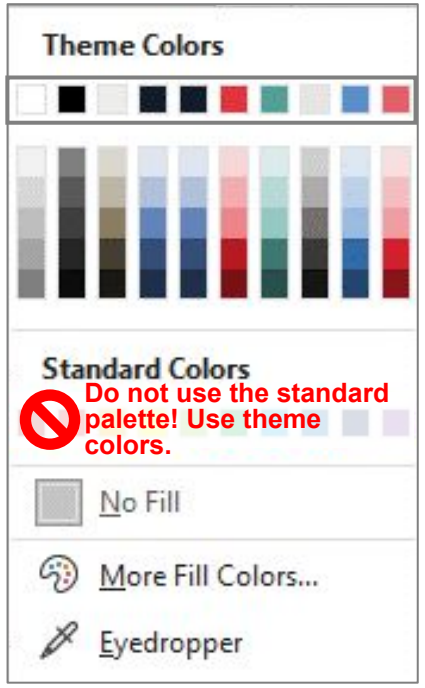

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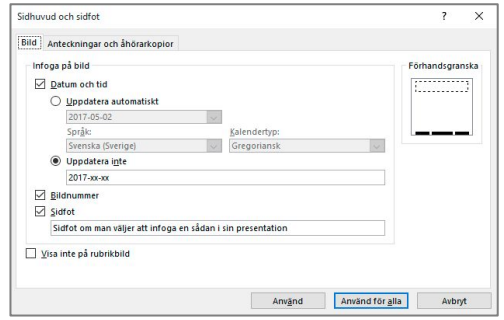

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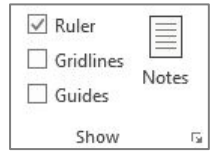
Make sure that objects/text are all placed within the slide margins. To show the guides, go to **View** tab in the menu and check the box for **Guides**.



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Instructions
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Bullet list and format

The different levels available in the template.

- Bullet list 1
  - Bullet list 2
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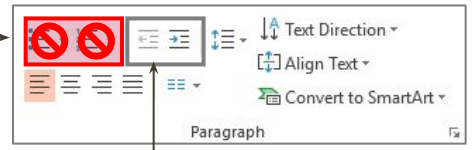

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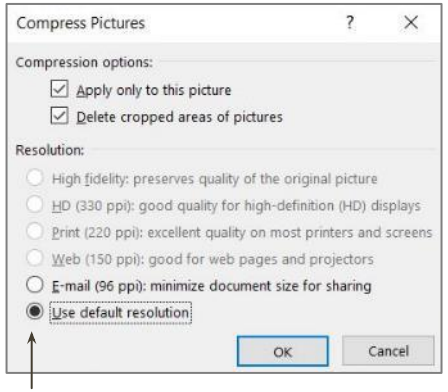

Choose **resolution.**