



# Advancements and Applications of Coherent Pluggable Technology in High Bandwidth Transport Networks

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BRKOPT-2556



# Agenda

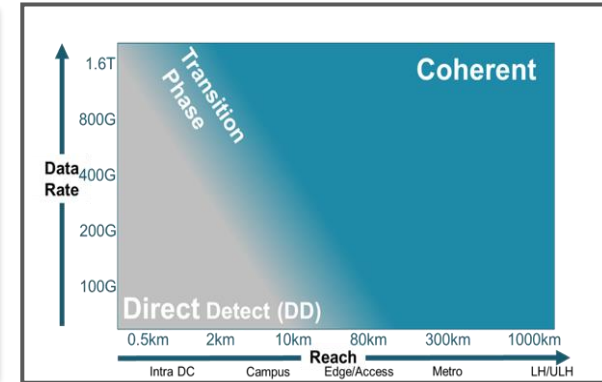
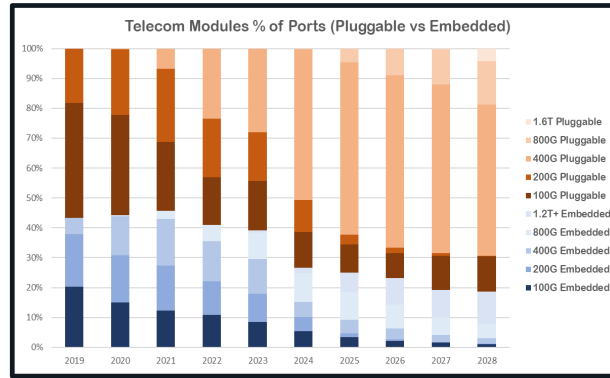
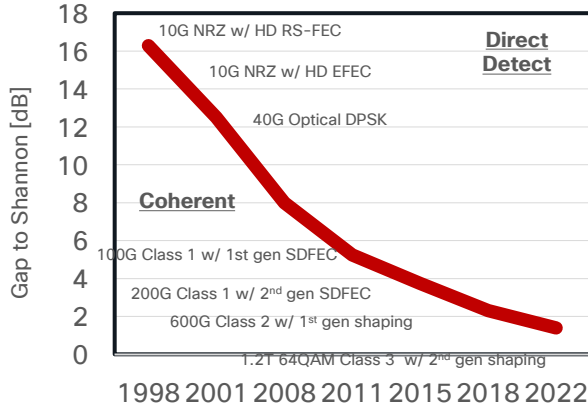
- Technology & Market trends
- Innovations & Product offerings
- Coherent Plugs – Why?
- Customer Use Cases & Applications

# Technology Trends

CISCO *Live!*



# Trends in Optical Networking



- Approaching Shannon Limit
  - Incremental improvements in spectral efficiency
  - Ongoing investment driven by cost, power reduction

- Shifting trend towards coherent pluggables\*
  - 400ZRx: fastest coherent product ramp ever
  - Gaining share in DCI/Metro

- Coherent moving to shorter reach applications
  - Higher volume
  - Interoperable
  - Pluggable

*High-volume standardized applications will drive next-generation industry investment*

# Open Networks

## OPEN LINE SYSTEMS

Any vendor coherent transponder or spectrum connects into Line System



ALL Cisco Line Systems are OPEN



## OPEN COHERENT INTERFACES

Interoperable standards-based coherent DWDM interfaces supported in MSA standard form-factor



Cisco committed to driving OPEN standards



## OPEN MANAGEMENT

Vendor Neutral device management  
Multi-layer, Multi-domain, Multi-vendor management



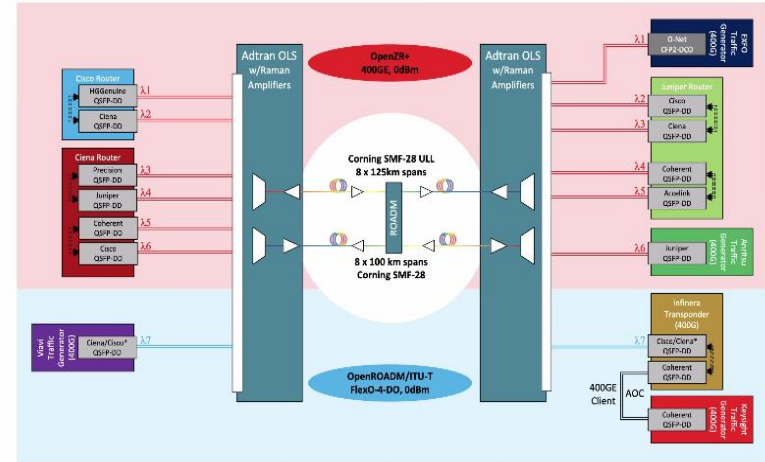
Cisco participating in key forums and developing MGMT support



# Standardization & Multi-vendor Interoperability Ecosystem

- Industry efforts to drive rapid multivendor time-to-market and economies of scale
- Cisco drove multiple industry standardization
  - Co-authored OIF 400ZR project start; editor
  - Actively drove 800ZR and 800G ZR+
  - Co-authored OIF 1600ZR project start
  - OpenZR+ MSA founding member & Co-Chair
- Contributed oFEC to support higher performance coherent interfaces

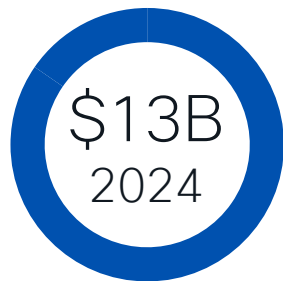
## OFC 2024 Multi-Span Interoperability Demo



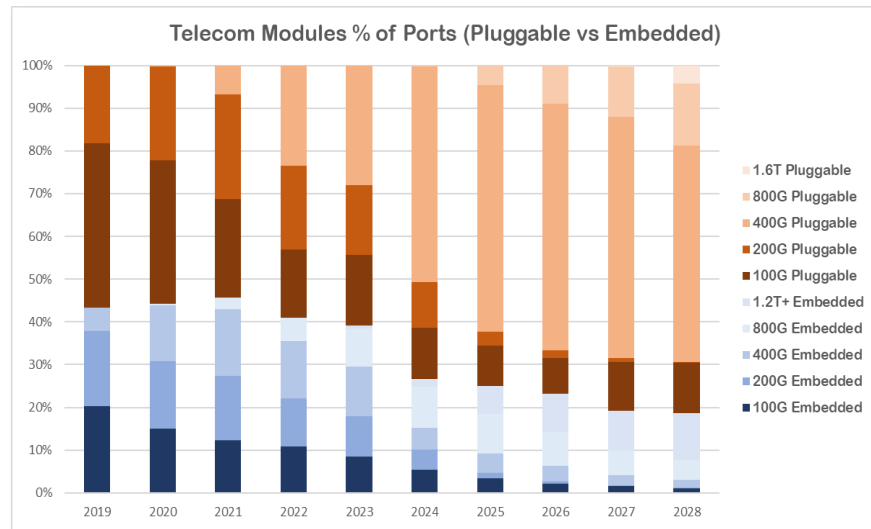
# Market Trends



# Big Opportunity and rise of “Coherent Pluggables”



\*Source: Signal AI 3Q24 Transport Hardware & Markets Report

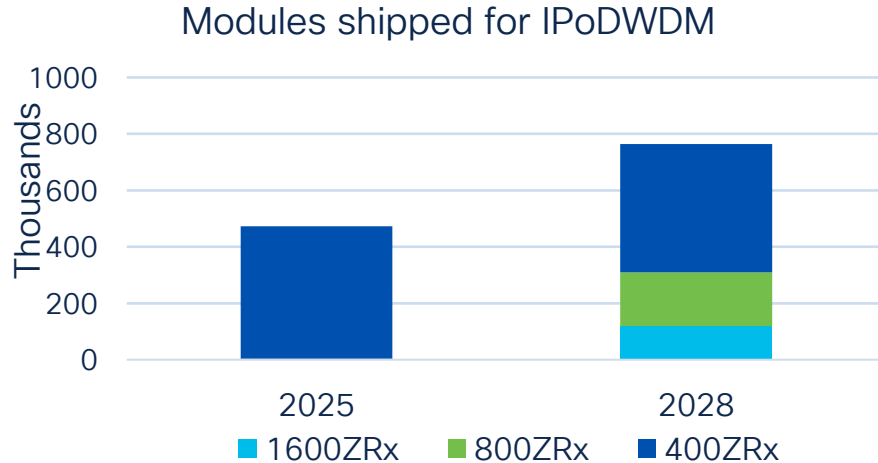


Today >70% of the coherent ports are pluggable coherent optics\*\*

*Cisco/Acacia is pioneer and market leader for coherent pluggables*



# IPoDWDM being deployed in volume ..

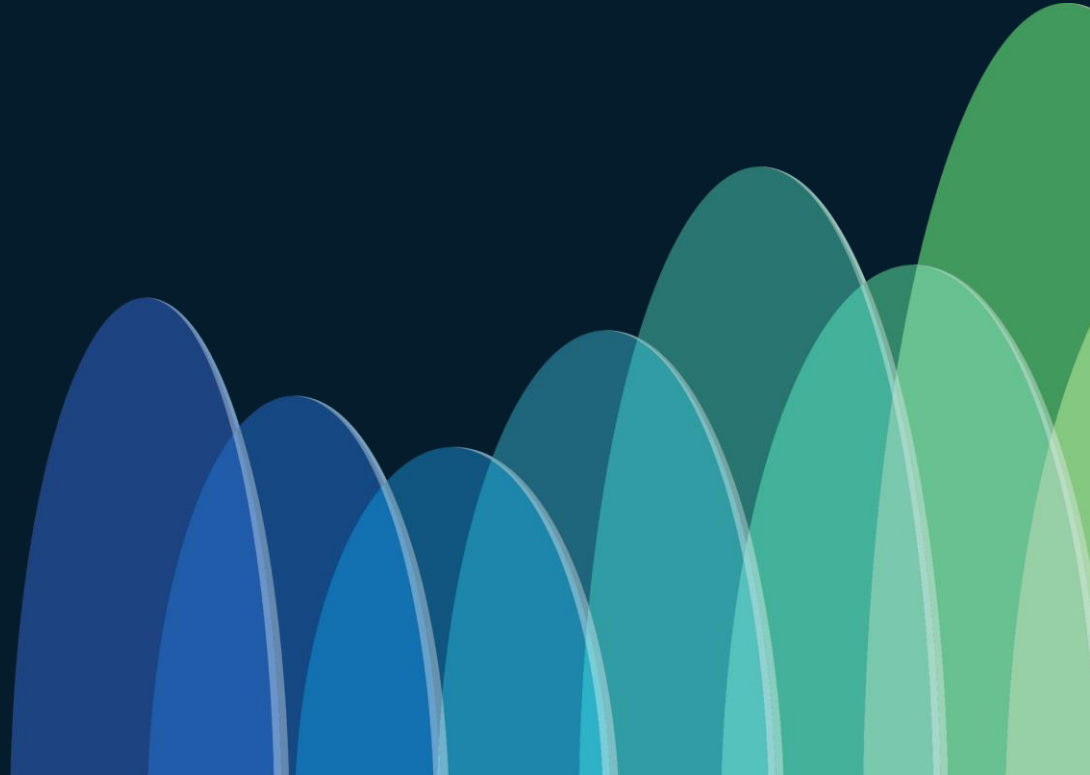


Source: Signal AI, IP-over-DWDM Pluggables Forecast, Aug. 2024

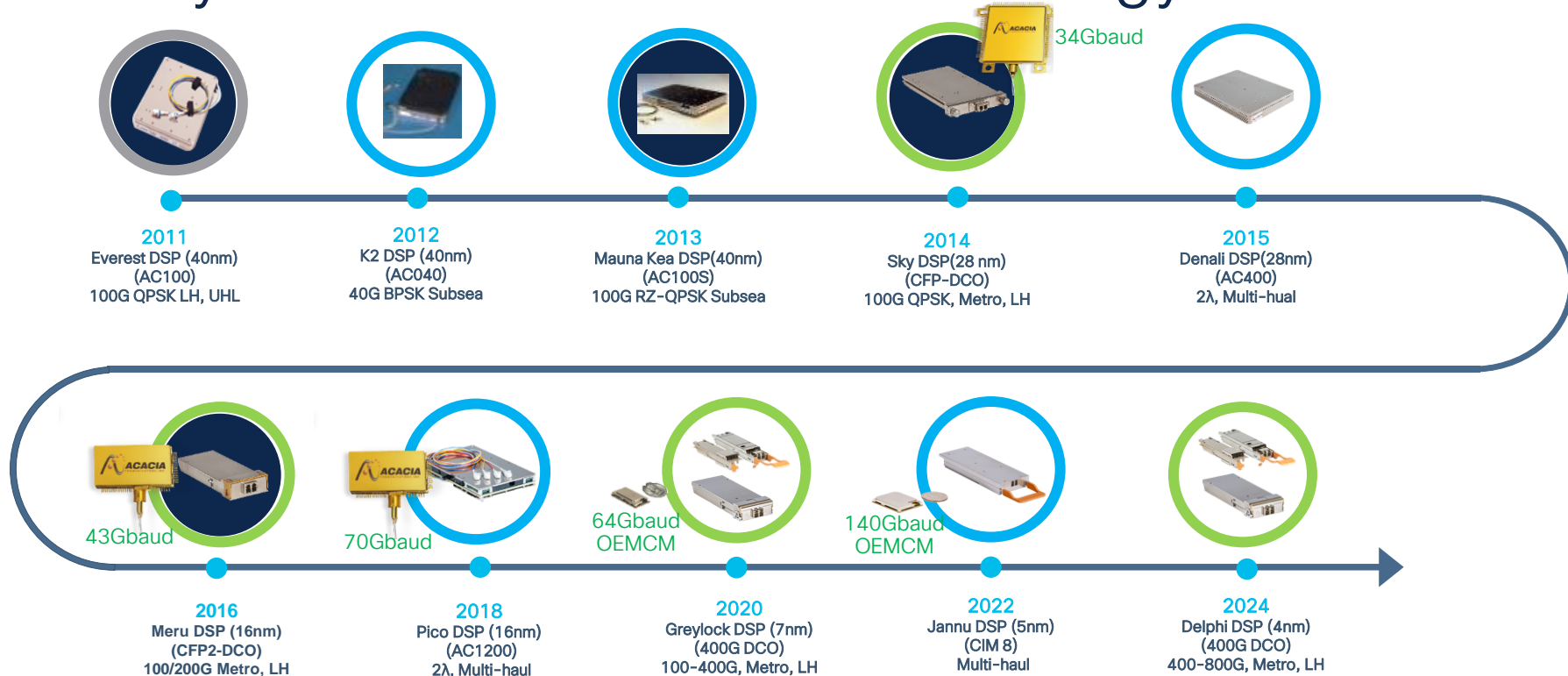
- IPoDWDM took off with “Metro DCI” deployments by hyperscalers
- Service Providers, Enterprises now started deploying IPoDWDM architecture in volume
- Next-gen coherent plugs are being designed for IPoDWDM application

# Cisco/Acacia Innovations

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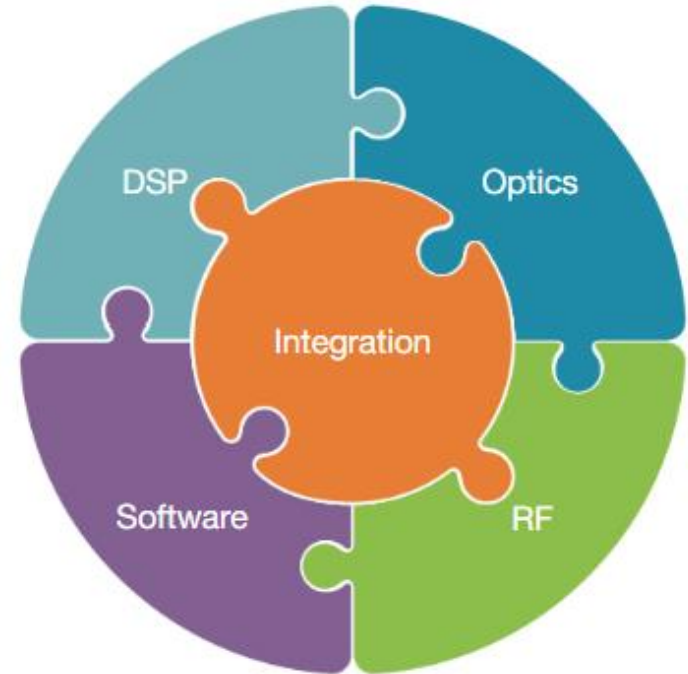


# History of Acacia Coherent Technology

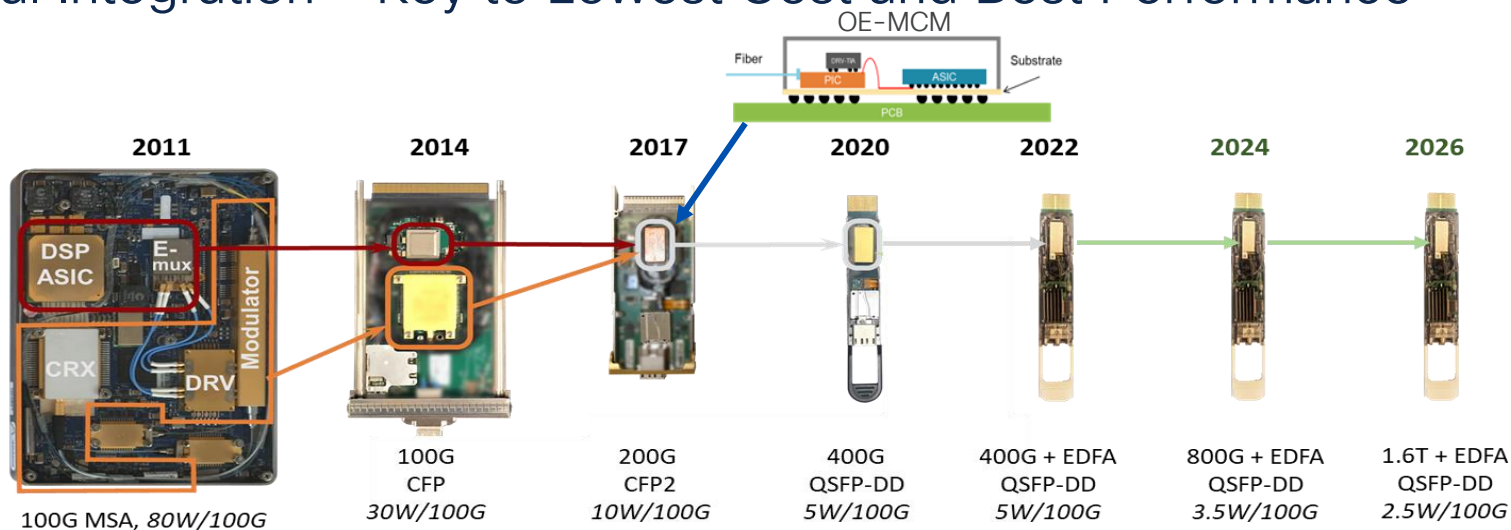


# Innovation Leadership

- Coherent pluggable technology leader
  - #1 in coherent module vendor worldwide<sup>1</sup>
- 
- Diverse markets served
  - DCI, Metro, Long-Haul, LEO, Submarine, Access, Campus
- 
- 100% Vertically Integrated
  - In-house key components: DSP/ASIC, Optics, RF
  - Advance 3D packaging



# Vertical Integration - Key to Lowest Cost and Best Performance



**In-House:**

DSP

+ SiPh Optics

+ OE-MCM

+ ASIC

100% Vertical

QAM:

QPSK

QPSK

16QAM

16QAM

PCS

PCS

CMOS:

40nm

28nm

16nm

7nm

4/3nm

2nm

Optics:

Discrete, InP, LiNbO3

SiPh

SiPh

SiPh

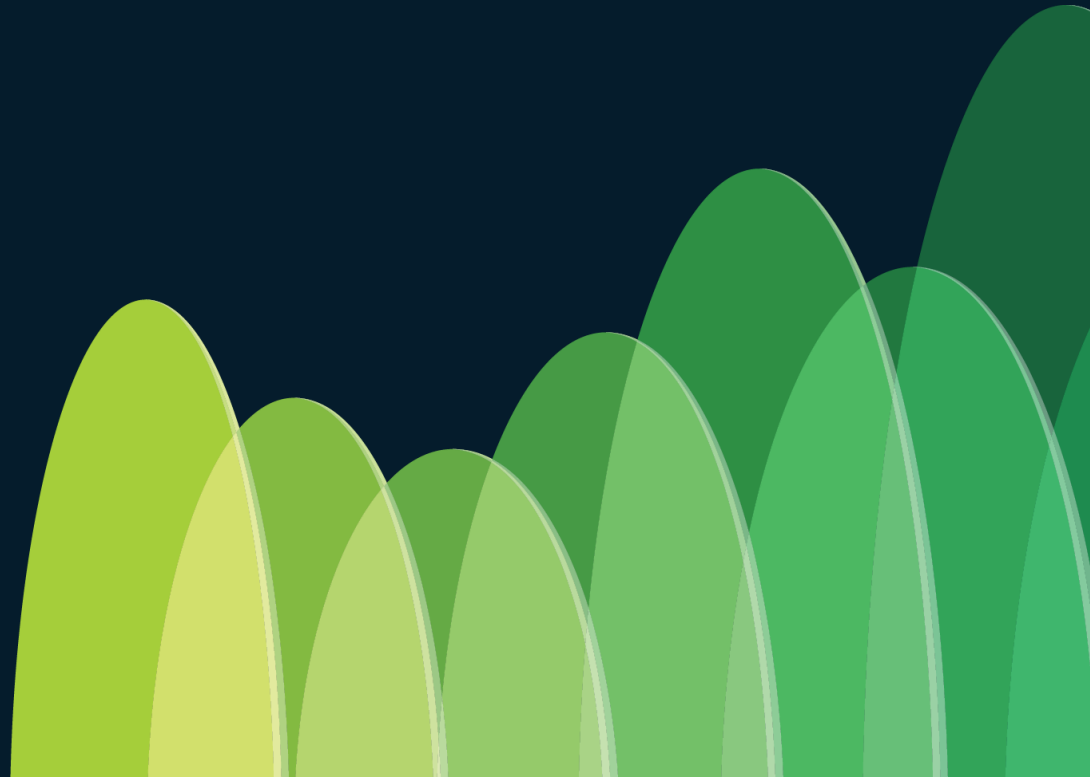
SiPh

SiPh/TFLN

*Cisco is the only company that is 100% Vertically Integrated today*

**cisco** Live!

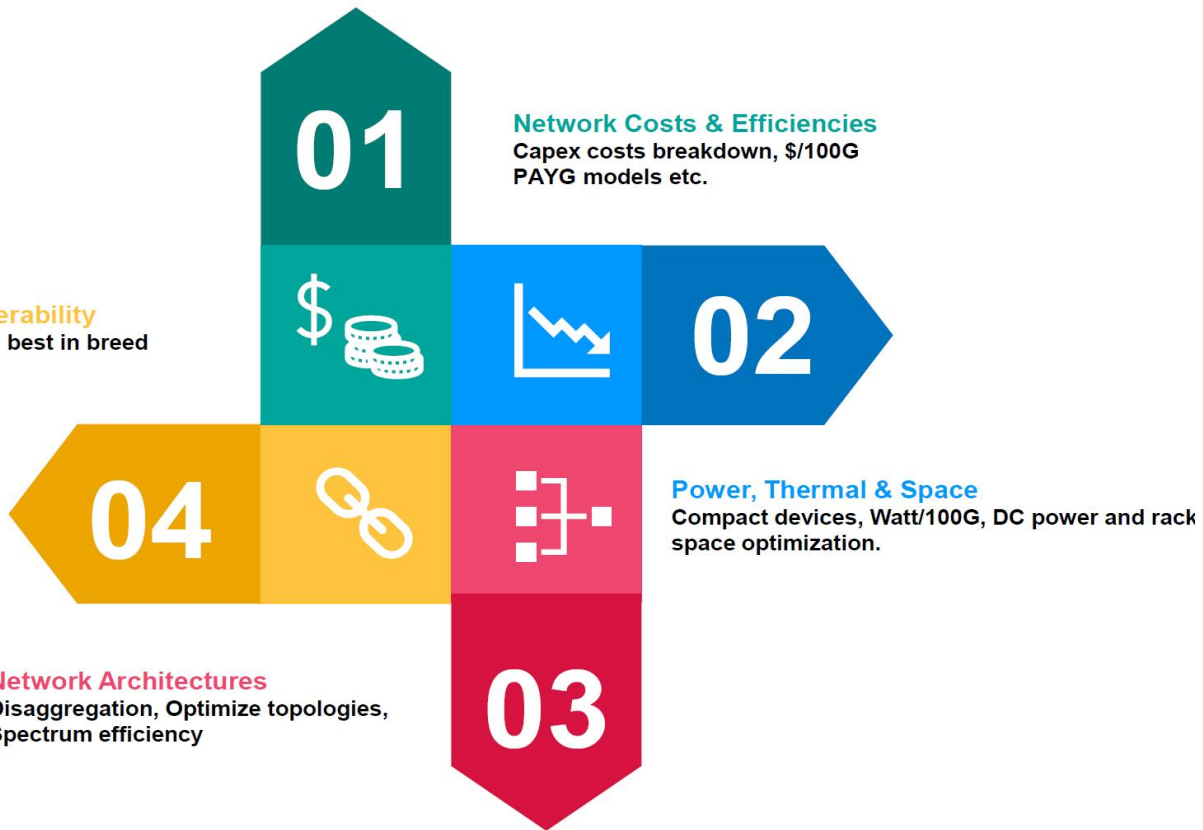
# Why Coherent Pluggables?



# Coherent pluggable brings some important levers



**Drives Interoperability**  
MSAs/standards, best in breed adoption



# Cisco Coherent Optics Value Proposition

Pioneer in Coherent Pluggables

- 4th generation DSP for MSA coherent pluggables
- Market leader in 400G pluggable ports

Industry leading performance

- Low power consumption
- Designed for C/CD/CDC ROADM architectures

Best in class Quality

- 80M+ service hours without failure for 400G Bright ZR+

100% Vertically Integrated

- In-house DSP, PIC, Laser, RF components

Scalable and Reliable Global Supply Chain

- Fabless Manufacturing
- Scalable module build/test capacity to meet demand



# Product Offerings

# Approaches of Coherent Implementation

2014

2016

2020

2024

MSA  
Pluggable  
(aka DCO)



Industry's first pluggable coherent module (100G CFP)



100G/200G CFP2-DCO



400G pluggable portfolio in QSFPDD, OSFP and CFP2



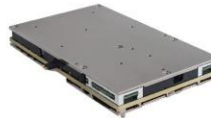
800ZR/ZR+ and 400ULH pluggables – QDD & OSFP

Deployed in router/switches and transport platforms (e.g., 8K, ASR9K, NCS, Nexus 9K etc.)

Multi-Haul  
Performance  
Optimized



400G multi-haul module (AC400)



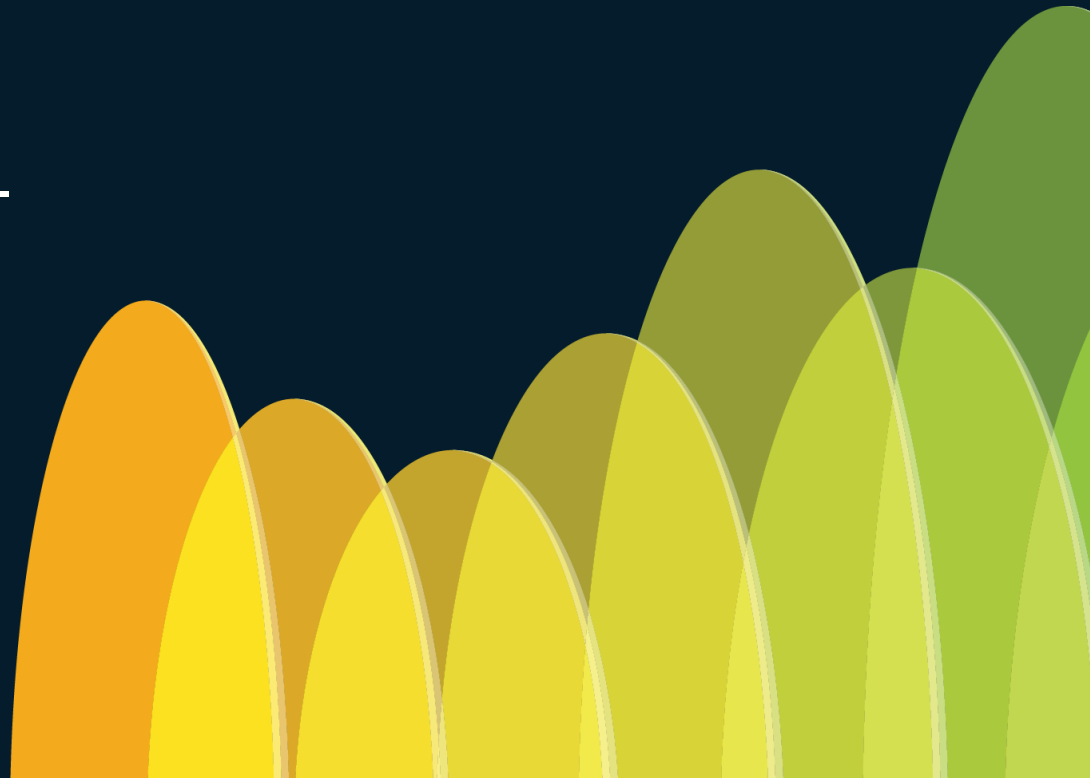
1.2T Coherent Module (AC1200)



Industry's first 1.2T coherent multi-haul pluggable (CIM8)

Deployed in transport platforms (e.g., NCS 1004, 1014 etc.)

# Power optimized – MSA Pluggables



# Comprehensive 400G MSA Pluggables Portfolio

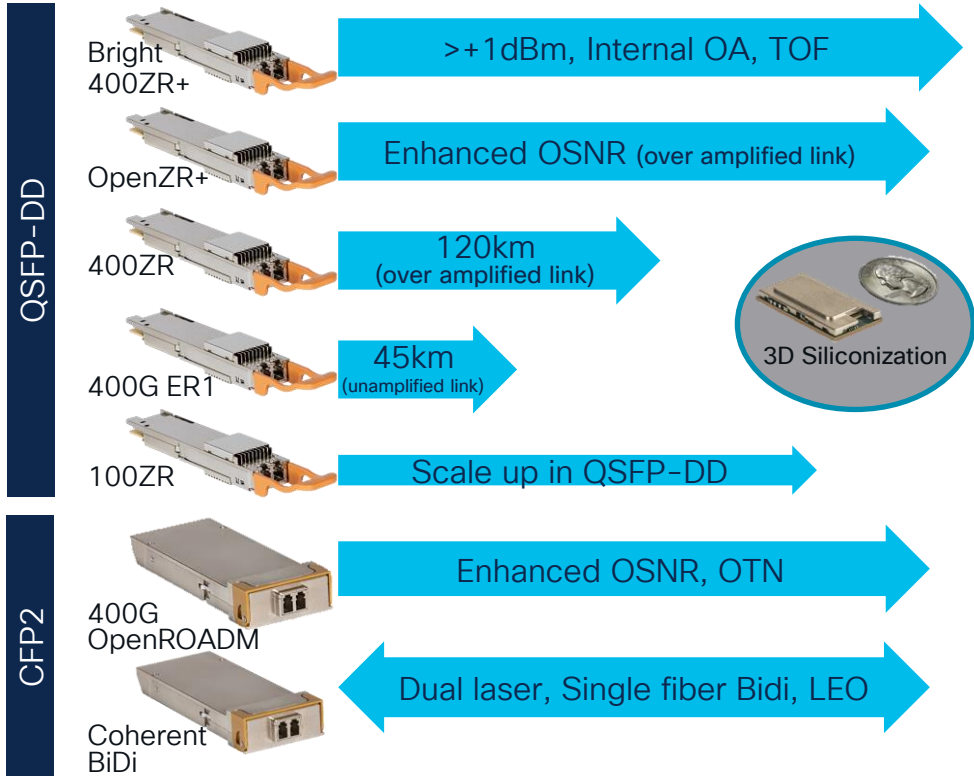
Industry leading 400G pluggable deployments

Best in class quality

Standards compliant



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# 400G QDD Digital Coherent Optics Portfolio

## ER1



### Point to Point

Intra-data center, campus interconnect, core-to-edge router



### Lowest Cost

Based on fixed laser with simple point-to-point connectivity



### Short Reach

Up to 45KM for unamplified at 13dB

Use Case %



Network Coverage

## ZR



### Point to Point

Web, Data Center Interconnect, Non-SP/SP router interconnect



### Low Cost

Lowest cost 400G DCO option for very simple designs



### Short Reach

Up to 120KM for P2P amplified links

Use Case %



Network Coverage

## Bright ZR+



### Transport Centric

Service Providers, Routed Optical Networking



### High TX Power

+1dbm for difficult spans; interop with brownfield transponder & legacy line systems



### Advanced Features

TOF, OTN and L1 Encryption features; integrated optical amplifier

Use Case %



Network Coverage

## ULH



### Transport Centric

Service Providers, Routed Optical Networking



### Long haul optimized

400G with **RON Anywhere** up to 3000km, high Tx power



### Power optimized

Designed to fit in all routers support 400G Bright ZR+ today

Use Case %



Network Coverage

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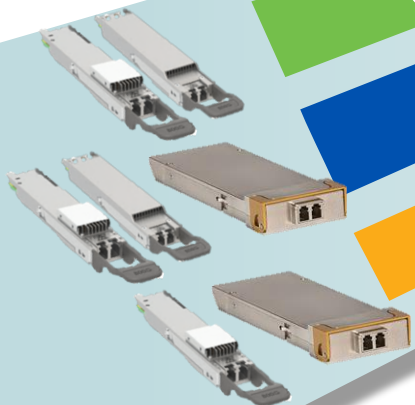
# Welcome to the Next-Gen Coherent Pluggables !

- Latest 4nm CMOS process
- Up to 131 Gbaud Optics
- 1st to support interop PCS 800G ZR+ (OpenROADM) and OIF 800ZR modes
- Supports CMIS 5.3
- C & L Band

800ZR

800G ZR+ (Interop PCS, +1dBm)

400G Ultra Long Haul



Silicon Based



# 400G Pluggables Comparison: Today & Future

		400ULH	Bright ZR+
Data rate	Baudrate/Format	Modes	Modes
400G	118Gbd QPSK	X	
	Multiple PCS modes for different channel plans	X	
		X	
		X	
	60Gbd 16QAM	X	
200G	60Gbd QPSK	X	X
100G	30Gbd QPSK	X	X

→ 400G ULH provides >200% reach than Bright in 2x spectrum

→ 400G ULH provides >100% reach than Bright in 33% more spectrum

→ 400G ULH provides >50% reach than Bright in the same spectrum

→ 400G ULH would be backward compatible with Bright ZR+ in OpenZR+ 2.0 modes.

400G ULH modes with Delphi

OpenZR+ 2.0 MSA modes

# Pluggable Coherent Innovation continues

*Delphi 400G-ULH, 800ZR+ available today*

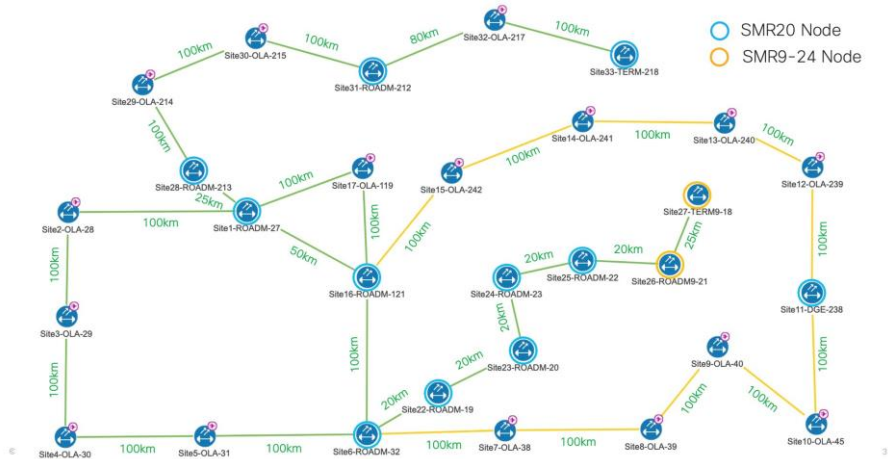


Designed for existing 400G host platforms



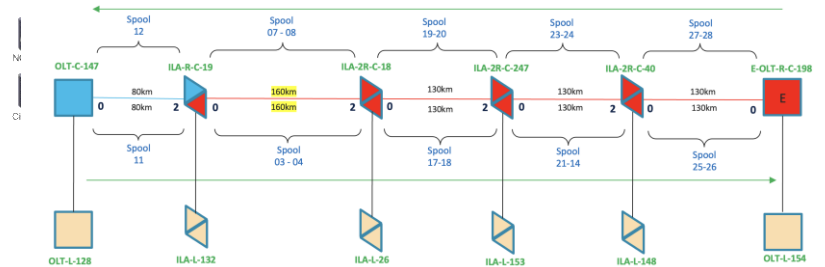
Designed for new 800G host platforms

## 400G ULH over 3000km NCS 2000 network



## 800ZR+ over 1200km NCS 1010 C+L network

### Demo 3: Fiber Spool per Span + Direction





# Customer Field Trials - 400G ULH & 800ZR+

## 400ULH

- Denver to Chicago - 2250km route
- Multiple ROADMs
- Mixed fiber, G.652 + G.655
- 400G 98Gbaud / 112.5GHz spacing
- Healthy margin (>1.6dBQ) in both directions

## 800ZR+

- Frankfurt to Munich, 634km
- Mix of G.652 and G.655 with several long spans > 100km
- Multiple ROADMs
- 800ZR+ OpenROADM interoperable mode with margin



# What's next?

- 1.6T ZR

- Major decisions made by OIF
- Single optical carrier, 240Gbaud-16QAM, oFEC
- Target Power: <30W
- Target schedule: samples in 2H 2026



- 1.6T ZR+

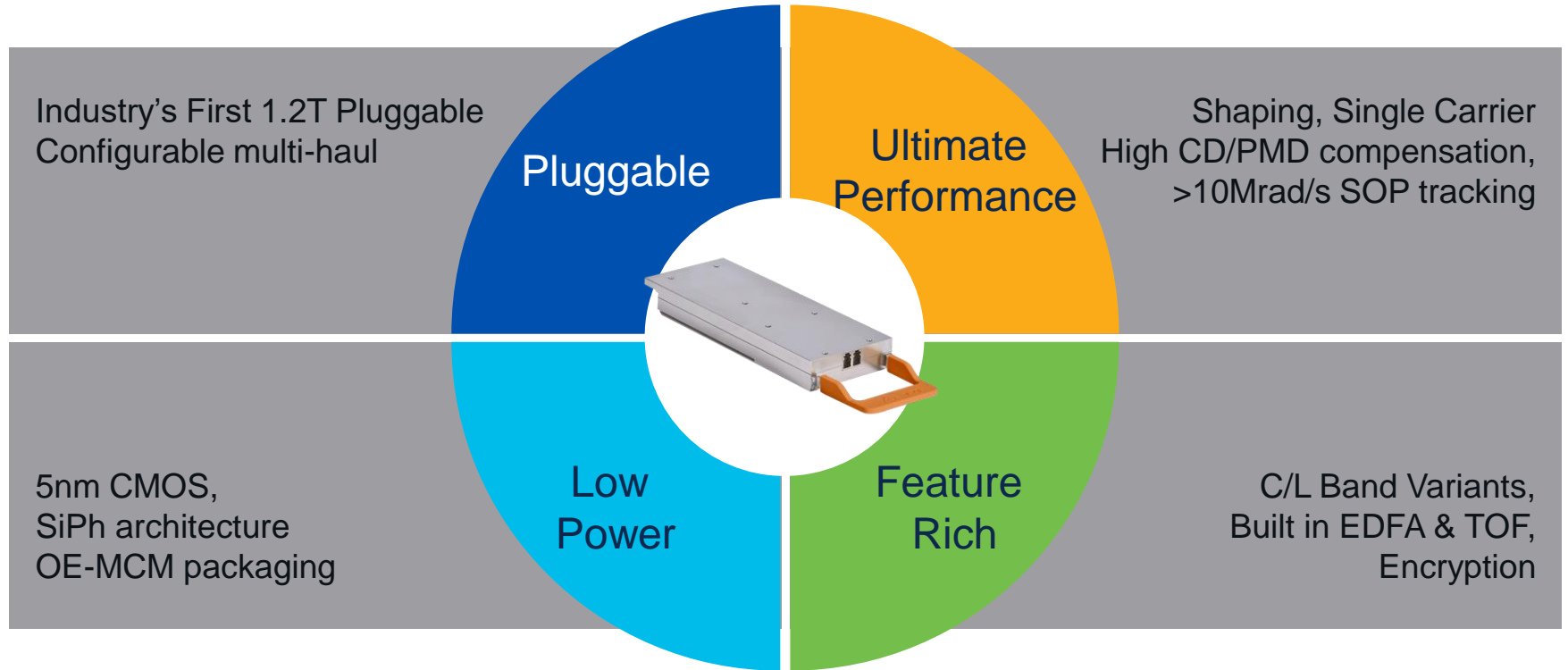
- Project start in Q1, 2024
- Cover 800G UHL (C/L-band)
- Discussions focused on EEPN
  - Laser linewidth requirements
  - Single or 2/4 sub-carriers
- Target Power: <35W
- Target schedule: samples in 2027



# Performance optimized – Multi-haul modules



# Coherent Interconnect Module 8 (CIM 8)



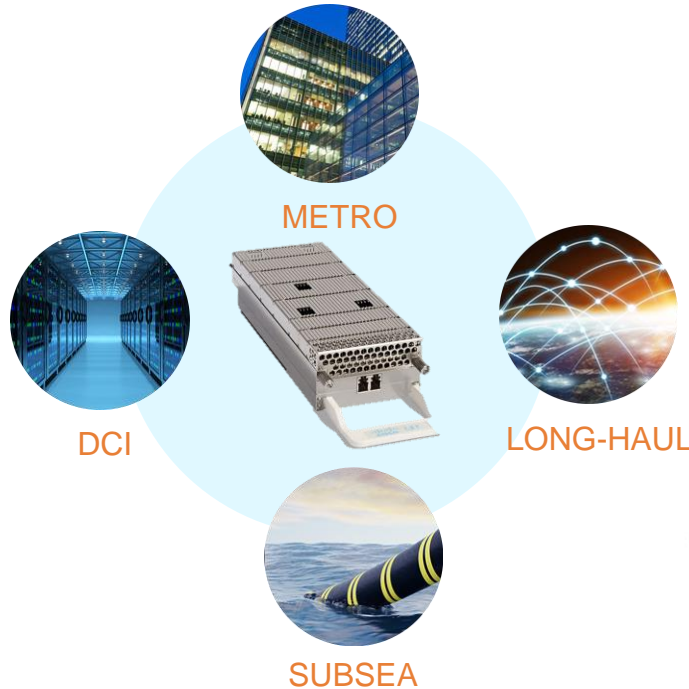
# First Pluggable to Break into the Terabit Era

Coherent Interconnect Module 8 (CIM 8) powered by Jannu DSP

20%+ performance  
with 3D shaping –  
800G covers 90% of  
network

65% lower power than  
competition

3D Siliconization  
packaging



2.4Tbps Transponder



NCS 1014 Next-Gen  
compact modular



Single carrier 140Gbd 1.2T faceplate pluggable

# Top Networks Are Adopting Our Technology

## NCS 1014 Industry Leading Performance

**verizon**



Commercial fiber network with 1Tbps across 14x spans



windstream wholesales



1 Tbps wavelength over a 1,100 km link across Windstream's Intelligent Converged Optical Network



800Gbps on the Amitié transatlantic communications cable



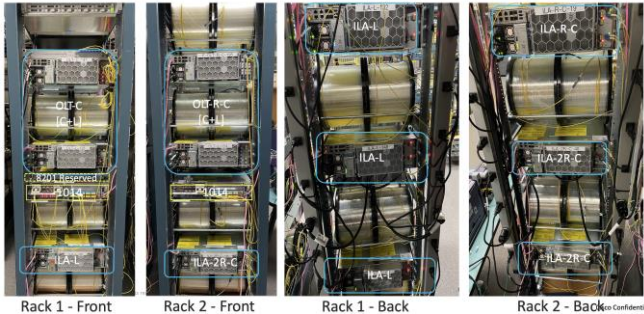
Longest distance 400 Gbps transmission trial on the Indigo subsea cable system; 18,400 km from Sydney to Singapore

# NCS 1014 CIM8 delivers 64T for C+L Long Haul



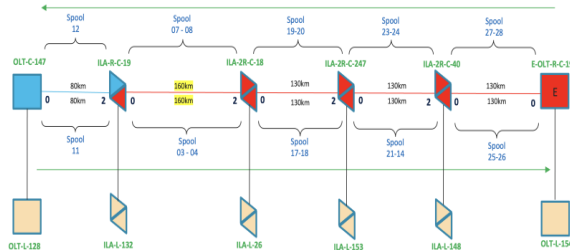
64T (32T in C-Band and 32T in L-Band with NCS 1014 and Coherent Interconnect Module 8 over NCS 1010 C+L Open Line Systems and *Corning Vascade EX2500 fiber*

Demo 3: NCS 1010 LH



Rack 1 - Front    Rack 2 - Front    Rack 1 - Back    Rack 2 - Back Confidential

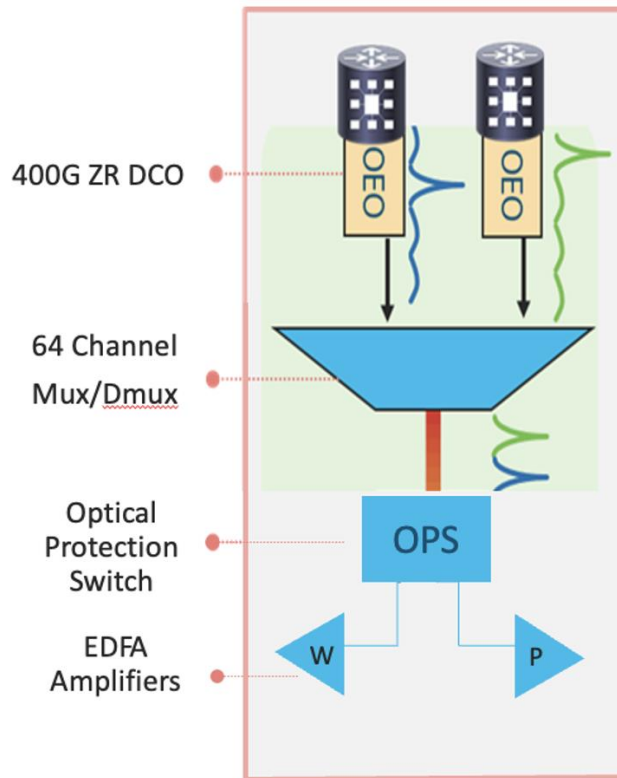
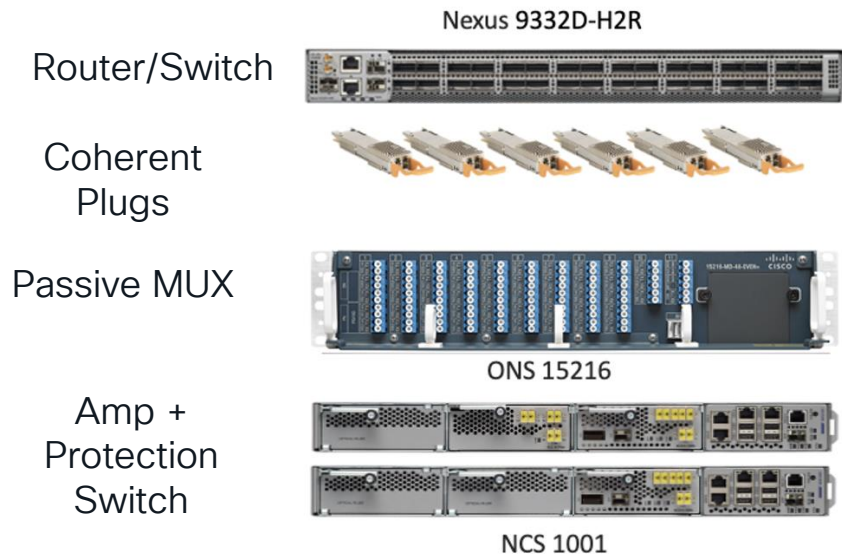
Demo 3: Fiber Spool per Span + Direction



# Applications & Customer Use Cases



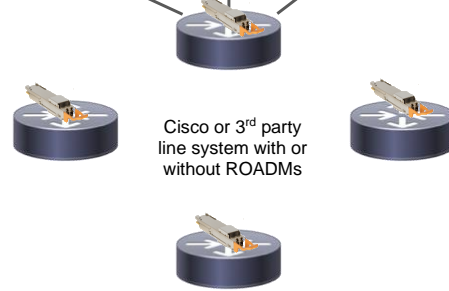
# Typical DCI/Enterprise Solution – Router Optics based



# Typical SP Customer Use Cases

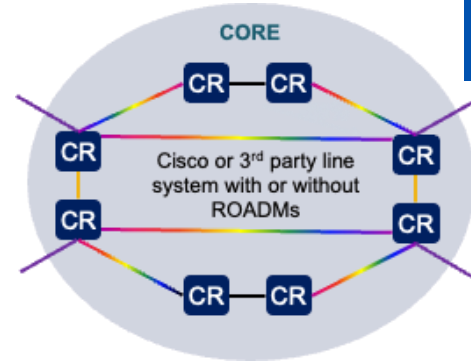
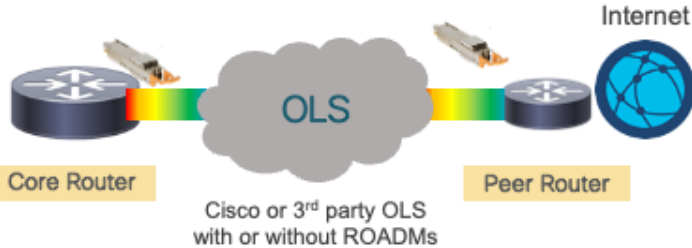
P2P non-WDM

< 80KM



Metro Aggregation

P2P DWDM



Core Network

# RON Deployments



TCO*	46%
CapEx*	35%
OpEx*	57%

348

Customers Engaged

300+

Customer deployments

4x

Growth in deployments in FY24

*Majority of the RON deployments are over 3<sup>rd</sup> party line system (Ciena, Nokia, Infinera etc.)*



\* ACG Research 2023

# 400G DCO Can Go the Distance

**SP in EMEA**

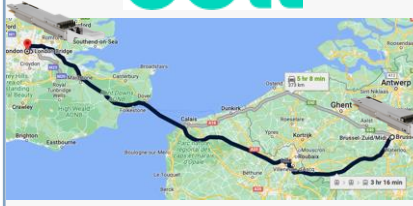


NCS-57C3

~675km

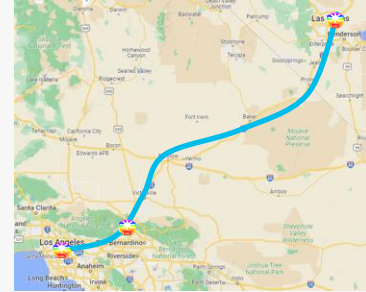
- Bright 400ZR+ QSFP-DD
- Alien  $\lambda$  over 3rd party line system
  - CDC ROADM, EDFA only
- >2.5dB margin
- Plug and play!

**colt**



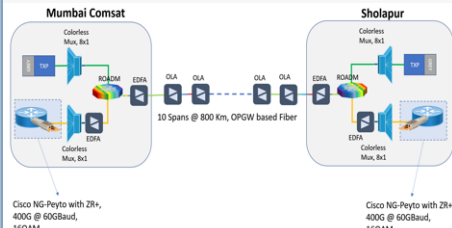
- Bright 400ZR+
- Across the English Channel with challenging high loss span
- Trial 1 at 430km; Trial 2 at 640km
- >2.5dB margin

**MSO in NA**



- Bright 400ZR+ with 8201
- 520km high loss E-LEAF fiber, span > 26.5dB
- Two different OLS vendors
- Error free with margin

**Tier 1 SP in India**



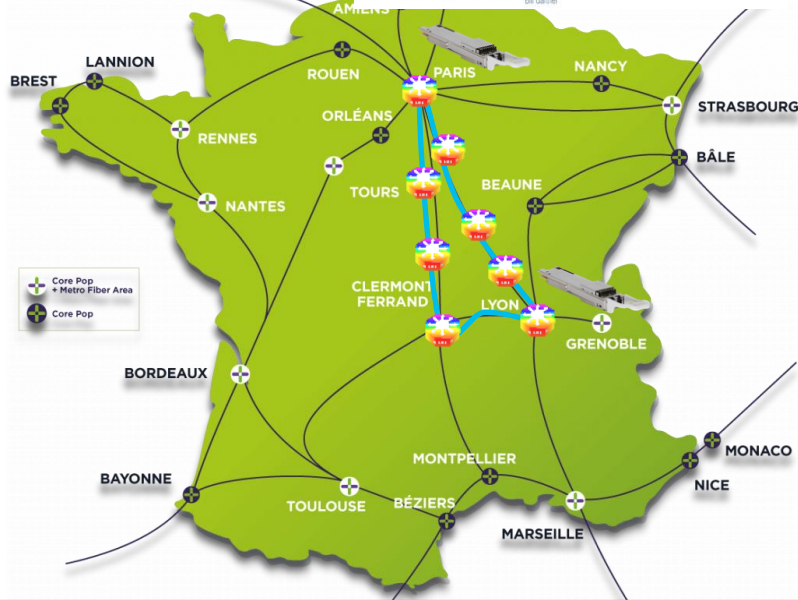
- 400ZR+ with Cisco routers
- >800km longest route
- Core network over 3<sup>rd</sup> party ROADM OLS

Bright ZR+ has reach 600-800KM with good deployable margin over ROADM based OLS

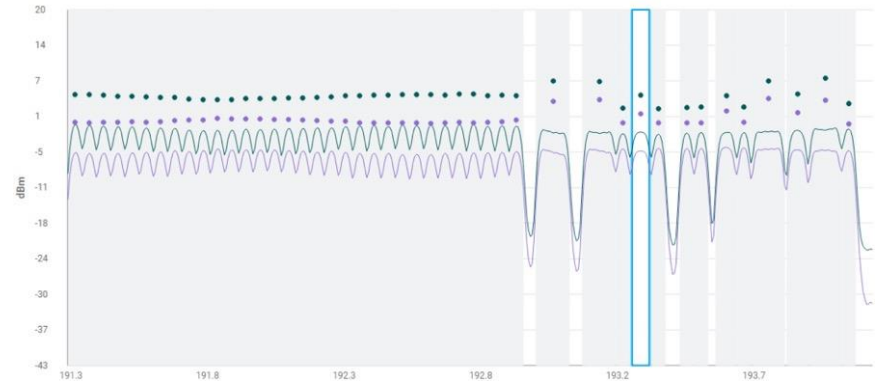
# Sipartech – 400GbE over 1337km with Bright ZR+



SP360: Service Provider  
Cisco at OFC 2023: Announcing Successful  
Test with Sipartech to Deliver 400G Over  
1,337 km  
Bill Garner



- Mixed SMF28 and E-LEAF fiber with 8 ROADM sites
- Alien  $\lambda$  over 3<sup>rd</sup> party CDC ROADM line system, plug and play!

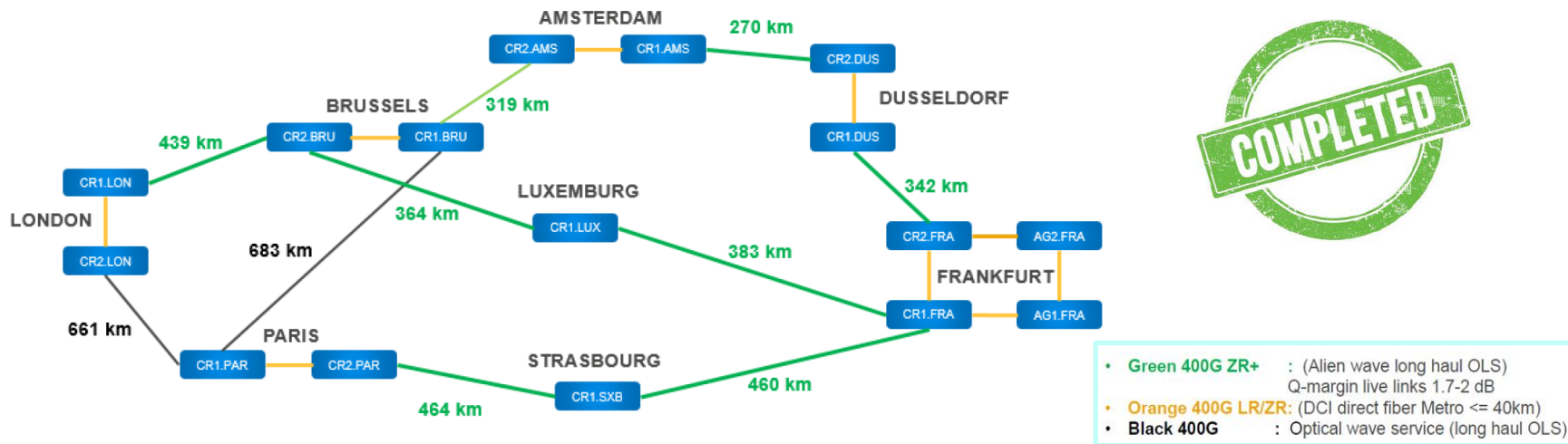


“With the interoperability of Cisco’s equipment, we can deploy our next generation 400G+ services with speed, simplicity, and flexibility to meet our customers’ needs, while optimizing energy expenditure and our carbon footprint as part of our global strategy.” – Julien Santina, Sipartech CEO

# Colt Packet Router Core transformation using 400G DCO

Pioneering adoption of 400G ZR/ZR+ over OLS – transformed Colt Global IQ Packet Network.

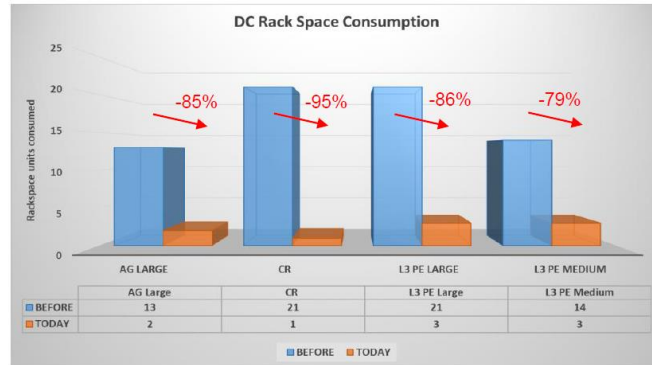
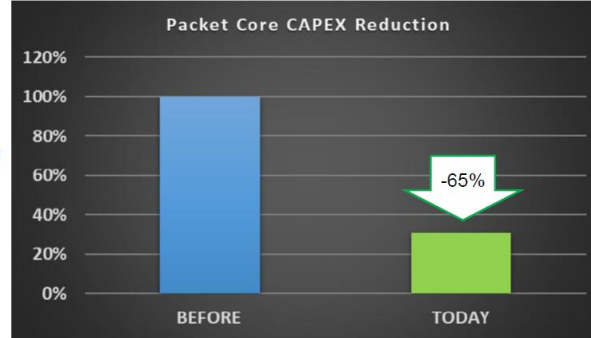
- Successfully deployed on Colt's European core backbone.
- Cisco's SiliconOne 8000 hardware with 400G ZR/ZR+ optics over Colt's next-gen OLS from Ciena.
- Prior experience from successful optical alien-wave deployment, spectrum products.



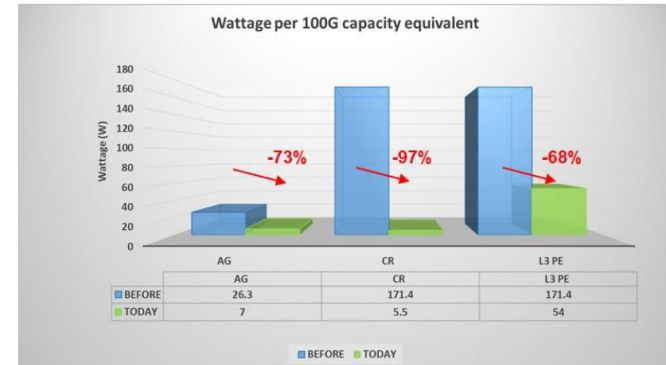
<https://www.coit.net/resources/colt-takes-network-innovation-to-new-heights-with-a-400g-capable-routed-optical-networking-solution-on-its-iq-network/>

# Colt's Packet Core Transformation – Benefits & Outcomes

Capex reduction in packet core network by 65%



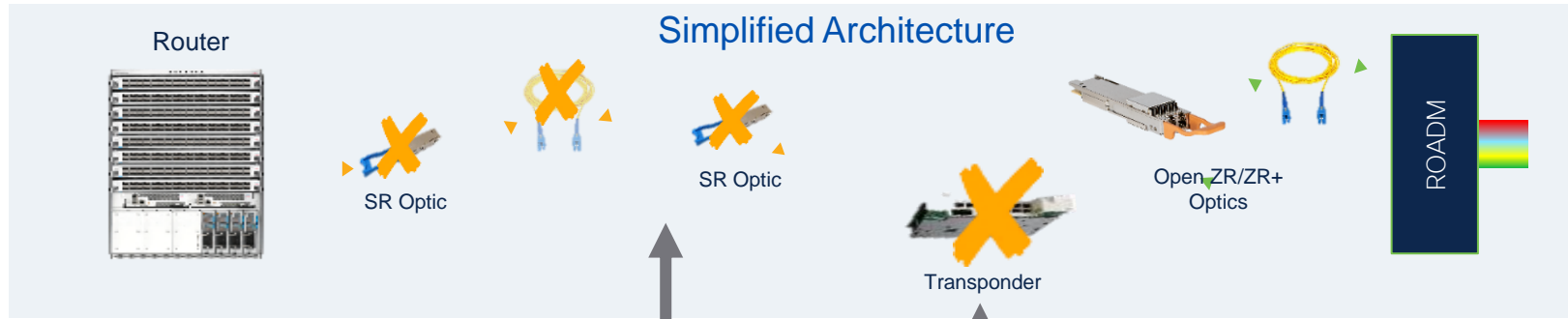
DC rack space reduction by 79% to 95% using compact routers in Core, Aggregation and IP Edge layers



Watt per 100G improvement in core routers by 97%.



# Summary – Coherent Optics enables IP-Optical Convergence



- Eliminate transponder and associated shelf/chassis
- Eliminate client optics

**“Simplicity is the ultimate sophistication”  
– Leonardo da Vinci**



# Webex App

## Questions?

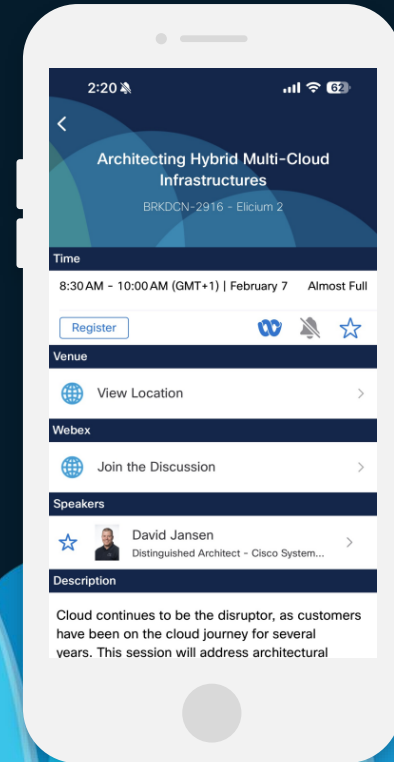
Use the Webex app to chat with the speaker after the session

## How

- 1 Find this session in the Cisco Events mobile app
- 2 Click “Join the Discussion”
- 3 Install the Webex app or go directly to the Webex space
- 4 Enter messages/questions in the Webex space

Webex spaces will be moderated by the speaker until February 28, 2025.

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Participants who fill out a minimum of 4 session surveys and the overall event survey will get a unique Cisco Live t-shirt.

(from 11:30 on Thursday, while supplies last)



All surveys can be taken in the Cisco Events mobile app or by logging in to the Session Catalog and clicking the 'Participant Dashboard'



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- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
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Thank you

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GO BEYOND

A series of overlapping, vertically-oriented ovals in various shades of blue, ranging from light to dark, positioned on the right side of the image.