Meeting the Need for Speed – 100G and Beyond

OFC-NFOEC 2011

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OIF OPTICAL INTERNETWORKING FORUM

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Outline

- **The 100G demand and challenges**
- **The OIF's approach**
- **100G status**
- **Beyond 100 – What, when, and at what cost?**

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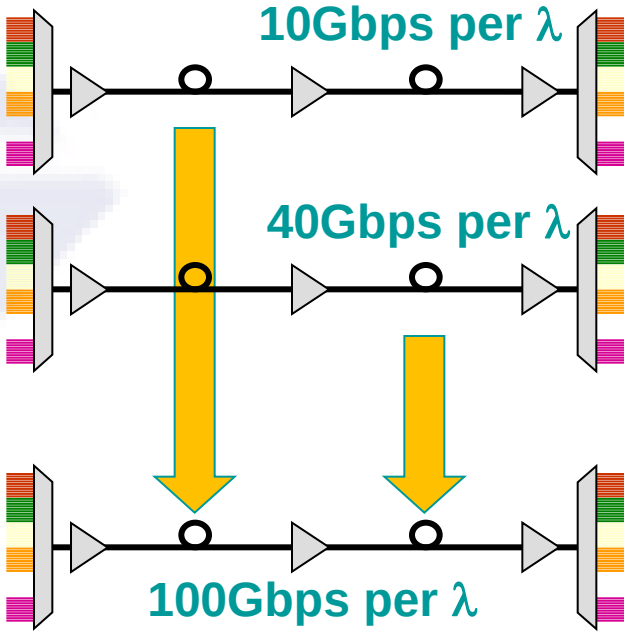
The 100 G Carrier Challenge

Objectives identified by the OIF Carrier Working Group

- **100G channels**
  - **100 GE and ODU4**
- **Scale system capacity**
  - **To 8-10 Tbit/sec**
- **On existing infrastructure**
  - **Reuse amps and ROADMs**
- **Improve CAPEX**
  - **Reduce cost/bit/sec/km**
- **Improve OPEX**
  - **Avoid parallel systems**



Primary application is for backbone networks

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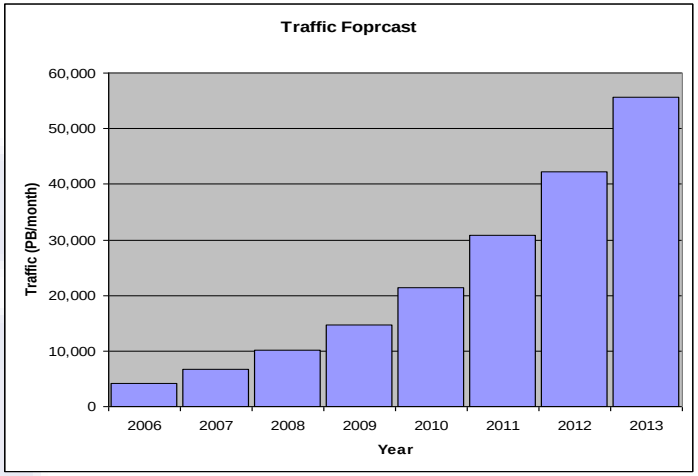
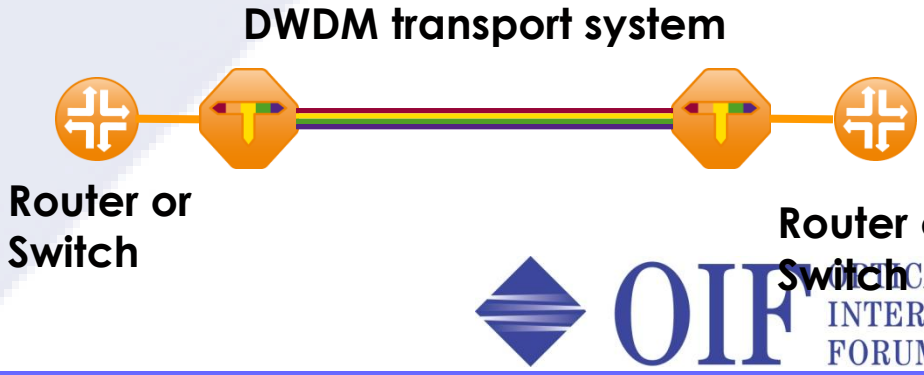
The Need for Speed

- **Growing bandwidth demand, exponential increase of backbone traffic**
  - **Exponential growth expected to continue**
  - **Pricing per bit to decrease**



- **Transport native 100G signals**
  - **Router and switch interconnections**
  - **100G services**



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* Source: Cisco Visual Networking Index: Forecast and Methodology, 2008-2013

The Need for Speed

- **Primary 100G demand**
  - **IP platforms**
  - **CDN – Content Delivery Networks (Super-Aggregators, Content Providers)**
- **OTN platforms**
  - **Provide highest transport bandwidth**
  - **Provide most energy efficient grooming and transport**
- **IEEE: 802.3ba published on June 22nd, 2010**
- **ITU-T: Amendment to ITU-T Recommendation G.709 to make mappings of 40GBASE-R into OPU3 and 100GBASE-R into OPU4 normative consented by ITU-T SG15 on June 11, 2010**

OIF 100G IAs transport solution over OTN available in 2010

The 100 G Technology Pipeline Challenge

- **Challenges**
  - **Highly fragmented industry**
    - **System vendors through technology suppliers**
  - **Weak business case**
    - **Large investment today, uncertain returns in future**
  - **Result – Reluctance to invest in critical technologies**

- **The Good News**
  - **Critical mass of support for one technology direction**
    - **Includes system vendors and transceiver suppliers**

Focused technology investments will reduce risk to all

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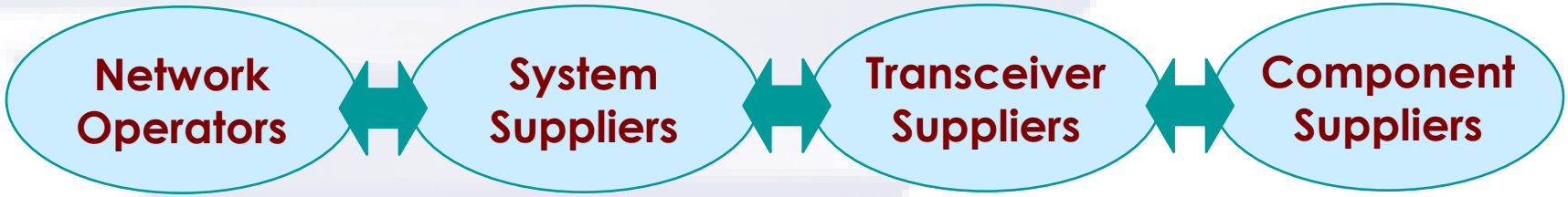
OIF's Role in 100G

Foster an eco system to accelerate the availability of economically attractive 100G transmission solutions for ULH DWDM networks



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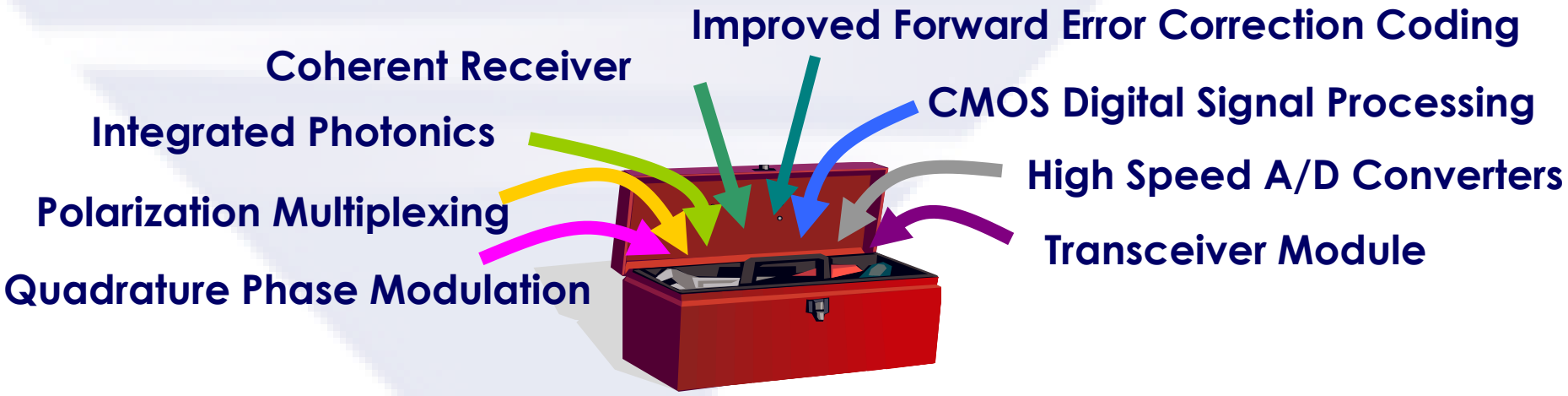
The 100G Toolkit
Two Key Technologies

- **Electronic Signal Processing**
- **Integrated Photonics**



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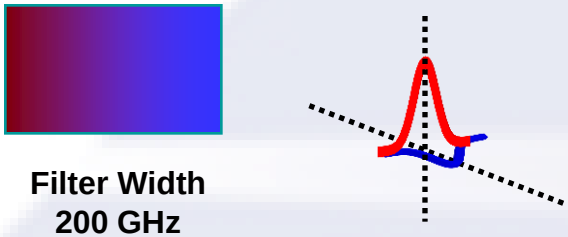
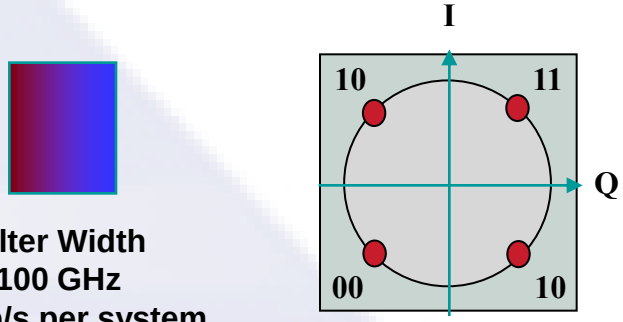
100G Modulation Format Assumption

Dual Polarization



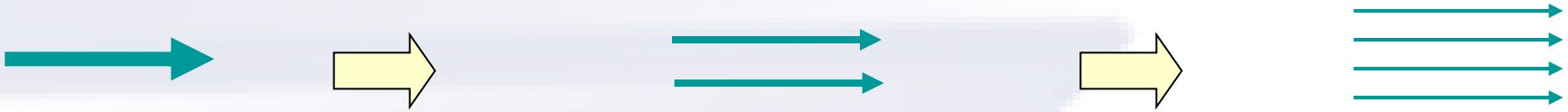
Filter Width
200 GHz
~ 2 Tb/s per system

Quadrature Phase Shift Keying



Filter Width
100 GHz
~ 4 Tb/s per system

Filter Width
50 GHz
~ 8 Tb/s per system



1 X 100 G **2 X 50 G** **4 X 25 G**

Trade speed for parallelism, then attack parallel complexity with photonic integration

- **Two independent polarizations**
  - Same optical frequency
  - Halves the data rate
  - Halves the spectral width
  - Doubles components
- **Data encoded into 4 phase states**
  - Phase symbol – 2 bits of data
  - Halves the symbol rate
  - Halves the spectral width
  - Doubles components

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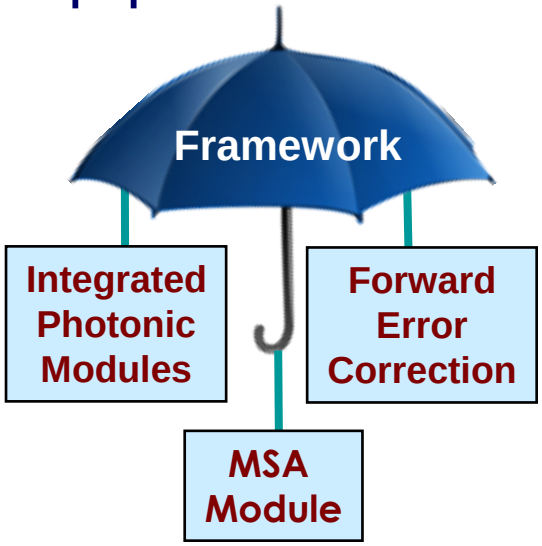
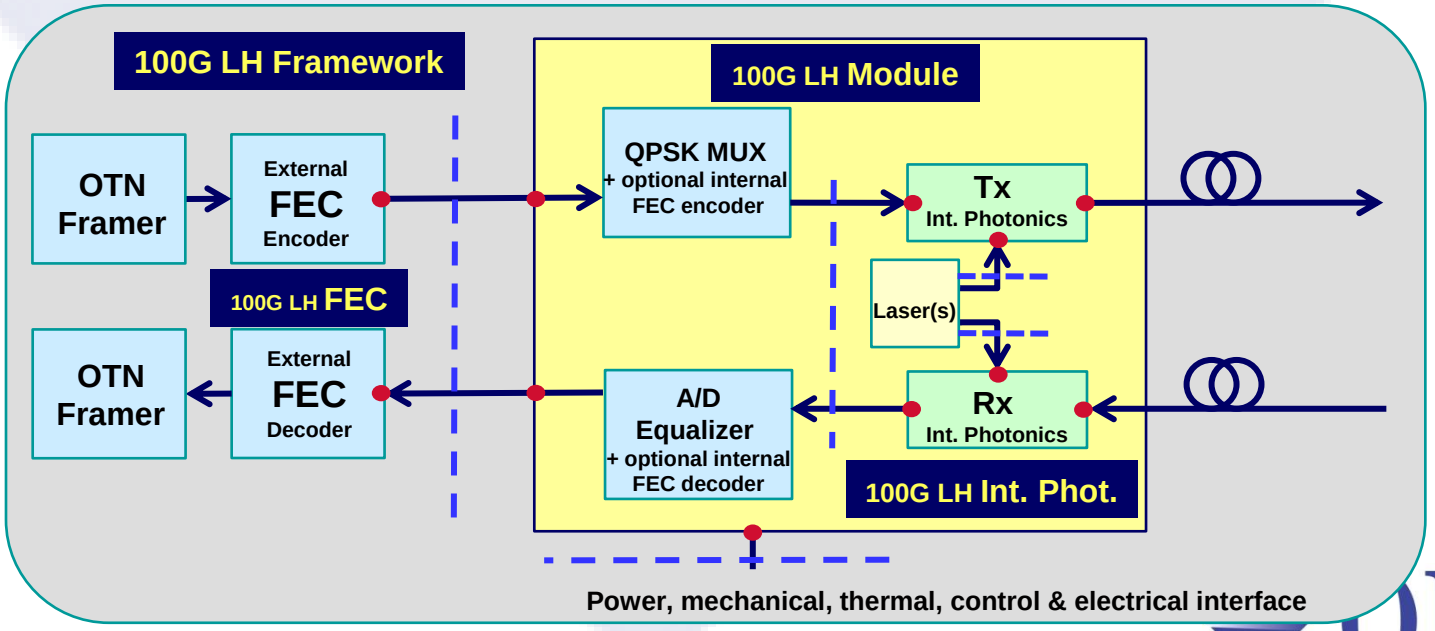
OIF's 100G DWDM Project Approach

Our Approach

- Select an application target – Core backbone networks
- Build upon IEEE and ITU-T standards
- Agree on modulation format
- Identify key technology building blocks and interfaces
- Develop IAs among building blocks
- Develop Implementation Agreements (IA) for MSA transceiver module and integrated photonics module
- Note that "Line side" DWDM system interoperability is not a current objective

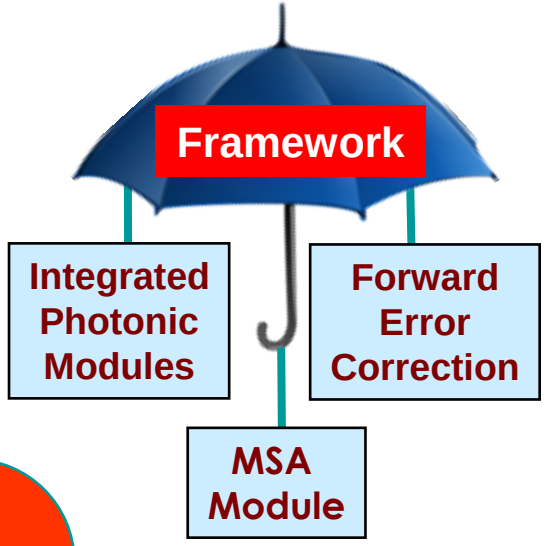


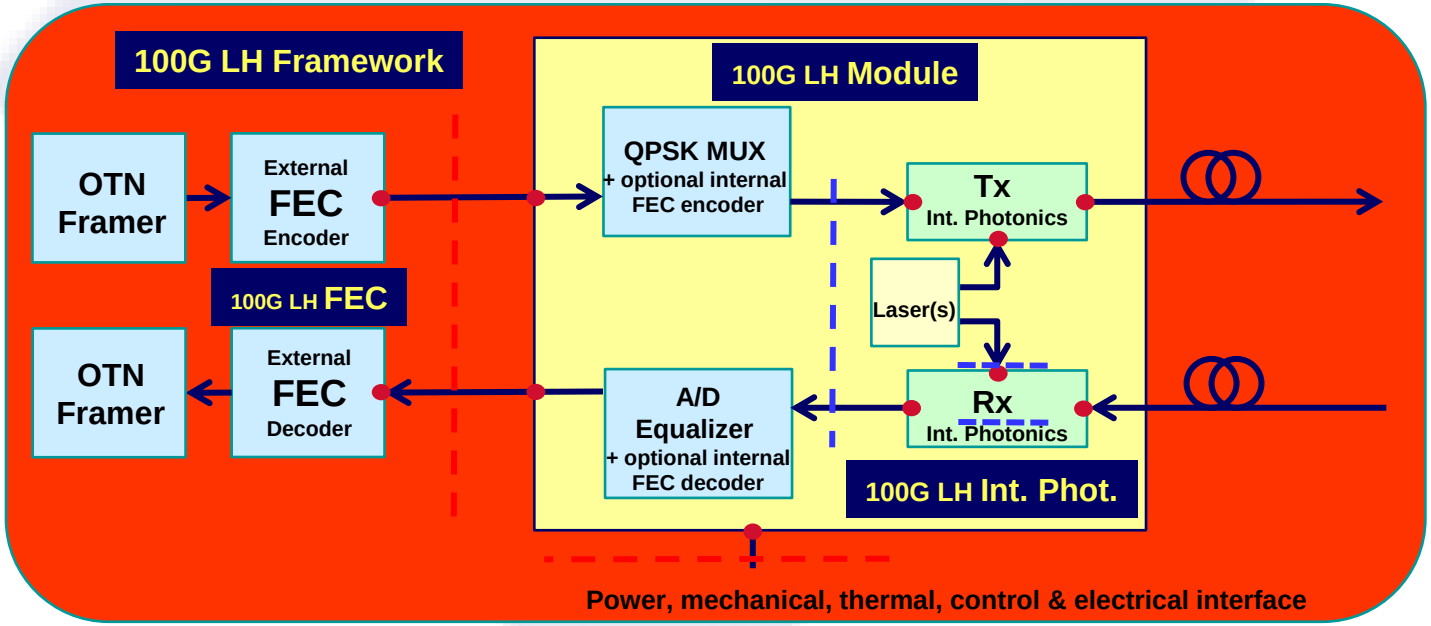


OIF's 100G DWDM Framework

Framework

- Starts with carrier requirements
- Creates consistent interfaces between blocks
- Provides:
  - An application description
  - A high level transceiver architecture
  - A transceiver modular decomposition





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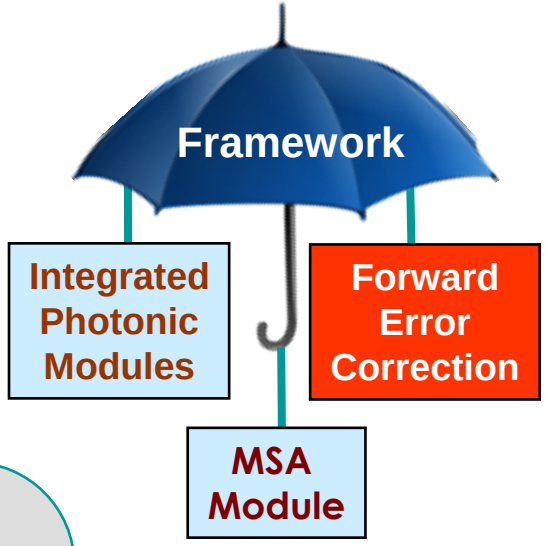
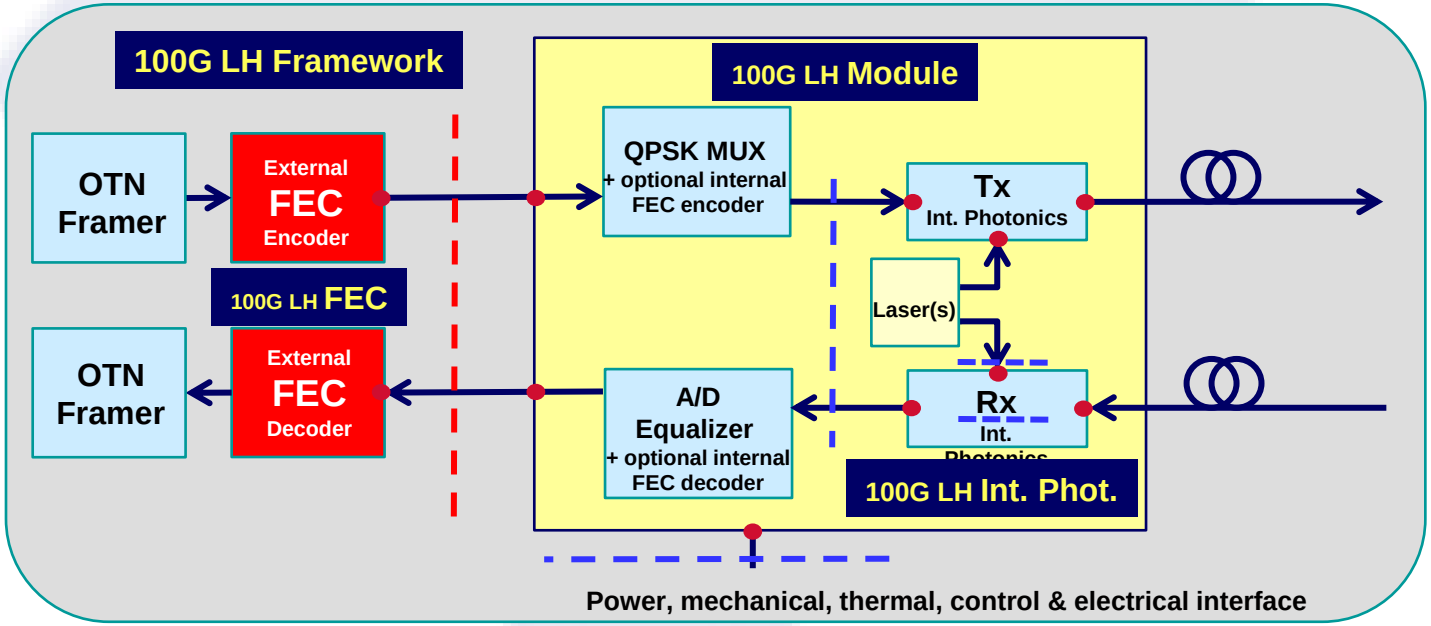
OIF's 100G DWDM Forward Error Correction

Forward Error Correction

- Determine the needs for FEC in the LH link
- Develop a channel model to answer key questions
- Study coding approaches
- Develop performance estimates





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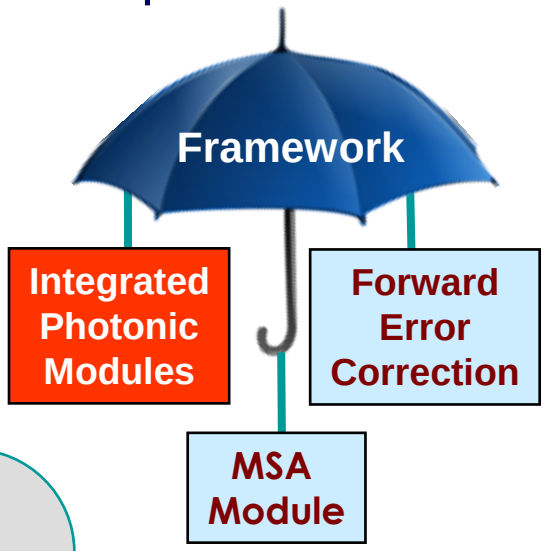
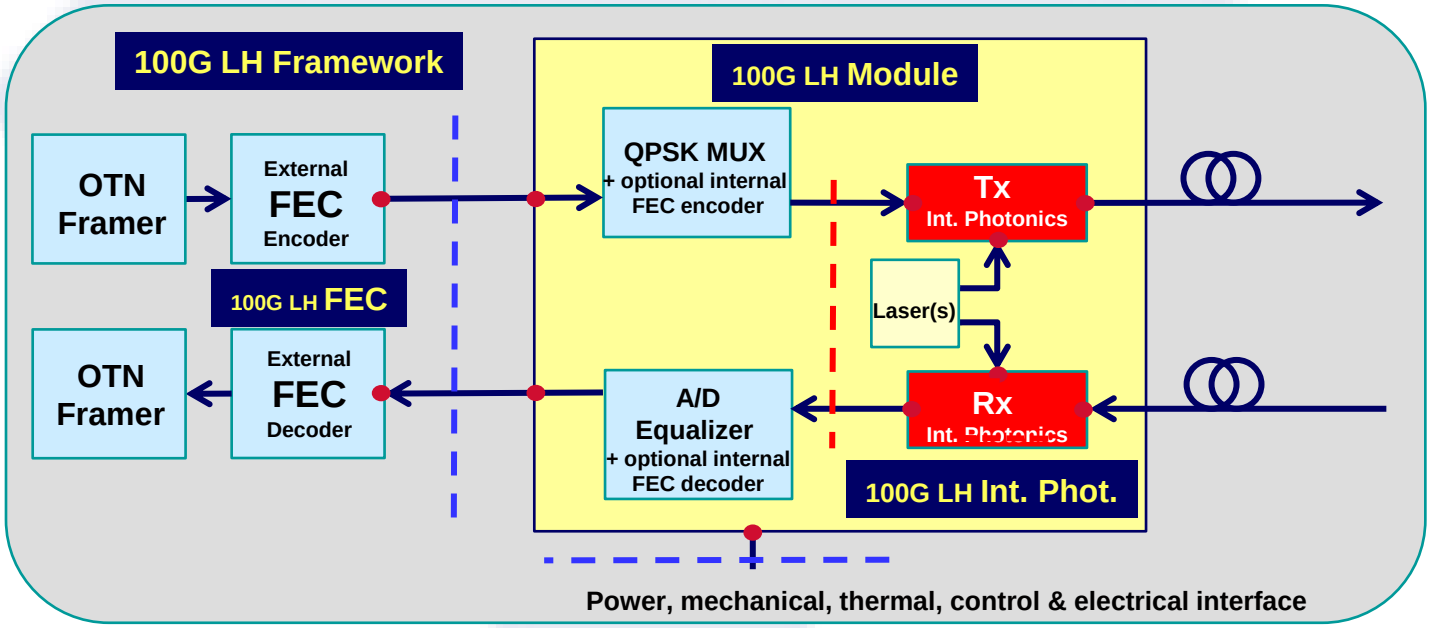
OIF's 100G DWDM Photonic Components

Integrated Photonic Modules

- Define the blocks and their key interfaces
  - Transmitter Module IA
  - Receiver module IA





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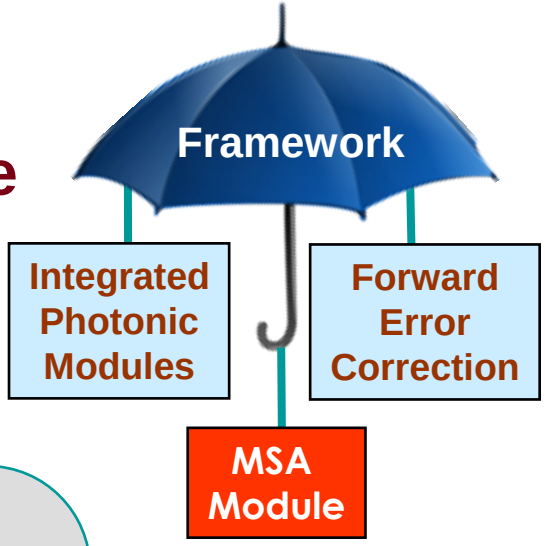
http://www.oiforum.com/public/documents/OIF-PMQ-TX-01.0.pdf
http://www.oiforum.com/public/documents/OIF_DPC_RX-01.0.pdf

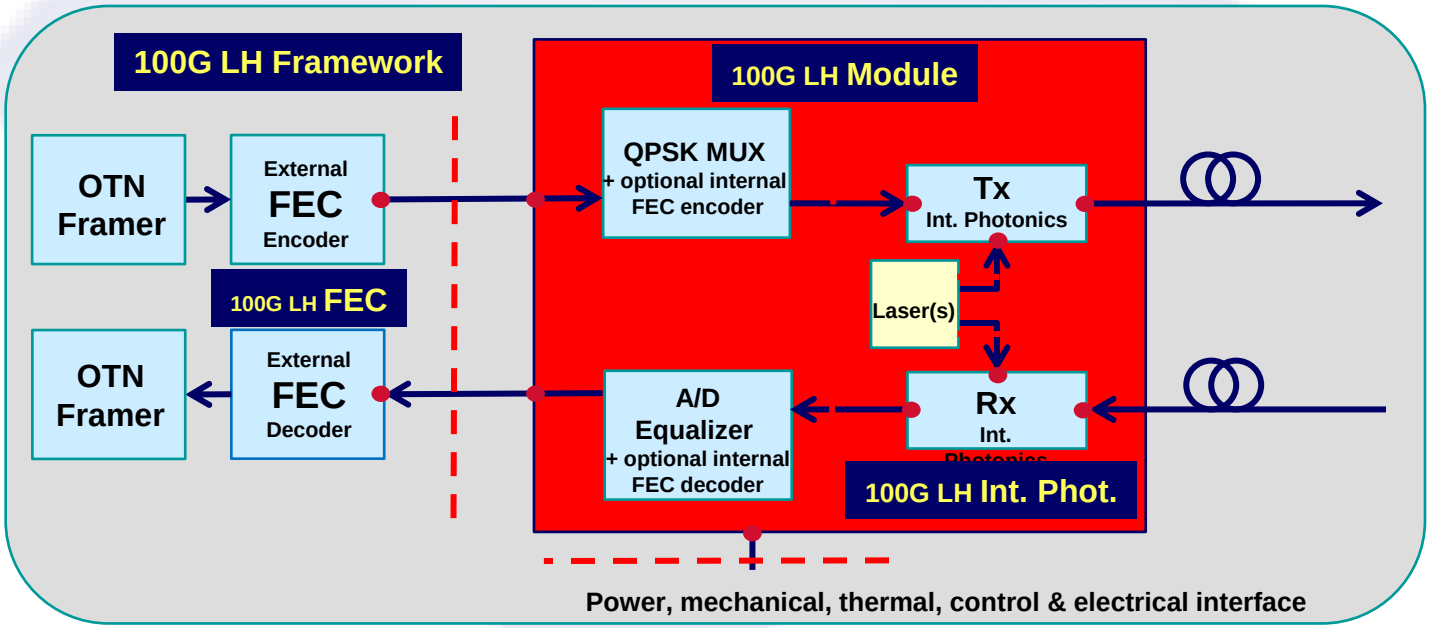
OIF's 100G DWDM MSA Module

MSA Module

Define a modulation independent module

- Mechanical dimensions, electrical connector
- Max power consumption
- High speed data & management interfaces





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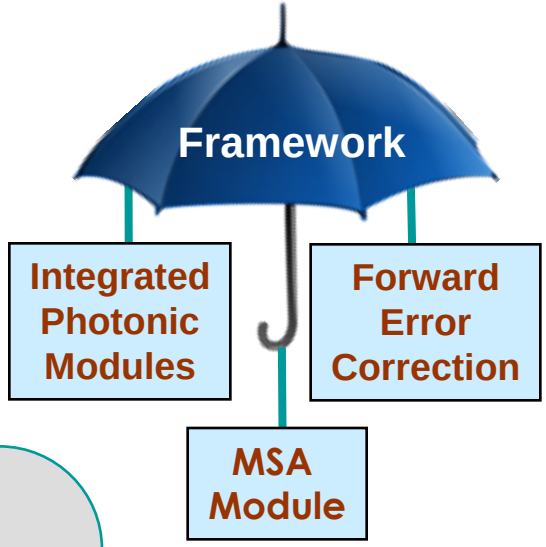
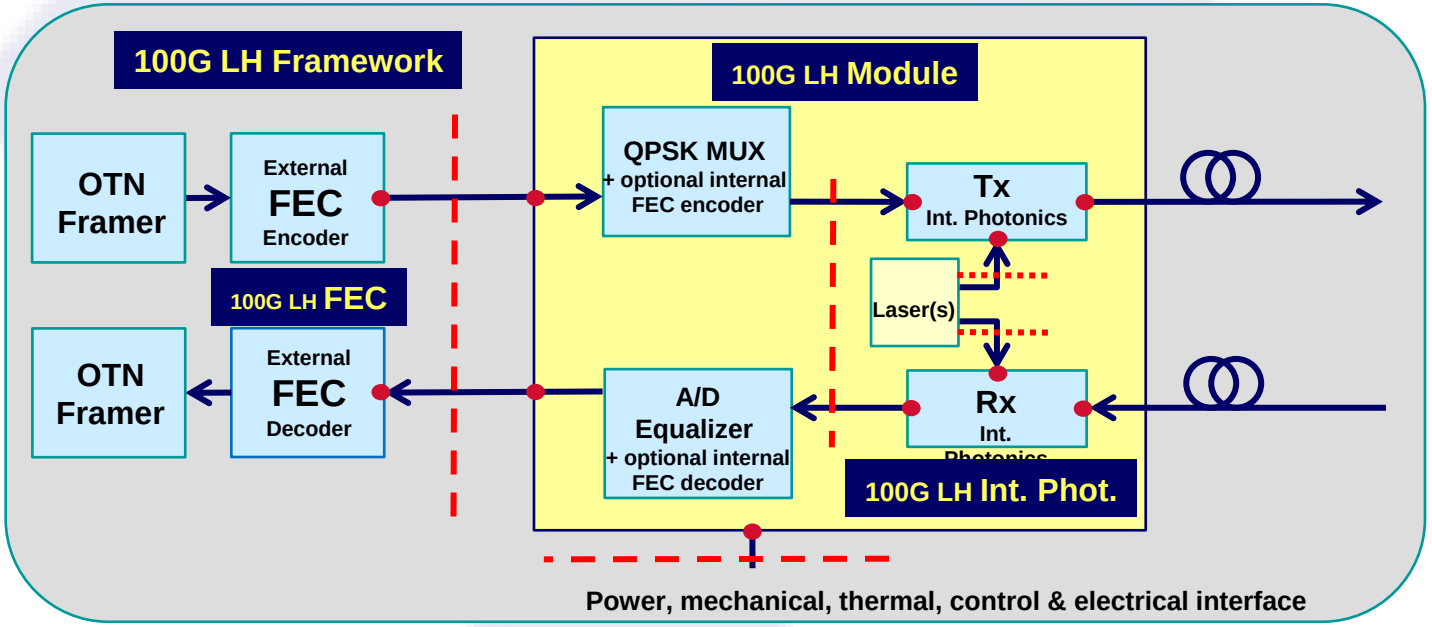
Summary : OIF 100G Project Structure

Result

A closely coupled set of projects which enables an eco system to provide products which meet the carriers' needs for 100G LH DWDM transport





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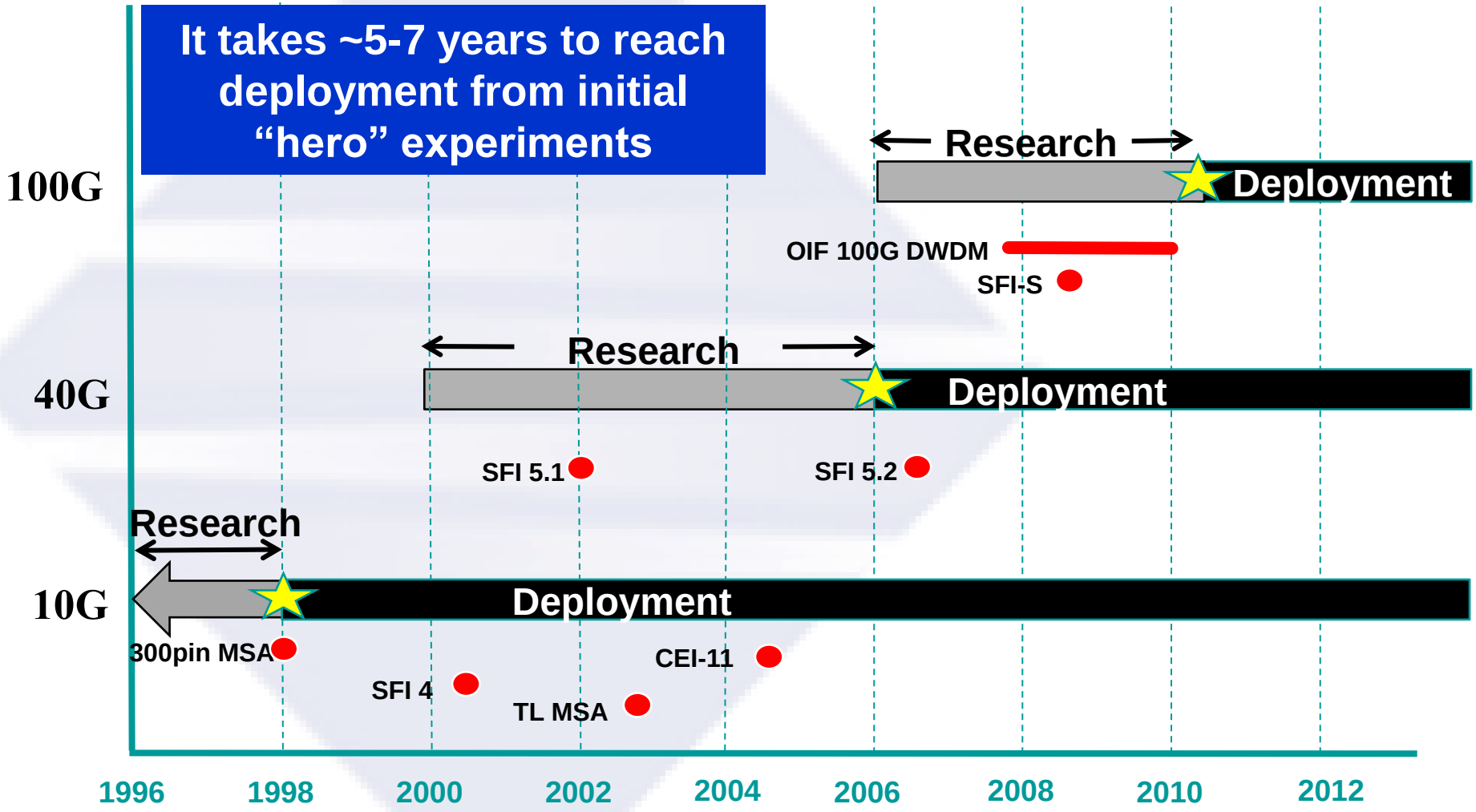
Historical Perspective: Research to Deployment

DWDM Optical Networks



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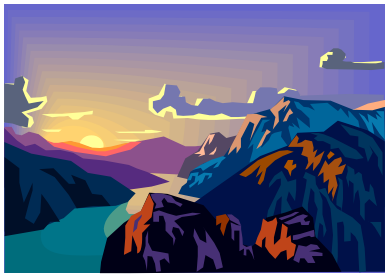
What Lies Beyond 100G?

- **What is our target?**
  - Channel scaling?
  - System capacity scaling?
  - Total network scaling?

- **What are the economics?**
  - Traffic growth projections?
  - How do we model costs?

- **How broad is our horizon?**
  - Timeframe?
  - Transmission?
  - + photonic switching?
  - + electronic switching?



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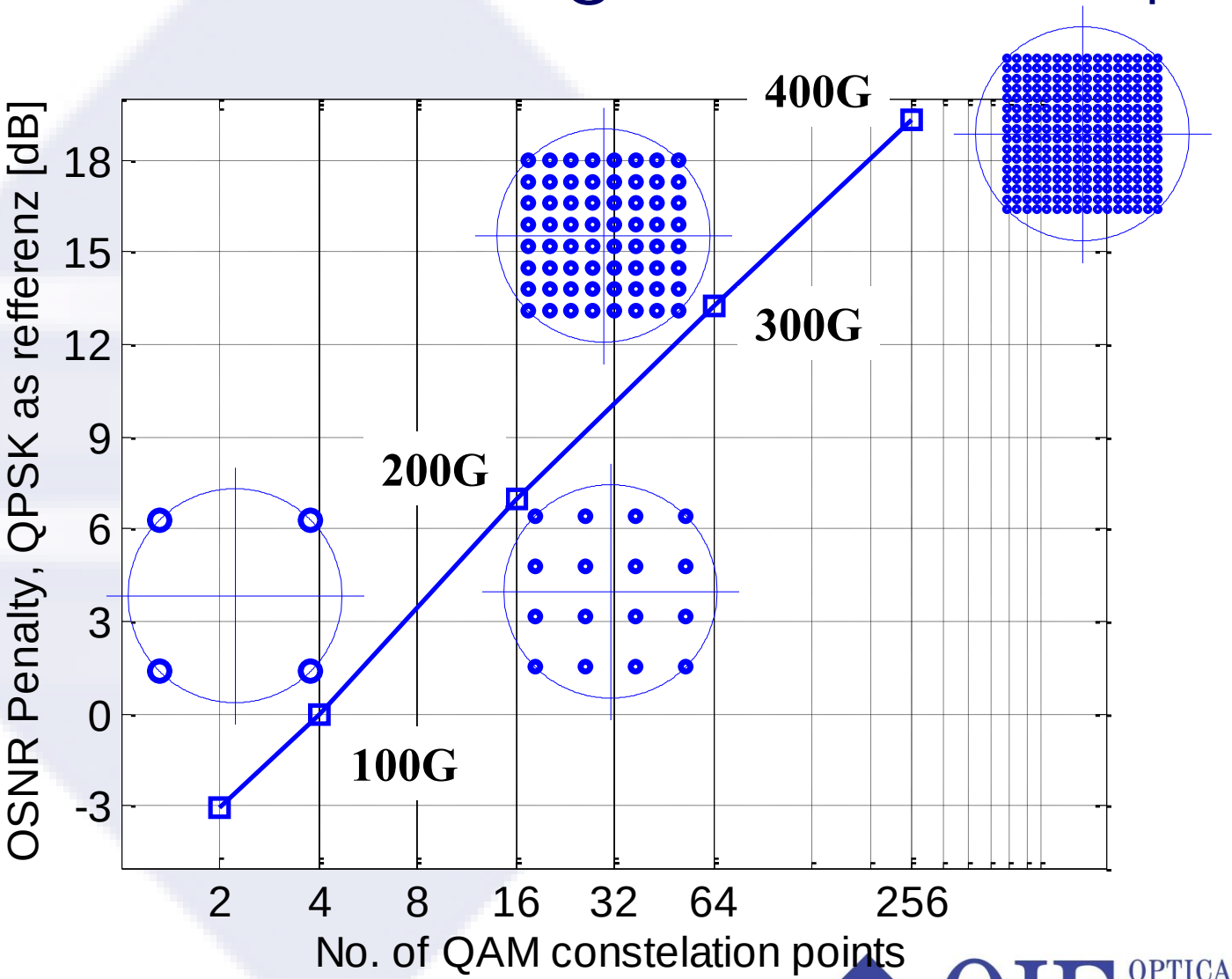
Is Scaling Of 100G An Option



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What is in the New Toolkit?
Expensive tools!

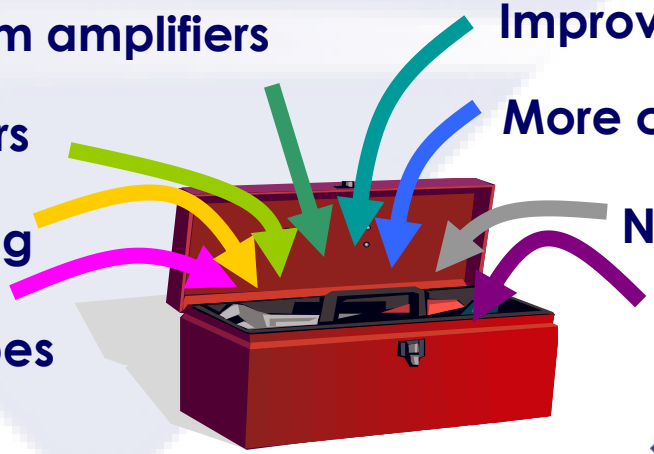
- **Long distance networks → infrastructure change!**
  - **400G requires much higher noise tolerance**
    - **Or settling for shorter propagation distances than 100G**
  - **We used many of our best tools at 100G**
    - **We might get further small incremental improvements**
  - **We need to expand our search for solutions**

Broader spectrum amplifiers

Lower noise amplifiers

Closer amplifier spacing

New Optical Fiber Types



Improved Forward Error Correction

More complex modulation formats

New ROADM and WSS designs

Highly Integrated Photonics

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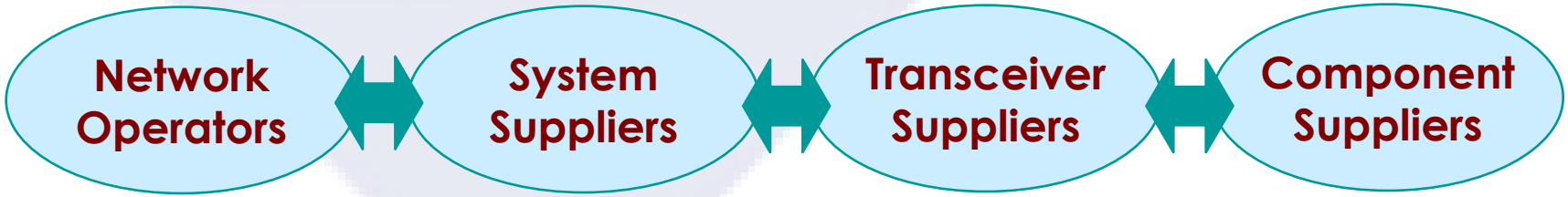
Beyond 100G - What Role for the OIF?
Beginning the Industry Dialog

- **Network Operator perspectives**
  - **Traffic patterns and projections**
  - **Network constraints, economic factors**

- **Technology perspectives**
  - **Which tools and materials are available?**



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Thank You

Questions?

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