EUROPEAN CLUSTER IN OPTICAL INTERCONNECTS

System Embedded Photonic Interconnect Technologies for Data Centre Environments

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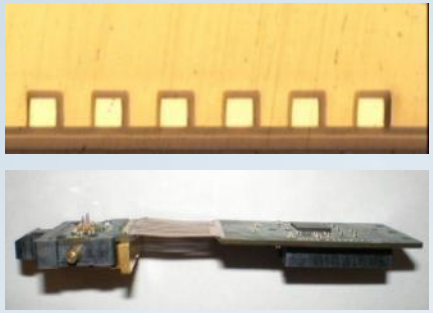
xyratex

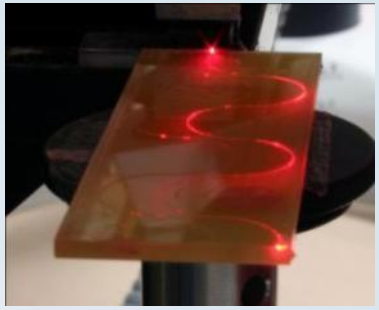
European Cluster for Optical interconnects Workshop
London

25th September 2013

Overview

- Xyratex photonics research overview
- Data centre technology trends
- Migration of embedded optical interconnect
- Research and development milestones
- Optically enabled data storage platforms
- International standards for optical PCB
- Collaborative research projects





Xyratex Overview

OEM Storage Solutions

- **18%** of worldwide external storage capacity shipped in 2011
- **> 4,000** Petabytes of storage shipped in 2011
- **Largest OEM** Disk Storage System provider

- **~ 50%** of w/w disk drives are produced utilizing Xyratex Technology (Company estimates)
- **Largest** independent supplier of Disk Drive Capital Equipment

Capital Equipment Solutions

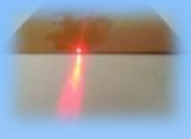
Xyratex Photonics Research and Development

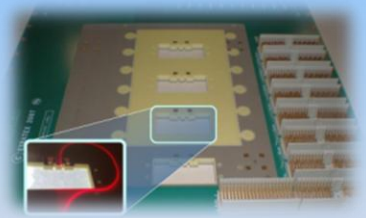
Future Data Storage Technologies

Development of data storage systems with embedded optical interconnect for future Exascale data centre and HPC environments

Research and Innovation

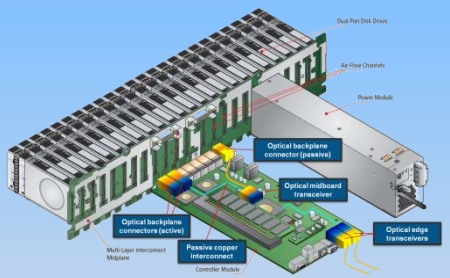
Advanced research and innovation in embedded optical interconnect technologies and intellectual property development

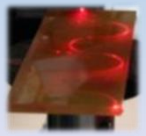


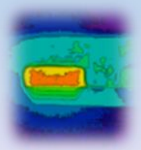


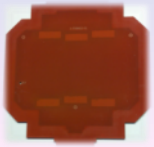
Network, Eco System and Standards

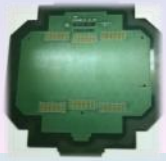
Strategic presence and influence in global photonics market to drive component eco-system and international standards





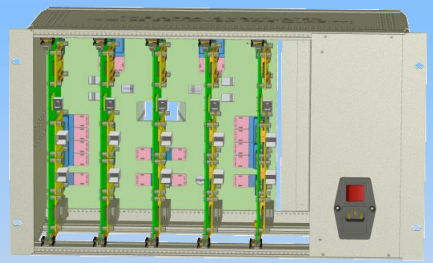


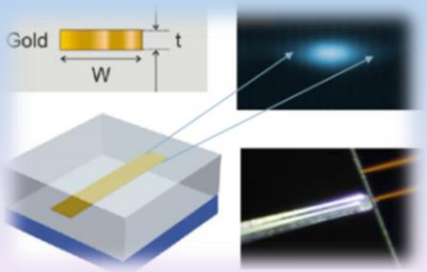




Collaborative Research Activities

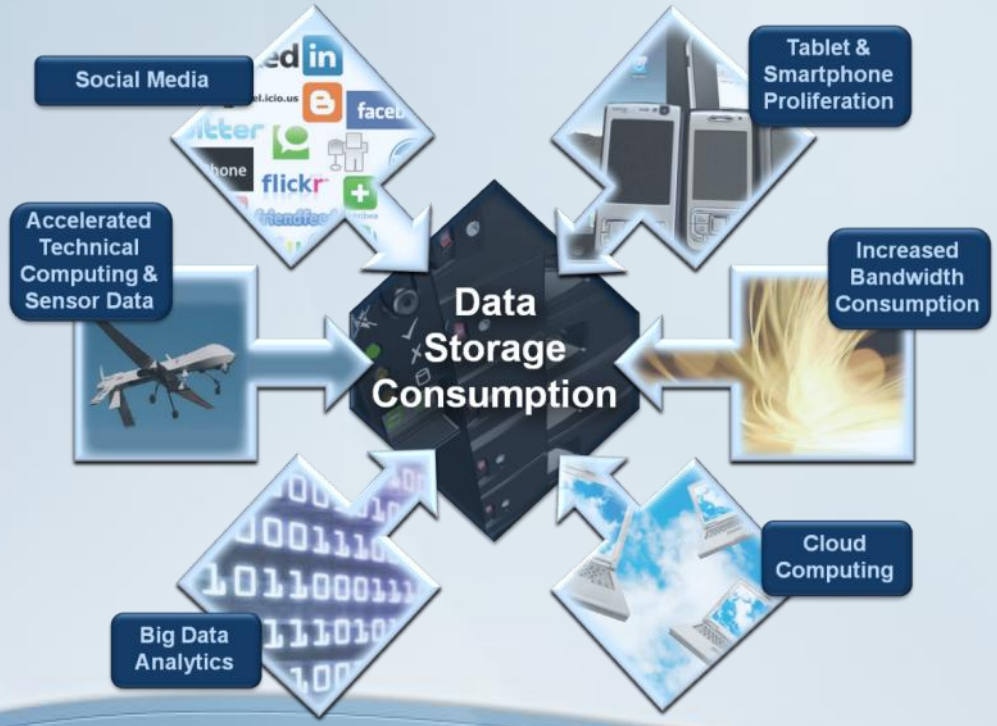
Leading international collaborative projects to develop disruptive embedded optical technologies for future data centre systems





What is System Embedded Optical Interconnect?

System embedded optical interconnect refers to the emerging field of optical interconnect technologies, which enable optical connectivity within Information and Communication Technology (ICT) platforms including:
Exascale Data Centre systems, High Performance Computers, Blade servers, Routers and Access Networks



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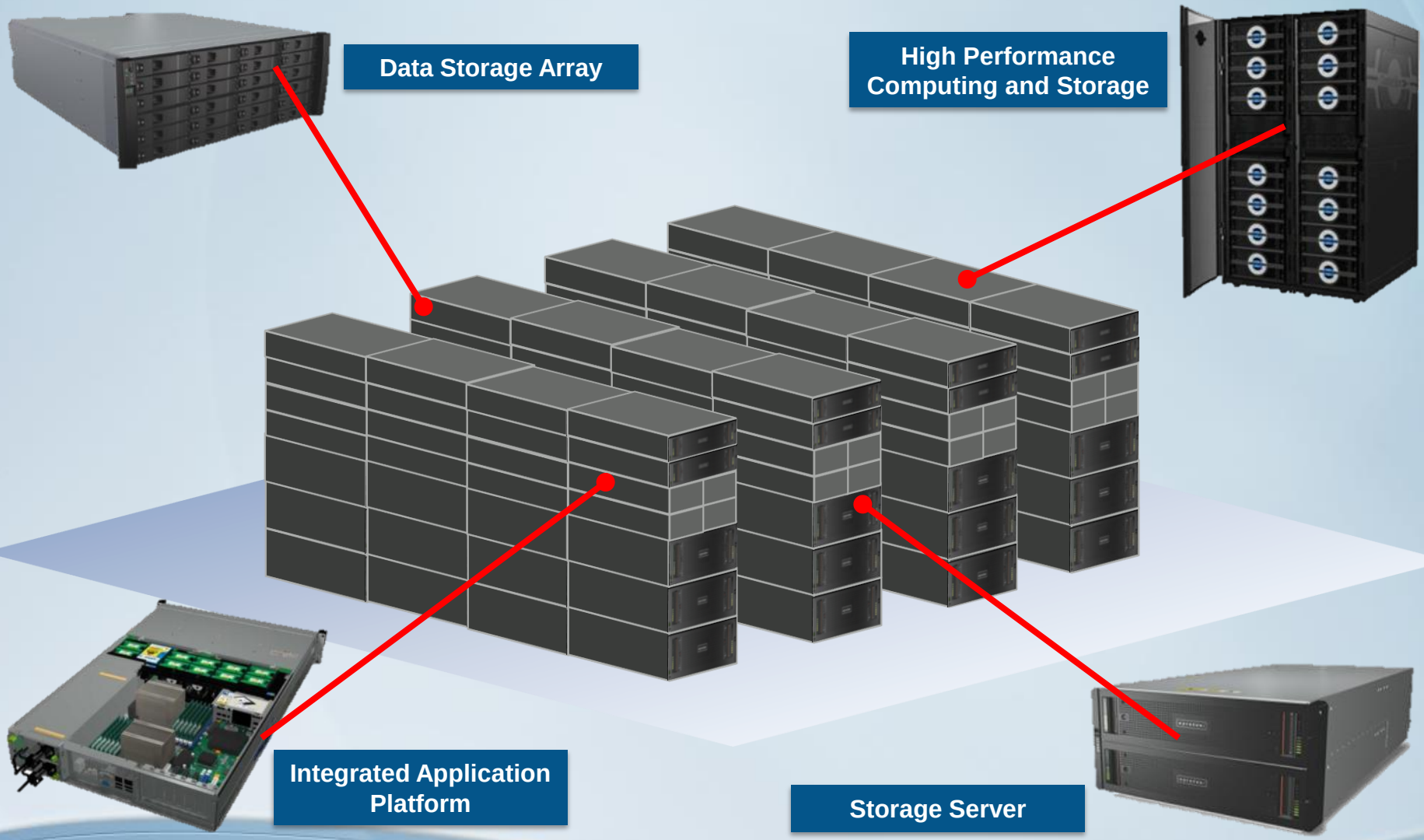
Building Blocks in the Data Centre



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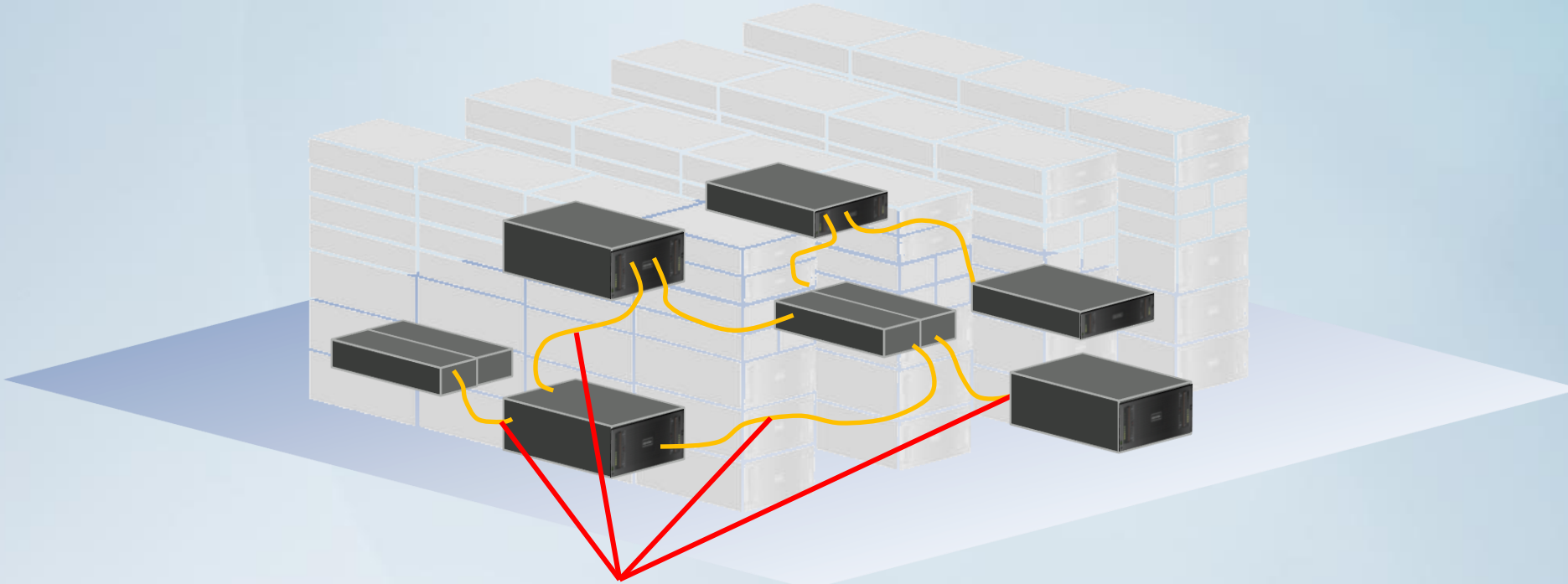
Increasing Disaggregation in ICT Networks

Servers, Racks and Data centres comprised of modular subsystems which can be broken apart and reassembled to satisfy broad range of ICT requirements



Higher bandwidth optical connections required between non-localised dispersed modules working together

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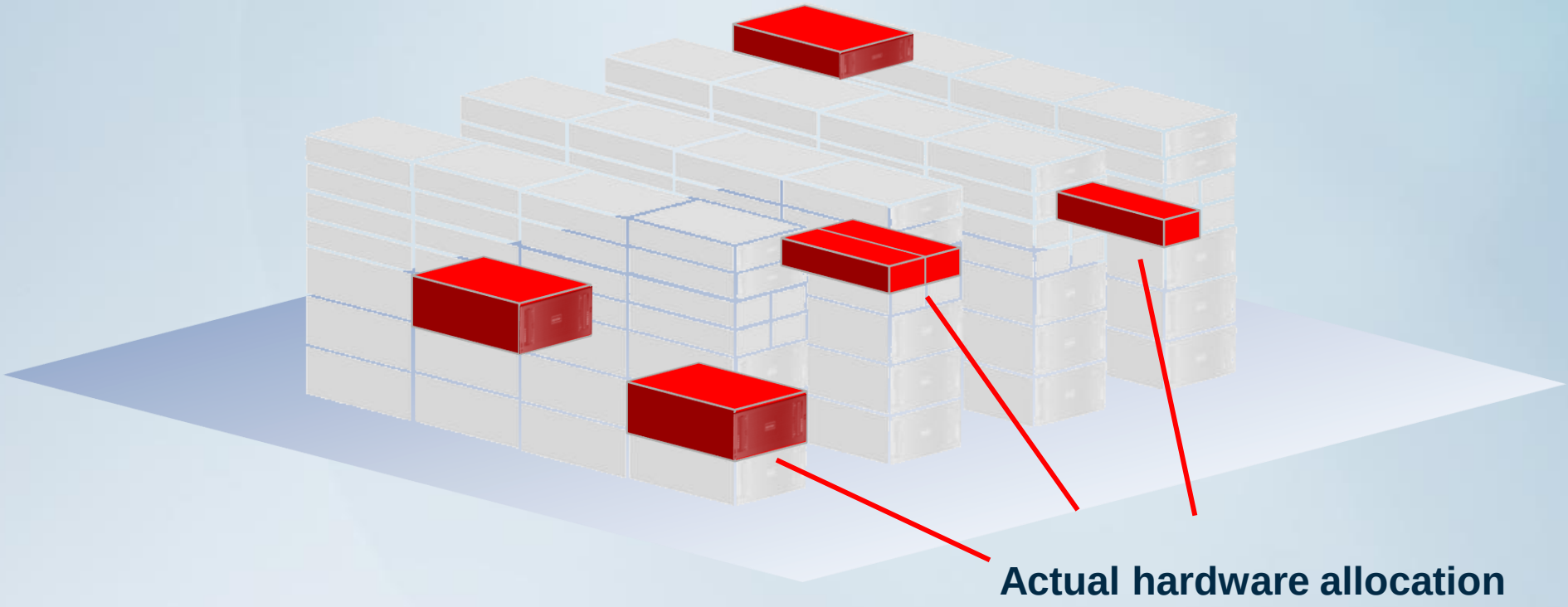
Increasing Virtualisation in Data Centres

Software defined networks or storage solutions, which allow user programmable provision of a broad range of ICT requirements



Increasing Virtualisation in Data Centres

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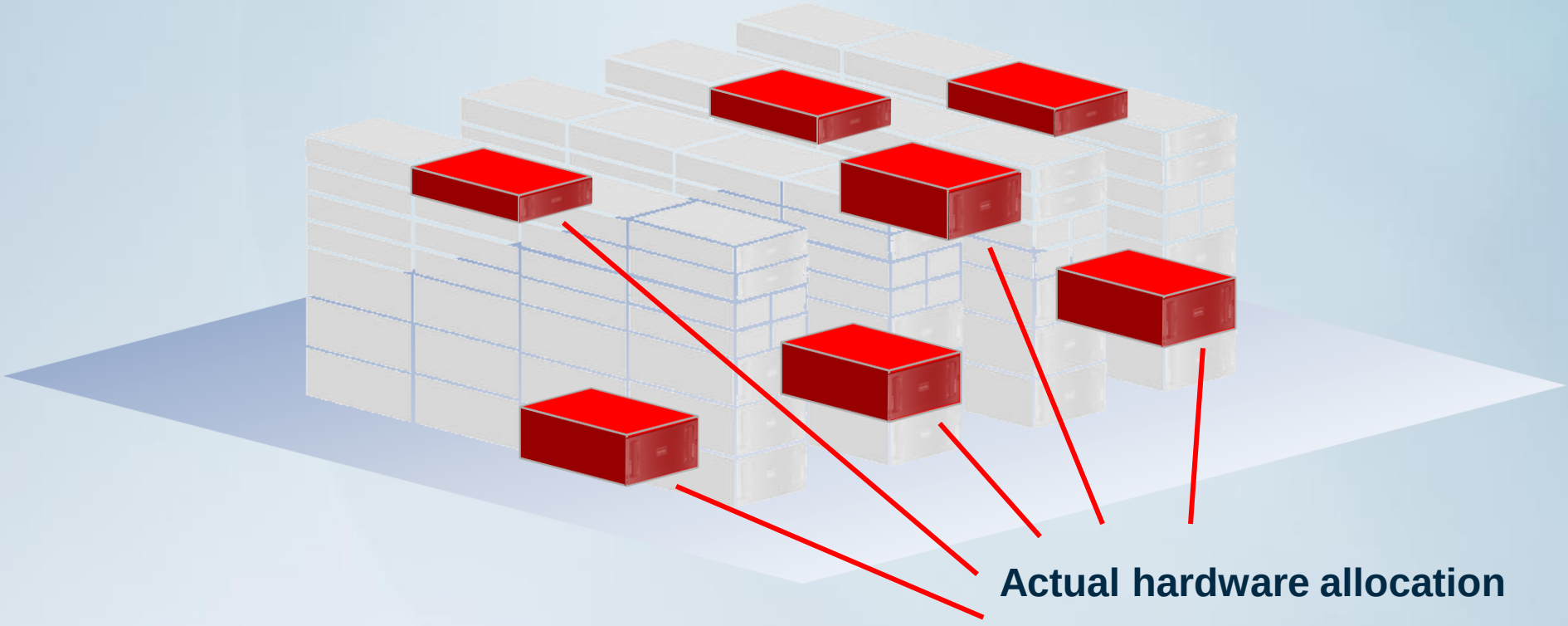

Increasing Virtualisation in Data Centres

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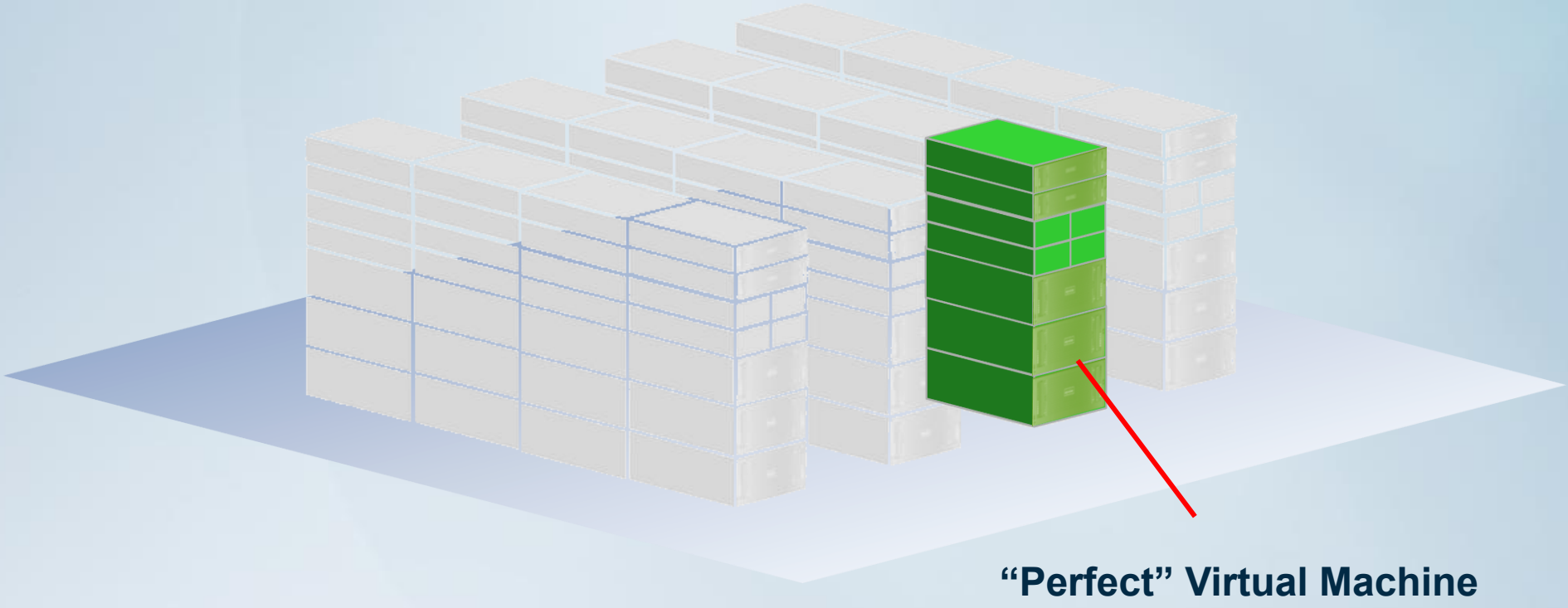
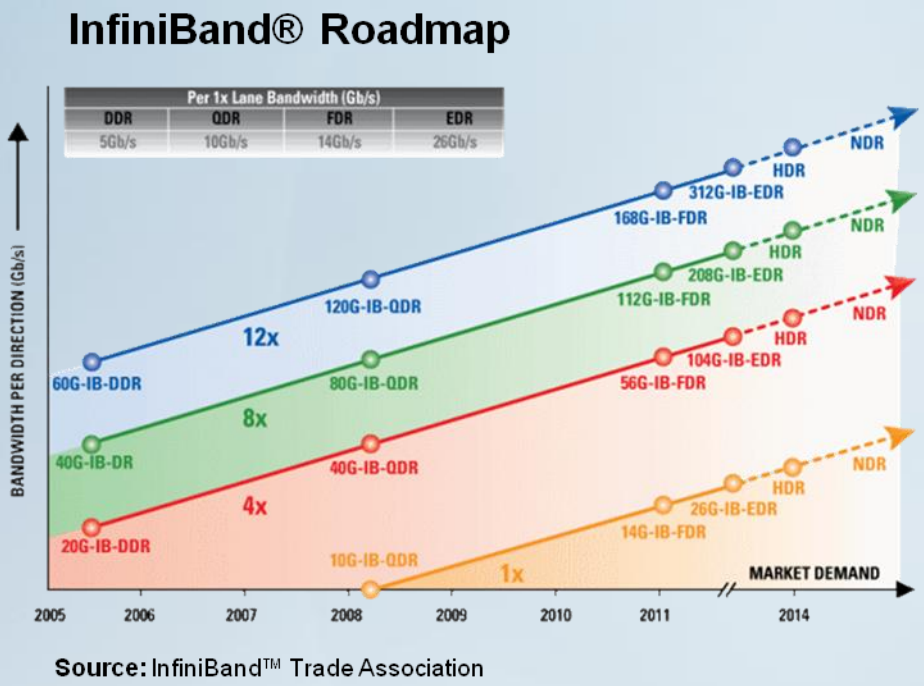
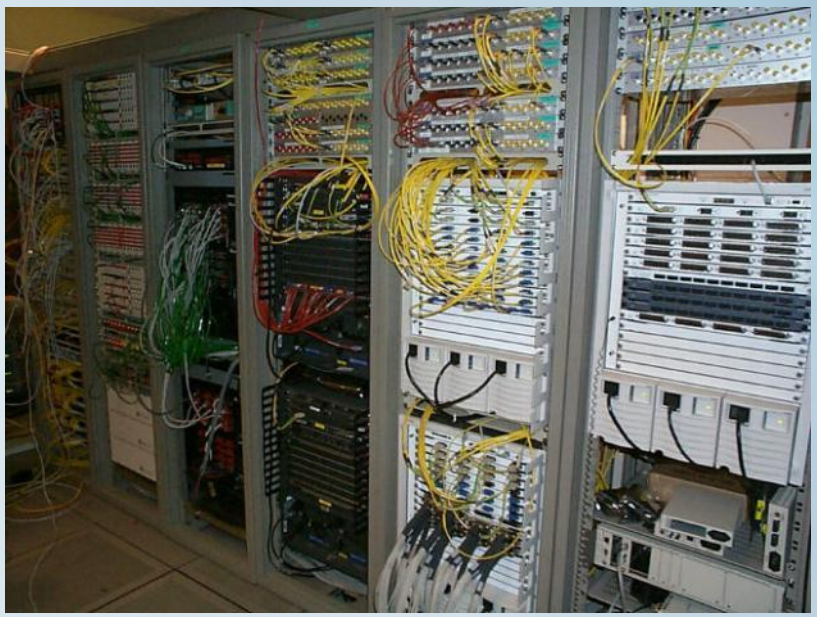


Link Speeds – Rack to Rack



Source: InfiniBand™ Trade Association



InfiniBand® protocol used predominantly for rack-to-rack communication in the switched fabrics inherent to enterprise data centres and high performance computers will provide 26 Gb/s per link by 2014 (EDR)

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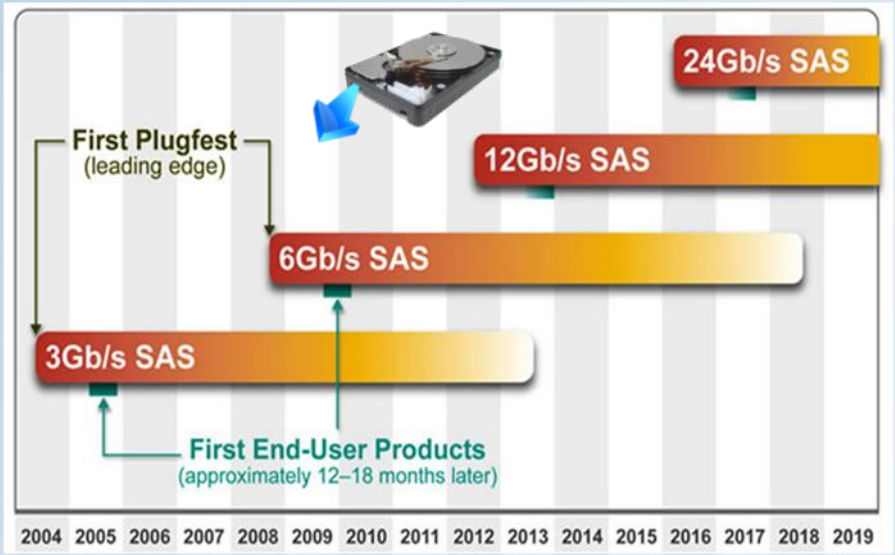
Link Speeds – Inside the System

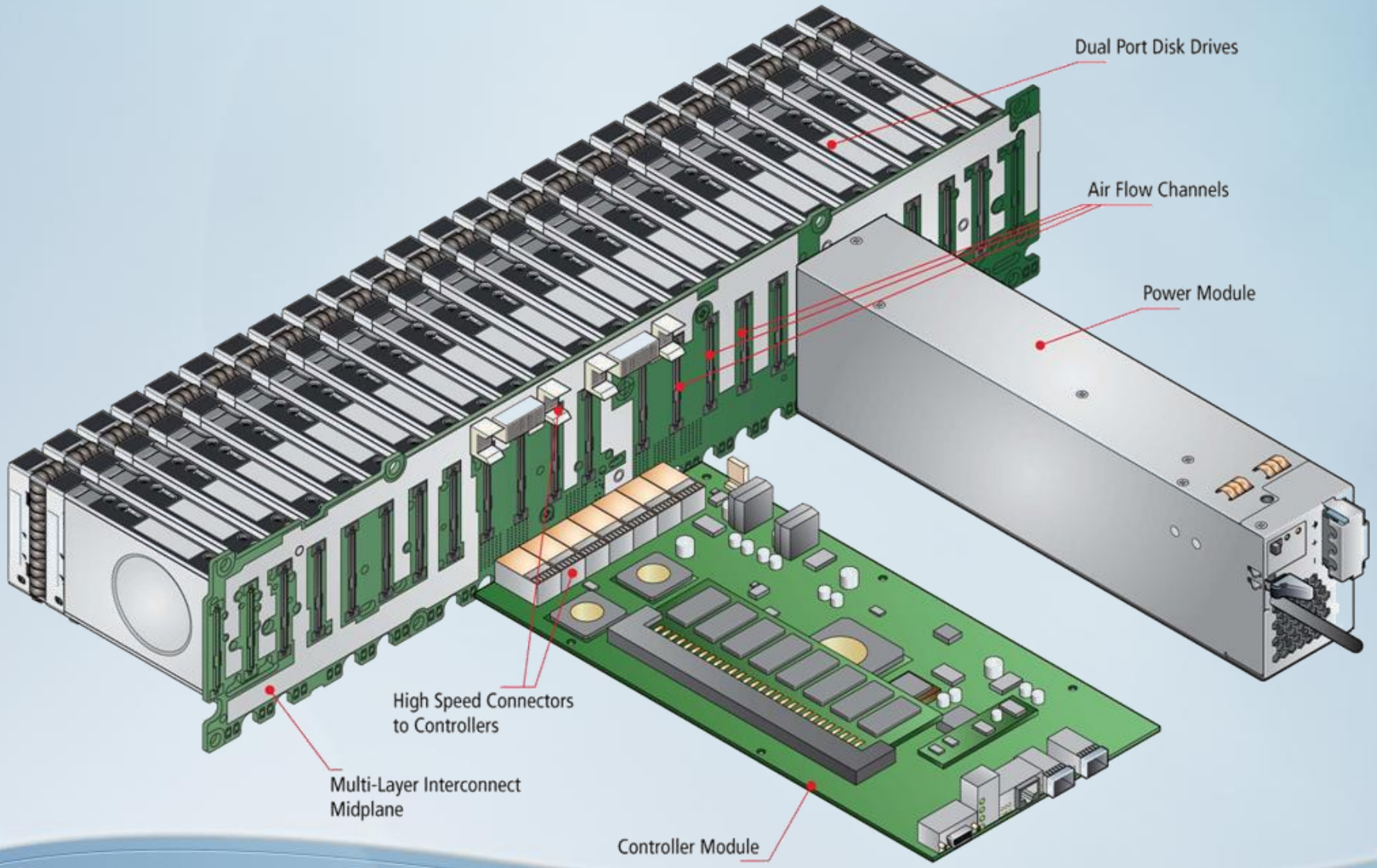
SAS™ Roadmap



Source: SCSI Trade Association

Serial Attached SCSI (SAS) architectures govern the high speed data links between controller peripherals and hard disk drives, which are set to increase to 24 Gb/s by 2016.

Data Centre Subsystem



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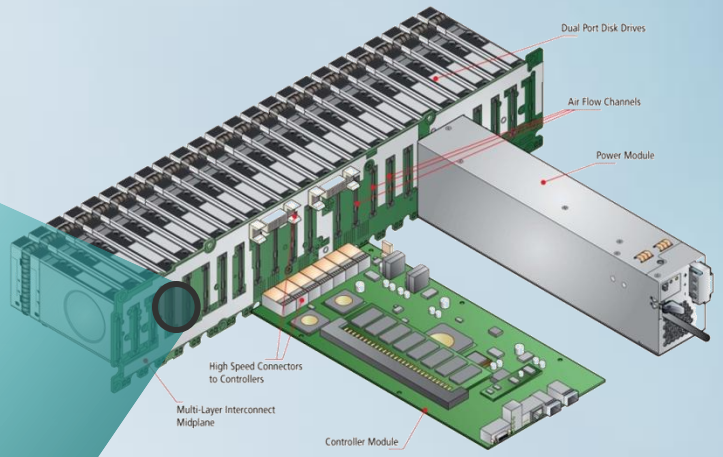
Data Centre Subsystem

Increase in Channel Density

Increase in Channel Bandwidth

Increase in Bandwidth Density



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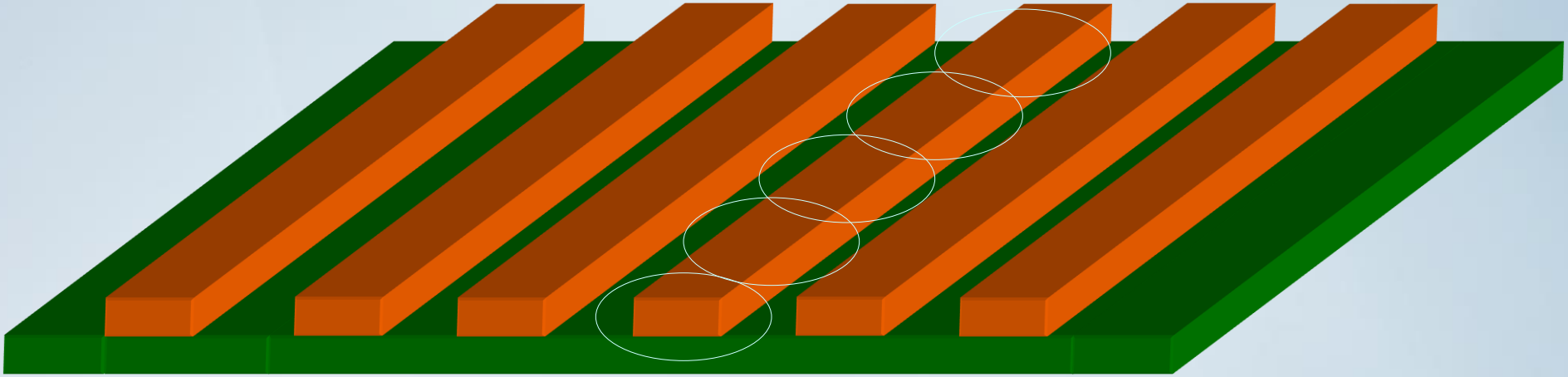
Crosstalk between PCB Signal Traces

- As signal speeds increase…
  - Crosstalk effects neighbouring traces
- Requiring that…
  - Traces are moved further apart
  - Number of PCB layers is increased



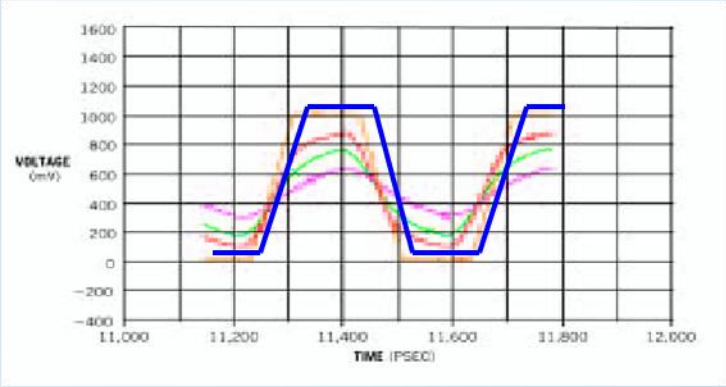
Dielectric Loss

As signal frequencies increase …

- Signal energy is lost through the dielectric

Requiring that …

- Trace lengths are reduced
- Signal power is increased
- Special dielectric materials are used
- Pre-emphasis and Equalisers



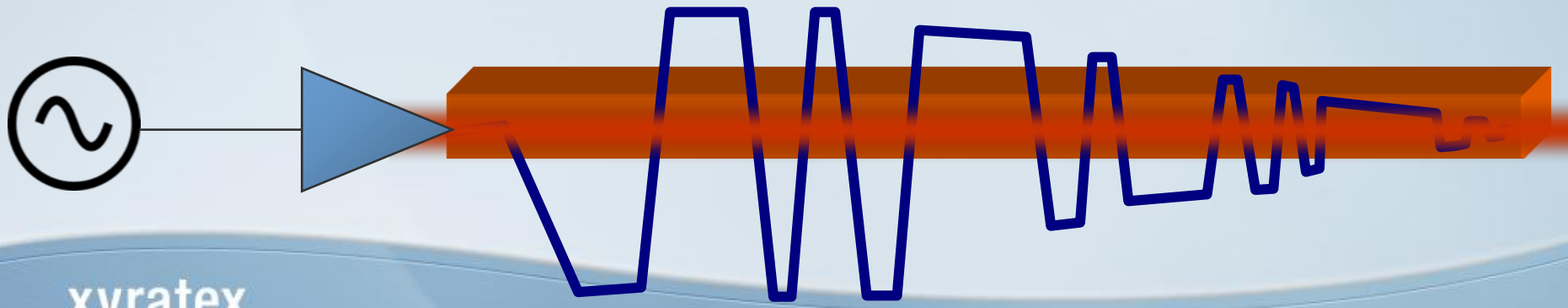
Zero Distance – Perfect Signal

After 10 inches through FR4

After 20 inches through FR4

After 40 inches through FR4

(simulated with Mentor Graphics' HyperLynx).



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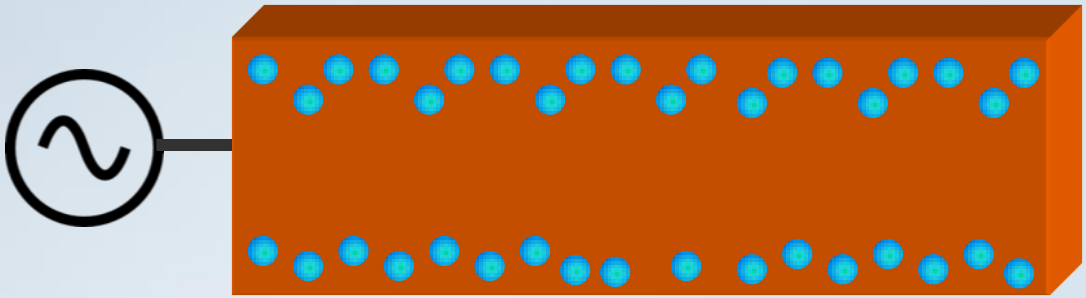
Skin Effect

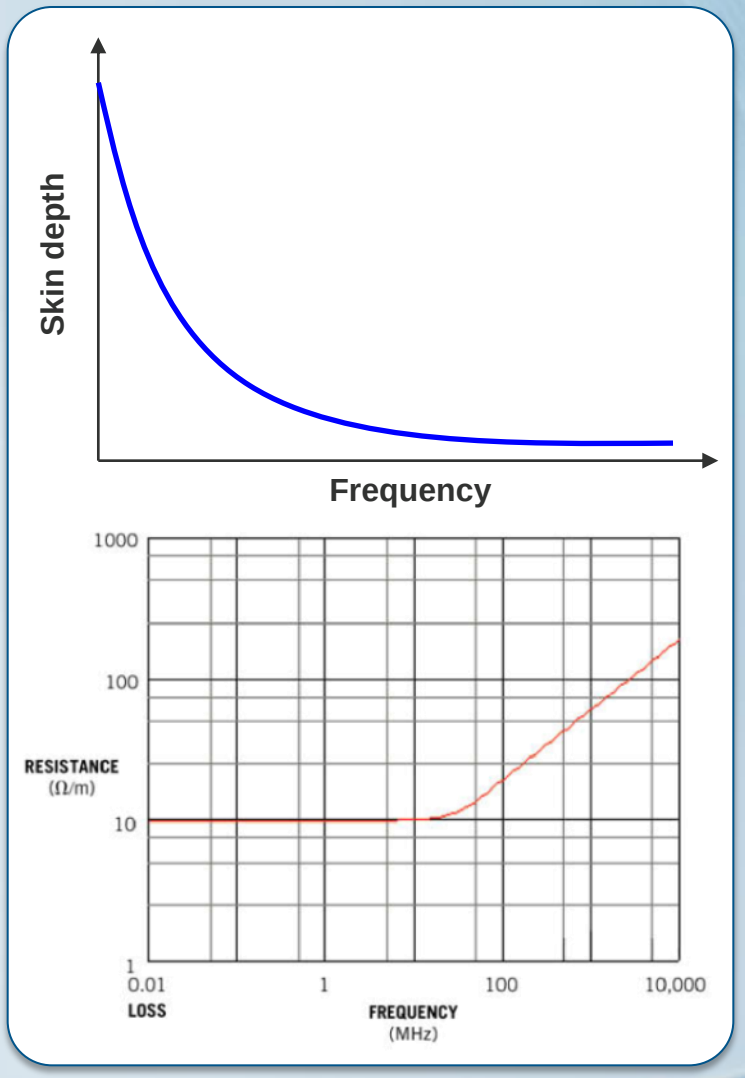
As signal frequencies increase …

- Charge carriers squeeze around the outer trace edges

Causing …

- Effective resistance of trace to increase
- Increased signal power dissipation

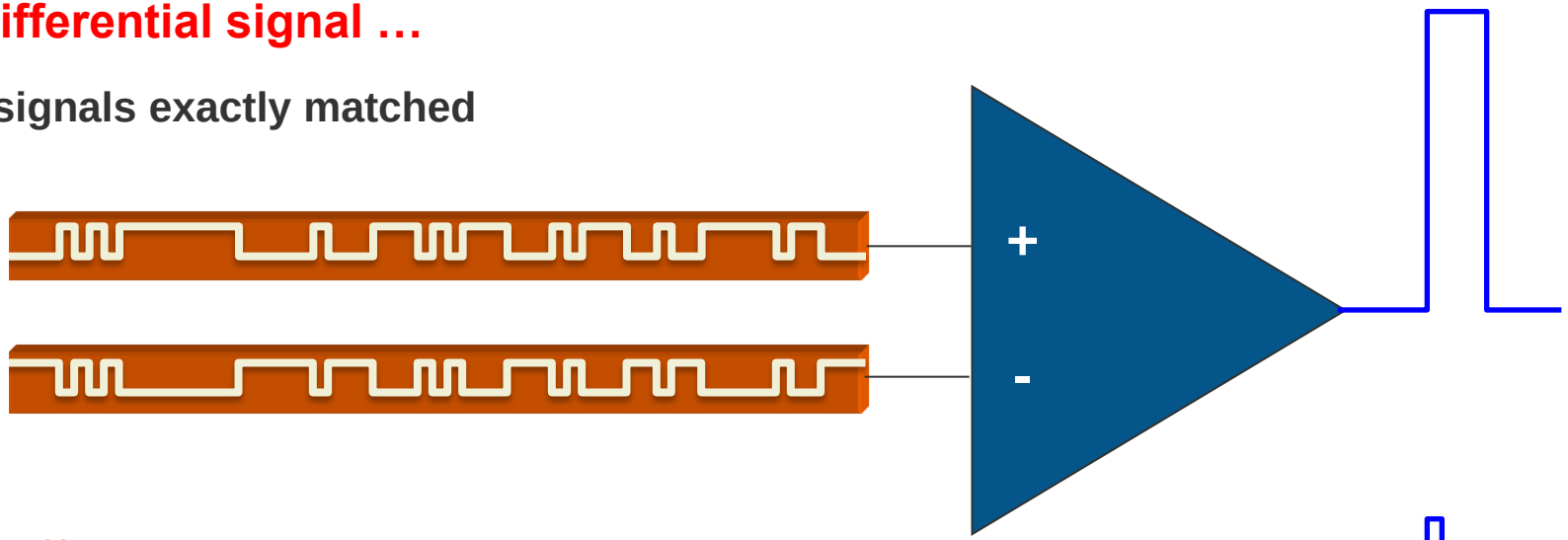




Signal Skew

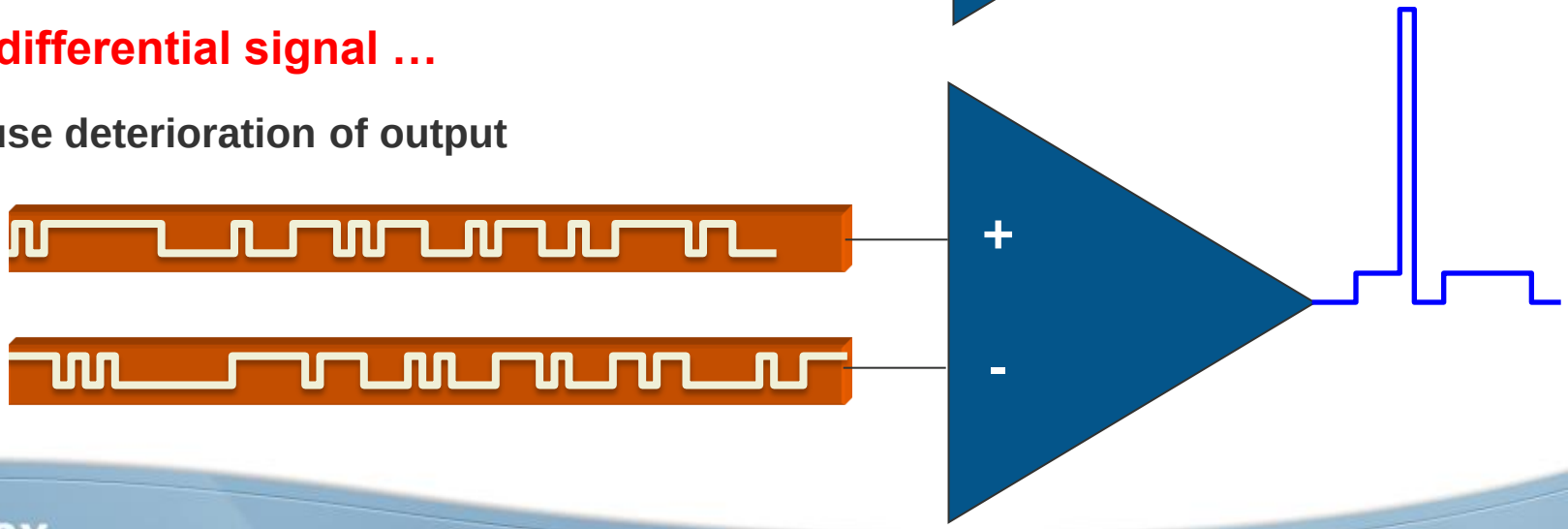
An ideal differential signal …

- Inverse signals exactly matched



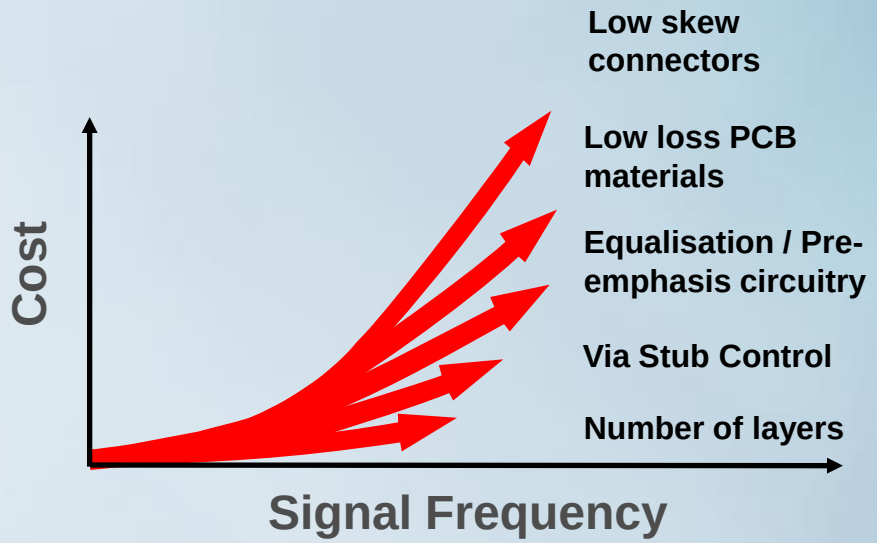
Skew on differential signal …

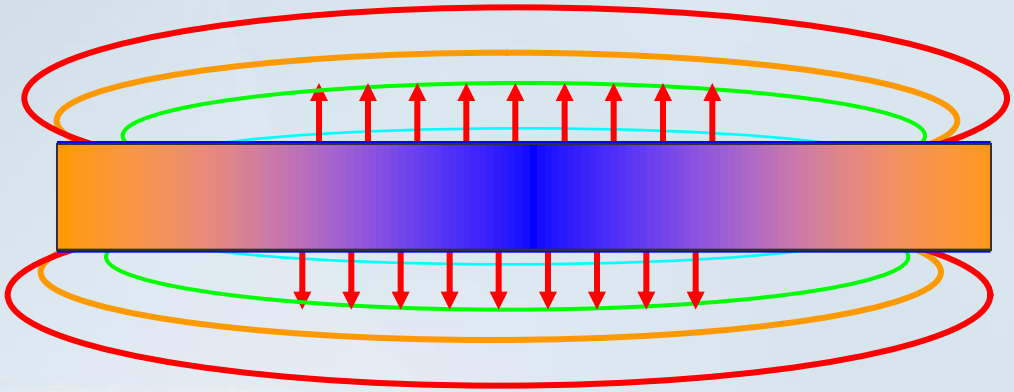
- Will cause deterioration of output

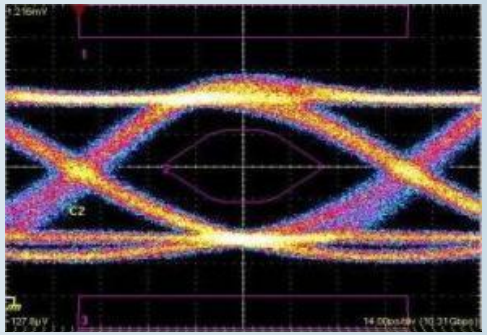


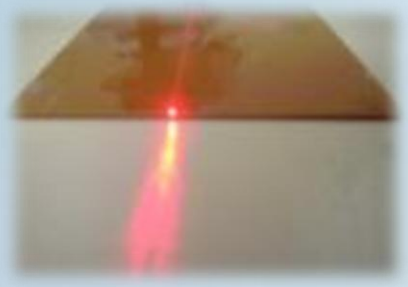
Cost and Performance Penalties of High Speed Copper

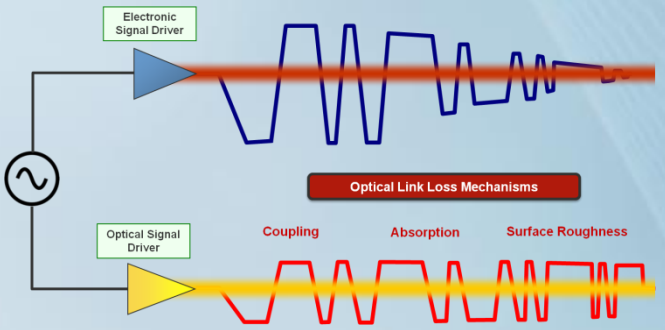
- Crosstalk
- Reflections
- Electro-magnetic interference
- Dielectric Loss / “Skin effect”
- Signal skew



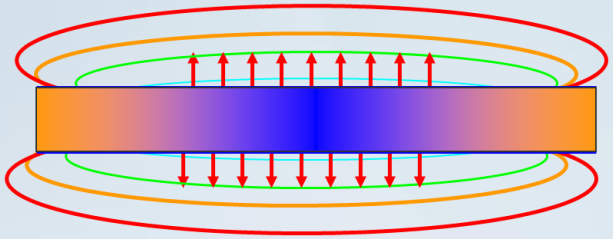


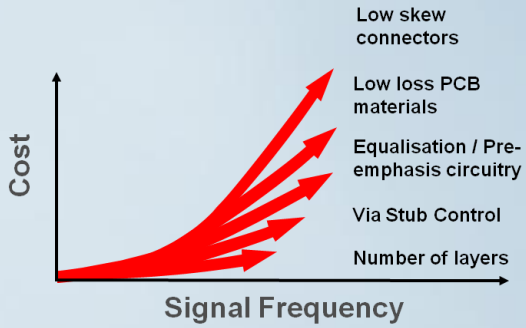






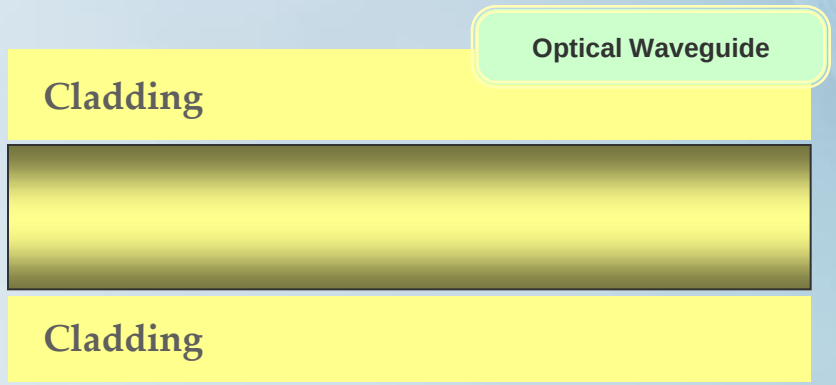
The Light Alternative

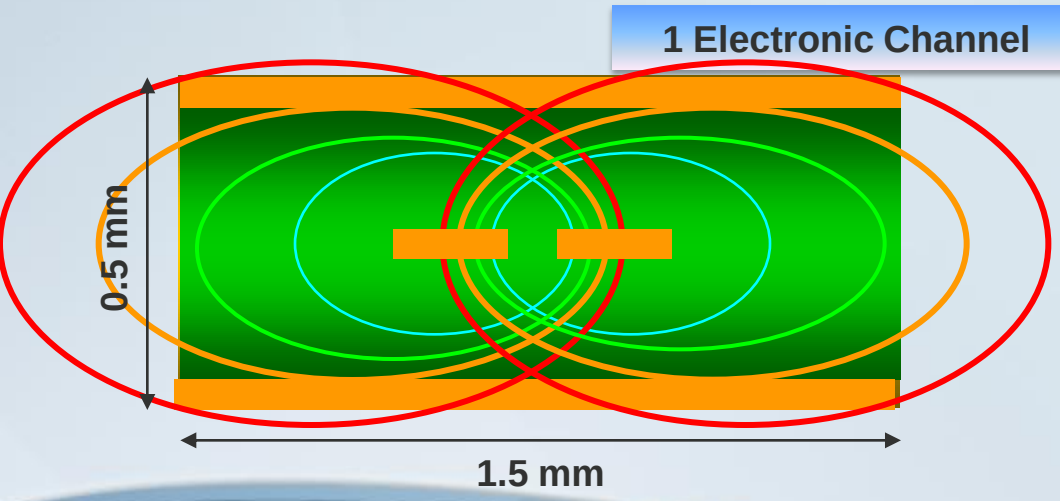


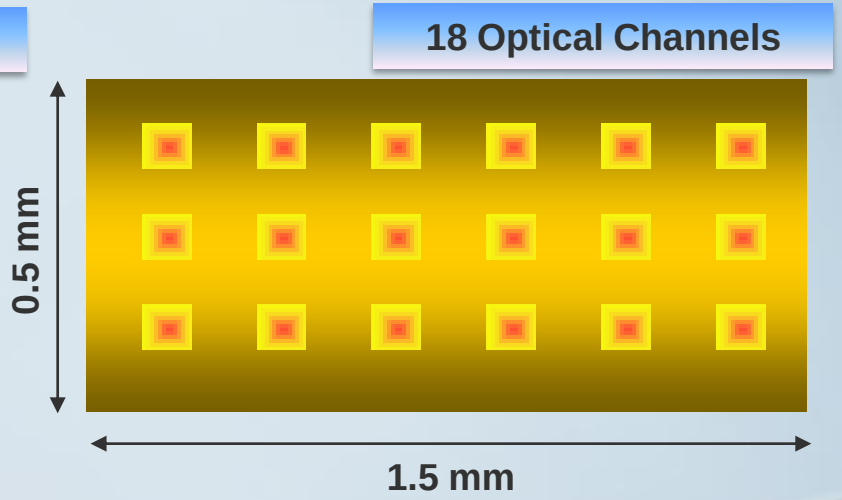


The Light Alternative

- Send data further
- Higher density
- Higher link bandwidth (x100)
- Advanced passive and active functionality (SoC, WDM)
- No RFI / EMI from waveguides







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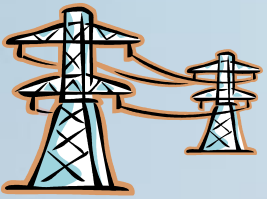
Reduced Power Consumption



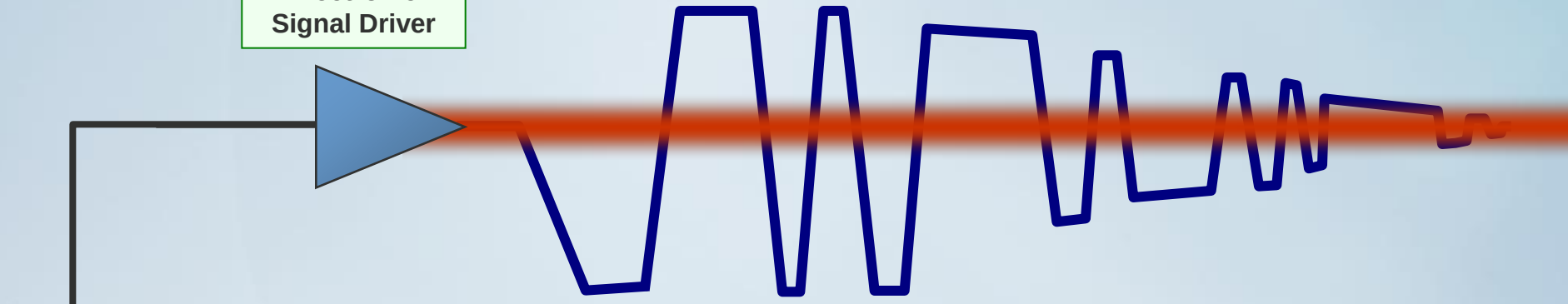
Copper Link Loss Mechanisms

Dielectric Loss

Skin Effect

Surface Roughness

Electronic Signal Driver



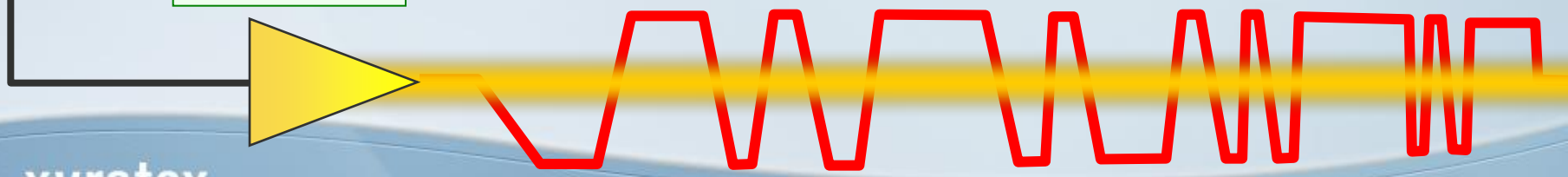
Optical Link Loss Mechanisms

Optical Signal Driver

Coupling

Absorption

Surface Roughness



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Material Reduction

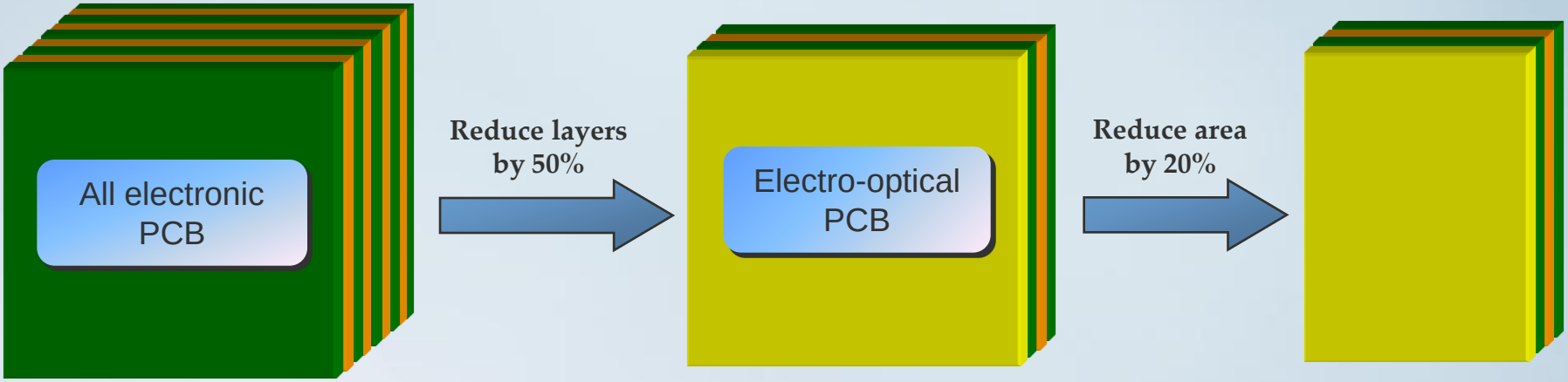
Total PCB material reduction of over 60%

Reduction in PCB Thickness

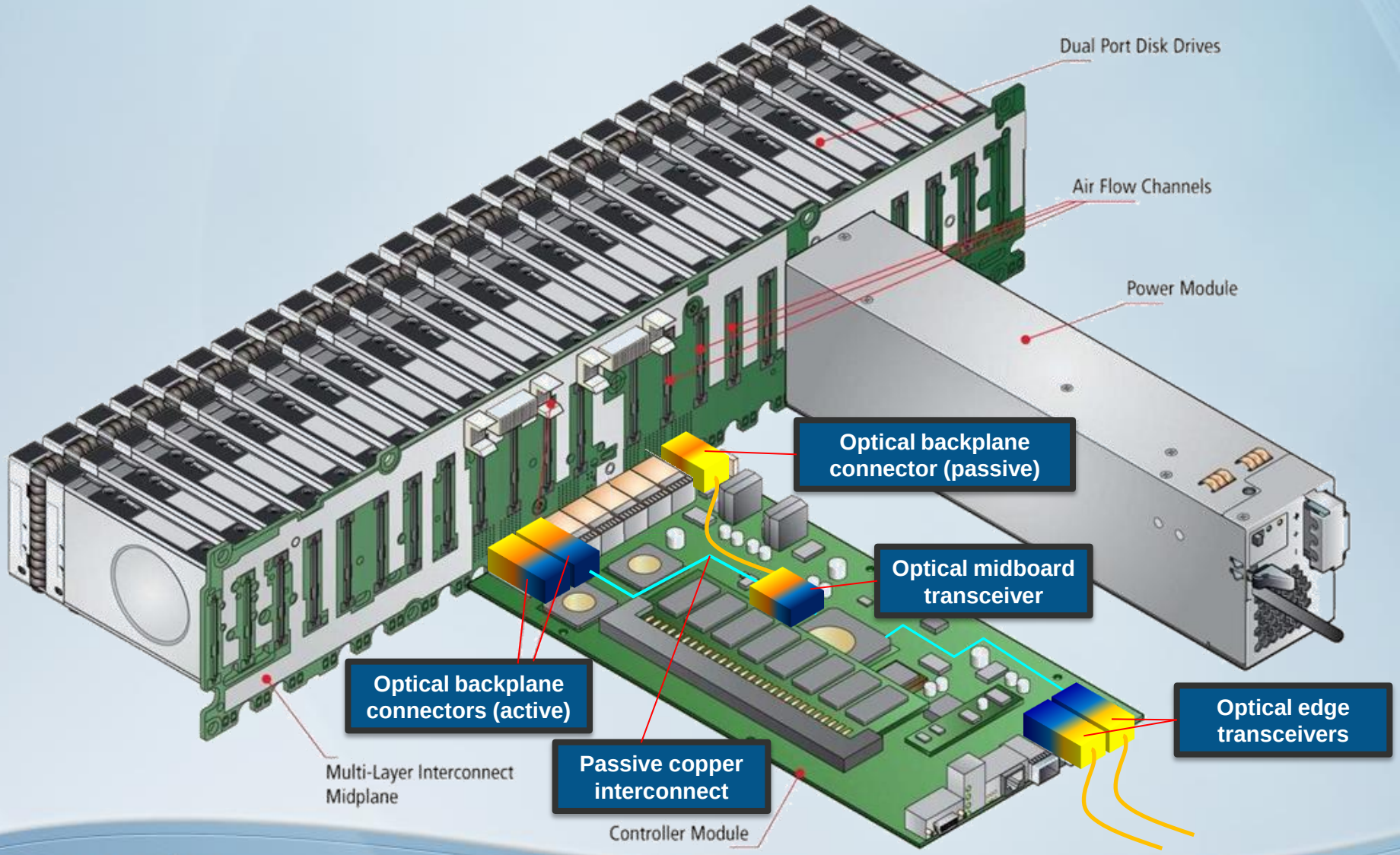
- Reduction in PCB layer count
- 50% in I/O dense systems

Reduction in PCB Area

- Reduction in I/O functional area
- 20% reduction in board area



Migration of Optical Interconnect



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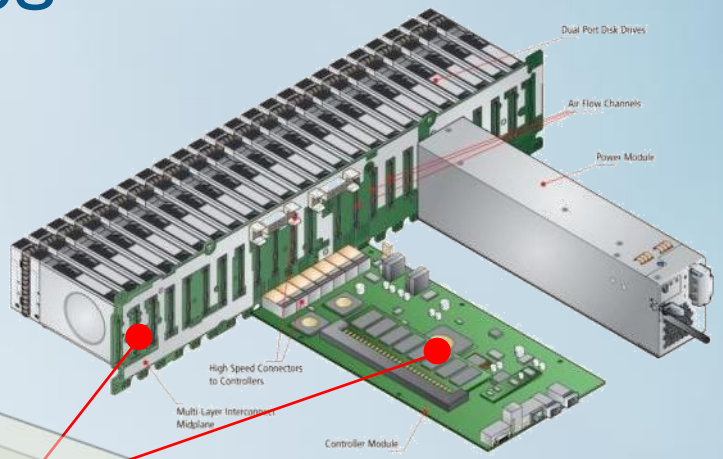
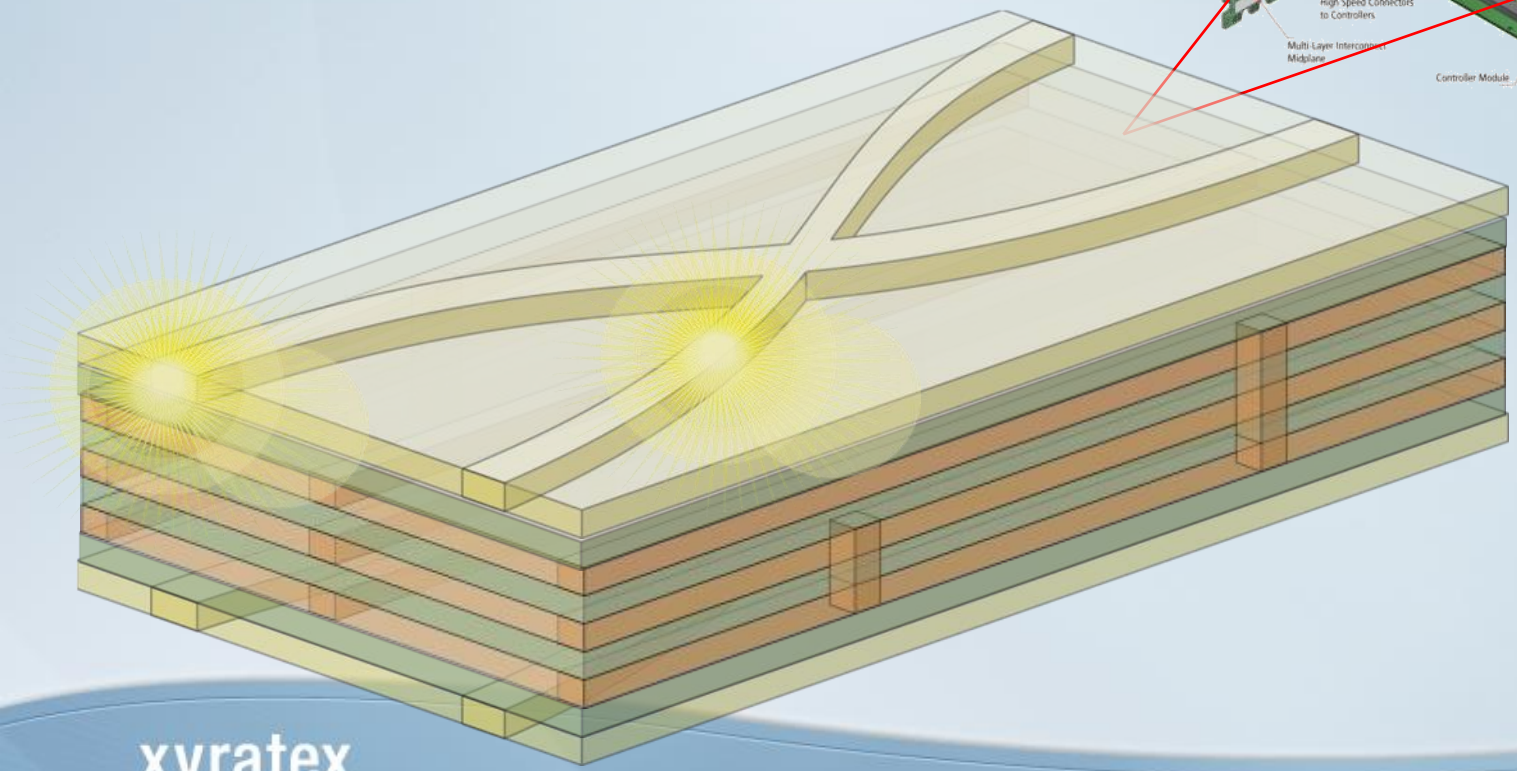
System Embedded Copper and Optical Architectures

- Copper layers for power distribution
- Copper layers for low speed communication
- Optical layers for high speed communication





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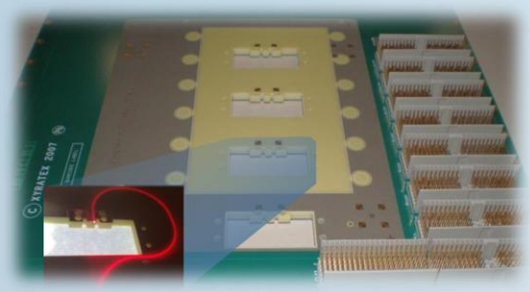


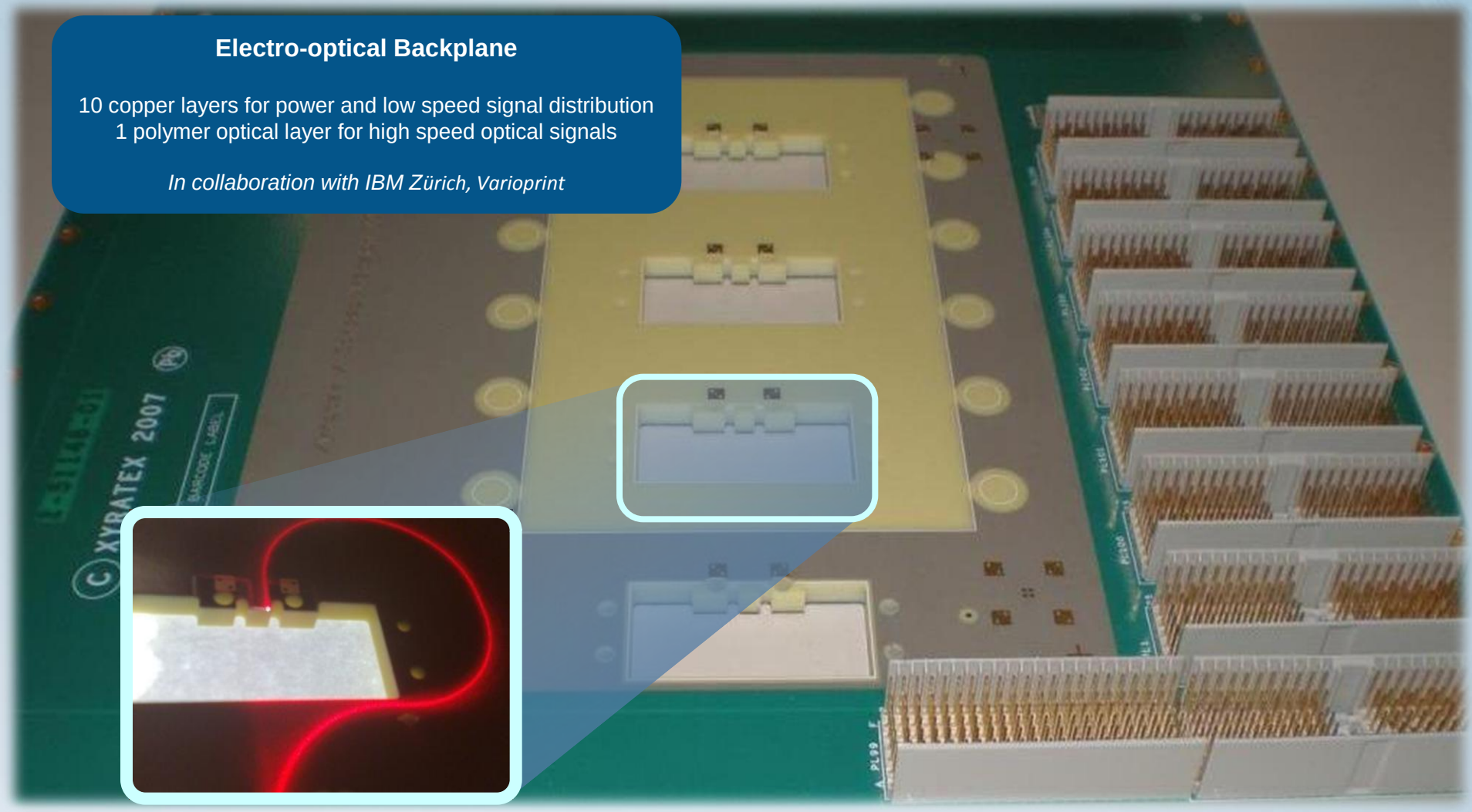
Research and Development Milestones

Electro-Optical Printed Circuit Boards

Electro-optical Backplane

10 copper layers for power and low speed signal distribution
1 polymer optical layer for high speed optical signals

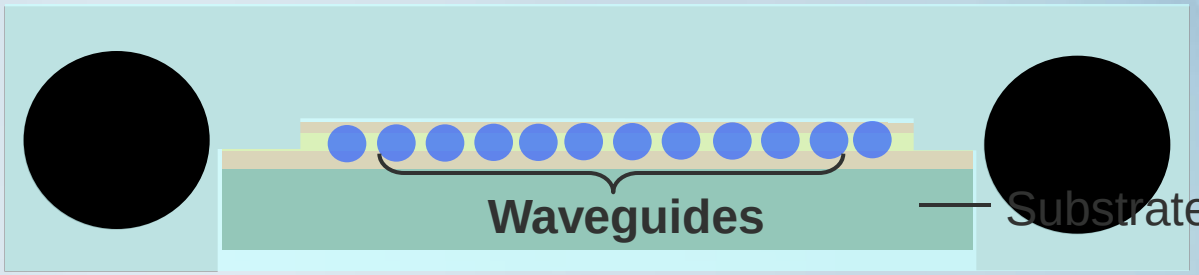
In collaboration with IBM Zürich, Varioprint

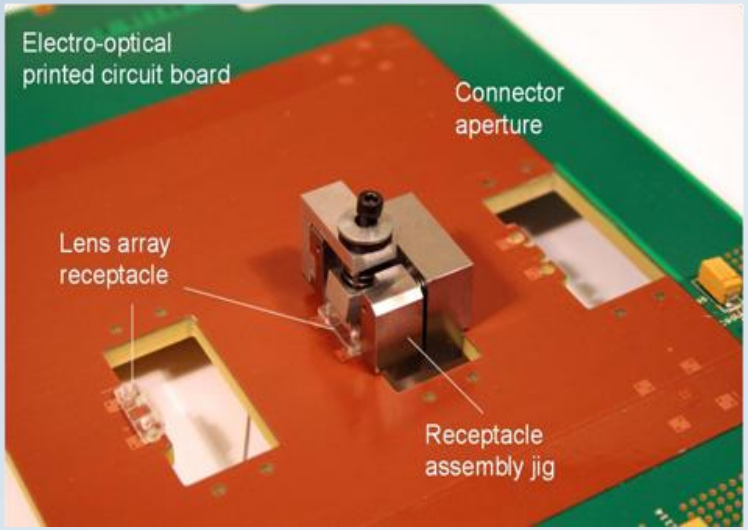


Optical Component Assembly

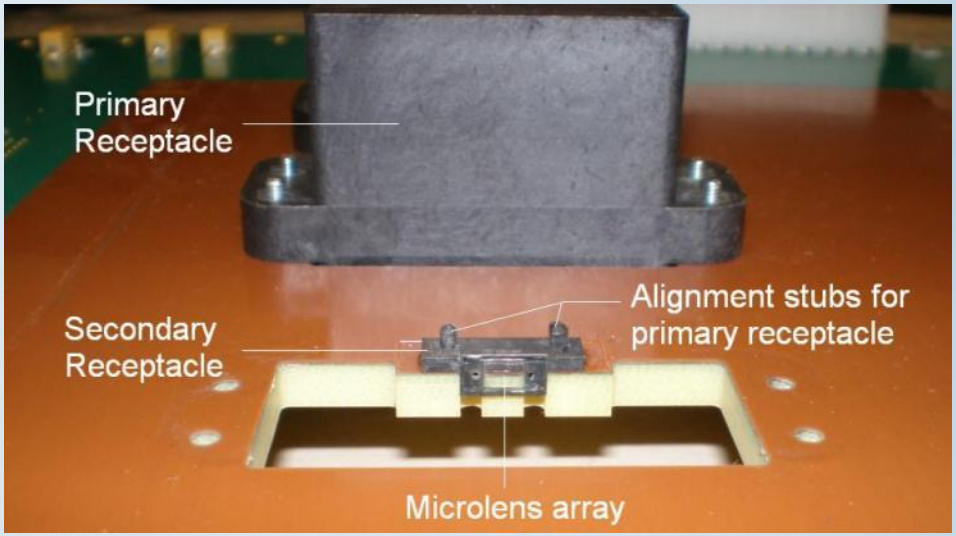
Alignment and Assembly

High precision reliable assembly of optical components onto embedded waveguides. Low cost solutions have been successfully de**veloped and demonstrated**





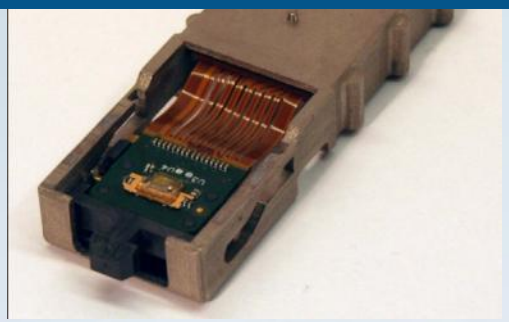
Optical assembly equipment for optical PCB components



Lensed waveguide interface receptacles

Pluggable Electro-Optical PCB Connectors

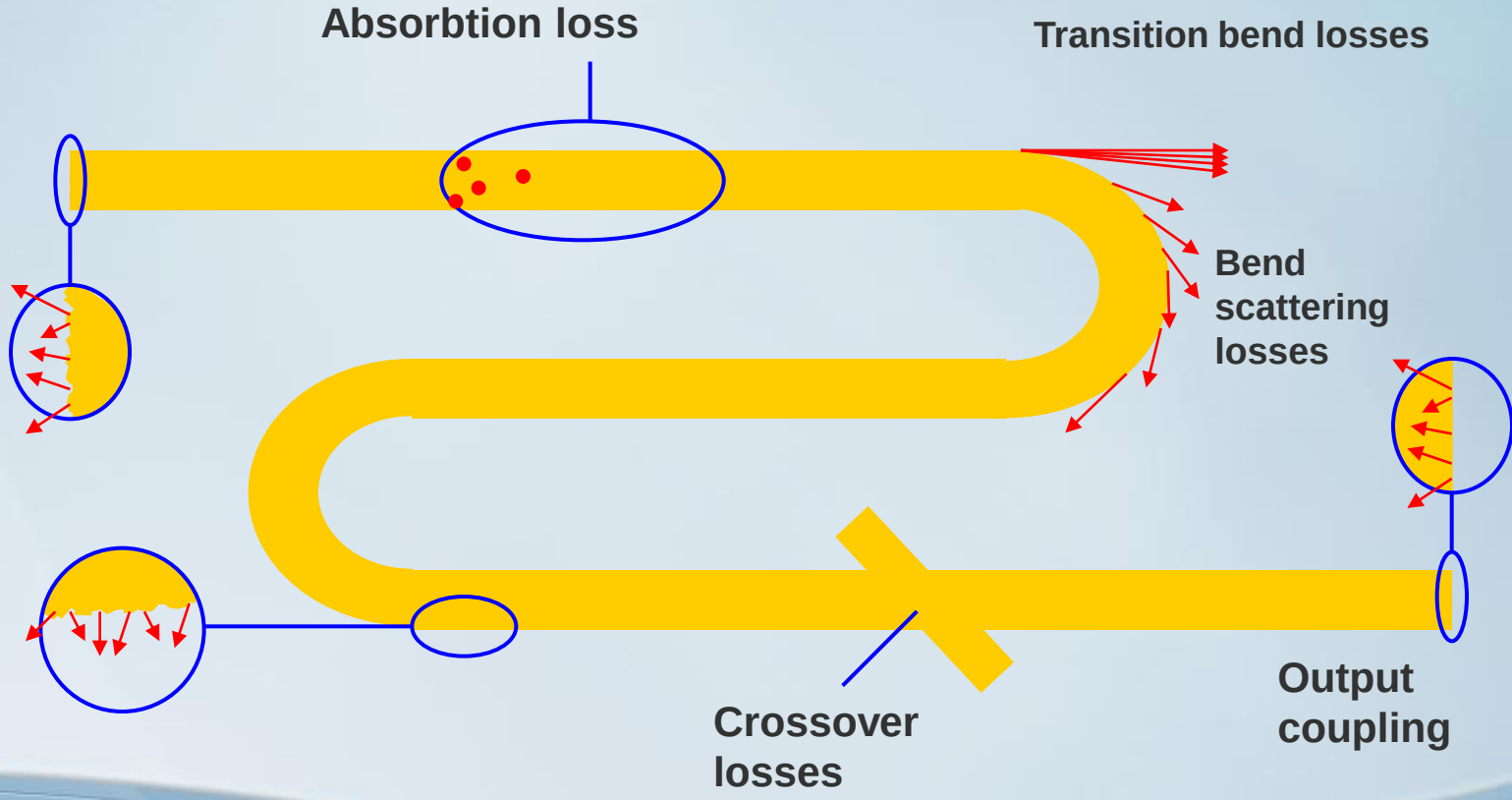
Pluggable Optical Backplane Connector
Quad 90 Gb/s transceiver with custom pluggable optical interface and housing and mechanism allowing backplane pluggability



FirstLight Demonstrator
10 Gb/s test card platform with electro-optical backplane and pluggable optical backplane connectors

xyratex

Loss Mechanisms in Waveguides



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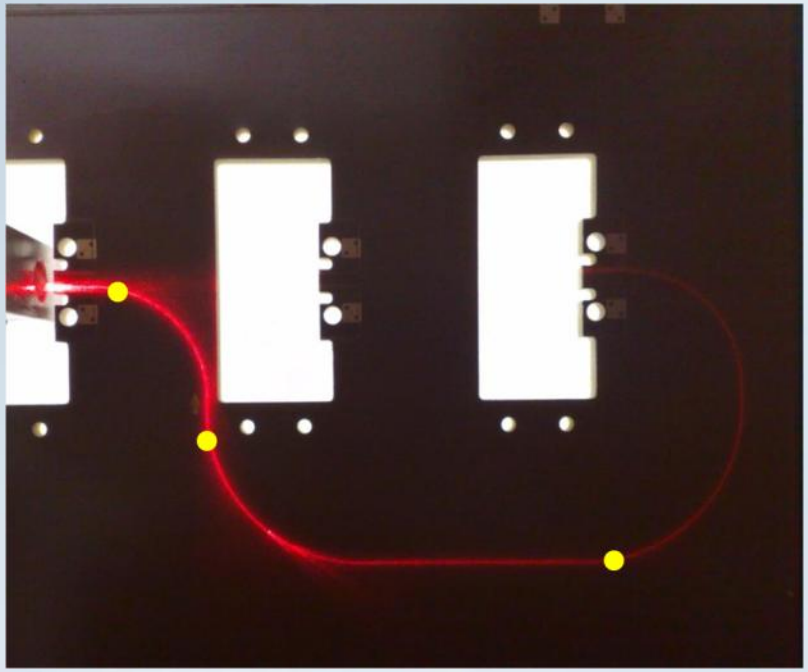
Waveguide Bend Losses and Dispersion

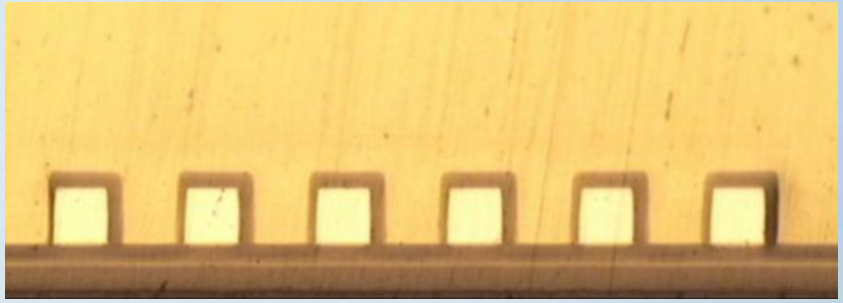
Waveguide bend losses

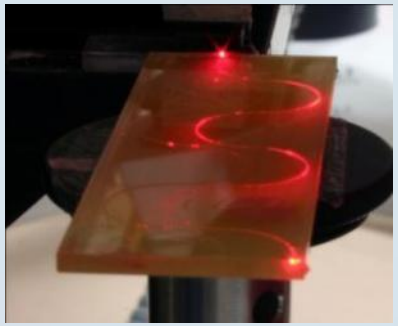
- Transition bend loss caused by NA mismatches between bend segments
- Greatest loss shifts when bend radius is reduced from one segment to another
- Bend scattering losses due to greater modal concentration on outer bend wall, therefore more sidewall scattering

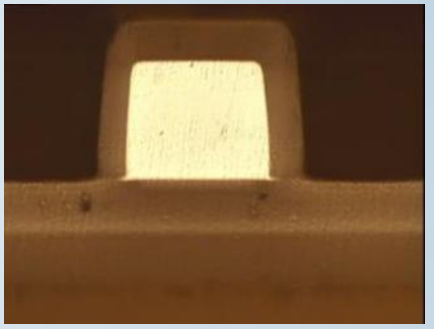
Mitigate bend losses

- Research into proprietary nested core structures with reduced optical bend loss allowing tighter bend radii. This however has a dispersion penalty due to step-index waveguide profile
- Need to develop planar waveguide with graded index structure









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Data Storage Systems with Embedded Optical Links

A technology demonstration of a data storage system enclosure with 12G optical polymer waveguide interconnects

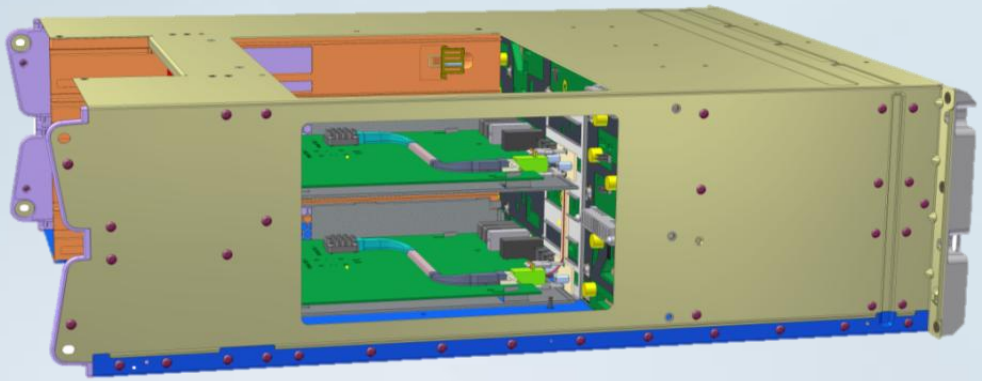
Finisar

HUBER+SUHNER

vario-optics ag

LSI

- Prototype 4U **Xyratex OneStor™** enclosure with embedded optical interconnect
- Collaboration with **Finisar**, **Huber+Suhner**, **vario-optics ag**, **LSI** to provide full eco-system for embedded optical interconnect in data storage platform
- First demonstration of **12G SAS optical links** between internal data storage controllers
- Optical links comprised of ***polymer optical waveguides***



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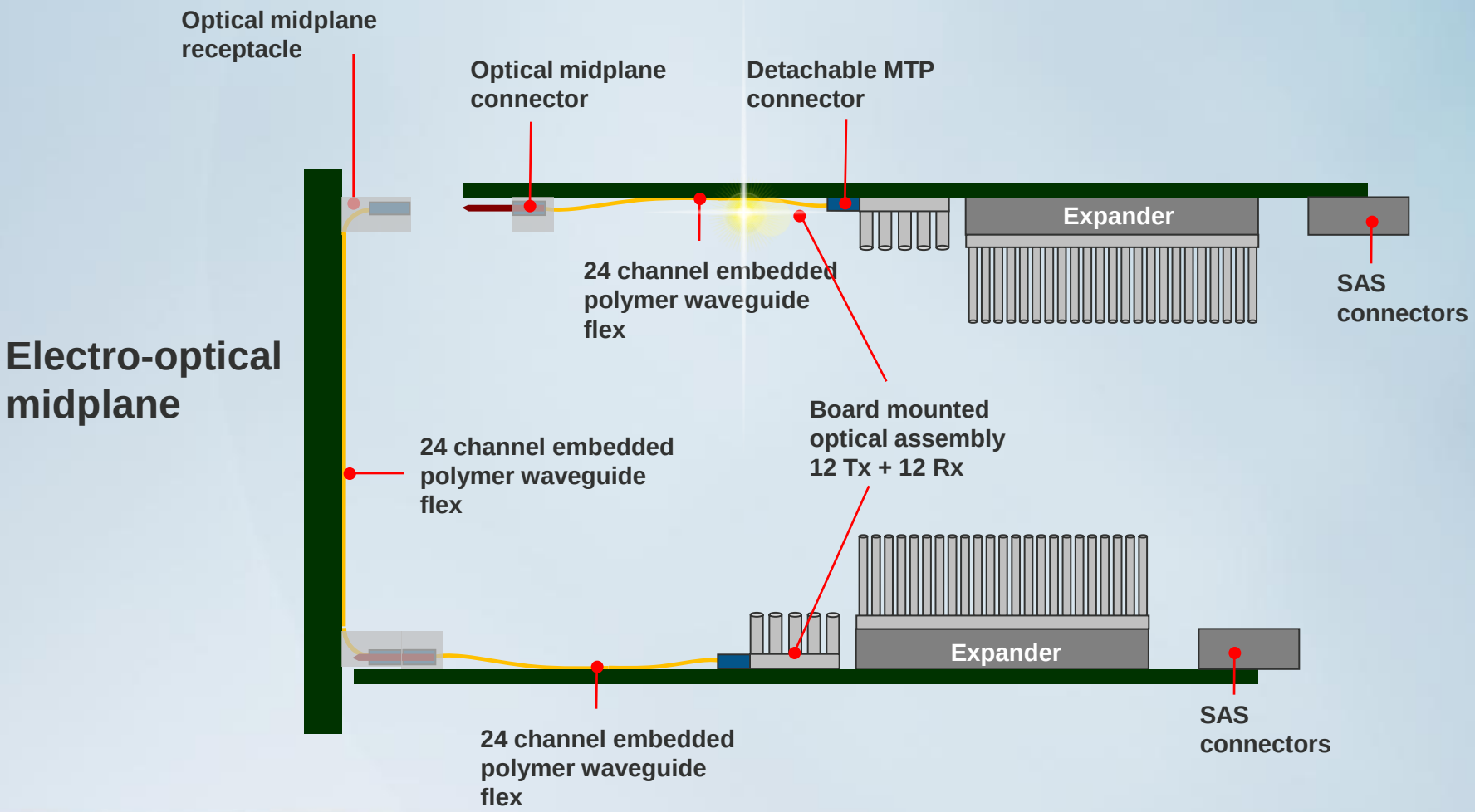
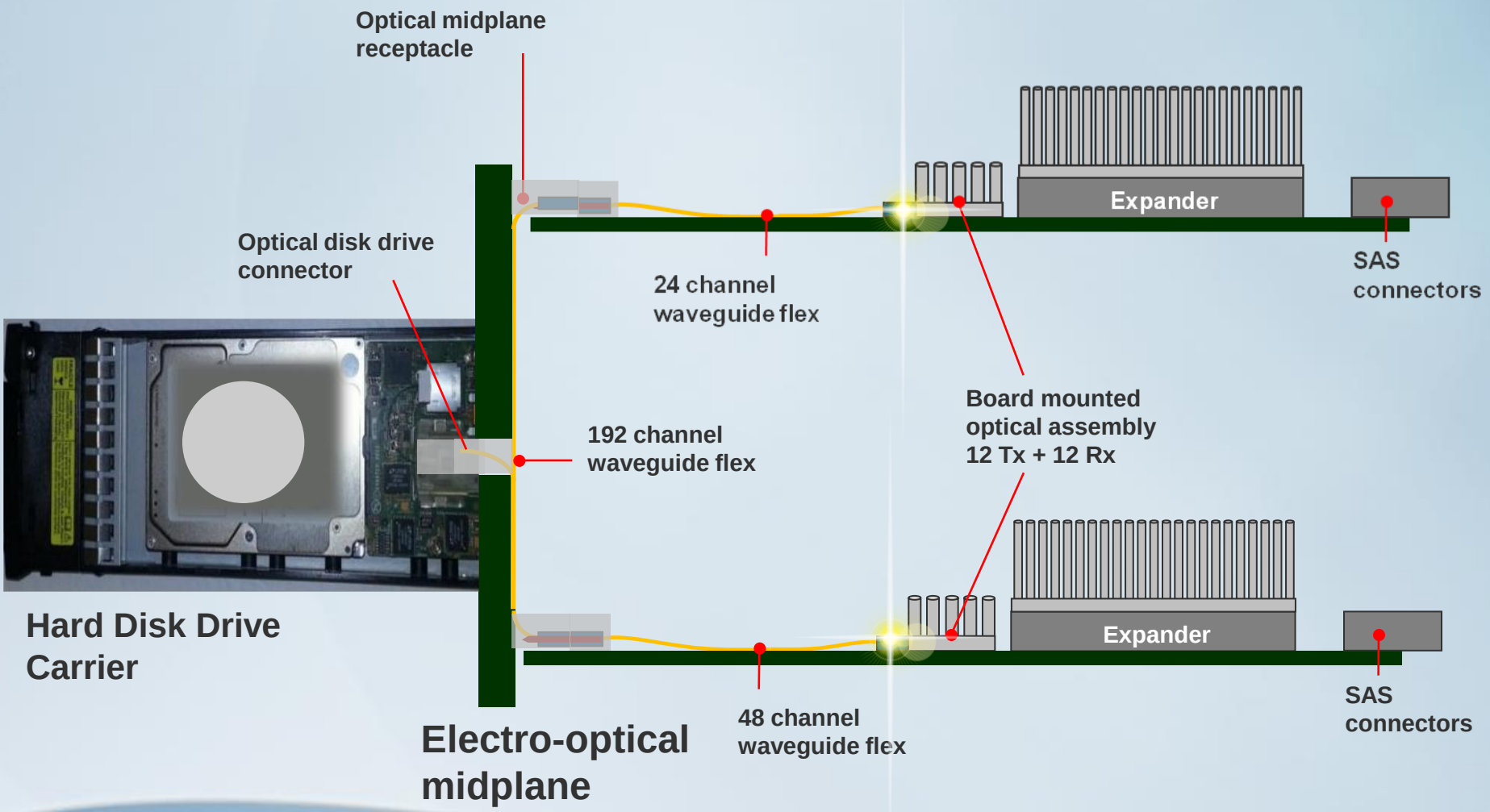
LightningValley Demonstration Platform



LightningValley Demonstration Platform

Successful exhibition of LightningValley demonstrator at ECOC 2012 in Amsterdam

ThunderValley2 Demonstration Platform



ThunderValley2 Demonstration Platform

A technology demonstration of the first fully optically interconnected 2U24 OneStor™ data storage platform

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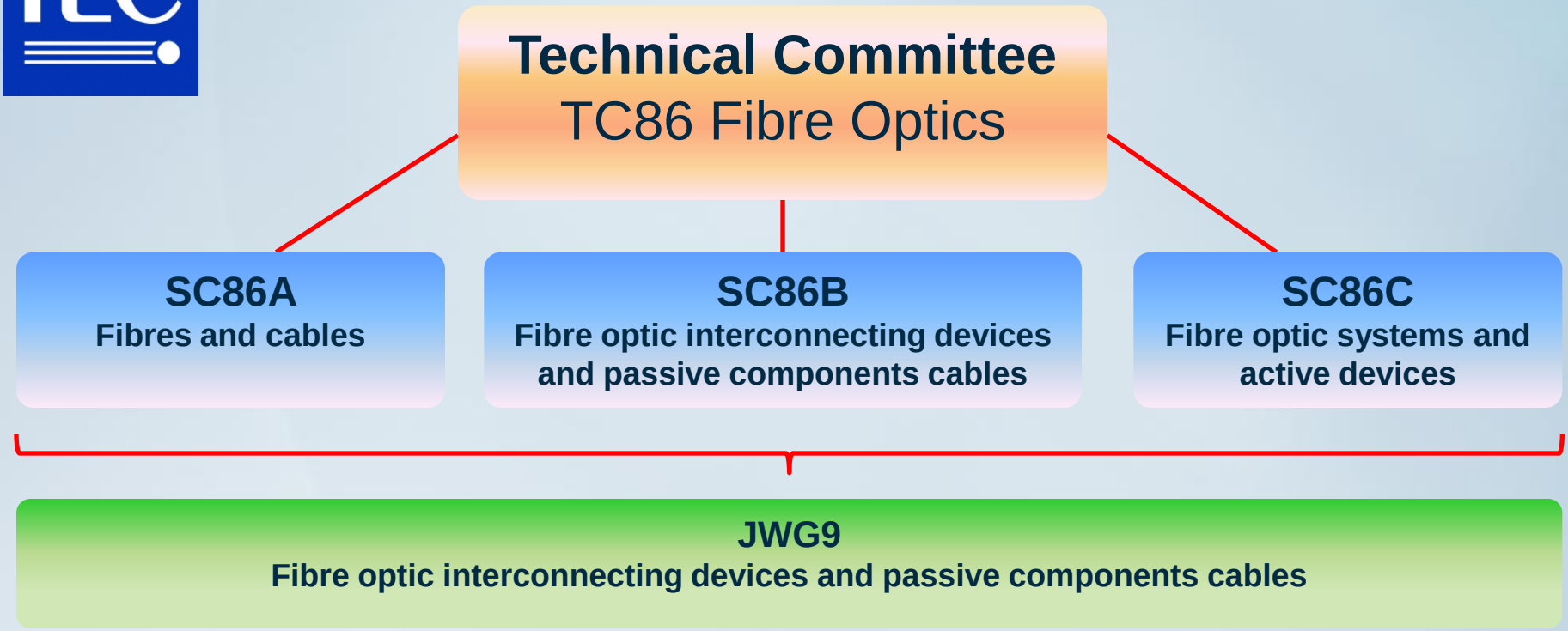
International Standards Activities for Embedded Photonics

International Electro-technical Commission

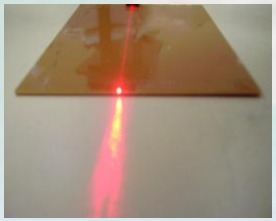
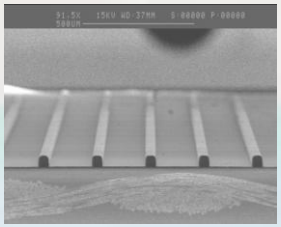
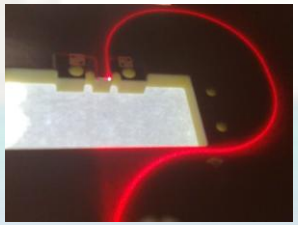
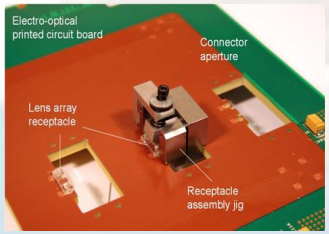


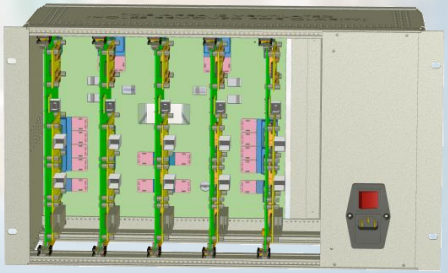
International Standards Activities for Embedded Photonics

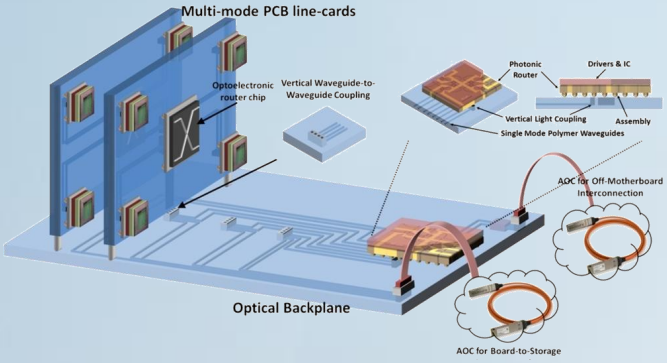
Joint Working Group JWG 9
Optical functionality for electronic assemblies

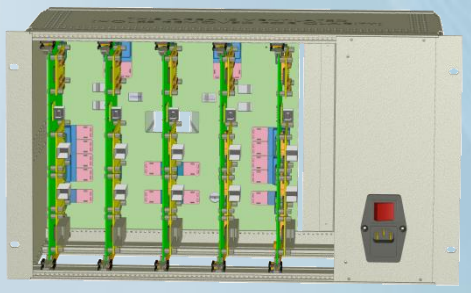
To prepare international standards and specifications for **optical circuit boards** and **optical back planes**, intended for use with **opto-electronic assemblies**. Other devices intended for use with optoelectronic assemblies such as fibre optic connectors, passive optical devices, active devices, dynamic devices, etc., are directly standardized at the existing WGs in TC86.

Chairman: Etsuji Sugita

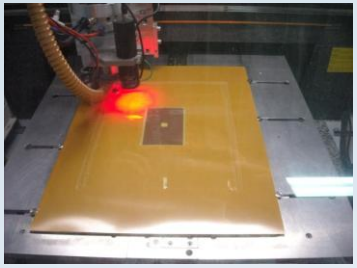





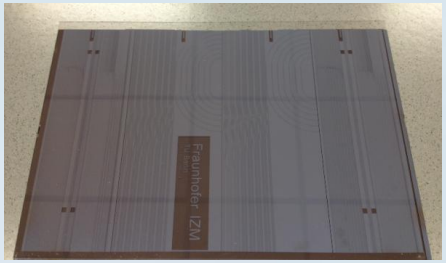


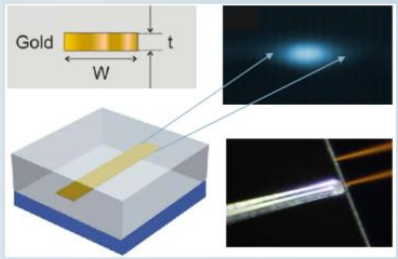




Collaborative Research and Development Activities







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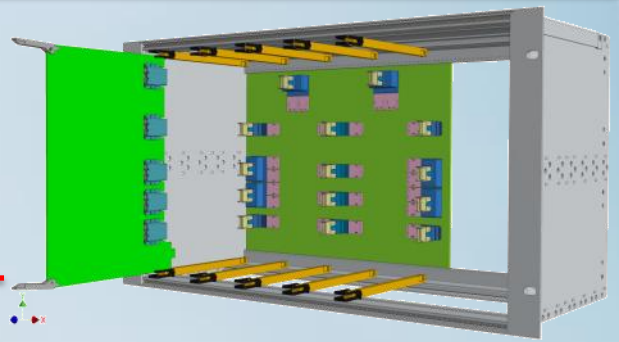
System Embedded Photonics In Access Networks

What

SEPIANet

Develop electro-optical PCBs with embedded glass waveguides and supporting interconnect technologies



Who

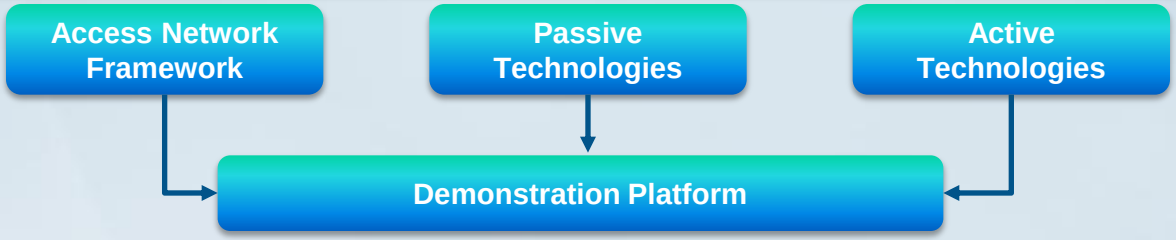
Germany
- ❑ Fraunhofer IZM
- ❑ V-I-Systems
- ❑ ILFA GmbH

UK
- ❑ Xyratex
- ❑ Conjunct
- ❑ TerOpta

When

Start date: 1st July 2011
End date: 1st January 2014

How

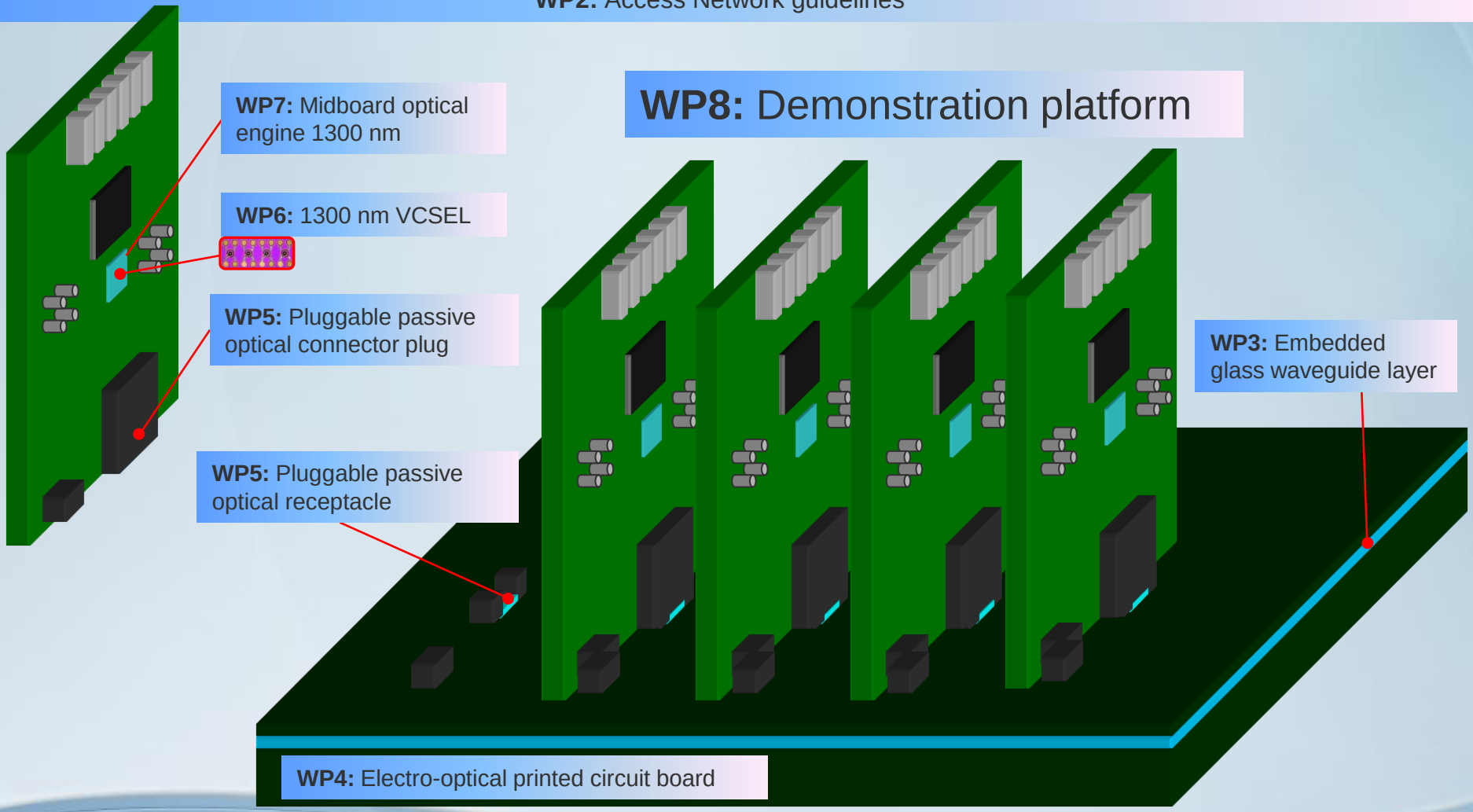


Why

- ❑ Deployment of embedded glass waveguide in PCB technologies
- ❑ Development of universal optical PCB connector
- ❑ Development of high speed 1300 nm optical engine technology
- ❑ Demonstration of system bandwidth enhancement through board-level embedded photonic interconnect

SEPIANet Project Deliverables

WP2: Access Network guidelines



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SEPIANet Demonstration Platform

Technology demonstration of a high speed optically enabled communications system enclosure with PCB embedded planar glass waveguides,1300 nm transceiver assemblies and pluggable connectors

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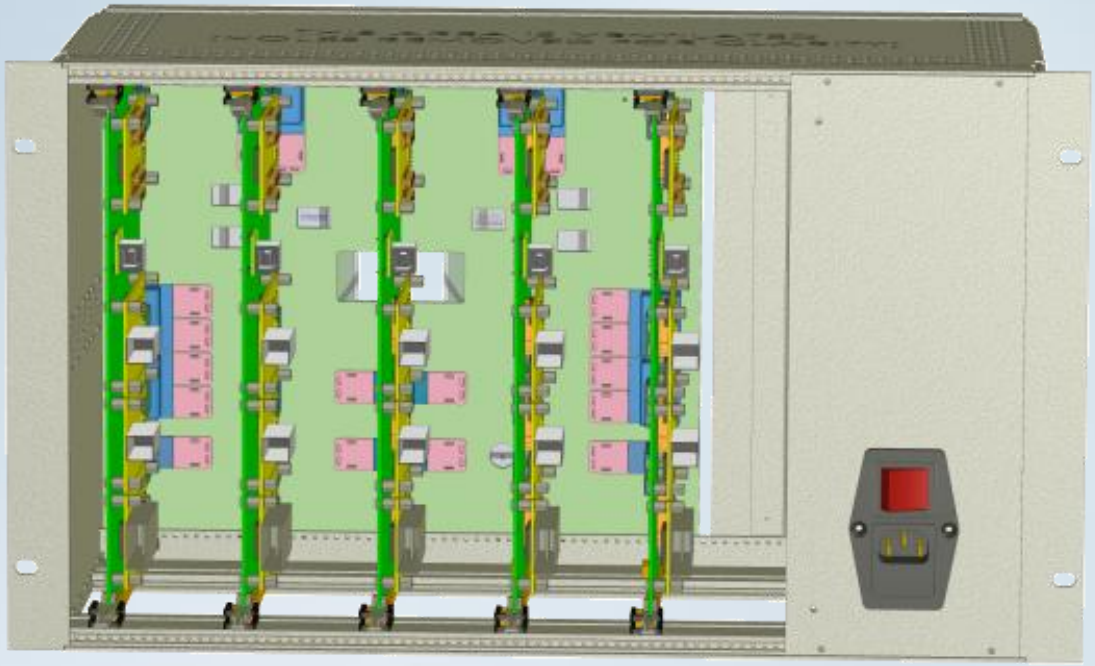
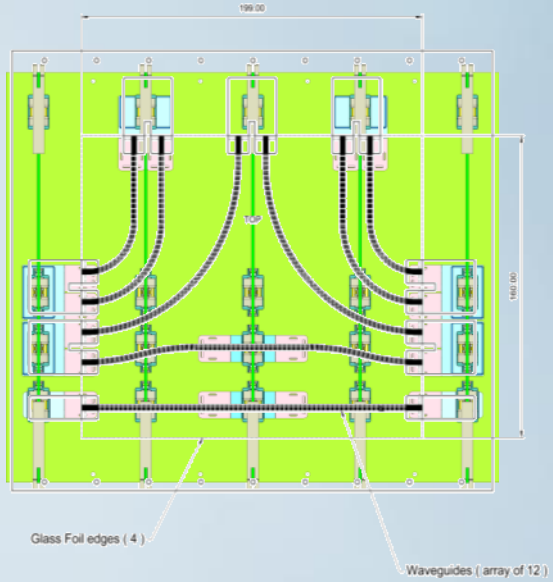
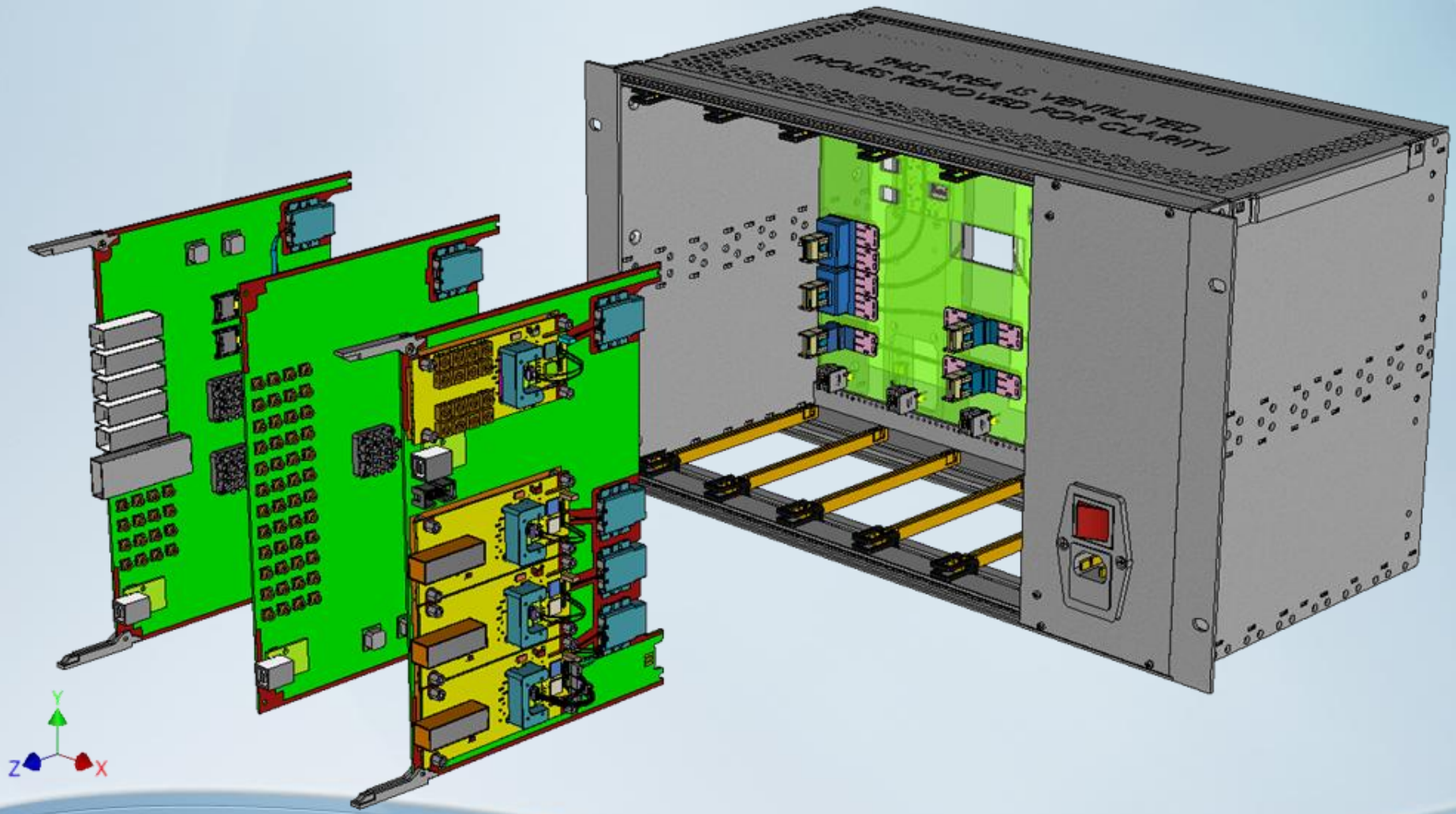
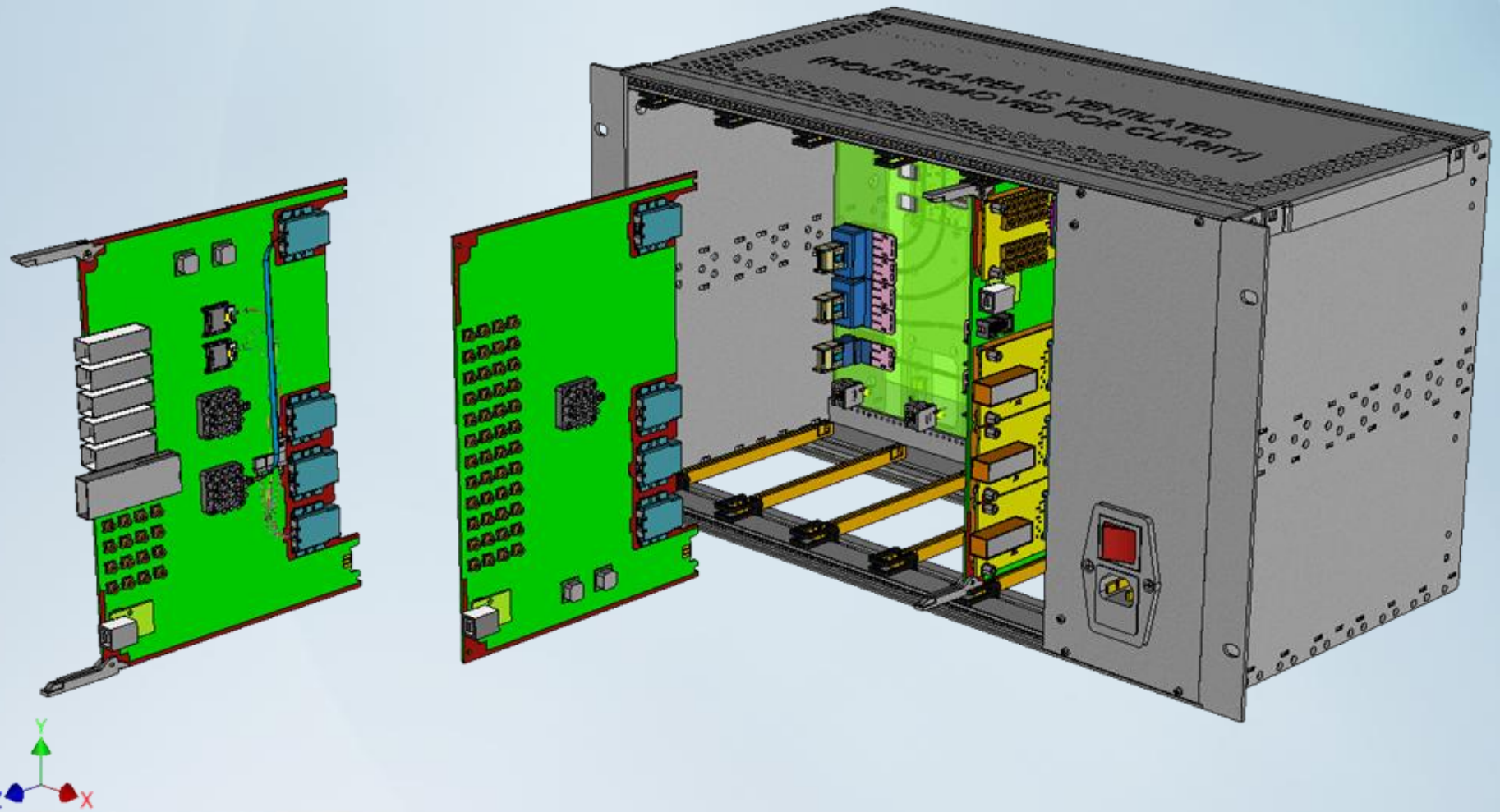




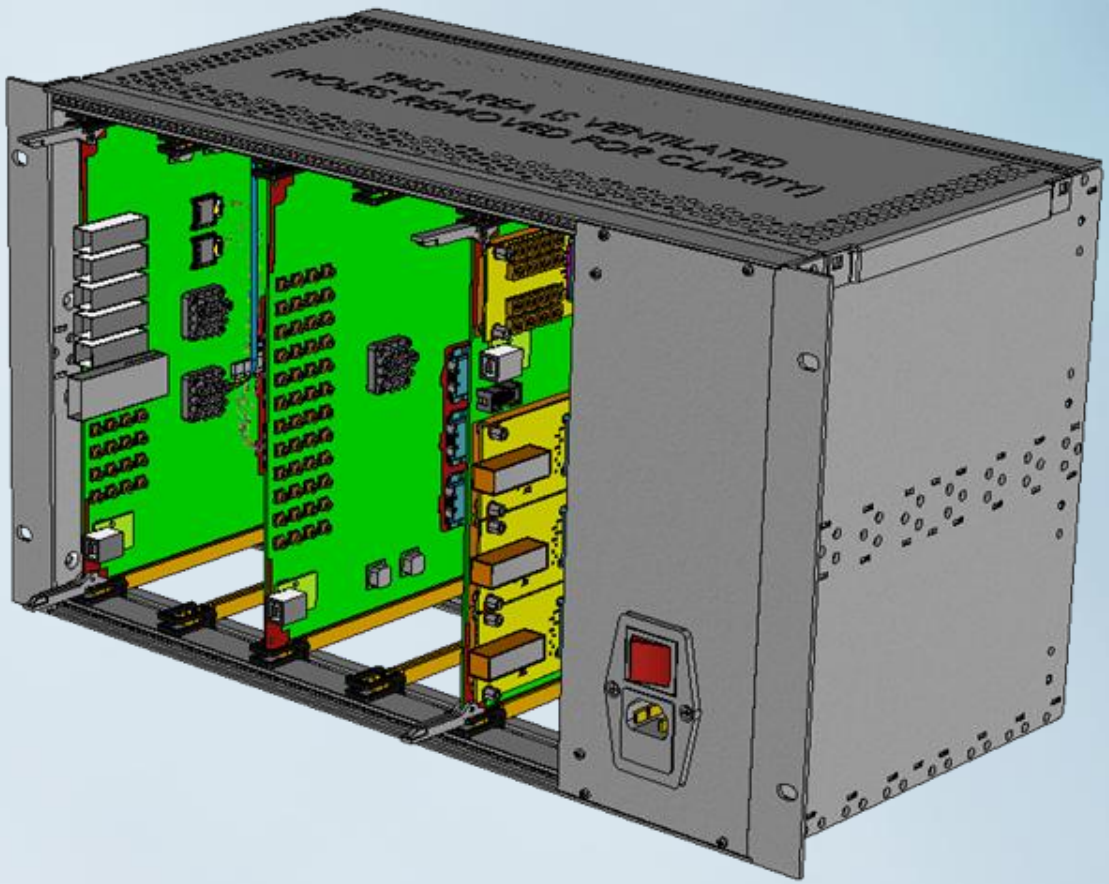
Demonstrator Assembly Concept



Demonstrator Assembly Concept



Demonstrator Assembly Concept

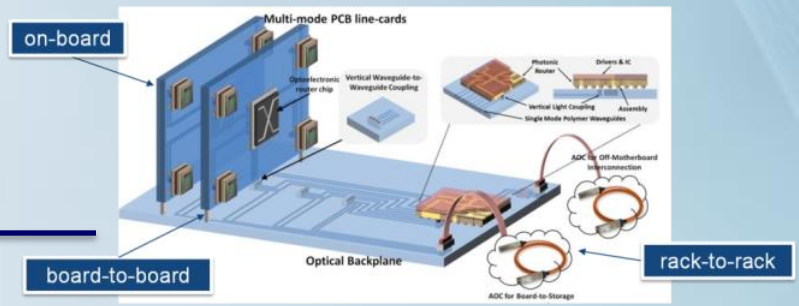


PhoxTrot – Integrated Photonics for Data Centres and HPCs

What

PhoxTrot

EU Integrated Project focusing on high-performance, low-energy and cost and small-size optical interconnects across the different hierarchy levels in Data Centre and High-Performance Computing Systems: on-board, board-to-board and rack-to-rack



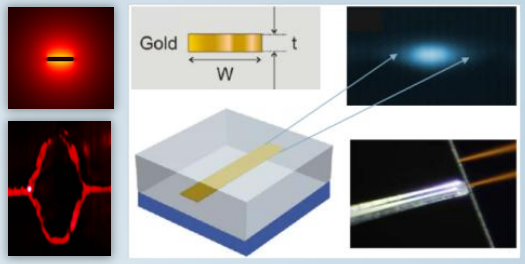
Who

Project type
FP7 Integrated project

18 EU partners
Coordinator: Fraunhofer Institute

When

Start date: 1st October 2012
End date: 1st October 2016



How

Plasmonics | Si Photonics | CMOS electronics | III-V | Glass | Polymers

Why

- Generic building block technologies (transmitters, modulators, receivers, switches, optochips, multi- and single-mode optical PCBs, chip- and board-to-board connectors) that can be used for a broad range of applications, extending performance beyond Tb/s and reducing energy by more than 50%
- Unified integration/packaging methodology as a cost/energy-reduction factor for board-adaptable 3D SiP transceiver and router optochip fabrication whole "food-chain" of low-cost and low-energy interconnect technologies concluding in functional > Tb/s prototype systems for chip-to-chip, board-to-board and rack-to-rack interconnection (1.28Tb/s 16QAM Active Optical

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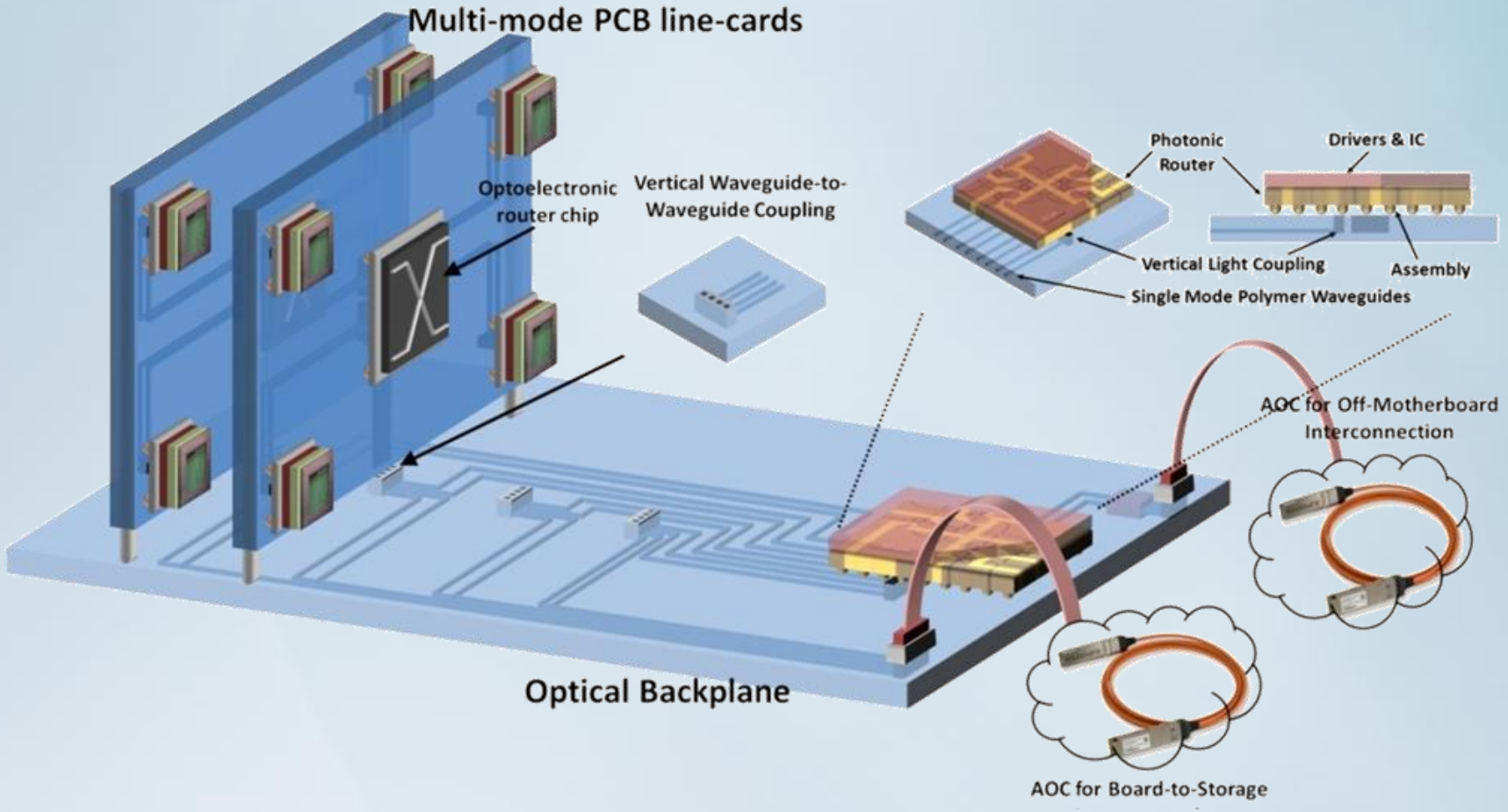
PhoxTrot Milestones and Deliverables

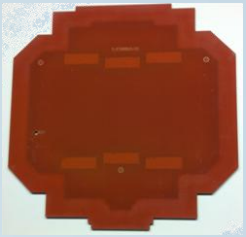


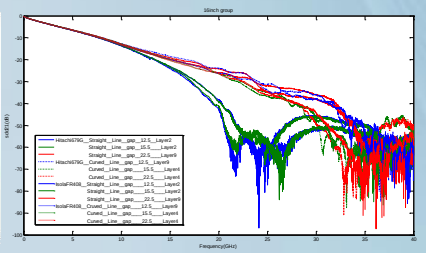
HDPuG – High Density Packaging User Group

What

Optoelectronics

Largest industrially research and development project in polymer waveguide and high speed copper interconnect in electro-optical PCBs





Who

Project type

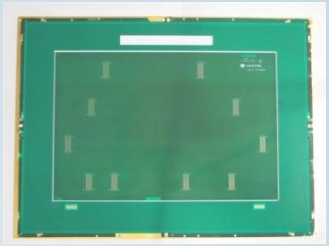
Industrial collaboration

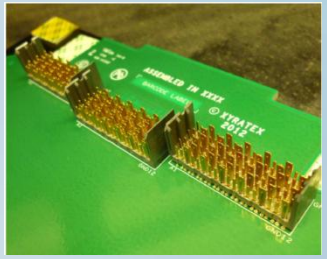
Partners

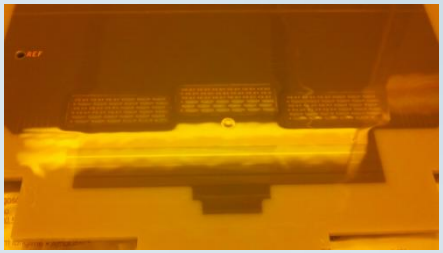
TTM (coordinator)
Cisco
Alcatel-Lucent
Boeing
Celestica
Compass EOS
Ericsson
Flextronics
Fujitsu
Huawei
IBM
Intel
ITEQ

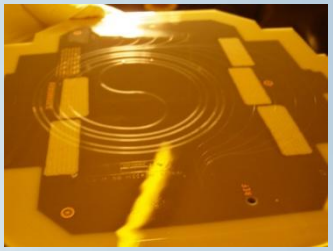
Partners / Contributors

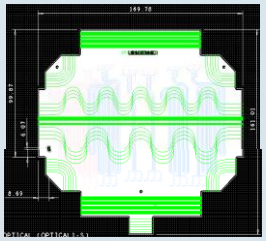
Xyratex
Juniper
National Semicon.
Nihon Superior
Multek
Oracle
Panasonic
Philips
Viasystems
Amphenol
Dow Electronic Materials
Dow Corning
Hitachi
Isola
Optical Interlinks
Quandong Shenghyi
Rogers

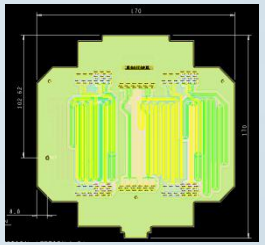


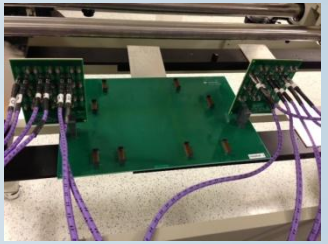












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Conclusion

- **Exponentially increasing bandwidth densities** approaching design limits of internal electronic interconnect
- **Emerging eco-system** in system embedded optical interconnect
- First fully **optically enabled data storage** platforms developed
- **International standards activities** in board-level optical interconnect and assembly technology
- Strong **global photonics research and development activities** to implement optical interconnect in future ICT systems

Thank you for your attention

Richard Pitwon
Lead Photonics Technologist

E-mail: richard_pitwon@xyratex.com