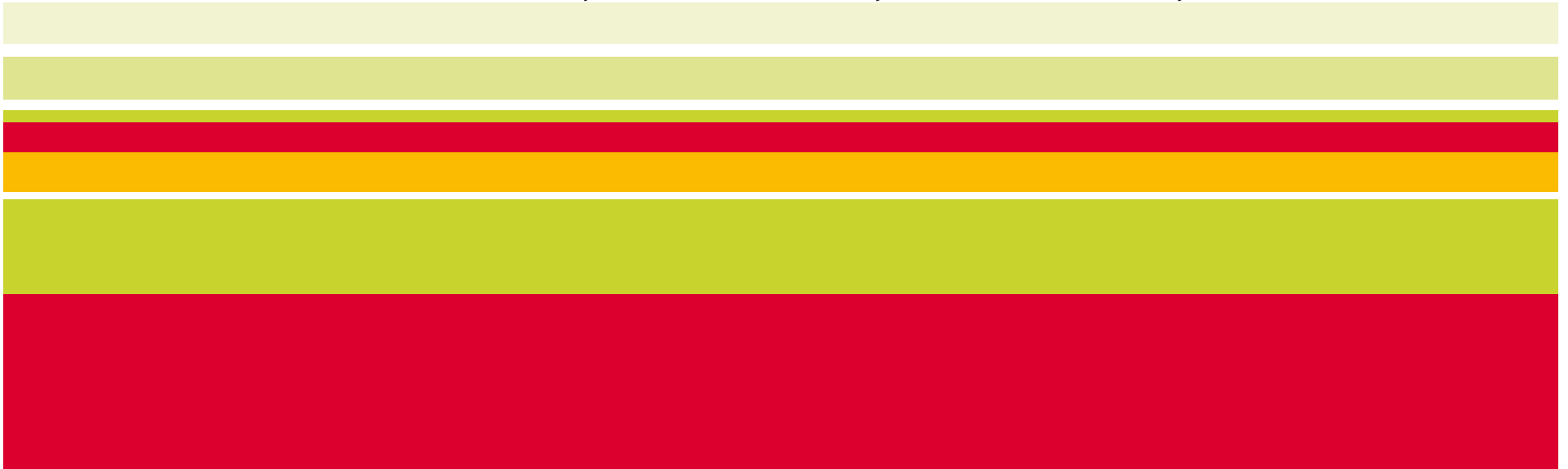




# **100 GBit/s I/O – Herausforderungen für Steckverbinder**

Steckerverbinderkongress, Würzburg, Juni 29/30

**Dr. Sven Otte, Jan Hoffmann, James J. David,**



- ▲ Current Status of Market
- ▲ Market demands: mainly driven by internet revolution
- ▲ HSIO Lane & Link Bandwidth Roadmaps
- ▲ HSIO – Length versus Performance
- ▲ Hardware requirements
- ▲ IO recognition requirements
- ▲ Copper Cable assembly manufacturing
- ▲ AOC Value Chain
- ▲ Optical cable manufacturing
- ▲ FCI AOC in Juropa HPC
- ▲ Alignment of Coupling Unit and Laser
- ▲ Cable testing & validation
- ▲ Summary

# Current Status of Market



## Driving unprecedented development & evolution

### Large file transmission

- Videos
- MP3 files
- Images

### Social networks & communication

- Face Book
- MySpace
- You Tube
- Twitter

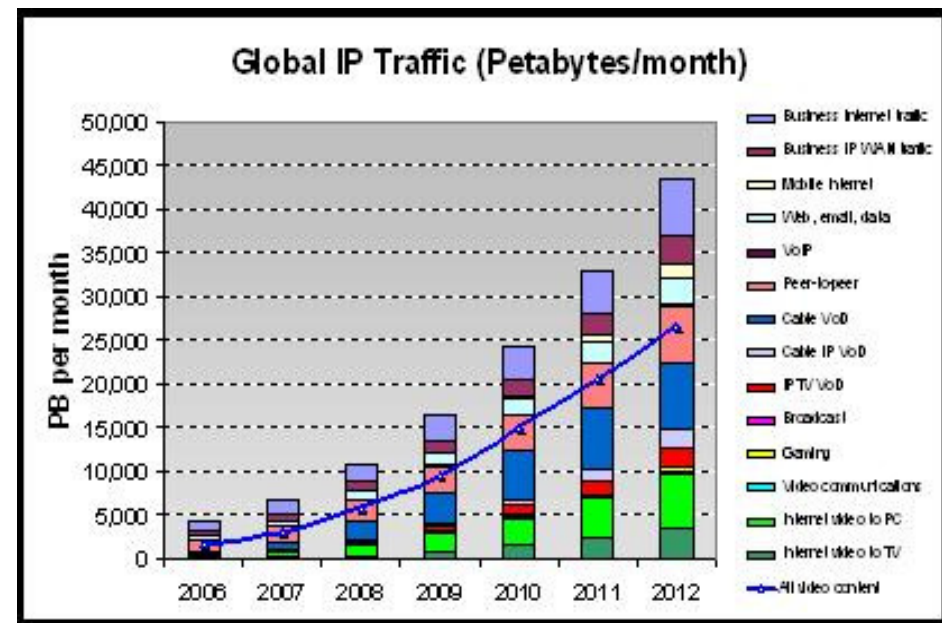
### Real time information & transmission

- News
- Sports
- World events

## No decline in sight

- IPTV
- Peer-to-peer
- Video on demand

## More and more global users added every day



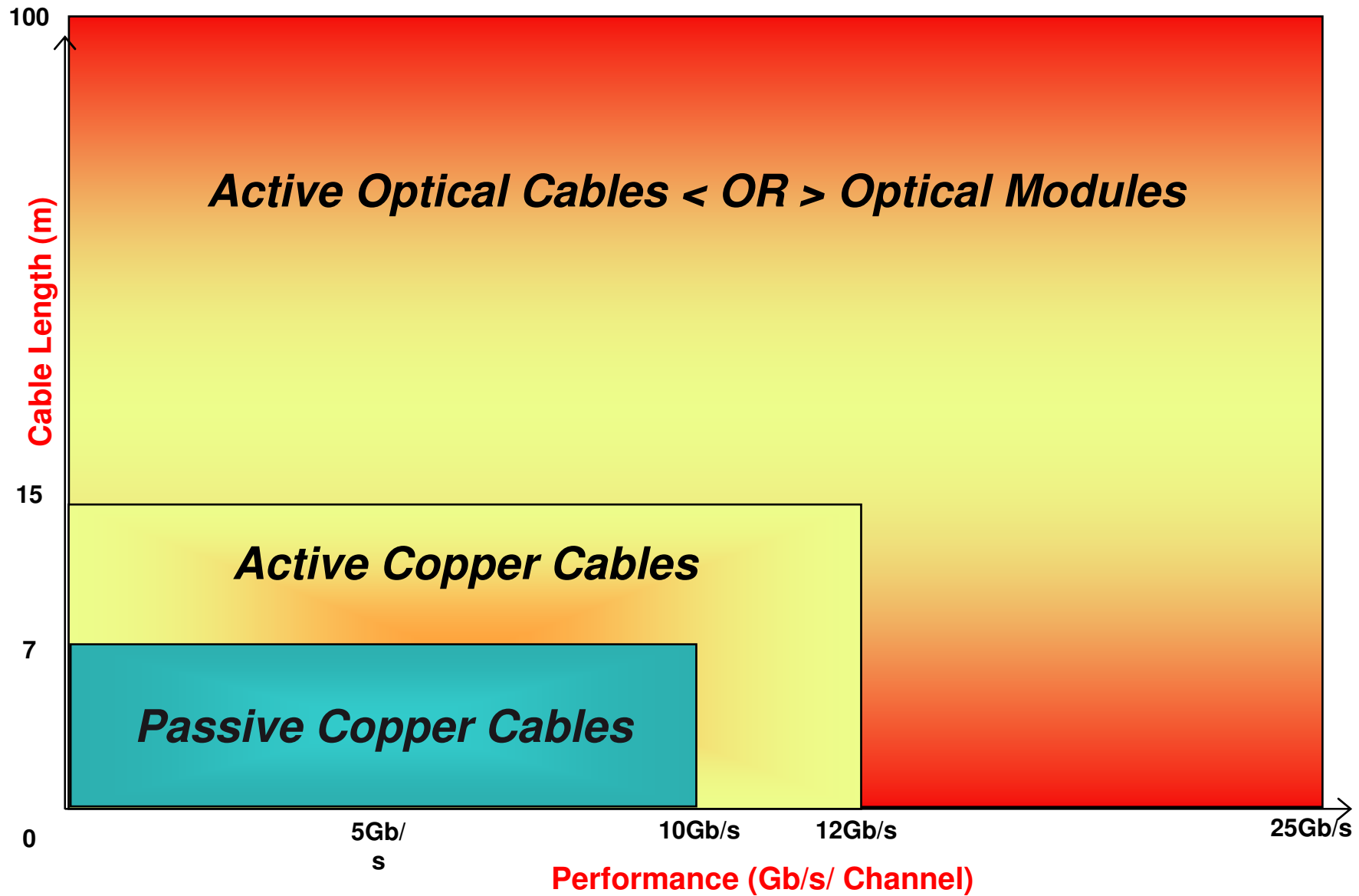
- Network migration to 100Gb/s is in development:
  - External Storage IO roadmap : SDR (2,5); DDR (5,0); QDR (10 Gbit/s)
    - FDR (14Gb/s) & EDR ( 25Gb/s) emerging
  - Ethernet roadmap:
    - 40Gb/s (4x 10) developing;
    - 100Gb/s (10x10 & 4x25Gb/s) emerging
- IO Copper & Optical Cabling systems require a common electrical interface:
  - High Density 10Gb/s serial signal lanes initially
  - 20 - 25Gb/s serial signal lanes recommended;
  - Technological performance (cost, power, reach) driven
- Standardization committees established to define overall link specification to meet the emerging high speed IO systems:
  - IEEE 802.3ba for 40G/s (4x10) & 100Gb/s (10 x 10) Copper interconnect (Cable & BP)
  - OIF CEI-28G –VSR Channel specification for 25Gbit/s IO lane speed
  - IBTA Working group for 4x25 & 12x25 Gb/s

# HSIO Lane & Link Bandwidth Roadmaps



		2006	2007	2008	2009	2010	2011	2012	2013	2014
PCI Express	X1	2.5 Gb/s (Gen1)			5 Gb/s (Gen2)		8 Gb/s (Gen3)			
	X4	10 Gb/s			20 Gb/s		32 Gb/s			
	X8	20 Gb/s			40 Gb/s		64 Gb/s			
	X16	40 Gb/s			80 Gb/s		128 Gb/s			
SAS	X1	3 Gb/s			6 Gb/s				12 Gb/s	
	X4	12 Gb/s Mini-SAS			24 Gb/s Mini-SAS		48 Gb/s Mini-SAS HD			
Fibre Channel FCoE	X1	4.25 Gb/s (4GFC)			8.5 Gb/s (8GFC)		14 Gb/s (FDR)		SFP+ / ZFP	
	X1				10 Gb/s SFP+					
Infiniband	X1	5 Gb/s (DDR)			10 Gb/s (QDR)		20 Gb/s (EDR)			
	X4	20 Gb/s EyeMax			40 Gb/s QSFP		80 Gb/s			
	X12	60 Gb/s			120 Gb/s CXP		240 Gb/s			
					10 Gb/s SFP+					
Ethernet	X1	10 Gb/s (4x2.5G) EyeMax			40 Gb/s QSFP		?????? 20-25 Gb/s per lane ????			
	X4				100 Gb/s CFP					
	X10				100 Gb/s CXP					

# HSIO – Length versus Performance



# Hardware requirements



## ■ Systems designs must account for:

- Multi-core processors
- Increased bus speeds
- Increased memory demands
- Increased power
- Signal integrity
- Heat dissipation & cooling



## ■ Closer working relationship system designers & I/O system suppliers

- Greater understanding of capabilities of each party
- Industry standards have facilitated this discussion

## ■ System needs

- Greater port bandwidth
- Greater port density
- Faster signal transmission
  - Meeting today's need and future needs – “future proofing”
  - 40 & 100 Gb/s total bandwidths identified
- Port configuration flexibility
- System recognition of cables
- I/O port standardization



High Speed  
**CONNECT/ONS**

# IO recognition requirements



- Addition of EEPROM to cable assemblies
  - Memory map defines pertinent information
    - Cable length
    - Copper or Fiber optic based cable
    - Passive or actively equalized
    - Cable manufacturer
    - Date code
    - Performance characteristics
    - Industry standard compliance
  - Memory map structure and content standardized
  - Some customer specific information can be added
  - Automatic traceability
- System hardware downloads information upon cable plug-up
  - System recognition of capability of the port
  - Better system management of the I/O function
  - Actively equalized cable assemblies
    - System knows to bus power
- Each cable must have an EEPROM and it must be programmed properly
  - Manufacturer must assure cable meets performance noted in EEPROM
- Plug-n-play simplicity for users / data center management
  - Industry standards want ease of use to be assured

## ■ Wire management / termination / repeatability

- Proper control and stability of process of transition from raw cable to wire termination

- Key area for assuring proper cable performance

- Must be repeatable & controlled

- Transmission speeds – 10 Gb/s +

- Sensitive to any geometric changes / variations

- Maintain raw cable construction

» For as long and consistently as possible

### ■ Areas of possible variation

- Cable jacket strip / EMI termination / cable strain relief

- Differential pair foil strip

- Differential pair insulation strip

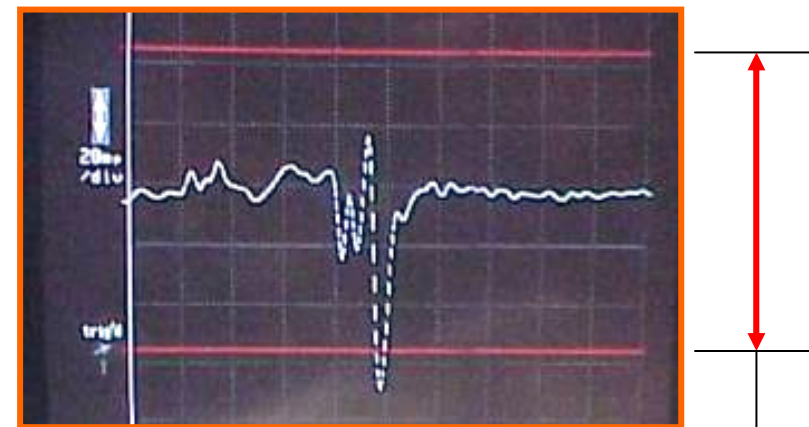
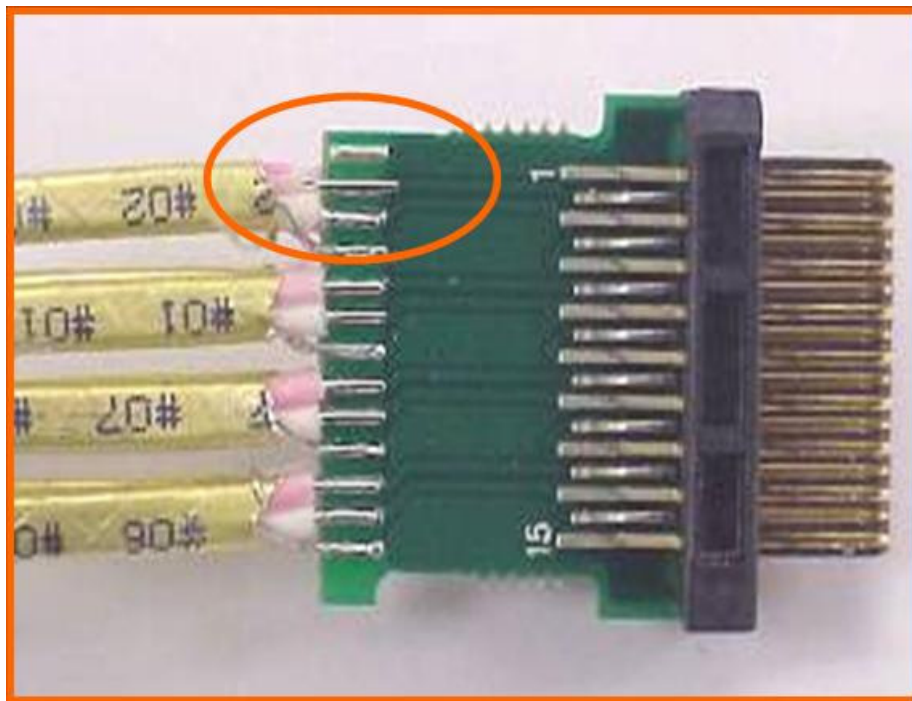
- Wire management

- Wire / differential pair length

- Wire termination

- Wire strain relief

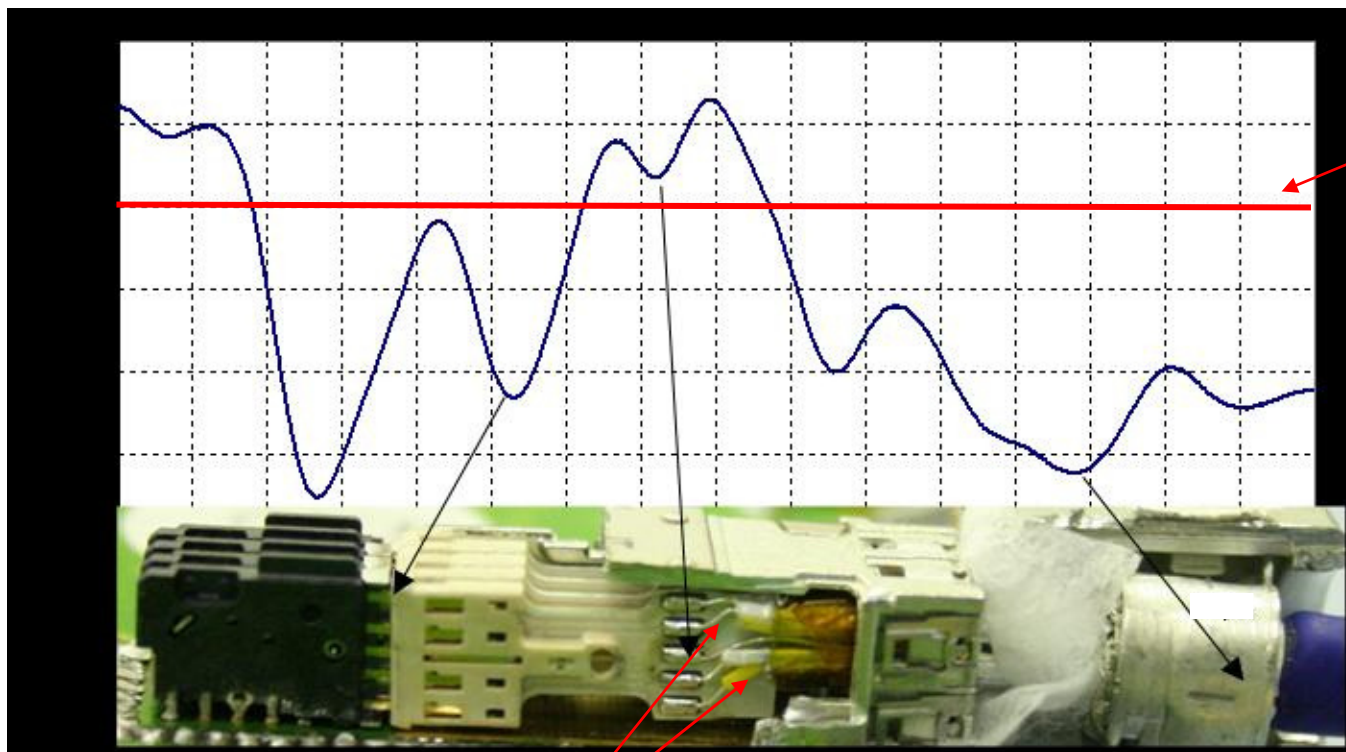
- Wire / differential pair strip length
  - Small variation in wire length cannot occur



Allowable impedance profile range

## Wire / differential pair strip length

- Small variation in foil strip length is not acceptable
- Improper care in wire management

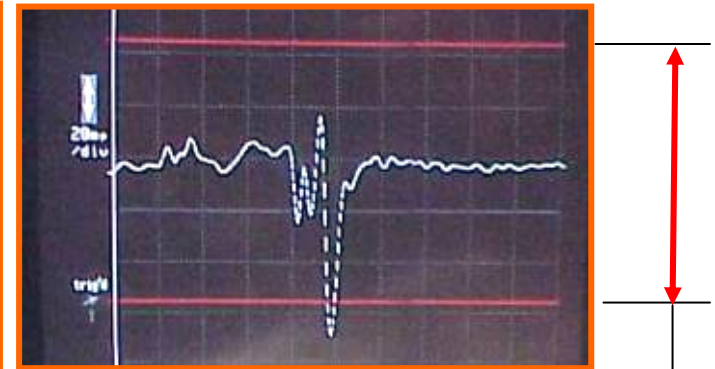


Upper impedance limit

Poor wire management  
& foil strip

## Wire termination

- Inconsistent or excessive solder
- Repair may be difficult or impossible



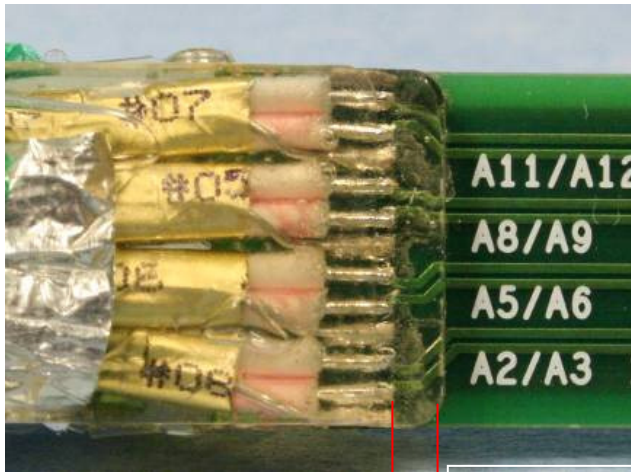
Allowable impedance  
profile range

# Copper Cable assembly manufacturing

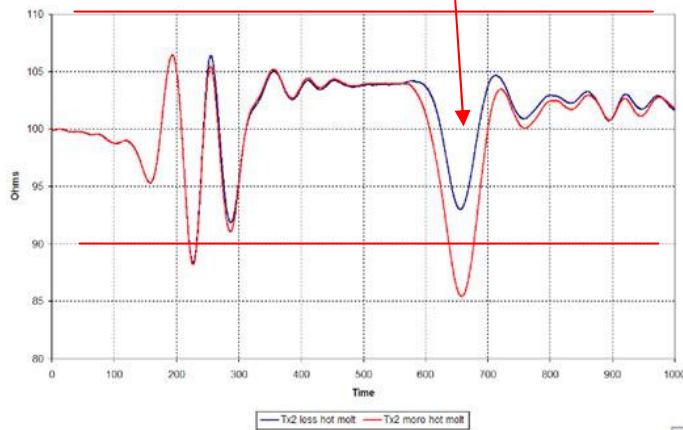


## Wire strain relief

- Wire strain relief / encapsulation must be controlled
- Excessive amounts affect impedance profile



Excessive overmold encapsulation

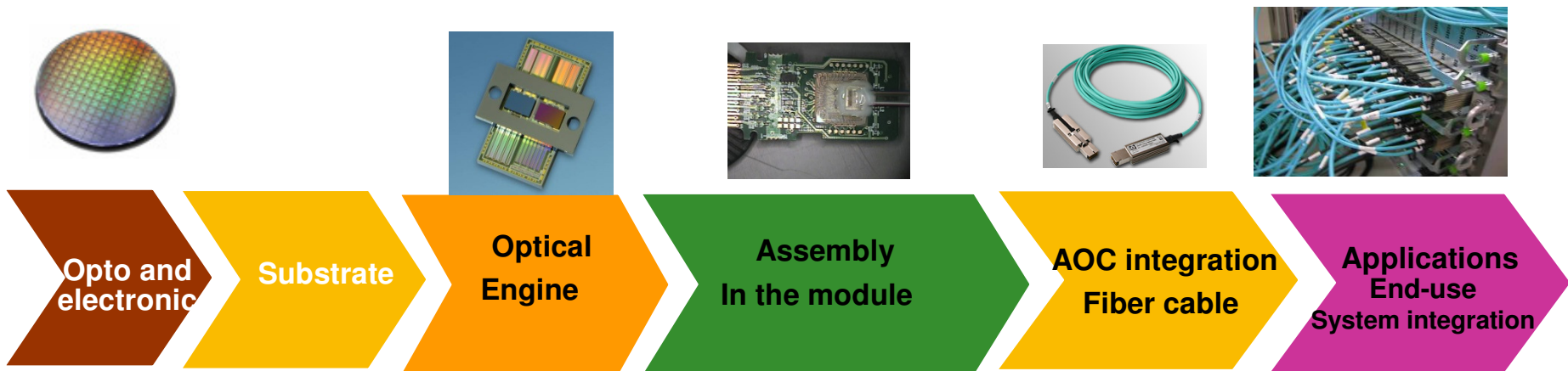


Allowable impedance profile range

# AOC Value Chain



- IC's and opto components are the critical components
- Integration/hybridation of components is key



## Termination

- Indoor Fiber Optic cable contains up to 24 multimode fibers
- CXP Fiber Optics cable assembly contains 4 terminations 2 at each end of the cable for RX and TX
- Strain relief done using a crimp solution
- Tensile strength used on the cable depends on the cable structure. Usual values are about 600N to 800N

## Fire rating – OFNP, UL-V0

## Cable Characteristics

- Propagation Delay (Typ. value 5ns/m)
- Skew (max. Channel to Channel: 1ns)
- The minimum bend radius is a critical parameter for cable deployment

## Fibre quality OM1,2,3

Wavelength		Minimum modal bandwidth MHz.km		
		Overfilled launch bandwidth		Effect laser launch bandwidth
Fiber Type	Core diameter	850 nm	1300 nm	850 nm
OM1	62.5 µm	200	500	Not specified
OM2	50 µm	500	500	Not specified
OM3	50 µm	1500	500	2,000
OM4	50 µm	3500	500	4,700

# FCI AOC in Juropa HPC



240 Gbit/s Active Optical Cable



Supercomputer Juropa (Jülich) #10 worldwide



Not working copper cables

# Alignment of Coupling Unit and Laser



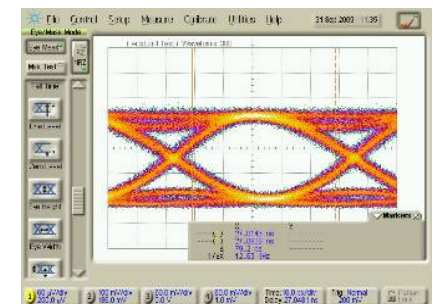
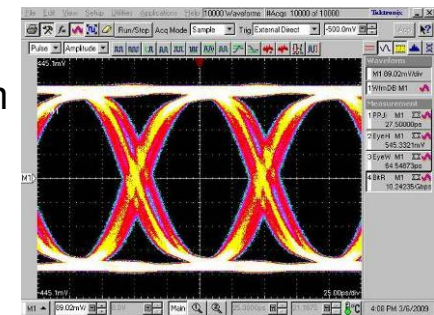
- Coupling of laser light into the fibre accomplished by an active alignment process
- Alignment of optical coupling unit requires tight process control
- Laser have various modes
- Non optimal coupling may cause some modes not to be coupled into the fiber
- Non optimal alignment result in optical loss and additional noise due to mode partitioning effects

# Cable testing & validation



## Optical and Copper Cable for Nx10Gb/s requires

- Functional testing
  - Cable capability assessment
  - Eye Mask, BERT
    - Require significant investment & proper technical support
    - Difficult to fully bring to the manufacturing floor
  - Wave distortion penalty (WDP) & Voltage Modulation Amplitude (VMA)
    - Measure overall cable functionality vs. overall allowable system loss
    - Accomplished using defined data streams & S-parameter data with defined codes & scripts
    - Resulting values are compared to allowable WDP & VMA loss for a given AWG wire size and cable length
  - Pre optical test before assembly
    - Optical amplitude
    - Optical receiver sensitivity
- Challenge to manufacturers is bringing this level of signal integrity scrutiny to manufacturing floor



# Summary



- Internet is demanding increased bandwidth & signal speeds driven mostly by video rich applications and social networking demands
- System and I/O solution designers are challenged by a number of conflicting needs like higher signal speed but with greater density and higher power but with better system efficiency to meet the industry needs
- Industry standards are driving and defining the present and future I/O system interfaces and interconnect schemes
- Higher port density, port configuration standardization and system recognition of the cable plugged into the port are all near term requirements
- Actively equalized cable assemblies can be used to either extend the copper cable length to as long as possible or to minimize the cable weight and bulk
- Cable assembly component quality and consistency and monitoring of the cable assembly manufacturing process are two key considerations to any viable high speed cable assembly manufacturer
- Final cable assembly testing is far more sophisticated for the high speed cable assemblies than what has been typically expected in the past
- These challenges will only increase in difficulty as we move from channel speeds of 10Gb/s to projected channel speeds of 16 and 20-25 Gb/s