The Fiber Formula – Fact, Fiction & Fantasy

Rodney Casteel, RCDD, DCDC, NTS, OSP - CommScope, Chair TIA FOTC
Paul Neveux, Jr., Ph.D. - Superior Essex International, LP
Tony Irujo, OFS
David Asta, RCDD, Panduit
Tyler Vander Ploeg, RCDD, VIAVI Solutions
Jim Davis, Fluke Networks
Rob Gilberti, AFL
Romain Tursi, EXFO

Ag

First Half – 80 minutes

- FOTC Introduction – Rodney Casteel
- Standards Update – Paul Neveux
- Fiber Trends Update – Tony Irujo
- MPO Technology – David Asta
- Fiber Testing & Inspection – Test Manufacturers

Break – 15 minutes

Second Half – 80 minutes

- Hands-on stations

Fiber Optics Tech Consortium

www.tiafotc.org

- Part of the Telecommunications Industry Association (www.tiaonline.org)
- Formed 24 years ago as the Fiber Optics LAN Section.
- Mission: to provide current, reliable, and vendor neutral information about fiber optics and related technologies for advancing new and better communications solutions.
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- Superior Essex
- The Siemon Company
- VIAVI Solutions

Fiber Optics Technology Consortium

- Recent Webinars Available on Demand
  - Implementing Next-gen PON Technologies over Existing Fiber Infrastructure
  - Essential Testing for MPO Systems
  - Field Testing MPO/MPT Connectors to Support 100 Gb/s and Beyond
  - Smart Buildings, Smart Networks

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IEEE 802.3 OPTICAL FIBER ETHERNET STANDARDS UPDATE

Paul Neveux

Review: 10, 40 and 100 Gb Ethernet on MMF

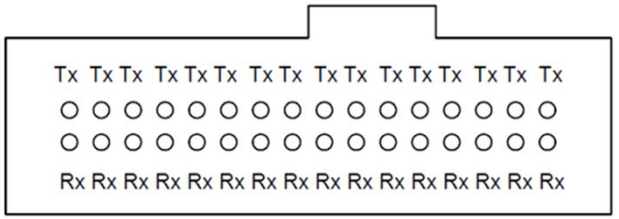
Ethernet Speed	IEEE Task Force	Designation	Fiber Type	Number of Fibers	Maximum Link Length (m)	Maximum Channel Insertion Loss (dB)
10 Gb	802.3ae	10GBASE-SR	OM3	2	300	2.6
40 Gb	802.3ba	40GBASE-SR4	OM3	8	100	1.9
40 Gb	802.3ba	40GBASE-SR4	OM4	8	150	1.5
100 Gb	802.3ba	100GBASE-SR10	OM3	20	100	1.9
100 Gb	802.3ba	100GBASE-SR10	OM4	20	150	1.5
100 Gb	802.3bm	100GBASE-SR4	OM4	8	100	1.9
400 Gb	802.3bs	400GBASE-SR16	OM3/4/5	32	80/100/100	1.9

Review: 40/100/200/400 Gb Ethernet on SMF

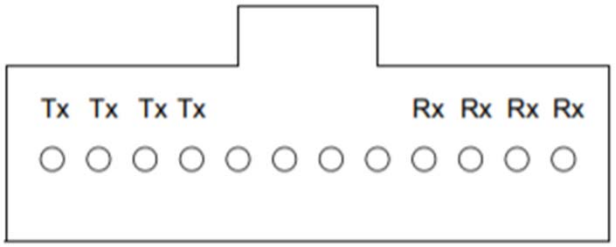
Ethernet Speed	IEEE	Designation	Wavelengths	Number of Fibers	Max. Link Length	Max. Channel Insertion Loss (dB)
40 Gb	802.3ba	40GBASE-IR4 40GBASE-LR4	4 λ	2	2 km 10 km	4.0 6.7
100 Gb	802.3ba	100GBASE-LR4	4 λ	2	10 km	6.3
200 Gb	802.3bs	200GBASE-DR4 200GBASE-FR4 200GBASE-LR4	4 λ	4 2 2	500 m 2 km 10 km	3.0 4.0 6.3
400 Gb	802.3bs	400GBASE-DR4 400GBASE-FR8 400GBASE-LR8	4 λ 8 λ 8 λ	4 2 2	500 m 2 km 10 km	3.0 4.0 6.3

IEEE 802.3bs – 200/400 Gb/s Ethernet

MMF MPO:



SMF MPO:



P802.3ca – 25G/50G EPON

P802.3cd – 50/100/200 Gb/s Ethernet

P802.3cm – 400 Gb/s over MMF

OPTICAL STANDARDS IN DEVELOPMENT

IEEE 802.3cd 50/100/200 Gb/s Ethernet

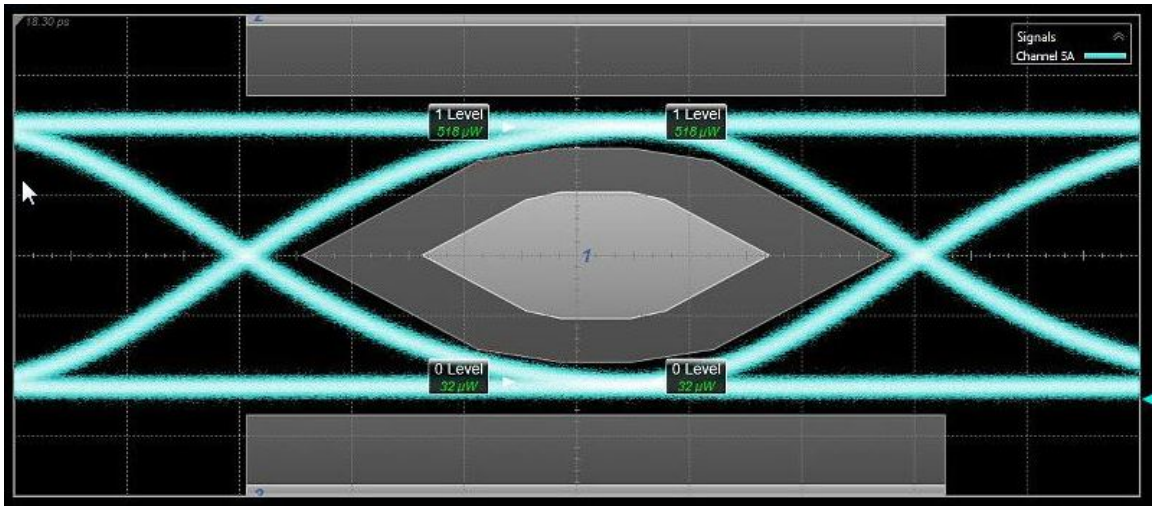
Objectives:

- 50 Gb/s Ethernet PHYs
  - MMF with lengths up to at least 100 m (OM4/5; 50GBASE-SR)
  - SMF with lengths up to at least 2 km and lengths up to at least 10 km
- 100 Gb/s Ethernet PHYs
  - MMF with lengths up to at least 100 m (OM4/5; 100GBASE-SR2)
  - Duplex SMF with lengths up to at least 500 m
- 200 Gb/s Ethernet PHYs
  - MMF with lengths up to at least 100 m (OM4/5; 200GBASE-SR4)

- Status: Approved in December 2018

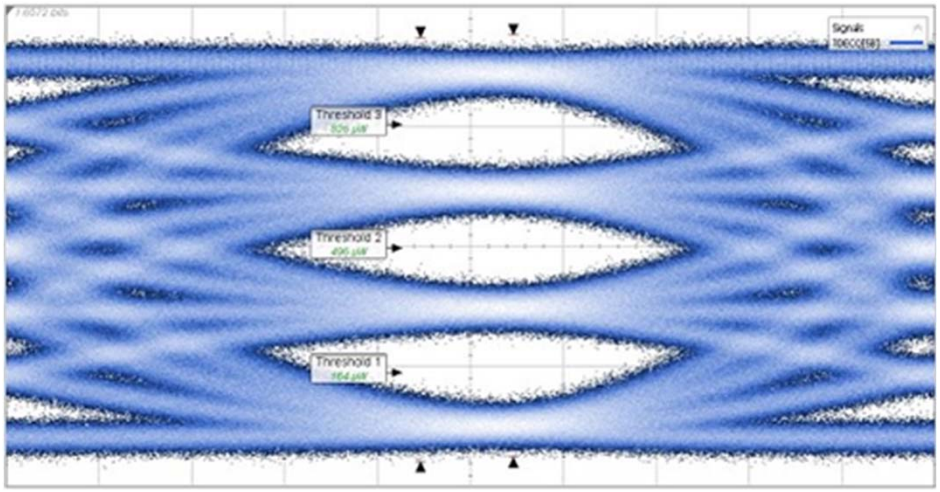
IEEE 802.3cd 50/100/200 Gb/s Ethernet

- Biggest hurdle is defining the limits of the “eye” diagram
- Below is eye diagram for NRZ encoding



IEEE 802.3cd 50/100/200 Gb/s Ethernet

- Actual data of relatively ‘clean’ transmission



IEEE 802.3cm 400 Gb/s over MMF

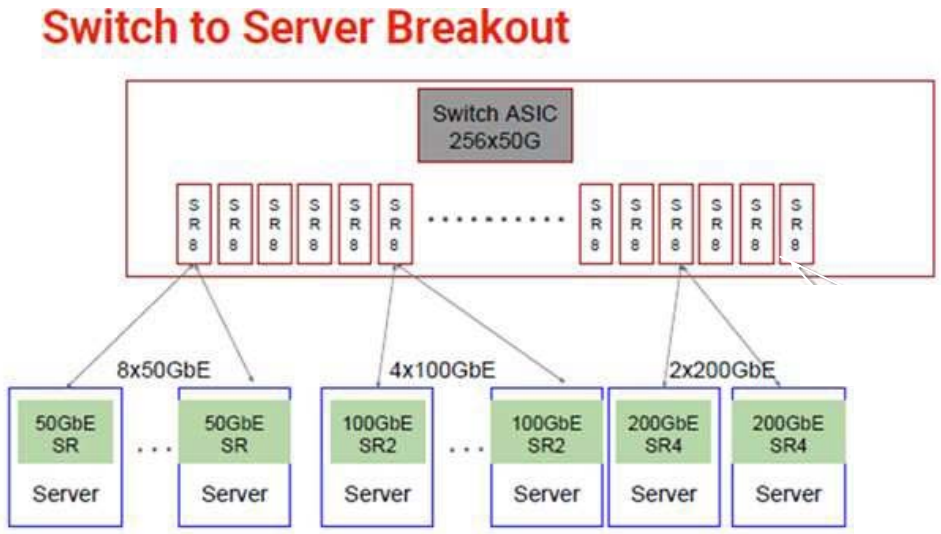
Objectives:

- Support a MAC data rate of 400 Gb/s
- Define a physical layer specification that supports 400 Gb/s operation over 8 pairs of MMF with lengths up to at least 100m
- Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least 100m

- 200GBASE-SR1.4 not approved as objective
- Will include OM3/4/5, with OM4 being the “baseline”
- Two implementations
  - 400GBASE-SR8 using a 16 or 24 fiber MPO
  - 400GBASE-SR4.2 over two wavelengths using 12 fiber MPO
- SR4.2 Wavelengths resolved: Nominal 850 nm and 910 nm
- MPO lane assignment not yet decided

Switch to Server Breakout

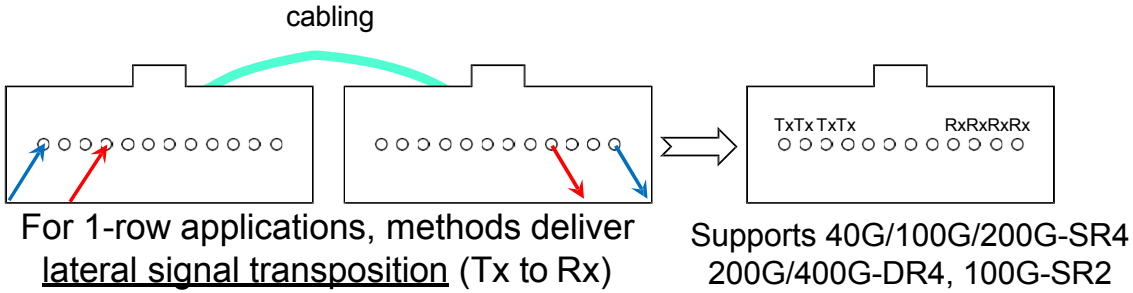
400G-SR8 module application will be primarily for breakout applications.



Polarity Considerations

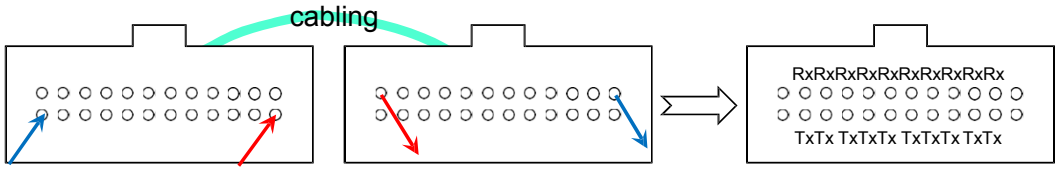
- TIA-568 describes three methods: A, B, C. ISO & CENELEC one.
  - All produce the same signal routing with different sets of components
  - Key application examples:

These signal routing conventions support all standard parallel applications including INCITS T11 10GFC 1200-Mx-SN4P-I and HIPPI-6400



For 1-row applications, methods deliver lateral signal transposition (Tx to Rx)

Supports 40G/100G/200G-SR4 200G/400G-DR4, 100G-SR2



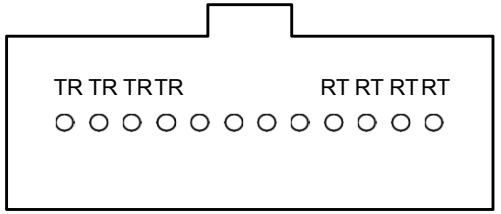
For 2-row applications, methods deliver lateral and row transposition (Tx to Rx)

Supports 100G-SR10, 400G-SR16

400GBASE-SR4.2 Implementation Approved

- FEC supported 26.5625 GBd using PAM4 modulation
- OM3 and OM4 lengths at least 100 meters
- OM5 length at least 150 meters
- Bi-directional Transmission (BiDi)
  - Allows easier VCSEL launch design
  - Larger eye safety margin, relative to a co-directional approach
  - 100G Bi-Di provides a path to support breakout applications

Proposed MDI lane assignment figure for 400GBASE-SR4.2



Legend
TR = Transmitter λ1, Receiver λ2 RT = Receiver λ1, Transmitter λ2

Connectivity requirement - TR lanes connect to RT lanes

400GBASE-SR4.2 Link Power Budget

Parameter	OM3	OM4	OM5	Unit
Effective modal bandwidth at 850 nm[a]	2000	4700	4700	MHz-km
Effective modal bandwidth at 918 nm	1210	1850	2890	MHz-km
Power budget (for max TDECQ)		6.6		dB
Operating distance	70	100	150	m
Channel insertion loss[c]	1.8	1.9	2	dB
Allocation for penalties[d] (for max TDECQ)		4.6		dB
Additional insertion loss allowed	0.2	0.1	0	dB

New Projects

- **50/200/400 Gb/s Ethernet over Single Pair SMF – To be P802.3cn**
  - 50 Gb/s over at least 40 km of SMF
  - 200 Gb/s over 4 wavelengths to distances of at least 40 km
  - 400 Gb/s over 8 wavelengths to distances of at least 40 km
  - Field Trial Data for reaches up to 27km

- **100/400 Gb/s Ethernet over Single Pair SMF – To be P802.3ct**
  - 100 Gb/s on a single wavelength capable of at least 80 km over a DWDM system
  - 400 Gb/s on a single wavelength capable of at least 80 km over a DWDM system

- **Super-PON – To be P802.3cs**
  - Support a passive point-to-multipoint ODN with a reach of at least 50 km with
  - at least 1:64 split ratio per wavelength pair
  - Support at least 16 wavelength pairs for point-to-multipoint PON operation
  - Support the MAC data rate of 10Gb/s downstream
  - Support the MAC data rates of 2.5Gb/s and 10Gb/s upstream

TIA 42 Standards Meeting Update

TIA 42.1 Premises Telecommunications Infrastructure: Update

Document Development

- Reaffirmation of TSB-162-A Telecommunications Cabling Guidelines for Wireless Access Points will be considered at the next meeting.
- TR-42.1 approved the PAR for TIA-568.0-E *Generic Telecommunications Cabling for Customer Premises* with Ray Emplit as editor.
- TR-42.1 approved the PAR for TIA-568.1-E *Commercial Building Telecommunications Cabling Standard* with Ray Emplit as editor.
- TR-42.1 approved the PAR for TIA-4966-A *Telecommunications Infrastructure Standard for Educational Facilities* with Diane Forbes as editor.
- TR-42.1 established a new task group to look at what work needs to be done for Edge Data Centers

TIA 42.11 Optical Systems

- **IEC SC86A and SC86B Liaison Reports**
  - Harmonization efforts between TIA, IEC and ITU
  - 200 micron SMF detailed specification being developed
- **ANSI/TIA-568.3-D-1**
  - The addendum, which includes provisions for OM5 fiber, was approved for publication
- **Contribution: Understanding Polarity Contribution**
  - Addresses issue of poorly written section in standard on polarity
  - Standard currently has “Methods” A, B and C using “Types” of connectors/adaptors A, B and C
  - Totally confusing

Component TYPE symbols

For determining polarity, we only need to look at the component level.

TYPE - A components **No Polarity Change** (within row)

TYPE - B components **Transpose Fiber** (within row - mirror effect)

TYPE - C components **Pair-wise flip** (within row)

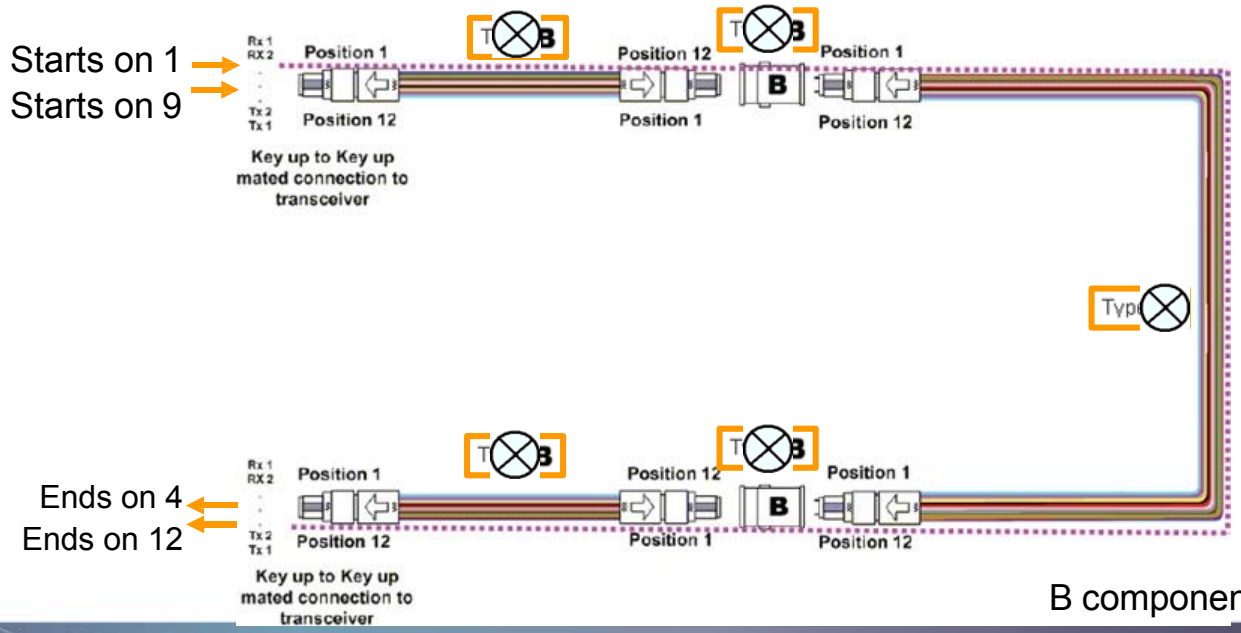
Compound symbol **Transpose Row** (added to component types A, B, or C)

* Note: this is only used with dual-row array systems *

Method B - Parallel

Near / Far End	Type-B array cable sequence Fiber Sequence (viewing the end face of the connector with key up)											
Near	1	2	3	4	5	6	7	8	9	10	11	12
Far	12	11	10	9	8	7	6	5	4	3	2	1

- Every time the light path encounters a **Type-B** component, the light path is transposed.
- You can ignore **Type-A** components



B components

TR-42.12 Optical Fibers & Cables

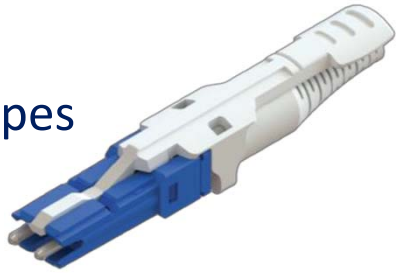
- VCSEL weighting function values for OM3/4 Systems
  - Initial analysis shows that the weighting functions are valid for 95% of the use cases
  - Ongoing work continues
- IEC fiber specification adaption update
  - ANSI/TIA 492000-C to be adaption of IEC 60793-2 (general)
  - ANSI/TIA 492AAAF to be adaption of IEC 60793-2-10 (multimode)
  - ANSI/TIA 492CAAC to be adaption of IEC 60793-2-50 (single-mode)
  - Working draft of 492000-C written, shared with spec editors
  - Editors will use to create help drafts of 492AAAF and 492CAAC

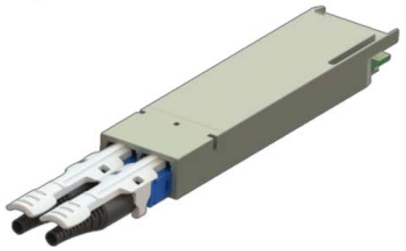
TR 42.13 Fiber Optic Passive Components and Metrology

- FOTP 171B Approved for 4th Committee Ballot
- FOCIS 19 (CS Connector) SEN-01; reviewed draft document

CS Connector

- Originally designed for transceivers with Dual WDM types
  - Adopted in several specifications
    - ✓ QSFP-DD, OSFP and COBO
- Design
  - A uniboot type connector (2-fiber)
  - Use of 1.25mm ferrule, pitched 3.8mm

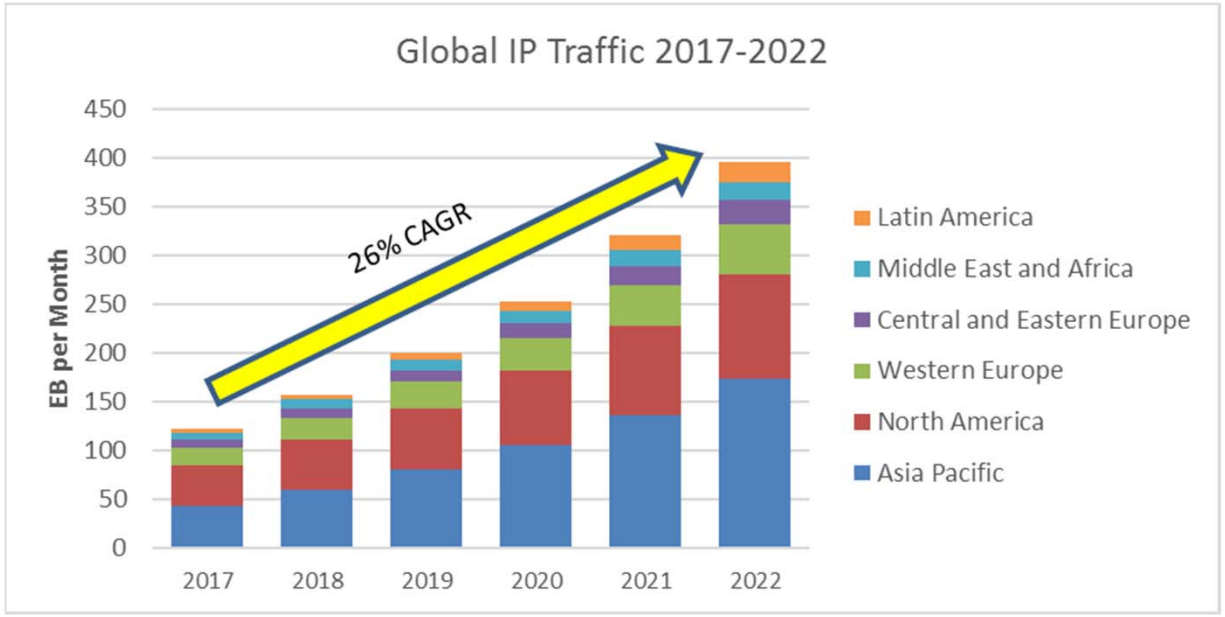




Fiber Industry Trends

Tony Irujo
OFS
tirujo@ofsoptics.com

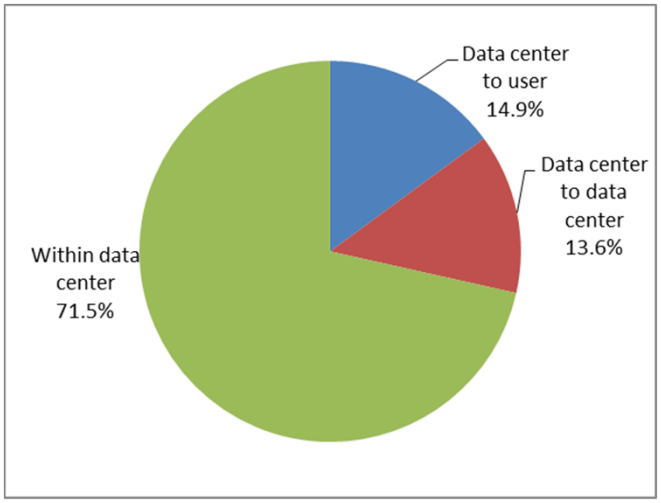
Network IP Traffic Growth

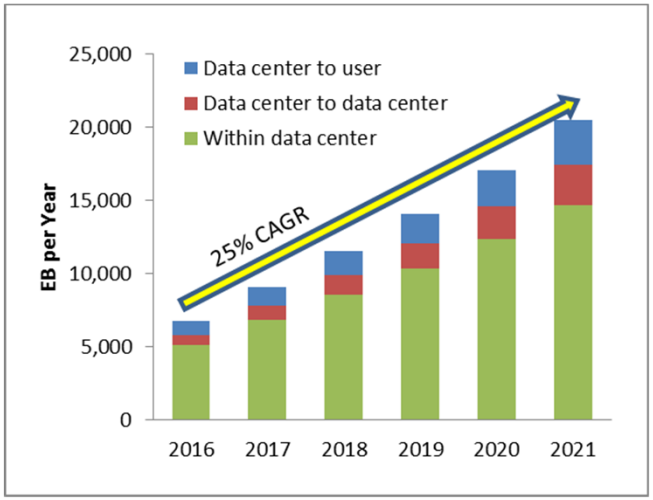


- Global IP traffic will reach 4.8 Zettabytes (10^{21}) per year in 2022. In 2017, global IP traffic reached 1.5 ZB per year
- Global IP traffic will increase 3x over the next 5 years
- Monthly IP traffic will grow to 50GB per capita in 2022, up from 16GB in 2017.
- Smartphones will make up 44% of total IP traffic in 2022, up from 18% in 2017.

"Cisco Visual Networking Index : Forecast and Methodology, 2017-2022" November 2018

Data Center Traffic

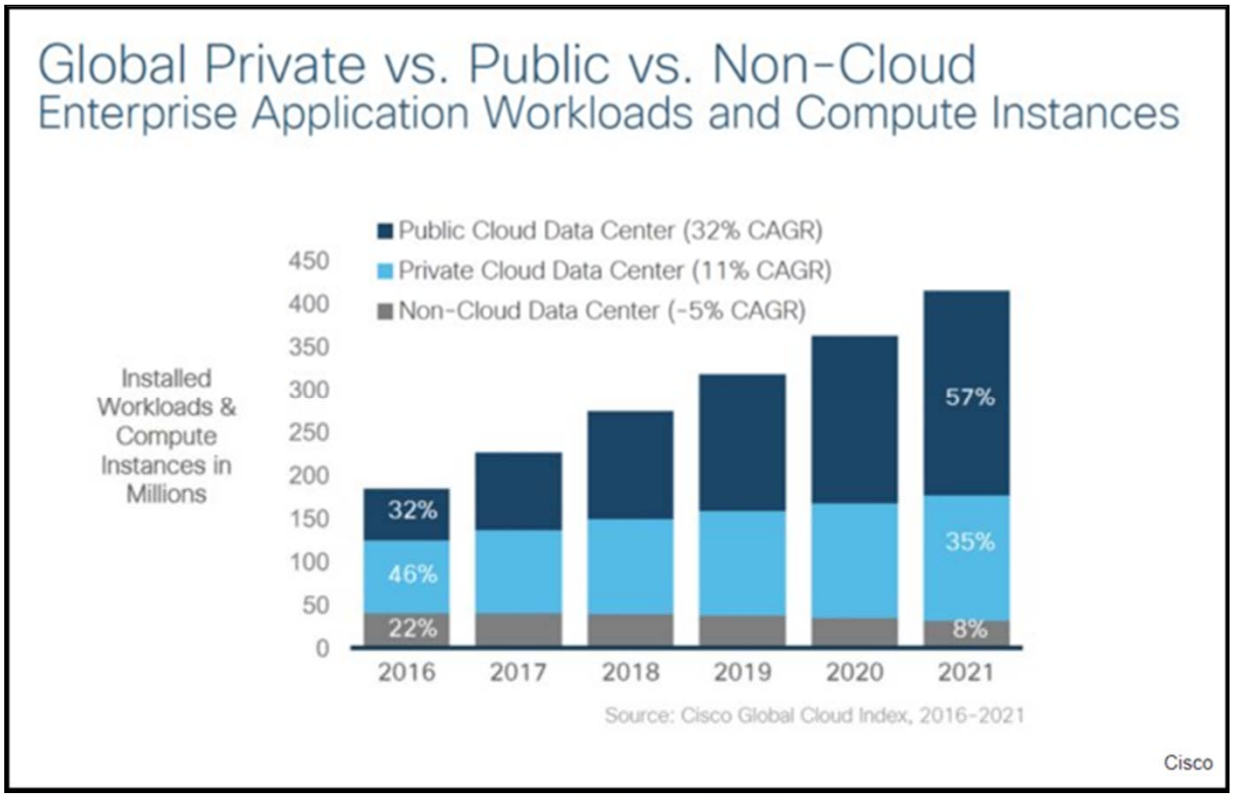




- Global data center traffic will reach 20.6 Zettabytes in 2021, from 6.8 Zettabytes in 2016
- Total East-West traffic will be 85%
- Traffic is growing at a 25% CAGR

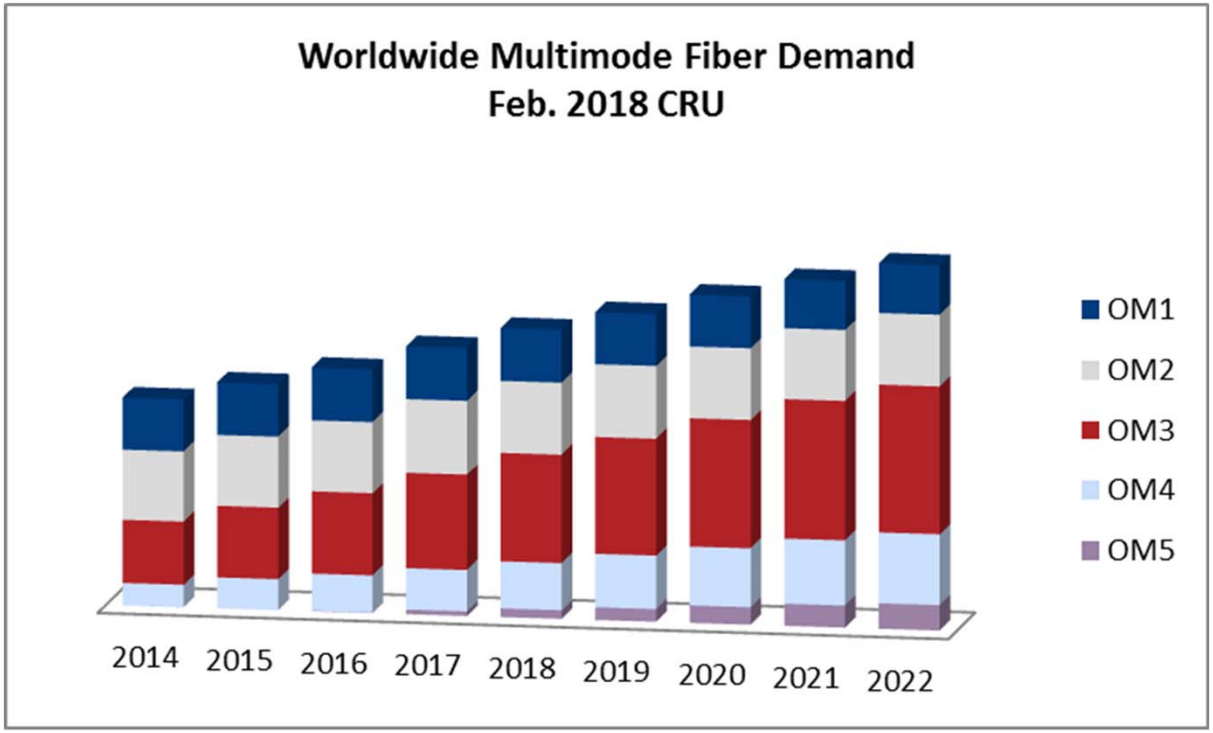
Source: Cisco Global Cloud Index: Forecast and Methodology, 2016-2021 January 2018

Global Data Center Traffic Growth

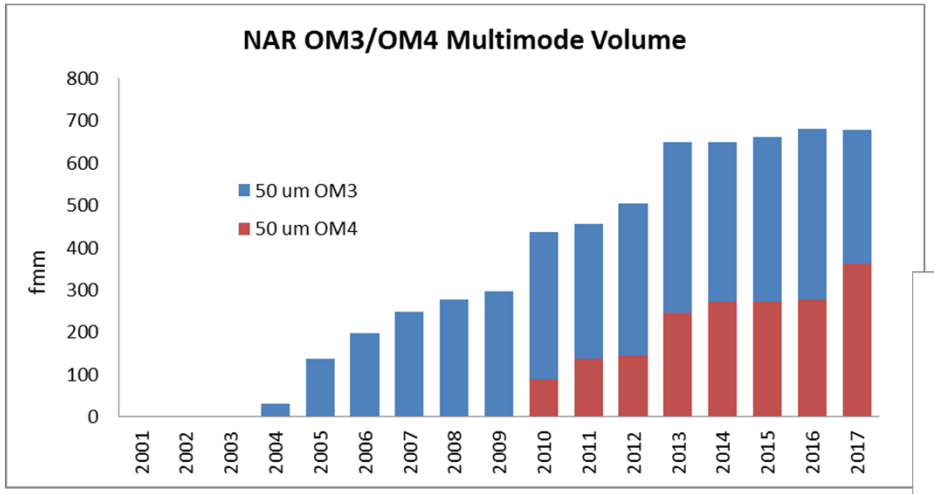


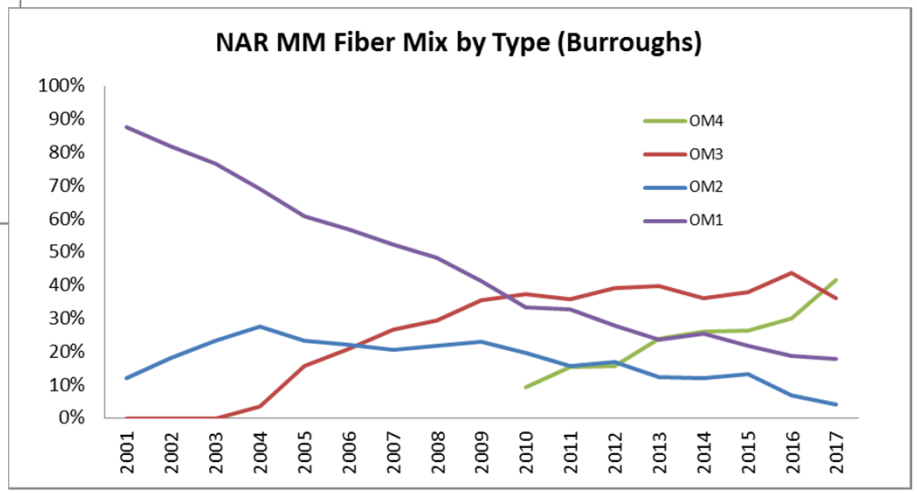
Worldwide Multimode Cable Demand by Region

All this demand combines to create multimode volume growth!



Burroughs North America Multimode Fiber Shipments

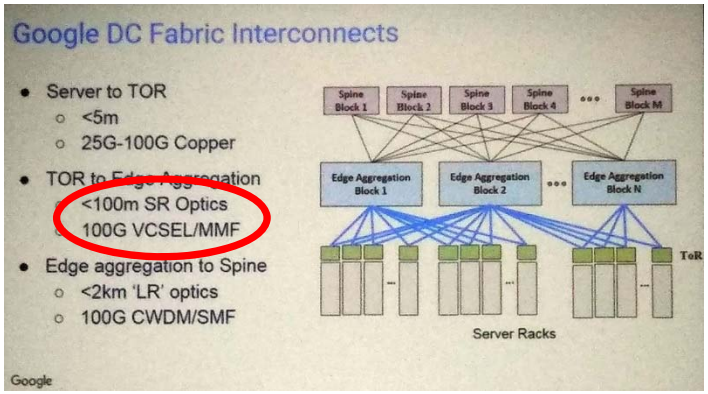


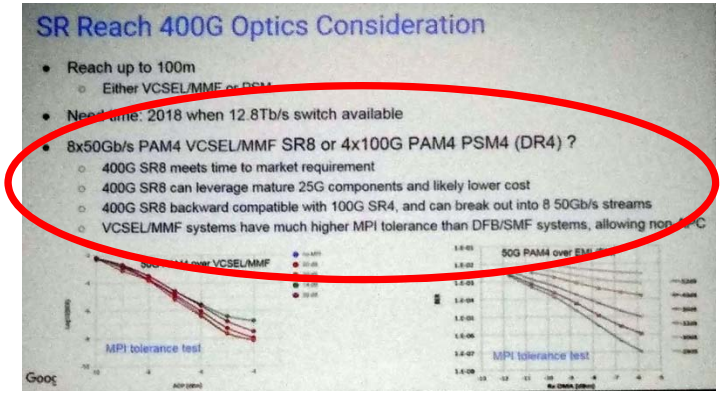


Source: Burroughs Multimode Fiber Reports

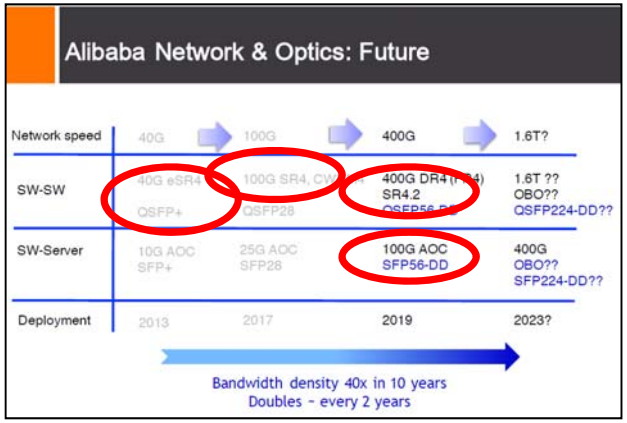
The hyperscale cloud market will continue to deploy multimode fiber!

- Google
  - Deploying 100GBASE-SR4
  - Roadmap to 400GBASE-SR8
  - Z. Shen of Google proposed 400GBASE-SR8 for 802.3cm
- Alibaba
  - Deploying 100GBASE-SR4
  - Roadmap to 400GBASE-SR4.2
- Baidu
  - Deploying 100GBASE-SR4
  - Roadmap to 400GBASE-SR4.2
- Other Big Cloud in US
  - Growing interest for 400G-SR4.2, including breakout





X. Zhou, Google, OFC 2018, San Diego



C. Xie, Alibaba OIF Q4 2018 Shanghai

C. Gang, Baidu, 2018 Optinet, Shanghai

Conclusions

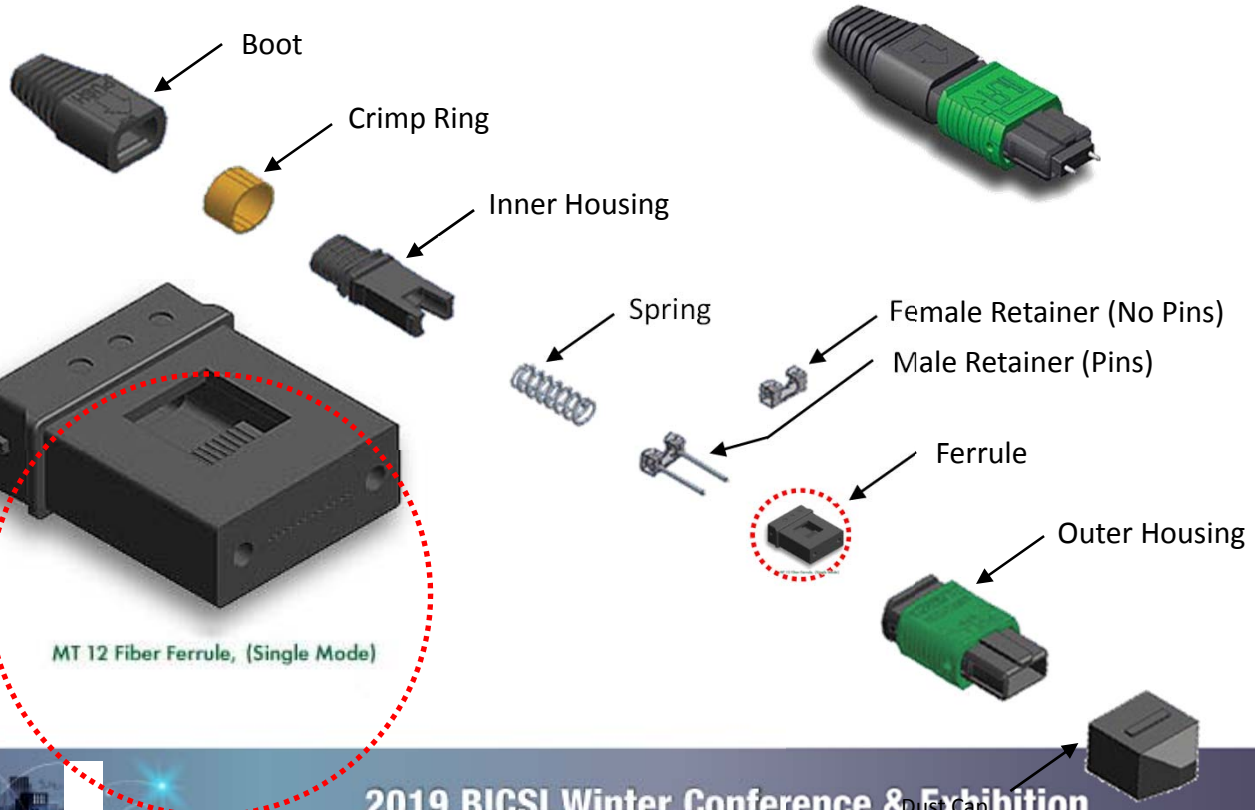
- Bandwidth demand continues to grow
- Multimode demand is growing
- Multimode fiber demand is moving to higher grade fiber types
  - OM4 fiber has the largest share (by type) in North America
- Hyperscale data centers are looking to deploy multimode fiber in next generation data centers

MPO TECHNOLOGY, TRENDS & CONFIGURATIONS

David Asta, RCDD
Panduit

PANDUIT

Anatomy of an MPO

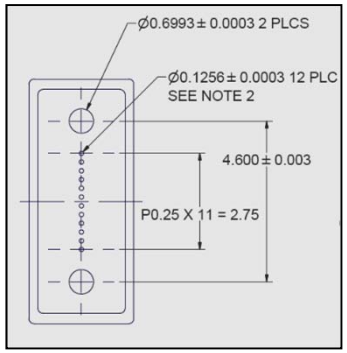


MPO 'Ferrule'

MT Ferrule Technology

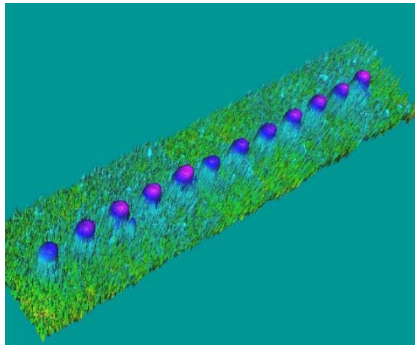
Optical performance is based on:

- Fiber Alignment (axial & angular based on ferrule & guide pin)
  - True Position of fiber-holes in the ferrule relative to alignment pin holes
  - Tolerance of the alignment pins
  - Diameter tolerance of fiber holes and alignment pin holes
- Fiber Tip Contact (endface geometry + connector spring force)
- Fiber Tip Cleanliness & Quality



Connector Component Quality

+



Endface Quality

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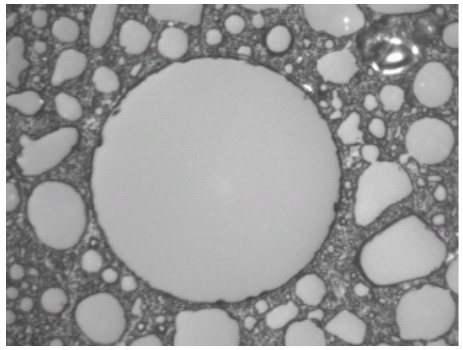


Fiber Tip Quality

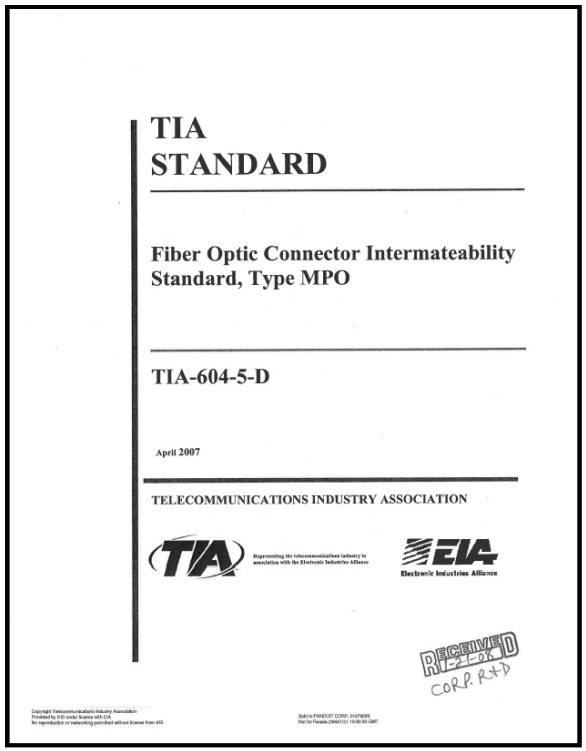
The fiber alignment is <u>independent</u> of the adapter!

TIA Connectivity Definition for MPOs

The MPO connector family is defined by two existing standards. Internationally the MPO is defined by IEC-61754-7. In North America the MPO is defined by TIA-604-5 (also called FOCIS 5).

FOCIS 18 presents the intermateability standard for connectors with the commercial designation of MPO-16 that support 16 fibers per row of fibers, and is used as an addendum to TIA/EIA-604, *(*2015 Edition, November 23, 2015)

4f through 72f fiber MPO Standard



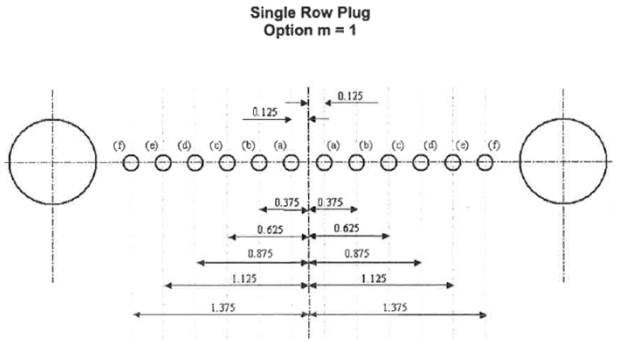
TIA
STANDARD

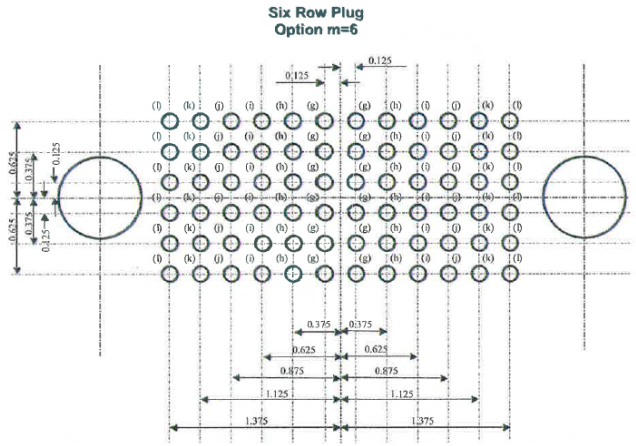
Fiber Optic Connector Intermateability Standard, Type MPO

TIA-604-5-D

April 2007

TELECOMMUNICATIONS INDUSTRY ASSOCIATION





What Does the Standard Say About MPO?

Plug designation

The complete designation for a FOCIS 5 connector plug is: FOCIS 5P-n-k-a-c-t

Where:

P designates that it is the plug

n is the number of fibers

k defines the keying configuration

a is the angle of contact

c designates alignment pins or holes

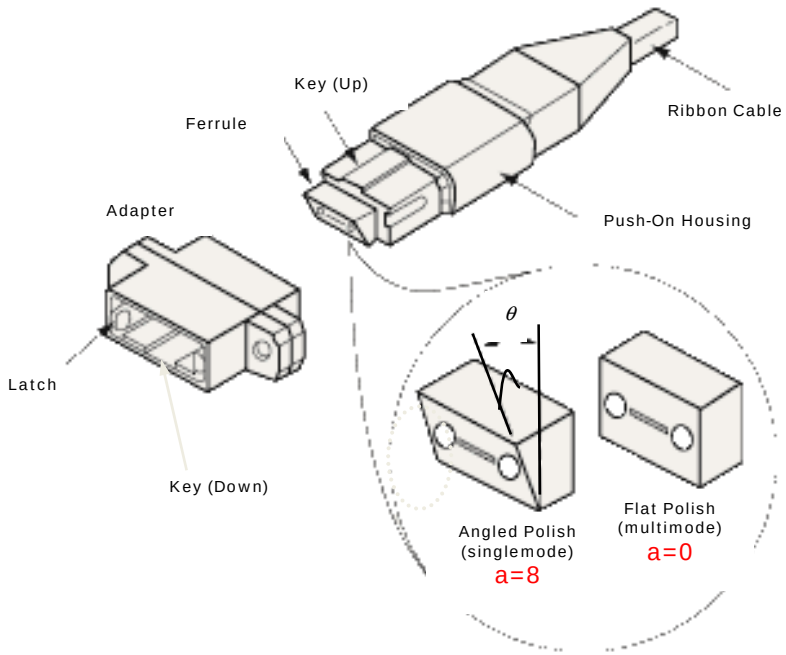
t alignment pin/hole diameter

Number of Fibers

Values have defined for the number of fibers

4, 6, 8, 10, 12, 16, 20, 24….

Singlemode Variant



- Singlemode MTP connectors are polished at a nominal eight (8) degrees with respect to the connector key
- Return Loss from the angled interface is maximized (>55dB)
- Assures that the normal Key Up/Key-Down adapter sleeve aligns the angled surfaces to compliment each other
- Precludes the use of Key Up/Key Up adapters for the single application (unless two different connector polishing orientations are made – not in the FOCIS document for SM)

Two Different MPO/MTP Adapters

Adapter designation

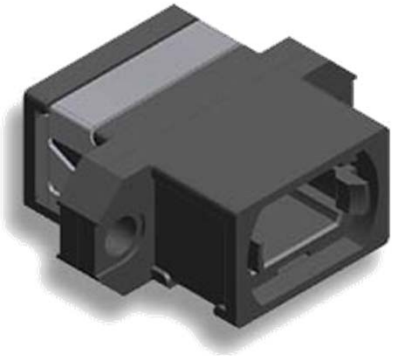
Designation for a FOCIS 5 connector adapter is: FOCIS 5A-k-m

where:

A designates that it is the adapter

k defines the keying configuration

m defines the mounting configuration



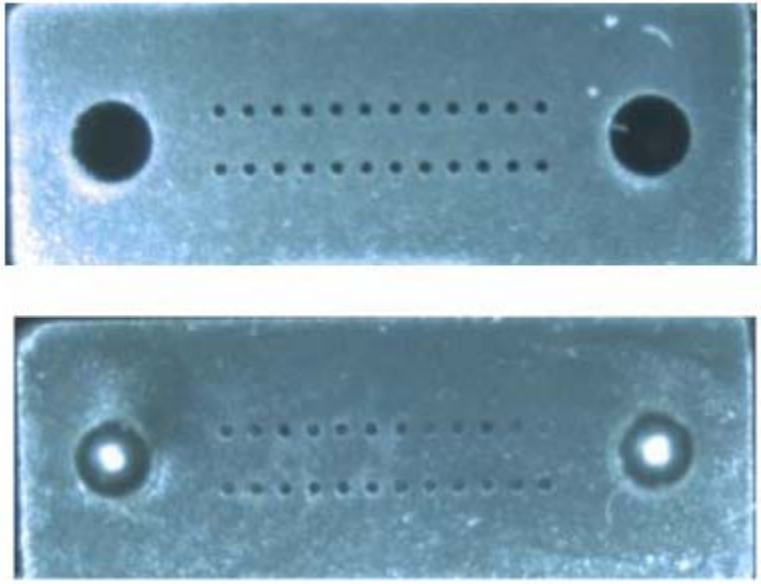
Adapter Keying Options

Two options are defined for the adapter keying configuration:

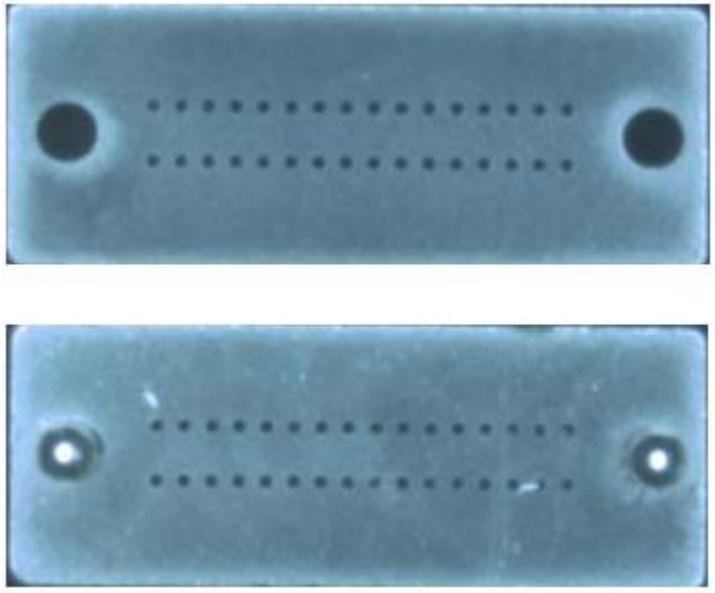
k = 1 - standard keying configuration for FOCIS 5 adapters

k = 2 - alternative keying configuration

FOCIS-5 & FOCIS-18 MPOs



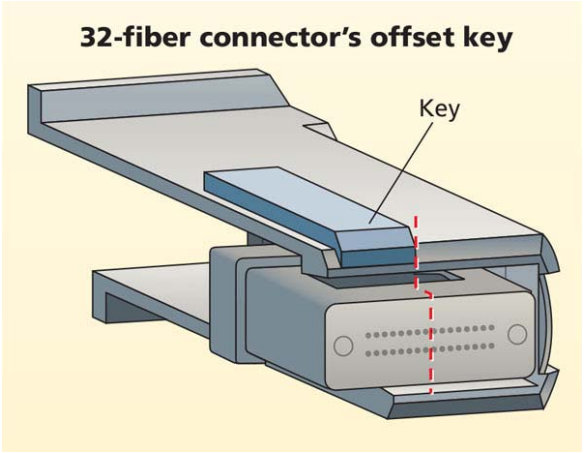
FOCIS-5, 24 fiber position connector



FOCIS-18, 32 fiber position connector

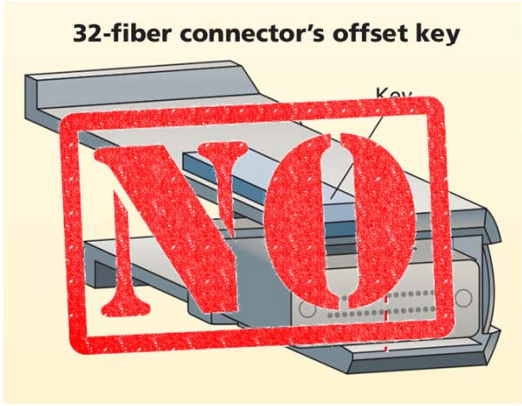
TIA Connectivity Definition for FOCIS-18 MPOs

- Published in Q4 2015
- Same MT ferrule footprint & fiber pitch in X & Y axes
- Different pin/hole diameter & pin pitch
- Limited to two rows maximum
- FOCIS 18 defines a flat polish only
- Flat is the norm for all MPO MM
- APC is the norm for all MPO SM
- Offset key to prevent mating with FOCIS 5 connectors
- FOCIS 18 MM connectors available in 1x16 (SR8) and 2x16 formats (SR16)



“Brute Force” - Multiple Lanes MPO

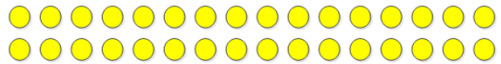
- Move toward 16 fiber units? 400GBASE-SR16
- 32/16-pin MPO connectors (TR 42.13)
  - Polarity descriptions that cover n-number of fiber units (TR 42.11)
  - 4 new fiber colors to support 16-fiber ribbons bundles (TR 42.12)
- Likely upgrade paths (MM) results in units of 4 fibers:
  - 40G ÷ 10G per fiber = 8 (2x4F) fibers (40GBASE-SR4)
  - 100G ÷ 25G per fiber = 8 (2x4F) fibers (100GBASE-SR4)
  - 400G ÷ 25G per fiber = 32 (2x16F) fibers (400GBASE-SR16)
  - 400G ÷ 50G per fiber = 16 (2x8F) fibers (400GBASE-SR8)
  - 400G ÷ 50G per fiber = 8 (2x4F) fibers (2 lambda = 400GBASE-SR4,2)
  - 400G ÷ 25G per fiber = 8 (2x4F) fibers (4 lambda = 400GBASE-SR4,4)



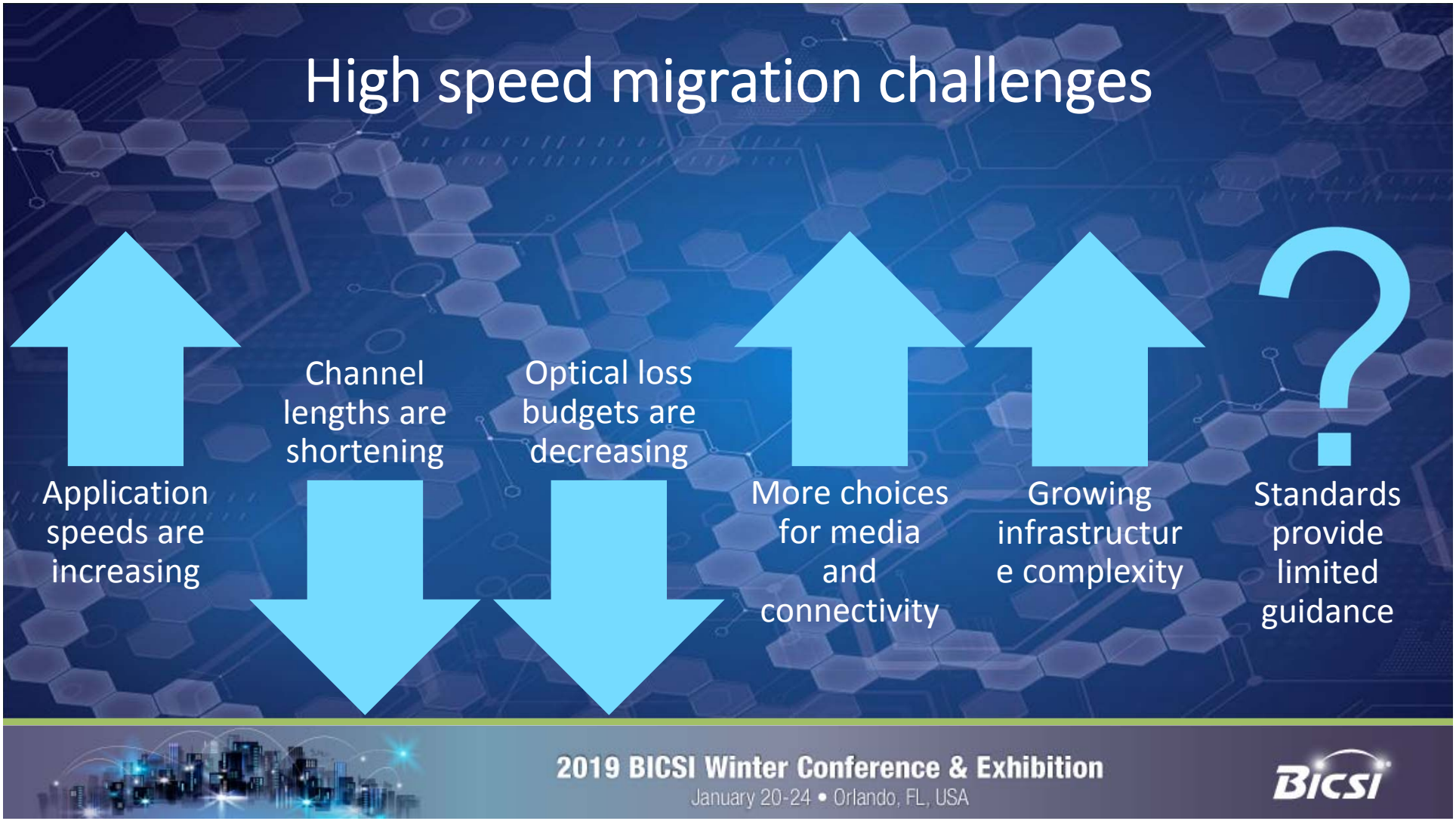
8 FIBER
(BASE8)

SFP/QSFP Fiber 'Migration'

SWDM or CWDM

	10G/Fiber	25G/Fiber	25G/λ - 4λ/Fiber
10G		N/A	N/A
25G	N/A		N/A
40G		N/A	N/A
100G			
400G	N/A		

High speed migration challenges



What should your physical infrastructure do…?

Support current and future applications

Optimize channel distances

Allow for additional connections

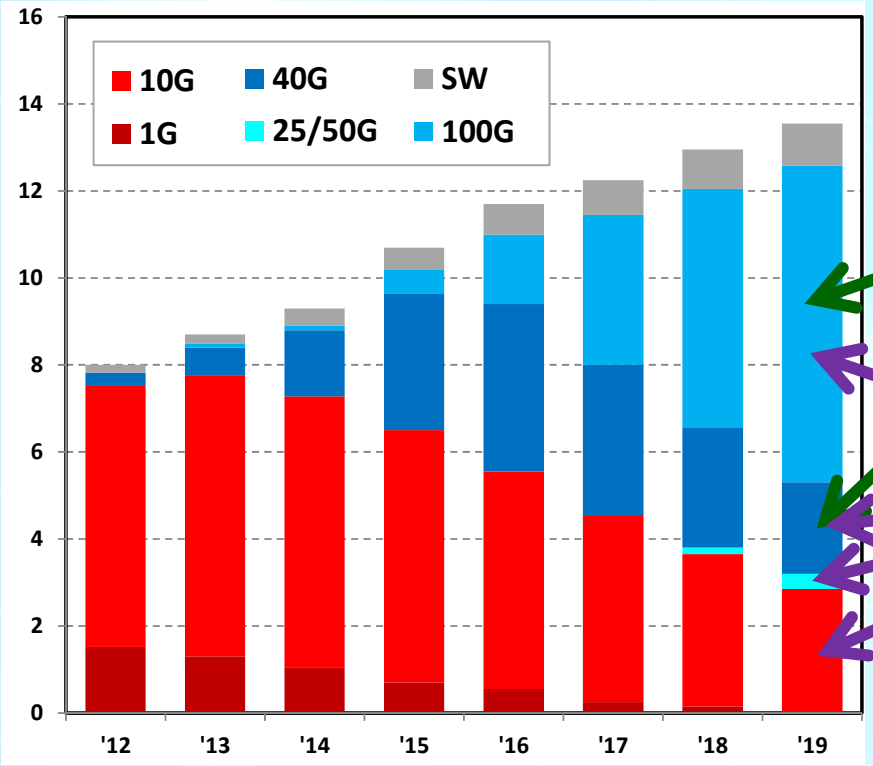
Simplify optical media selection

Provide for automated management

Enable flexible topologies

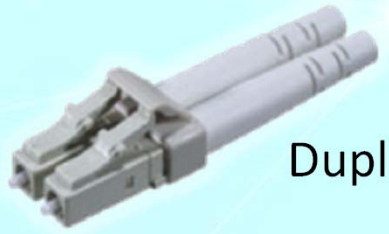
Data Center Market: Ethernet Switch Rev. ($B)

Revenue By Port Speed



Source: Dell'Oro – Oct 2015 (public webinar)

Parallel



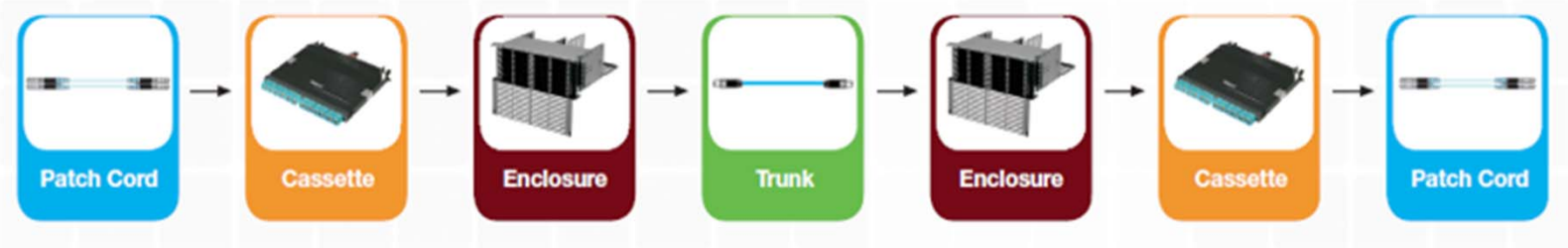
Duplex

Data Center connectivity through 2020+ likely to be mix of duplex and parallel

Which MPO for High Speed Migration?

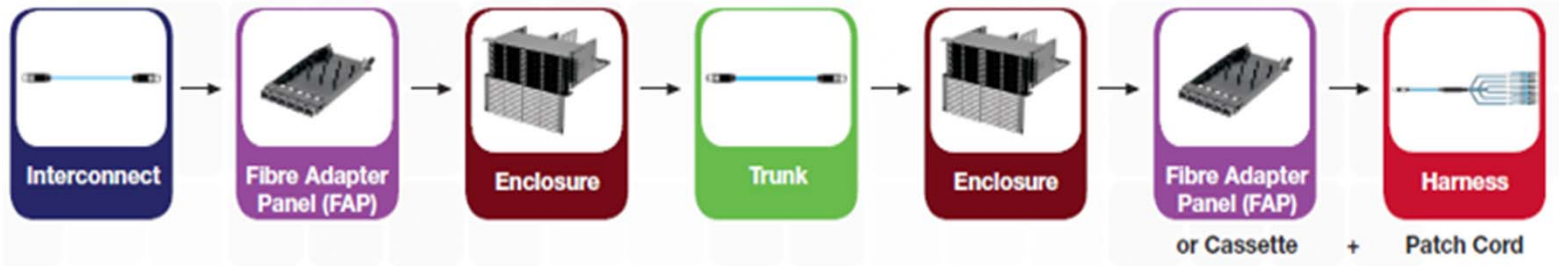
MPO-24	MPO-12	MPO-8
		
Future ready Lowest cost duplex support for multimode applications Highest panel density	**Large installed base** Existing multimode and singlemode preterm deployments Familiar interface and trunks	**Supports QSFPs** For multimode and singlemode transceivers and breakouts Lowest panel density

Duplex Cabling Applications



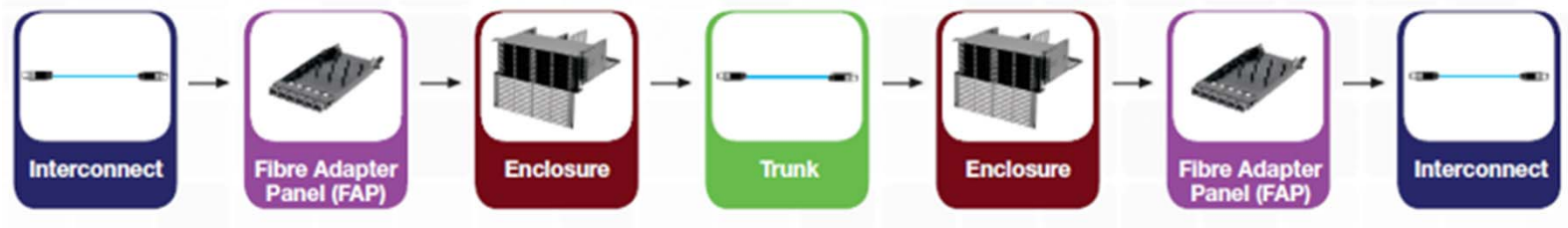
- **Examples:**
- **10G – 10G**
- **25G - 25G**
- **40G BiDi**
- **4, 8, 16, 32G Fibre Channel**

Parallel to Duplex Cabling Applications



- **Examples:**
- **40G – 10G**
- **100G – 25G**
- **100G – 10G**
- **64G – 16G Fibre Channel**
- **128G – 32G Fibre Channel**

Parallel to Parallel Cabling Applications



- **Examples:**
- **40G – 40G**
- **100G – 100G**
- **64G – 64G Fibre Channel**
- **128G – 128G Fibre Channel**

Bottom Line

- There are a multitude of options for migrating to higher speeds
  - OM3, OM4, OM5, SM
  - MPO 8, MPO 12, MPO 24, MPO 16, MPO 32
  - Parallel & Duplex
  - SWDM, CWDM
  - Proprietary Options
- Need to ensure the strategy includes
  - Long term planning
  - Most efficient, cost effective and sustainable option
  - A solution that can be tested and validated

Fiber Testing & Inspection

Tyler Vander Ploeg, RCDD, VIAVI Solutions
Jim Davis, Fluke Networks
Romain Tursi, EXFO
Rob Gilberti, AFL

Agenda

- Connector Inspection & Cleaning (Romain Tursi– EXFO)
- Tier 1 Testing (Carolyn Carter– Fluke Networks)
- Tier 2 Testing (Rob Gilberti – AFL)
- Testing MPO Connectivity (Tyler Vander Ploeg – VIAVI Solutions)
- Break (15 minutes)
- Hands On Training

Fiber Optic Connectors Inspection and cleaning

Romain Tursi
Product Specialist
EXFO

Connectors come in multiple flavors

- Single fiber connectors

- Multifiber connectors

⇒ And both can co-exists in same architecture

No. 1 cause of network failures is BAD connectors

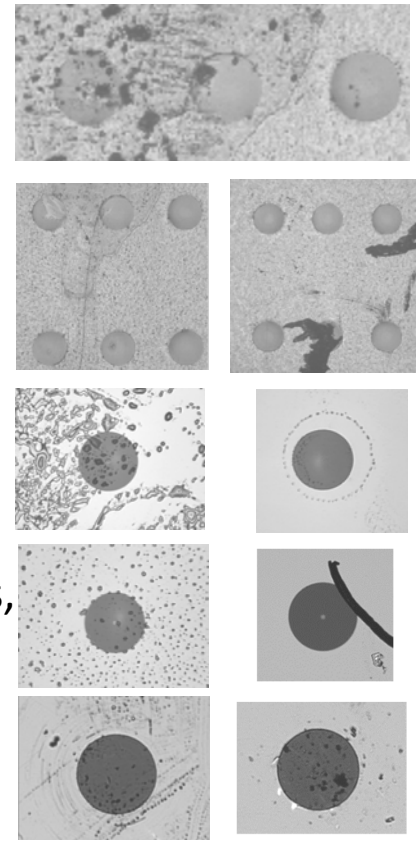
- NTT-Advanced Technology Research

80% **N**etwork owners report having connector issues

Why inspecting is important?

Not because it's nice to have clean connectors!

- Direct impact on IL & ORL => BER => System performance and Network reliability
- Bad connectors may work at low data rate and cause failure at higher data rate
- Some soils can change over time (freezing, drying, etc)

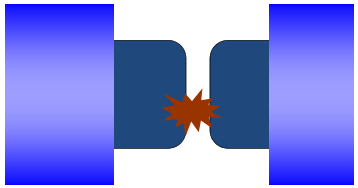


Why are connectors dirty or damaged ?

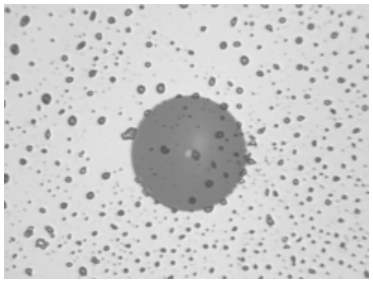
- Skin oil and particles, sticky fingers, hairs, drywall, dusty dust caps, etc…

Dust/dirt/debris residues transfer

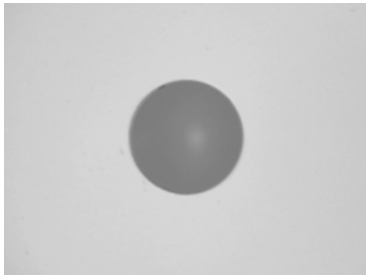
- A connection is made of 2 connectors….
- They should both be inspected and cleaned if needs be.



Before mating:

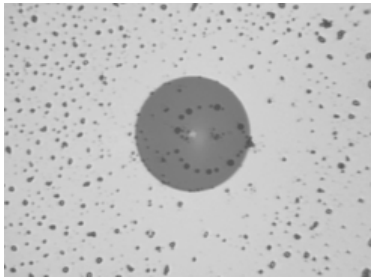


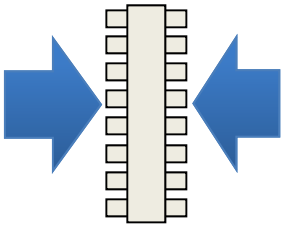
Connector A



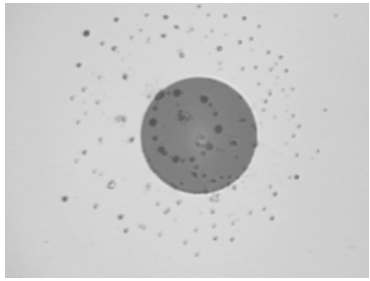
Connector B

After mating:





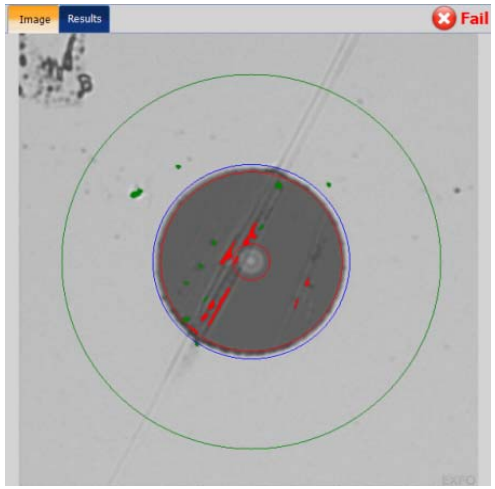
Patch Panel



Cleaning alone is not enough…or too much!

DAMAGED = REPLACE

You CANNOT clean a damaged connector

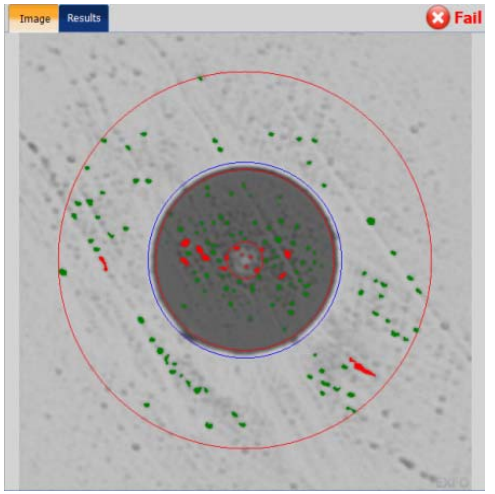


CLEAN = CONNECT

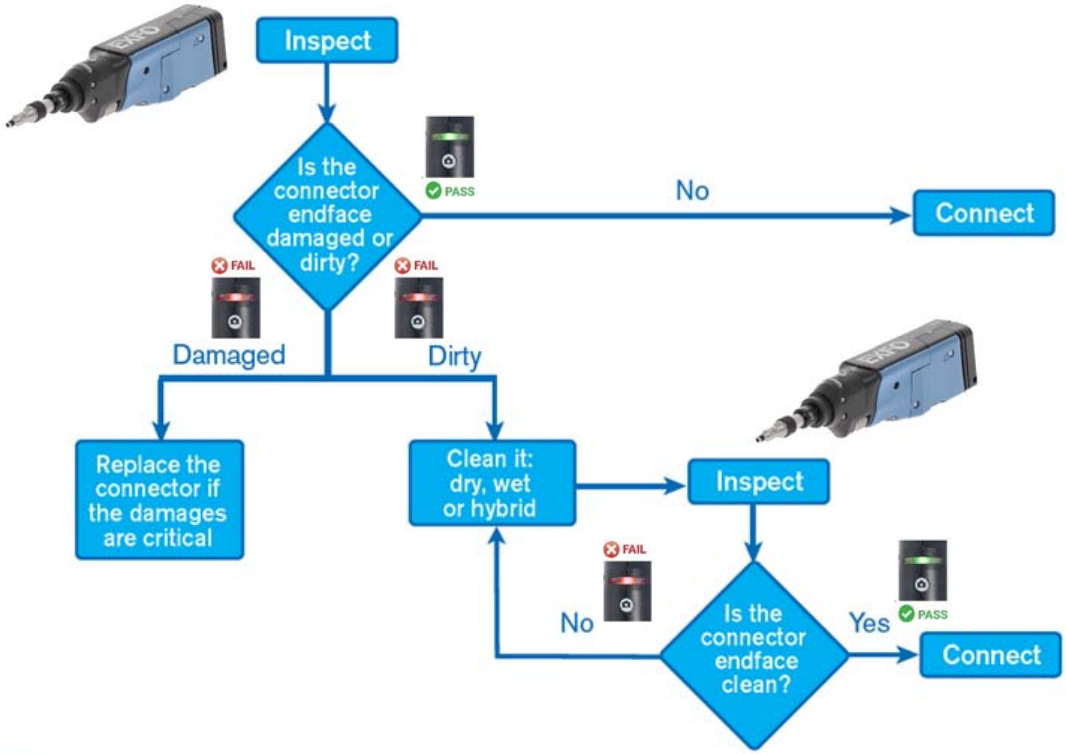
NO cleaning required

DIRTY = CLEAN

Clean ONLY if needed



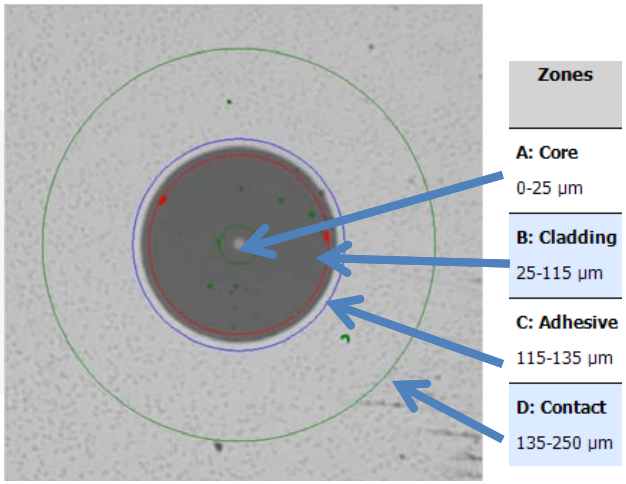
Inspection / Cleaning flow



Connector inspection standards

Standards-based criteria

- IEC 61300-3-35
  Fiber-optic interconnecting devices and passive components—basic test and measurement procedures
  http://webstore.iec.ch/
- IPC 8497-1
  Cleaning methods and contamination assessment for optical assembly
  http://www.ipc.org/



- Connectors are divided in **zones with specific tolerances**
- Zones & criteria **varies depending connector type:**
  - Singlemode vs Multimode,
  - UPC vs APC,
  - Single fiber vs Multifiber

Zones	Scratches	Defects
A: Core	None	None
B: Cladding	No limit ≤3 µm None >3 µm	No limit <2 µm 5 from 2 – 5 µm None >5 µm
C: Adhesive	No limit	No limit
D: Contact	No limit	None ≥10 µm

Example : Singlemode single fiber UPC connector zones and criteria as per IEC 61300-3-35 Ed.2

Pass/Fail automated assessment

Using an analytical software guarantees a uniform level of acceptance according to industry standards:

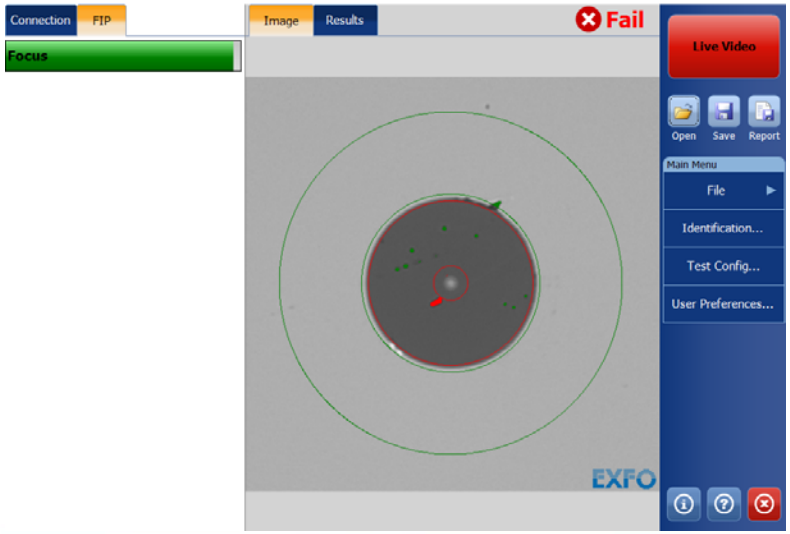


Image | Results — Fail

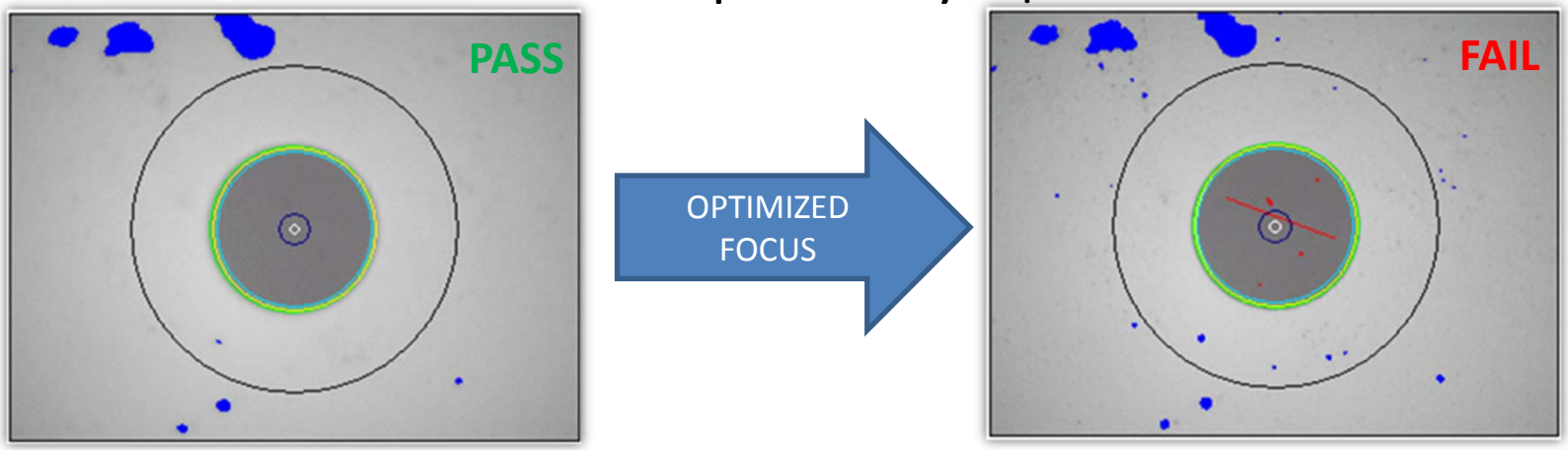
Inspection Results

Zones	Scratches			Defects		
	Criteria (µm)	Thld	Cnt	Criteria (µm)	Thld	Cnt
A: Core 0-25 µm	0 ≤ size < ∞	0	0	0 ≤ size < ∞	0	1
B: Cladding 25-120 µm	0 ≤ size < 3 3 ≤ size < ∞	Any 0	0 0	0 ≤ size < 2 2 ≤ size < 5 5 ≤ size < ∞	Any 5 0	6 4 1
C: Adhesive 120-130 µm	---	---	---	---	---	---
D: Contact 130-250 µm	0 ≤ size < ∞	Any	0	0 ≤ size < 10 10 ≤ size < ∞	Any 0	1 0

Test Configuration	Connector	Cladding
IEC SM SF UPC ORL ≥ 45 dB (61300-3-35, 1.0)	SF	125 µm

Beware of false positives

- **Focus adjustment and assessment might be user subjective**
  => PASS/FAIL results are impacted by a poor focus.



Out-of-focus image can hide critical defects delivering a « Pass » verdict

Optimized focus will ensure seeing all defects affecting performances

How to clean a connector?

Dry cleaning	
Convenience of readily available tools	Can possibly create electrostatic charges
Fast and easy	Not effective in removing all contaminant types

Wet cleaning	
Can dissolve complex soils and contaminants	Can leave residue on the ferrule when too much solvent is used and not properly dried
Eliminates the accumulation of electrostatic discharge on the ferrule	Solvent choice can be confusing with issues of performance and EH&S

Hybrid cleaning	
Cleans all soil types	Requires multiple products
Reduces potential static field soil accumulation	
Automatically dries moisture and solvent used in the cleaning process	
Captures soil in wiping material as an integrated aspect of cleaning	

Connectors inspection & cleaning conclusion

Leave nothing to chance:

- Inspect against appropriate standard, and clean only as needed
- Use reliable and repeatable processes, with controlled focus and pass/fail
- Be equipped for dry & wet cleaning
- Be ready to toggle between single and multifiber inspection and cleaning

=> Don’t plug & pray!

Tier I Testing of Fiber Optic Links

How much light is coming out of the end of the fiber?
How much should be coming out?

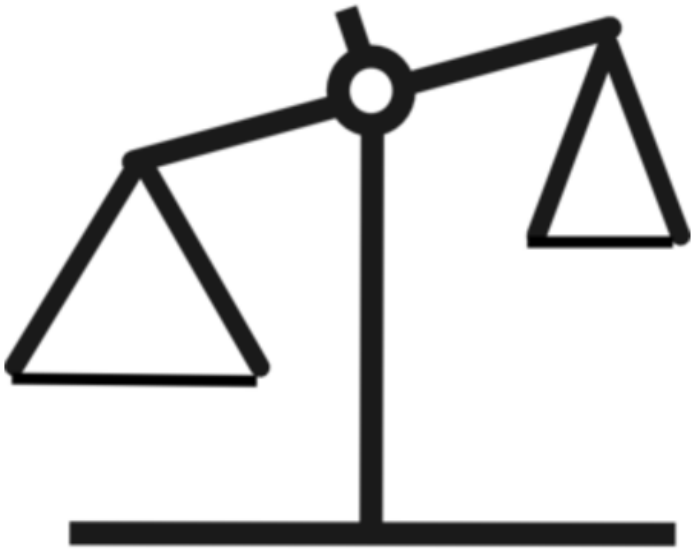
Jim Davis
Regional Marketing Engineer
Fluke Networks

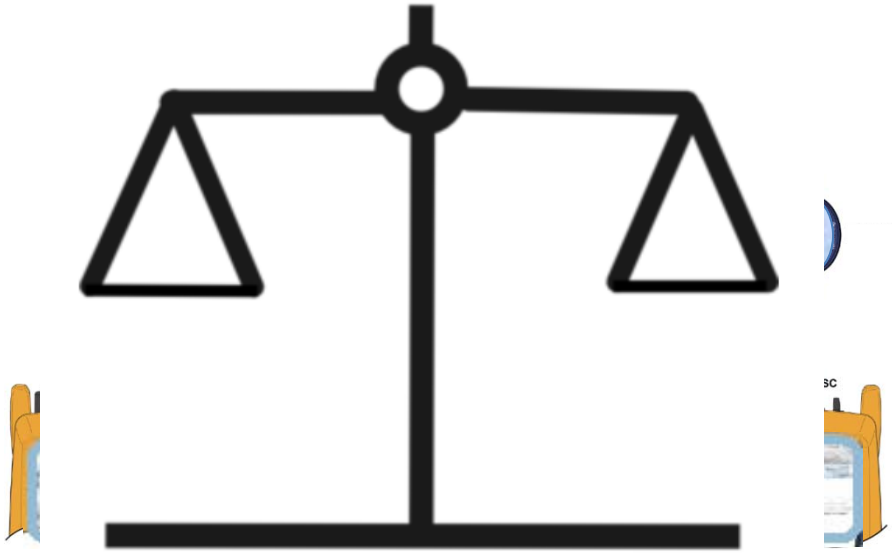
How Fiber Loss is Measured

Set a reference
Run a test
Find the difference

First set a reference

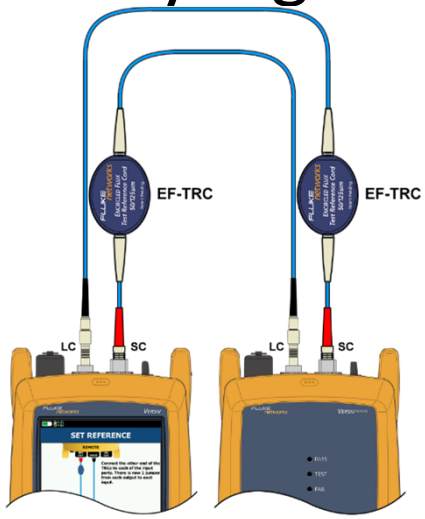
Then find the Difference





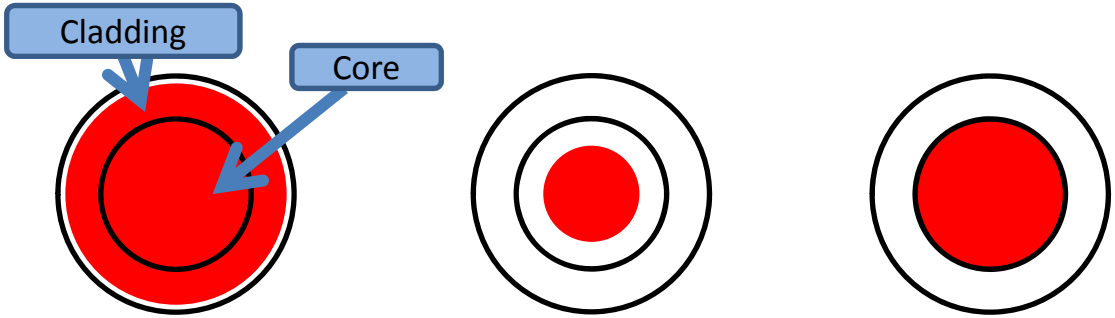
Accurate test process and values will reduce uncertainty

- For less uncertainty in our fiber testing, especially of ***multimode*** fiber, there are 4 key ingredients to loss testing
  - A one jumper reference
  - An LED source
  - Reference Grade Connectors
  - Encircled Flux compliance



Encircled Flux compliance

- The light source's launch condition determines how and where the light is distributed within the fiber



Source 1
Over filled

Source 2
Under filled

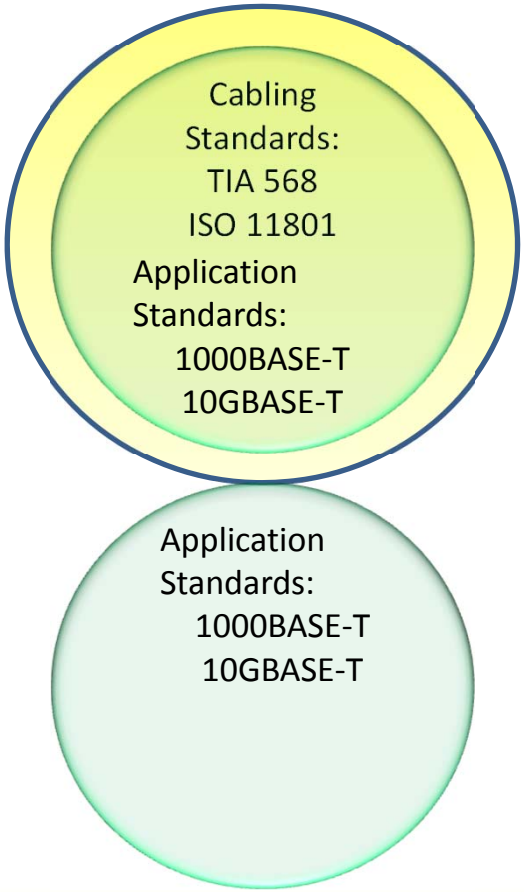
Source 3
EF
Compliant

CALCULATING A LOSS BUDGET

Difference between a TIA limit and an application limit

The Loss Budget determines what "Passes" and "Fails"

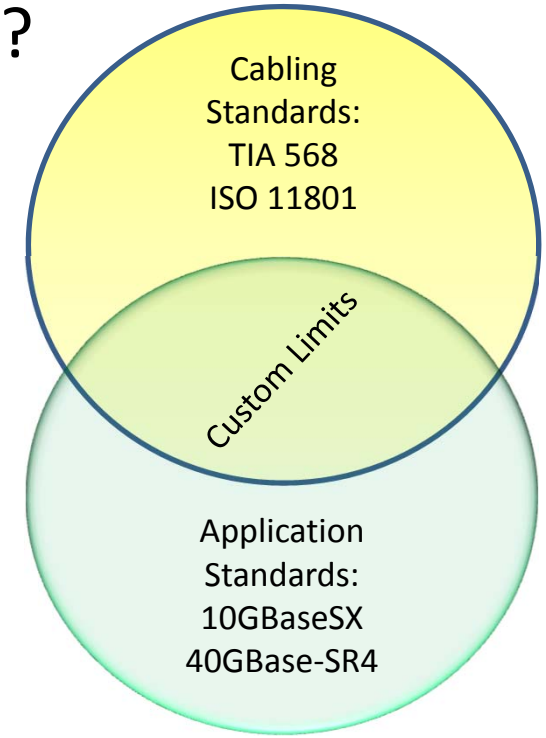
Which Limits to use?
Does this link really pass?



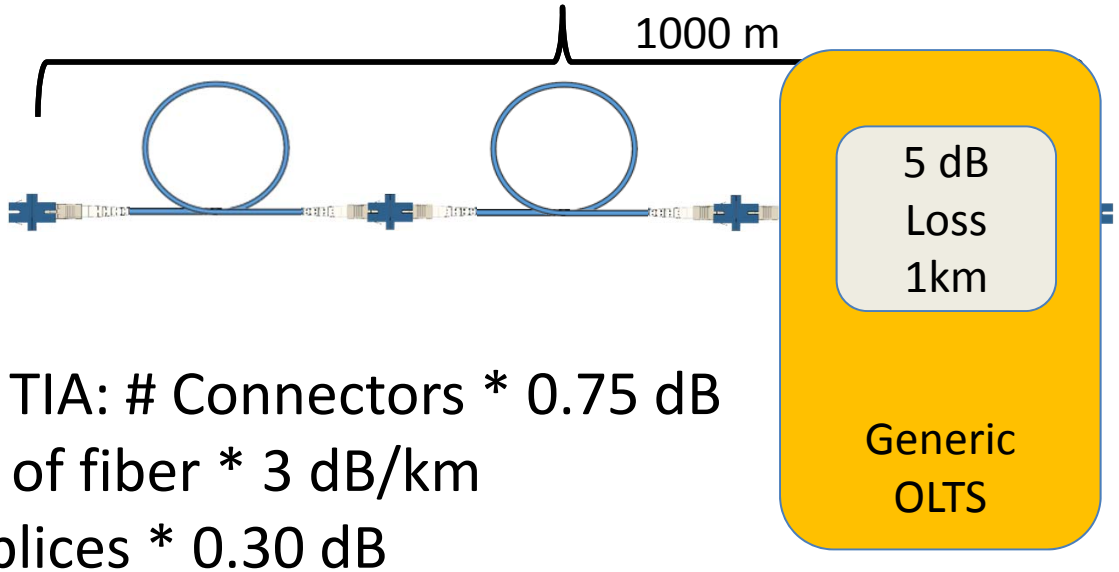
- There is no “Cat 6A” for fiber
- There is conflict between what the standard will support and what the application requires
- Installers should use Custom Limits to certify links

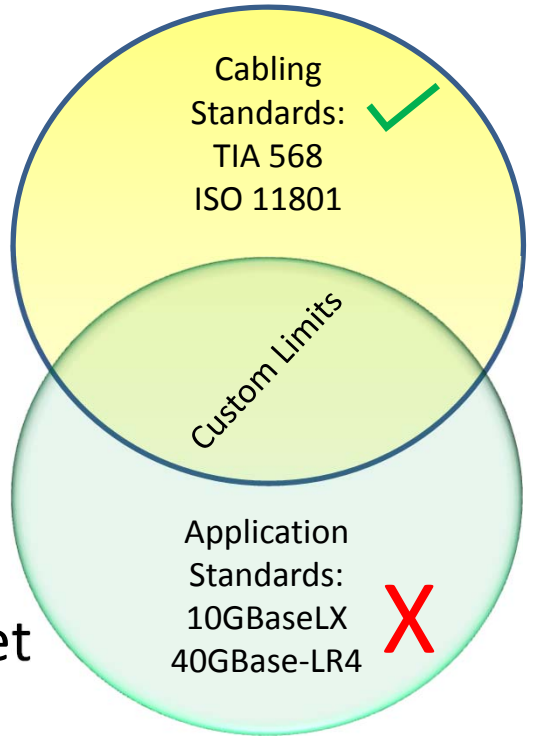
Which Limits to use?
Does this link really pass?

- There is no “Cat 6A” for fiber
- There is conflict between what the standard will support and what the application requires
- Installers could use Custom Limits to certify links
  - Manufacturers may offer a custom link loss calculator for their components



TIA Limits Vs. IEEE limits 10GBASE-SR

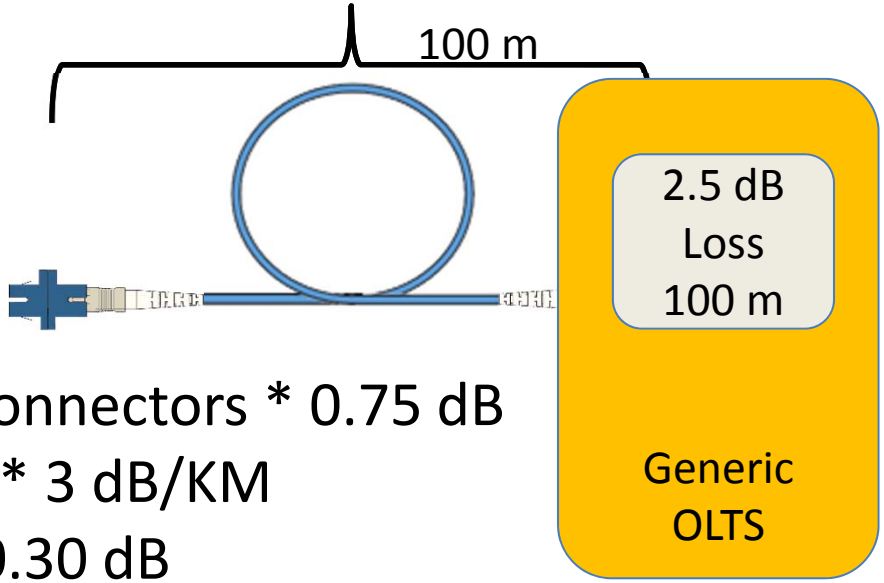




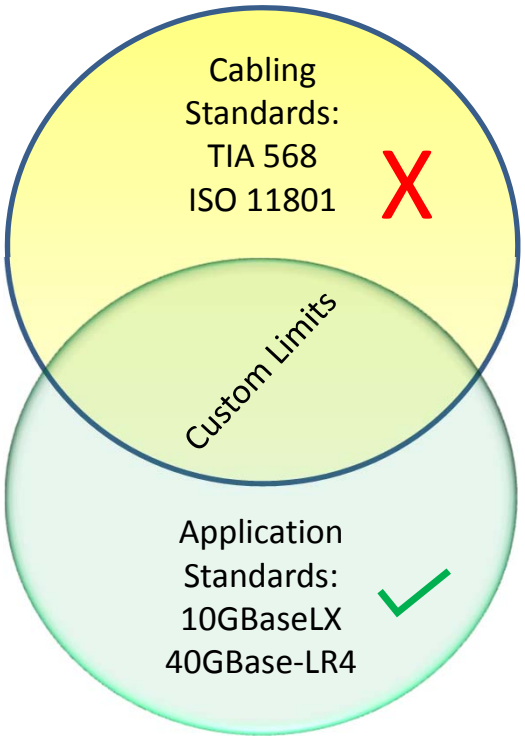
Per TIA: # Connectors * 0.75 dB
KM of fiber * 3 dB/km
Splices * 0.30 dB
The math 3.0 + 3.0 + 0 = **6 dB** – Total Loss Budget

IEEE 10GBASE-SR Limits = **2.6 dB** of loss and **300 Meters**

TIA Limits Vs. IEEE limits 10GBASE-SR

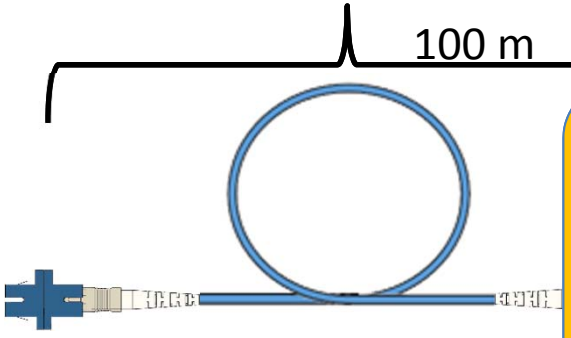


Per TIA: # Connectors * 0.75 dB
KM of fiber * 3 dB/KM
Splices * 0.30 dB
The math 1.5 + .3 = **1.8 dB** – Total Loss Budget

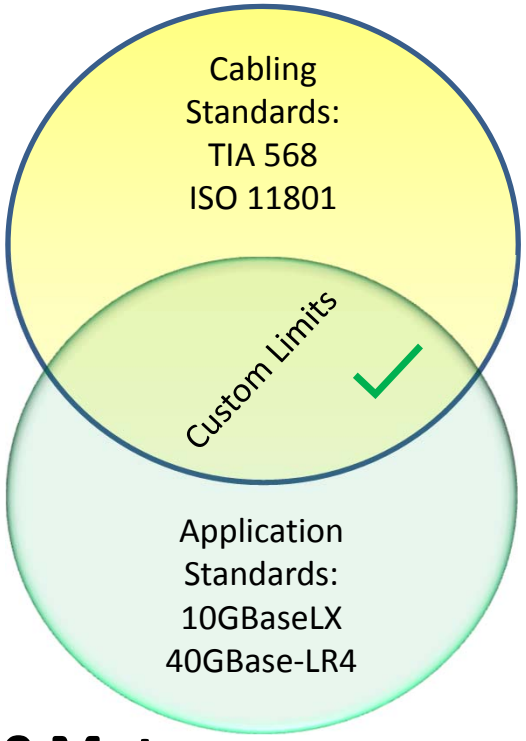


IEEE 10GBASE-SR Limits = **2.6 dB** of loss and **300 Meters**

TIA Limits Vs. IEEE limits 10GBASE-SR



Inspect and clean connectors if necessary and test it again



Per TIA: # Connectors * 0.75 dB
KM of fiber * 3 dB/KM
Splices * 0.30 dB
The math 1.5 + .3 = 1.8 dB – Total Loss Budget

IEEE 10GBASE-SR Limits = 2.6 dB of loss and 300 Meters

Tier I Conclusions

- Try to use a One Jumper Reference
  - If testing a connector that you do not have a port for on your power meter, you may have to set a three jumper reference
    - MPO, MTRJ, 'keyed' connectors
- Use the right loss budget
  - TIA/ISO variable 'length' based limit
  - IEEE fixed loss, fixed length application limit
  - Custom limit that mixes both

OTDR/Tier2 Testing of Fiber Optic Links

Rob Gilberti

Sr Product Line Manager

OTDR Functions

An OTDR uses Reflected Light to measure and characterize an Optical Fiber

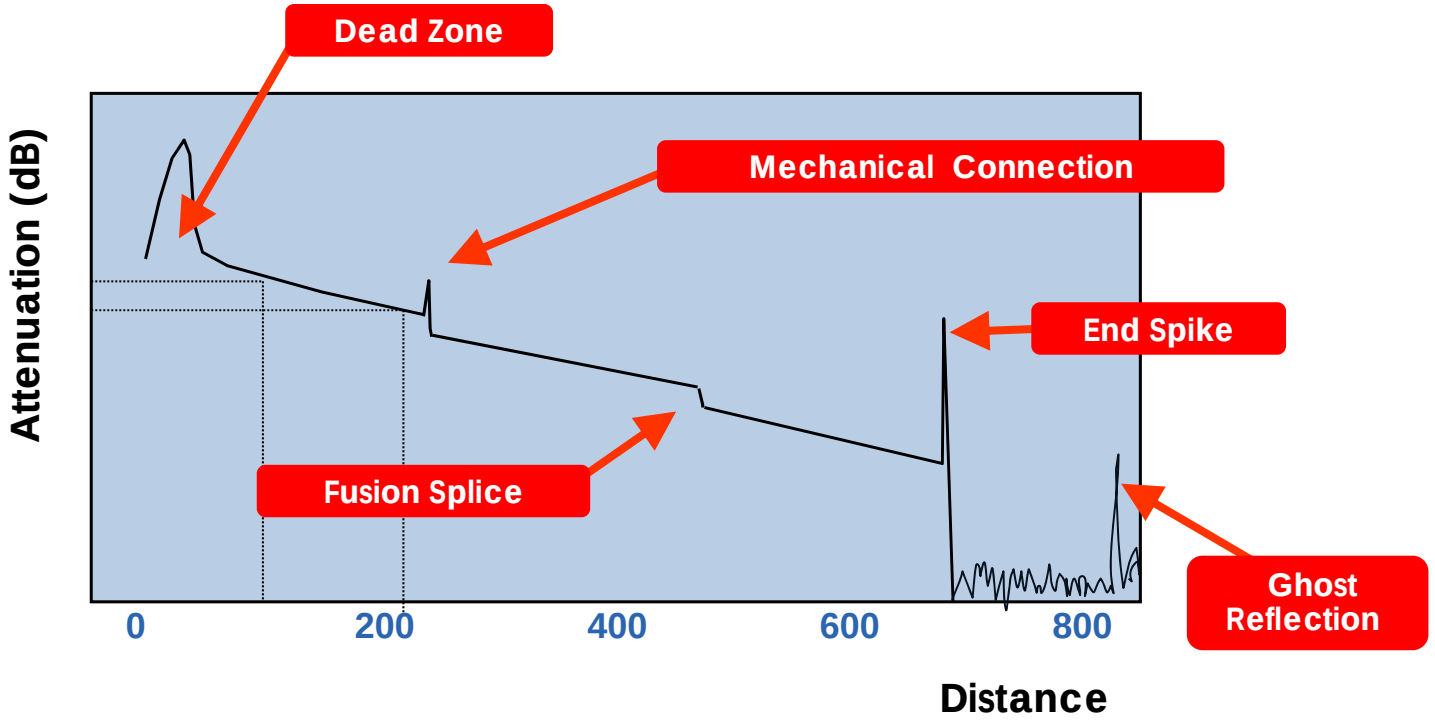
Functions

- Measure Loss and Distance
- Locate and Measure Connectors and Splices
- Locate and Characterize Faults – Macrobends, Breaks
- Measure Link Optical Return Loss (ORL)
- Evaluate Connector Reflections

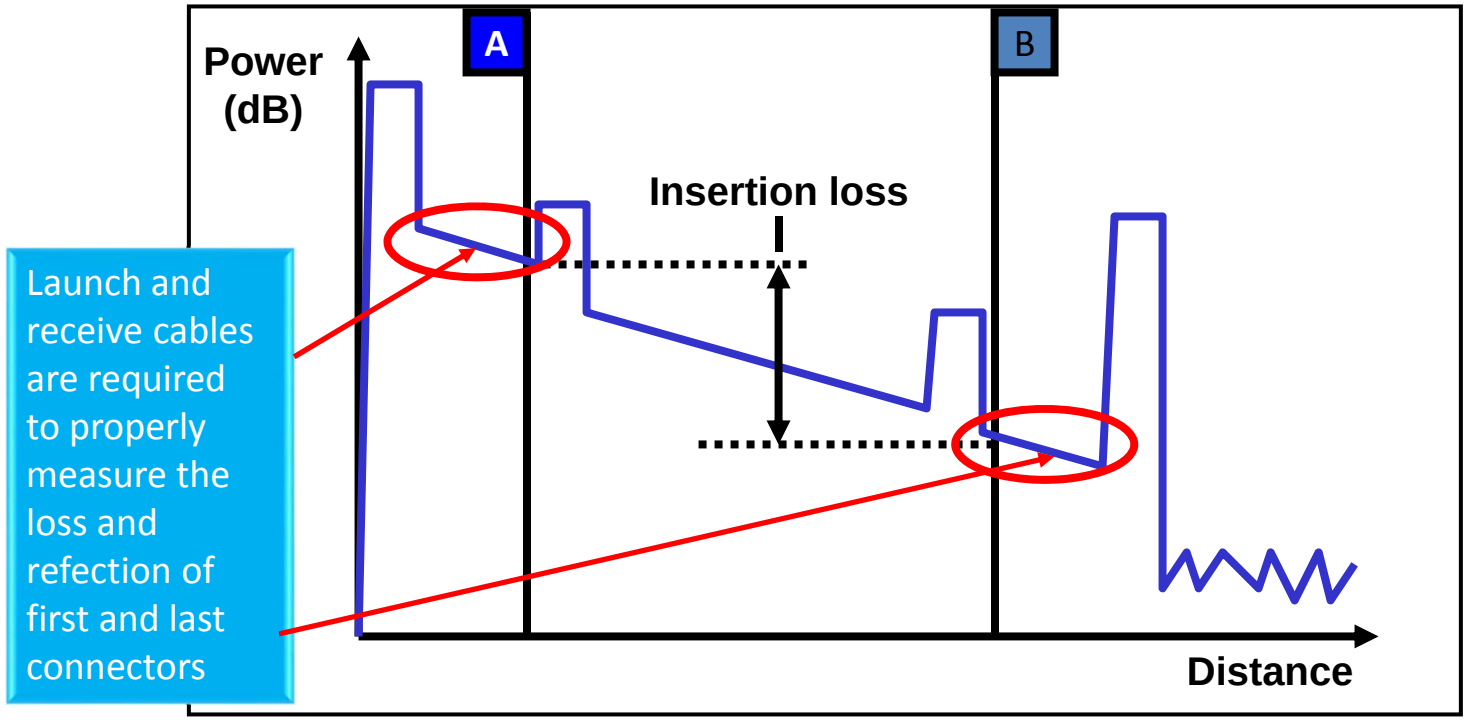
Applications/Uses

- Installation/Commissioning Troubleshooting
- Emergency Restoration
- Fiber/Link Characterization
- Maintenance
- Link/Network Quality Assurance

The OTDR Trace

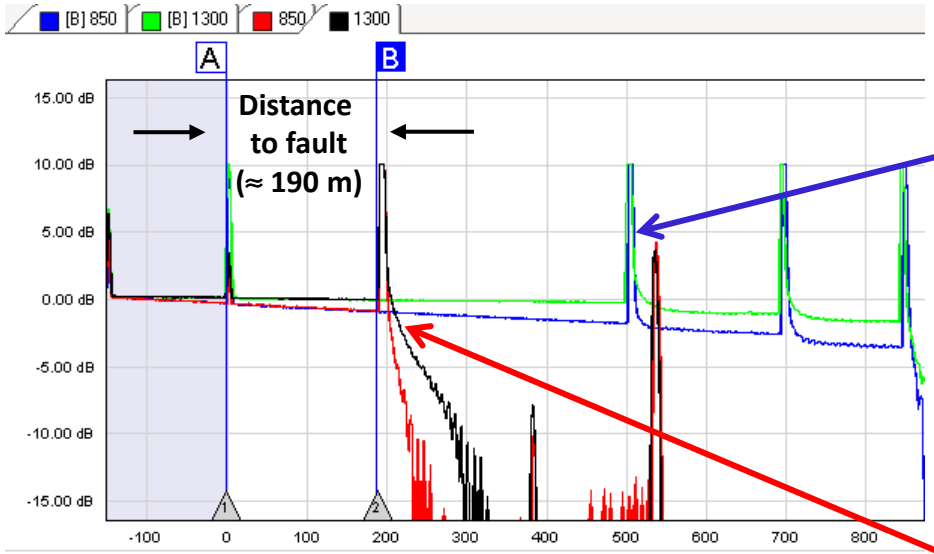


OTDR Two-point insertion loss including end connections



Launch and receive cables are required to properly measure the loss and refection of first and last connectors

Using an OTDR to Fault Locate



Relative Power (dB)

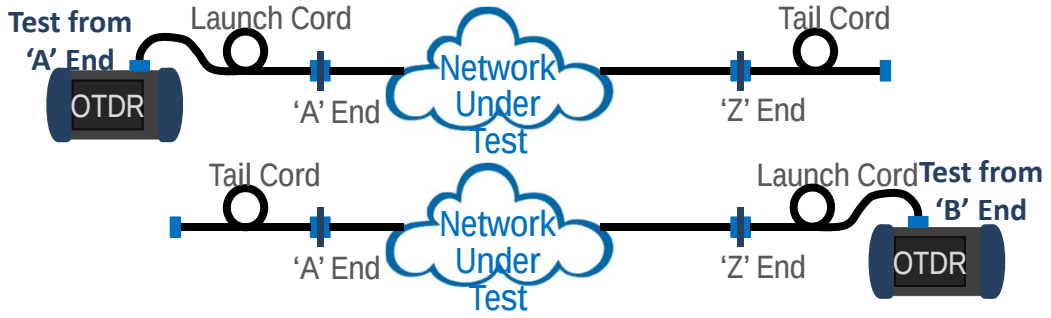
Distance (m)

Expected Trace from install

Captured Trace shows fault location

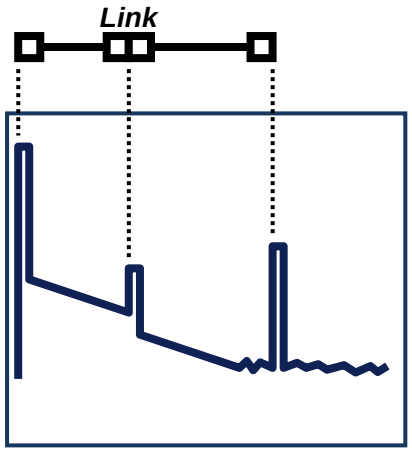
OTDR Bi-Directional Testing

- If backscatter characteristics are different from each fiber, measured loss across the event will be exaggerated in one direction and reduced in the other direction
  - Different fiber types (e.g. G.652.D vs. G.657.B2) have different backscatter
  - Older fiber typically has higher backscatter then newer fiber
- A more accurate measure of an event's loss is obtained by testing the network from each end and averaging the measured event loss in both directions at each event



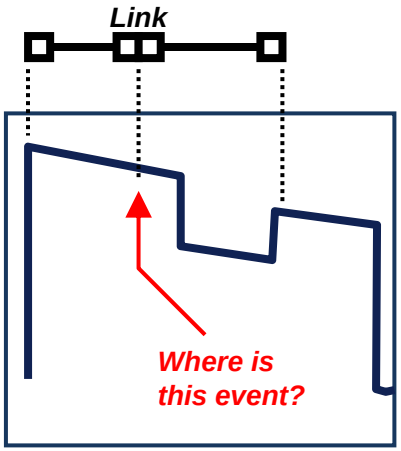
How to determine OTDR Pulse Width

Too Narrow



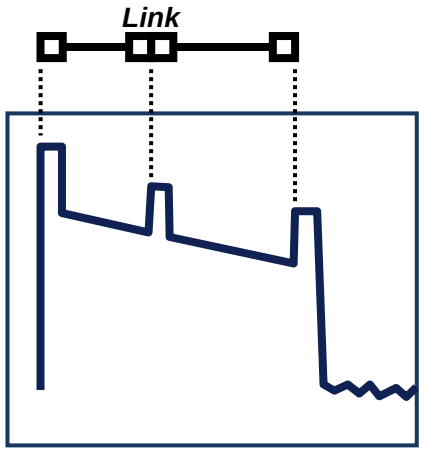
Trace “disappears” into noise floor

Too Wide



Can’t resolve events

About Right



Events can be seen and trace is smooth

Multi-Pulse Acquisition

Combines results of multiple pulsewidths

Reflectance – It's important!

Standards

	10Gbase	TIA-568.3-D	Industry
SMF	-26dB	-35dB	-35 to -50dB (UPC)
MMF	-20dB	-20dB	

High Reflectance can indicate poor quality connections or UPC/APC mismatches

Multi-fiber OTDR Testing with MPO Switch

Connect to MPO Network or use Hydra/Breakout to connect to individual fibers/connectors

OTDR controls switch via USB and Software cycles through 12 fibers automatically testing each fiber

OTDR captures .SOR files for 12 individual fibers for dual wavelength and consolidates data for single report

Testing MPO Connectors

OLTS for Tier I
OTDR for Tier II

Tyler Vander Ploeg, RCDD
Fiber Solutions Marketing Manager
VIAVI Solutions

Which MPO connections will you likely test?

12 Fiber

- Large installed base
- Existing MM & SM deployments
- Familiar interface and trunks
- For plug and play cassettes in datacom environment
- 40 Gig applications

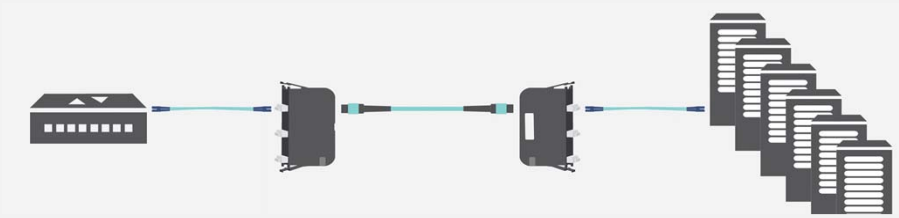
8 Fiber

- Supports QSFPs
- For MM & SM transceivers and breakouts
- Lowest panel density
- Removes 4 fibers in middle
- 40 & 100 Gig applications

24 Fiber

- Future ready
- Lowest cost duplex support for multimode applications
- Highest panel density
- For data center & server side
- 100 Gig applications

MPO Testing Scenarios



6 x 1/10Gbps Ethernet Channels (MMF)
6 x 1/10Gbps Ethernet Channels (SMF)

Tests to perform:
- Inspect all connections
- Test duplex (LC) drops w/duplex OLTS

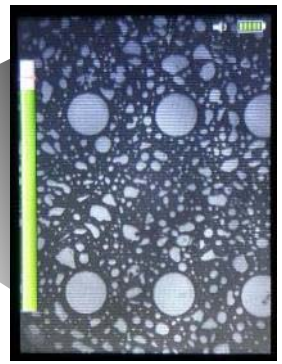
4 x 10Gbps Ethernet Channels (MMF)

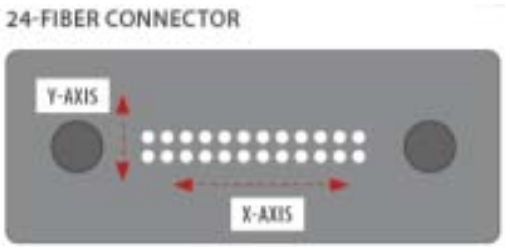
Tests to perform:
- Inspect all connections
- Test from MPO to simplex
- OR use fan-out cable and test MPO-MPO

40/100Gbps Ethernet Channels (MMF)
40/100Gbps Ethernet Channels (SMF – PSM4)

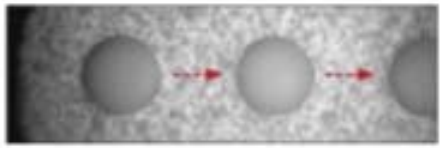
Tests to perform:
- Inspect all connections
- Test MPO Links/Channels

Inspect ALL fibers in a Multi-Fiber Connector

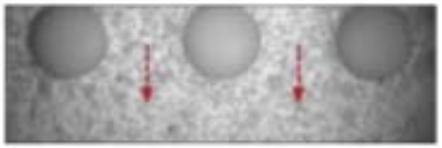


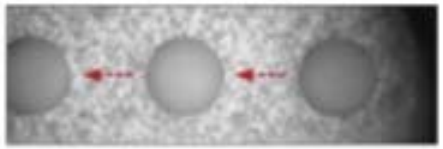


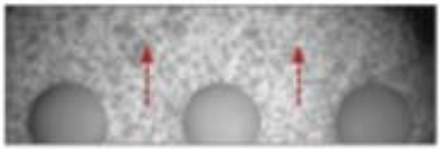
X-AXIS



Y-AXIS



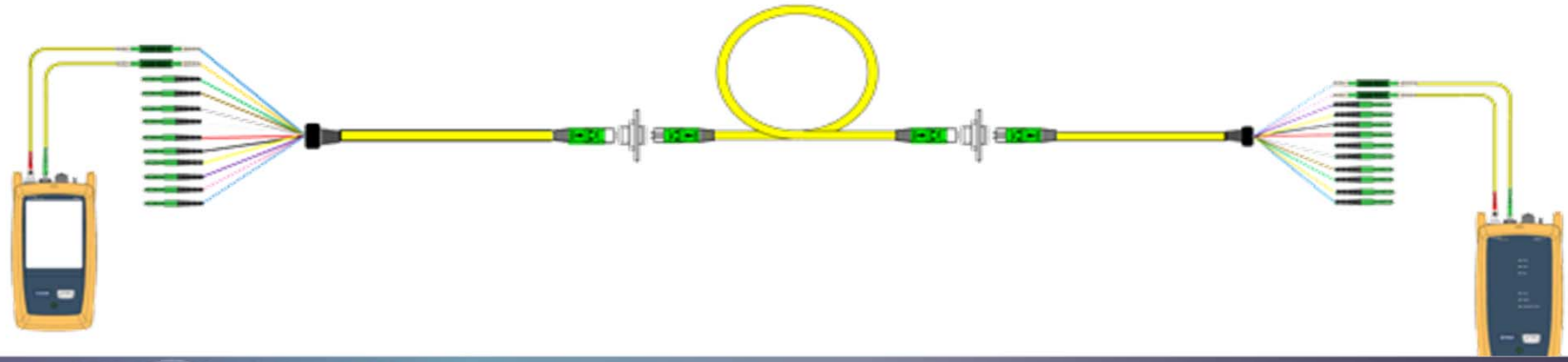




MPO Tier 1 Certification

Duplex Optical Loss Test Set

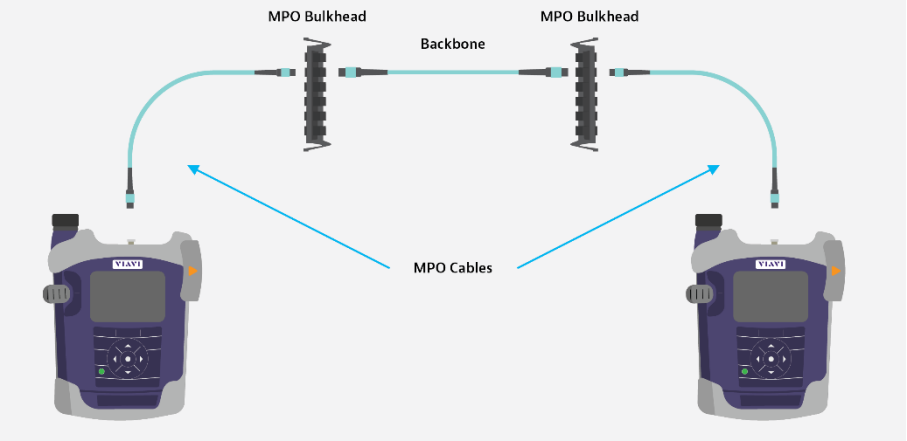
- Test MPO Links and Channels
- Loss, length and polarity
- Uses a cable or cassette to breakout MPO into simplex fibers
- Test results for each duplex fiber pair one set at a time



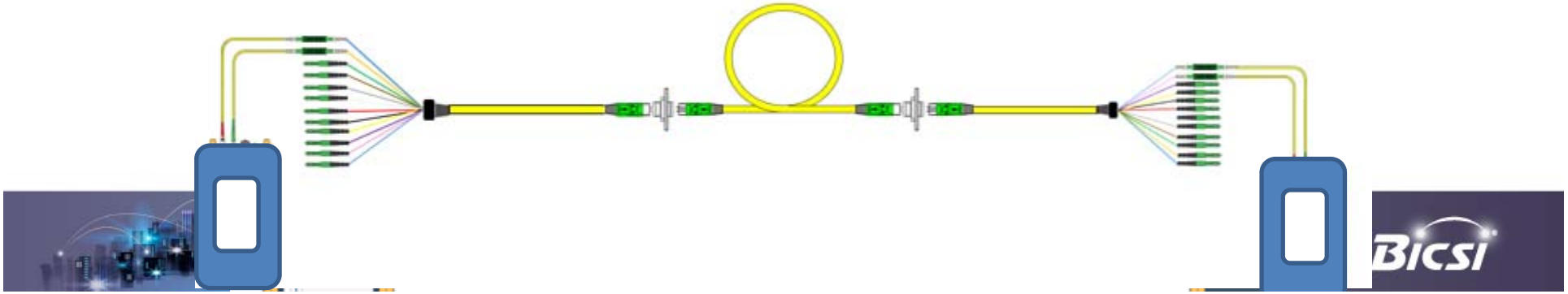
MPO Tier 1 Certification

Dedicated MPO Optical Loss Test Set

- Test MPO Links and Channels
- Loss, length and polarity
- Plug MPO connectors directly into field test device
- Test results for all fibers in the MPO connector together

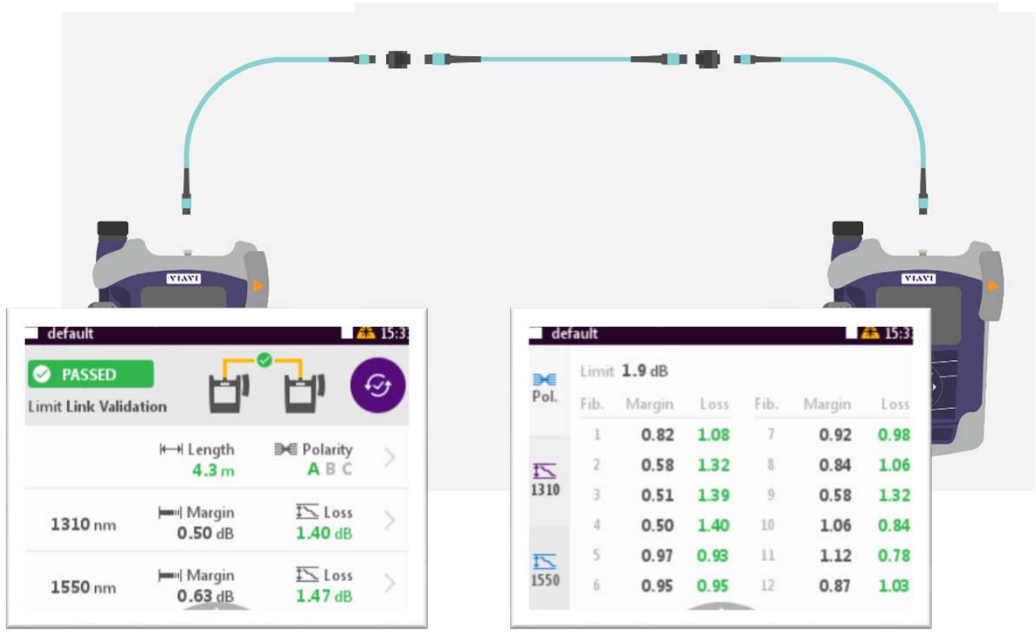


MPO/MTP Testing with Duplex OLTS – 3 Jumper Reference



Testing with Dedicated MPO OLTS

1. Set Reference with MPO test leads on each end
2. Add “Device Under Test” in middle
3. View & document results

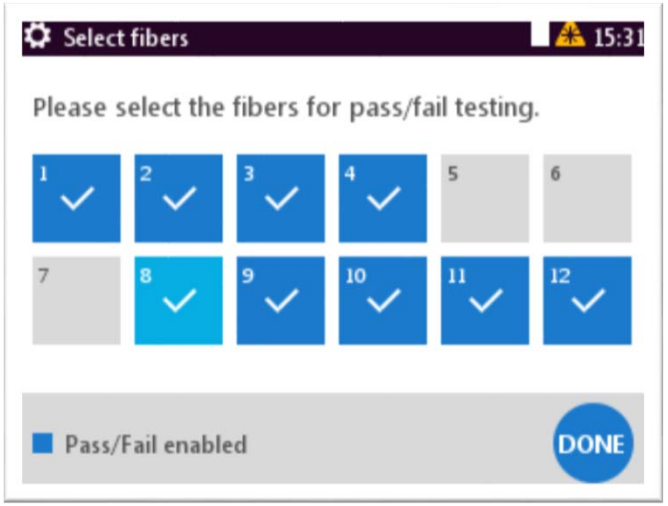


Main Challenge for Tier 1 Testing of MPO

- One-cord reference
  - If test set has pinned ports then unpinned to unpinned test cord must be used to perform reference
  - Receive cord is then added (unpinned to unpinned)
  - Can then test a pinned system
  - Cannot verify reference without adding a third cord
- There are MPO connectors available that allow pins to be retracted or removed
  - Helps solve pinned/unpinned challenges

Selecting Channels

- Can apply to any of the above scenarios
- Allows selection of which of the 12 channels are part of pass/fail analysis
- Eliminates false fails in cases when 8 or fewer fibers are present in MPO links (e.g. 40GBASE-SR4)
- Results reflect topology



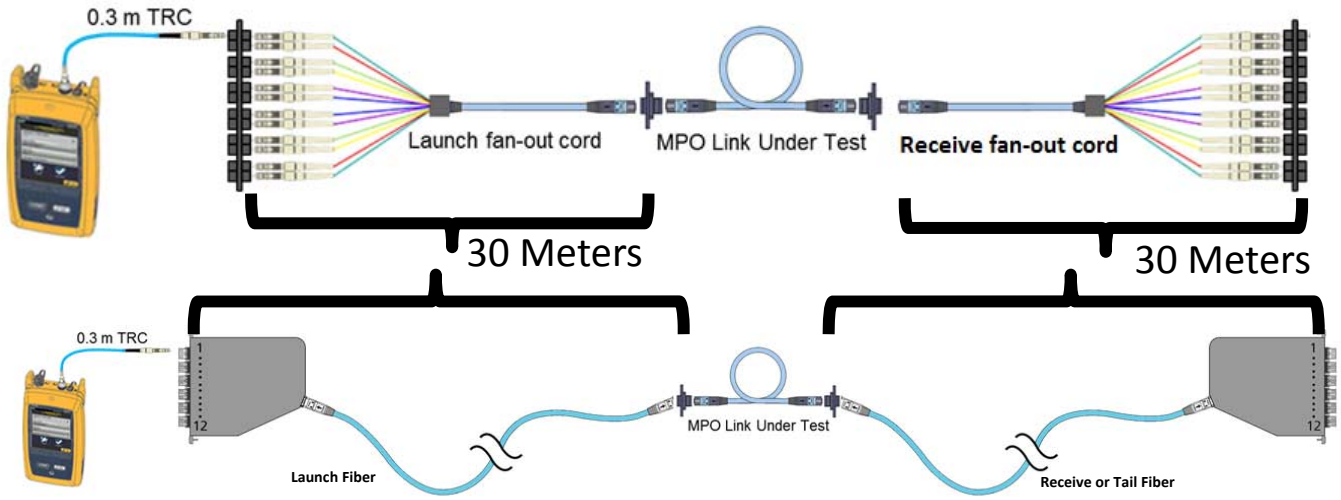
Tier 2 Testing of MPO

- Tier 1 testing cannot ensure individual event (splices and connection) losses are within spec OR the cable attenuation is uniform
- Tier 2 (OTDR) testing adds the characterization of these events to the certification test
- Tier 2 testing is also the ideal fiber trouble shooting tool to find the cause AND location of excess loss (incl. breaks) and reflectance
- Requires MPO switch or breakout cables
- Pinned/unpinned systems require different launch and receive cords

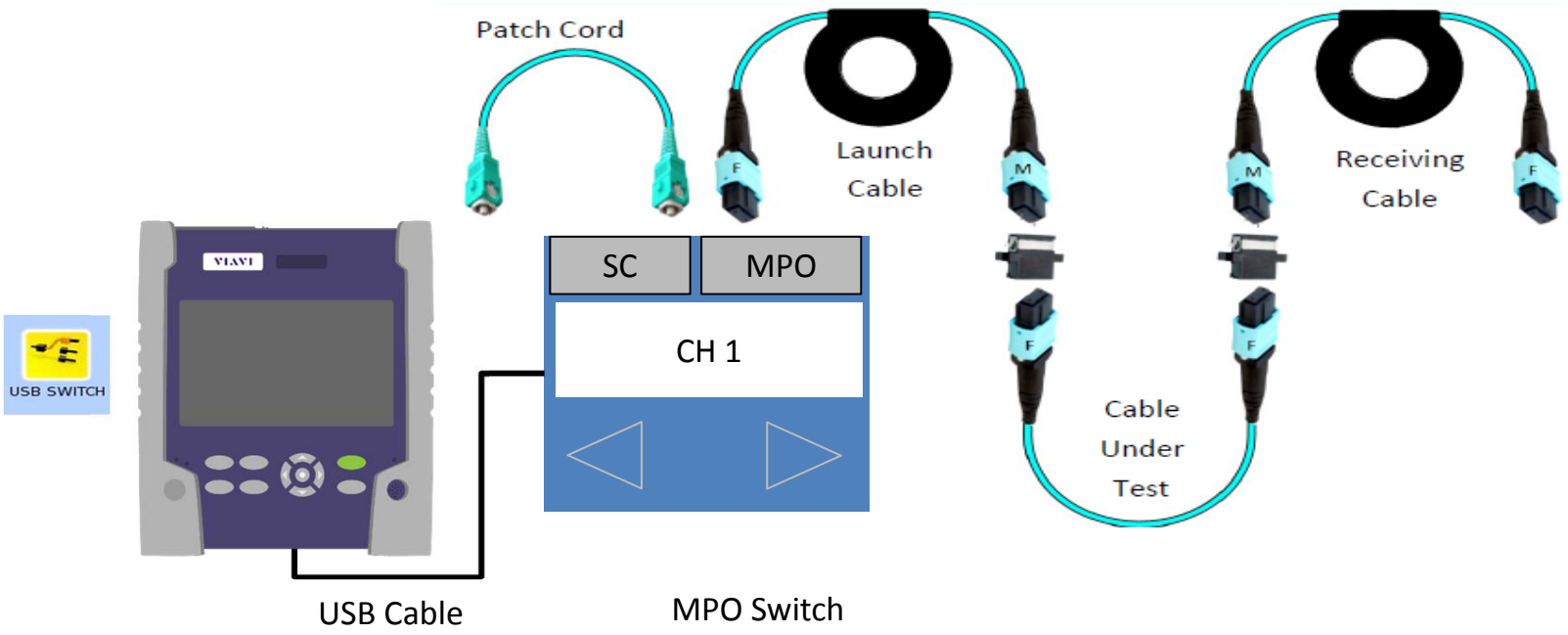
OTDR Testing of MPO Connectors

Don't forget your Pinned/Unpinned connections! ☺

- Ideally you will have **at least** 30 Meters of Launch and Receive fibers
  - Provided that the link under test is short: standards call out 100M and 150M
- Use a fan out cord or cassette to convert from Single fiber Port on OTDR



MPO OTDR Testing (External Switch)



Automatic switching driven by the OTDR via USB

Thank You For Your Time

COMMSCOPE®
Rodney Casteel RCDD/NTS/OSP/DCDC
rcasteel@commscope.com

ofs
Tony Irujo
tirujo@ofsoptics.com

PANDUIT
David J Asta RCDD
David.Asta@Panduit.com

SUPERIOR ESSEX
Paul Neveux, Jr., Ph.D
Paul.Neveux@spsx.com

AFL
Rob Gilberti
Rob.Gilberti@aflglobal.com

FLUKE networks
Jim Davis
jim.davis2@flukenetworks.com

EXFO
Romain Tursi
romain.tursi@exfo.com

VIAVI
Tyler Vander Ploeg, RCDD
Tyler.VanderPloeg@viavisolutions.com