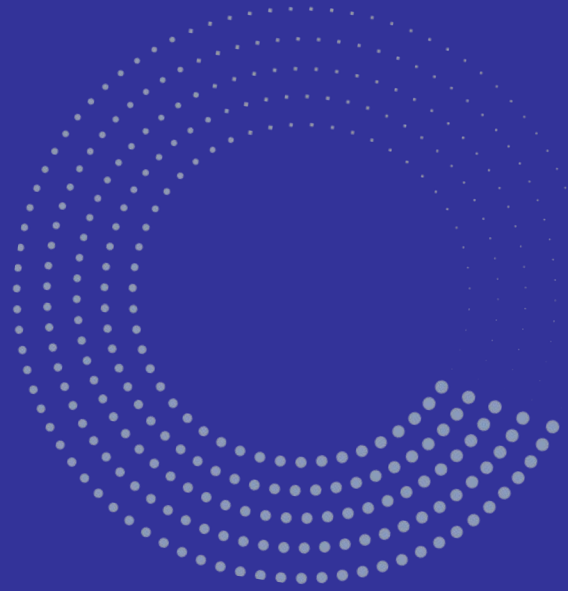
Tackling the Challenges of Fiber Testing in High-Density Fiber Data Centers



EXFO TRS RenTelco℠

Agenda

- Welcome and Introductions
  - Lindsay Welch, TRS-RenTelco Marketing Manager
- TRS Overview
  - Micah Hurd, TRS-RenTelco Product Manager
- EXFO: BA-4000 Technical Applications
  - Gwenn Amice, Senior Member of Technical Staff at EXFO
- EXFO/TRS-RenTelco Partnership: Equipment & Special Promotions
- Q&A – Joint TRS and EXFO

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We provide comprehensive Test & Measurement solutions delivering equipment-as-a-service.

Plan, acquire, and efficiently utilize instruments to maximize return on investment.

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- 5,000+ configurable models available, valued at over $500MM
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- State-of-the-Art 20,000 sq ft Calibration Lab on site
- Same-Day-Shipping with Next Day Delivery Available

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Strategic singular focus on the rental market

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INTRODUCTION

DENSIFICATION OF DC NETWORKS

1. GROWTH OF HYPERSCALE, CLOUD, AND AI-DRIVEN DATA CENTERS

AI and machine learning workloads require ultra-low latency and high-speed interconnects for best performances

Cloud providers (AWS, Google, Azure, META, X) continuously expand fiber infrastructure for global demand

2. DEEP INFRASTRUCTURE CHANGES

Parallel optics becoming predominant transmission technology, leading the way to high fiber count ribbon cables and VSFF type of fiber optic connectors.

3. ADOPTING RIGHT TESTING STRATEGY IS CRITICAL

Small mistakes in testing scale exponentially, impacting thousands of fibers.

Complexity increases the need for precise testing, polarity management, and connector cleaning.

Name	Standard	Release	Form factor	Wavelengths	Fiber	Distance	Loss (dB)	Fiber count	Connector
25GBASE-SR	IEEE 802.3by	2016	SFP28	850	OM3 OM4	70 100	1.8 1.9	2	Duplex (LC, CS, SN, MDC) 
50GBASE-SR	IEEE 802.3cd	2018	SFP56	850	OM3 OM4	70 100	1.8 1.9	2	Duplex (LC, CS, SN, MDC) 
100GBASE-DR	IEEE 802.3cd	2019	QSFP28	1310	OS1	500	3	2	Duplex (LC, CS, SN, MDC)
100GBASE-SR2	IEEE 802.3cd	2019	QSFP56	850	OM3 OM4	70 100	1.8 1.9	4	Base-4 (MPO)
100GBASE-VR	IEEE 802.3db	(Dec)	QSFP28	850	OM3 OM4	30 50	1.6 1.7	2	Duplex (LC, CS, SN, MDC) 
100GBASE-SR	IEEE 802.3db	(Dec)	QSFP28	850	OM3 OM4	60 100	1.7 1.8	2	Duplex (LC, CS, SN, MDC) 
200GBASE-DR4	IEEE 802.3bs	2017	QSFP56	1310	OS1	500	3	8	Base-8 (MPO) 
200GBASE-SR4	IEEE 802.3cd	2019	QSFP56	850	OM3 OM4	70 100	1.8 1.9	8	Base-8 (MPO) 
200GBASE-VR2	IEEE 802.3db	(Dec)	QSFP-DD	850	OM3 OM4	30 50	1.6 1.7	4	Base-4 (MPO) 
200GBASE-SR2	IEEE 802.3db	(Dec)	QSFP-DD	850	OM3 OM4	50 100	1.7 1.8	4	Base-4 (MPO) 
400GBASE-DR4	IEEE 802.3bs	2017	QSFP-DD	1310	OS1	500	3	8	Base-8 (MPO) 
400GBASE-SR4.2	IEEE 802.3cm	2020	QSFP-DD	850,910	OM3 OM4 OM5	70 100 150	1.7 1.8 2	8	Base-8 (MPO) 
400GBASE-SR8	IEEE 802.3cm	2020	QSFP-DD	850	OM3 OM4	70 100	1.8 1.9	16	Base-16 (MPO, SN-MT, MMC) 
400GBASE-VR4	IEEE 802.3db	(Dec)	QSFP112	850	OM3 OM4	30 50	1.6 1.7	8	Base-8 (MPO) 
400GBASE-SR4	IEEE 802.3db	(Dec)	QSFP112	850	OM3 OM4	60 100	1.7 1.8	8	Base-8 (MPO) 
800G-PSM8	800G Pluggable MSA	2020	QSFPDD-800	1310	OS1	100	2.8	16	Base-16 (MPO, SN-MT, MMC) 
800GBASE-VR8	IEEE 802.3df	TBC	QSFPDD-800	850	OM3 OM4	30 50	1.6 1.7	16	Base-16 (MPO, SN-MT, MMC) 
800GBASE-SR8	IEEE 802.3df	TBC	QSFPDD-800	850	OM3 OM4	60 100	1.7 1.8	16	Base-16 (MPO, SN-MT, MMC) 
800GBASE-DR8	IEEE 802.3df	TBC	QSFPDD-800	850	OS1	500	3	16	Base-16 (MPO, SN-MT, MMC) 

Optical fiber cable

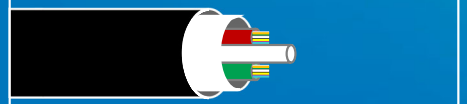
Gel filled loose tube

- Outdoor use
- Water-resistant gel
- Single or multi tube
- <250µm fiber buffer

Dry wrapped

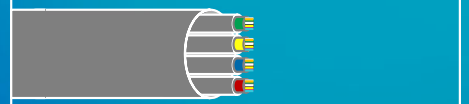
- Outdoor use
- Water blocking tape
- High density fiber
- <250µm fiber buffer

Aerial cable



- Outdoor use
- Gel filled or dry
- Strength member
- <250µm fiber buffer

Blown fiber cable



- Outdoor use
- HDPE tubes
- Compressed air installation
- <250µm fiber buffer

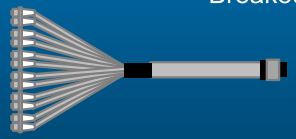
Tight buffered

- Indoor use
- Tight buffered
- Aramid protective yarn
- 900µm fiber buffer

Pre-term trunk

- Indoor use
- Hydra design
- Pre-connectorized
- <3mm cable jacket

Breakout cord



- Indoor use
- Breakout design
- Pre-connectorized
- <3mm cable jacket

Patchcord

- Indoor use
- Pre-connectorized
- <3mm cable jacket

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Optical fiber connectivity

Duplex

LC
- Lucent connector
- 1.25mm ferrule
- Also available in simplex

MDC
- VSFF
- 1.25mm ferrule
- Native duplex

SN
- VSFF
- 1.25mm ferrule
- Native duplex

CS
- VSFF
- 1.25mm ferrule
- Native duplex

Base-8/12

MPO-8
- Multi-fiber push on
- Single row 8 fibers
- Alignment pins

MPO-12
- Multi-fiber push on
- Single row 12 fibers
- Alignment pins

MMC-12
- VSFF
- Single row 12 fibers
- Alignment pins

Base-16

MPO-16
- Multi-fiber push on
- Single row 16 fibers
- Alignment pins

SN-MT-16
- VSFF
- Single row 16 fibers
- Alignment pins

MMC-16
- VSFF
- Single row 16 fibers
- Alignment pins

Base-24

MPO-24
- Multi-fiber push on
- Double row 12 fibers
- Alignment pins

SN-MT-24
- VSFF
- Double row 12 fibers
- Alignment pins

MMC-24
- VSFF
- Double row 12 fibers
- Alignment pins

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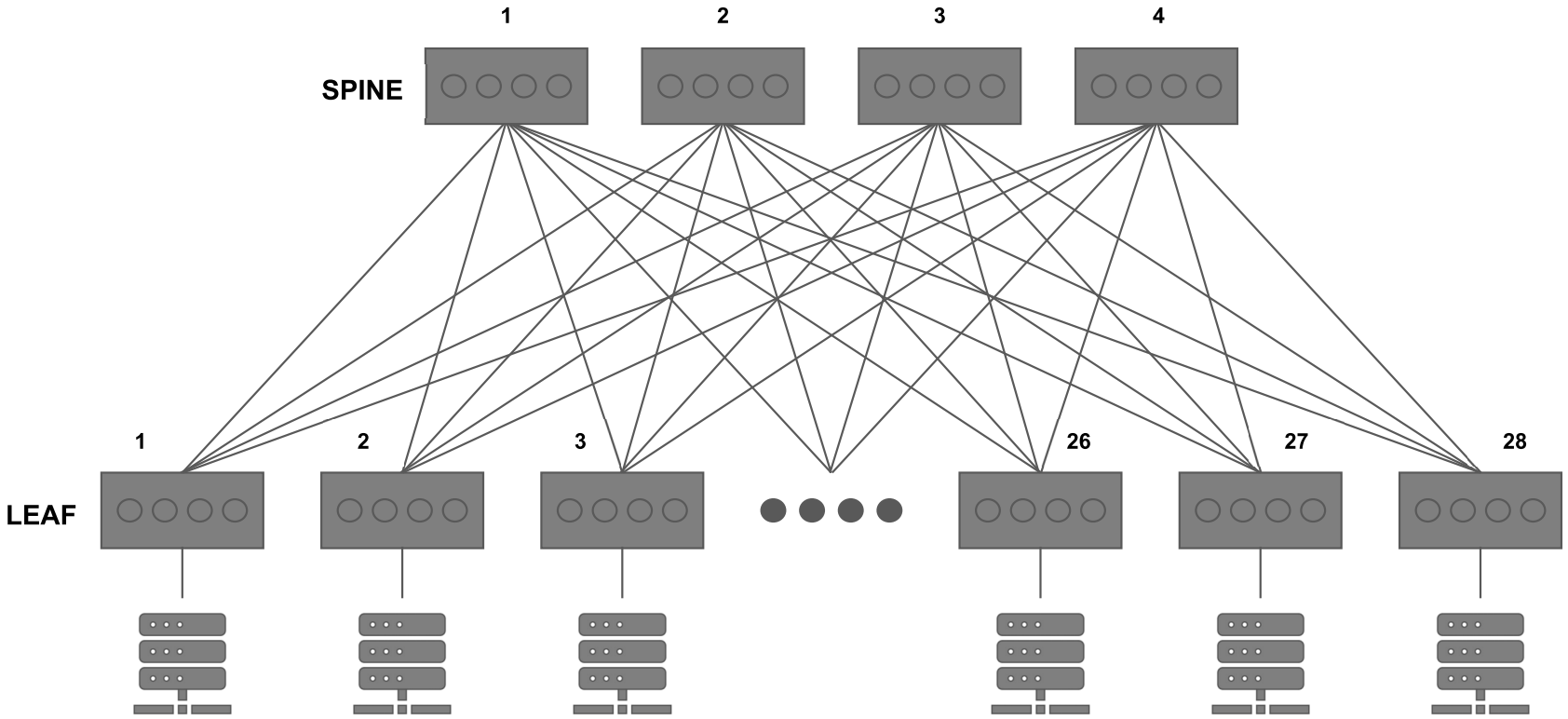
Spine and Leaf design

Load balancing	Redundancy	Fixed latency	Server capacity	Bandwidth	Expansion



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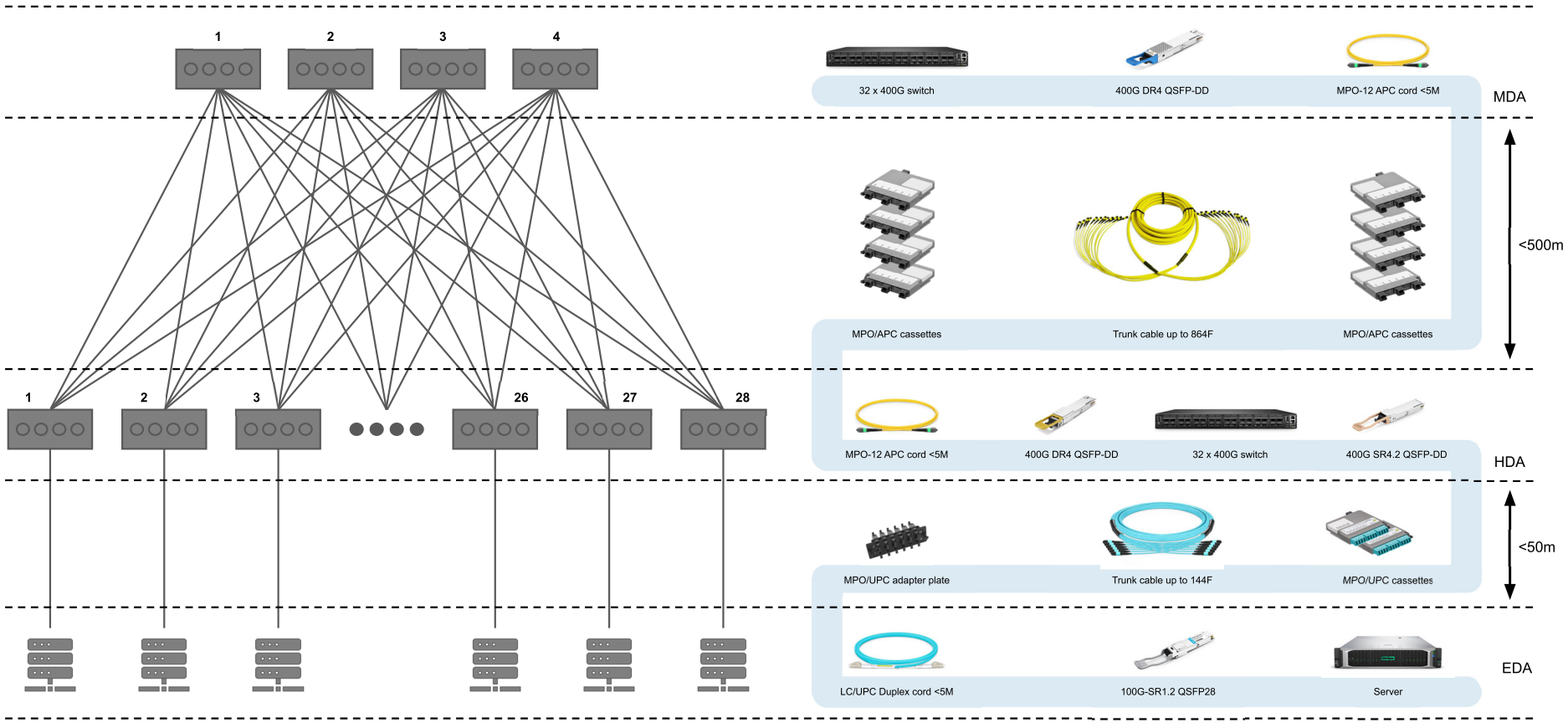
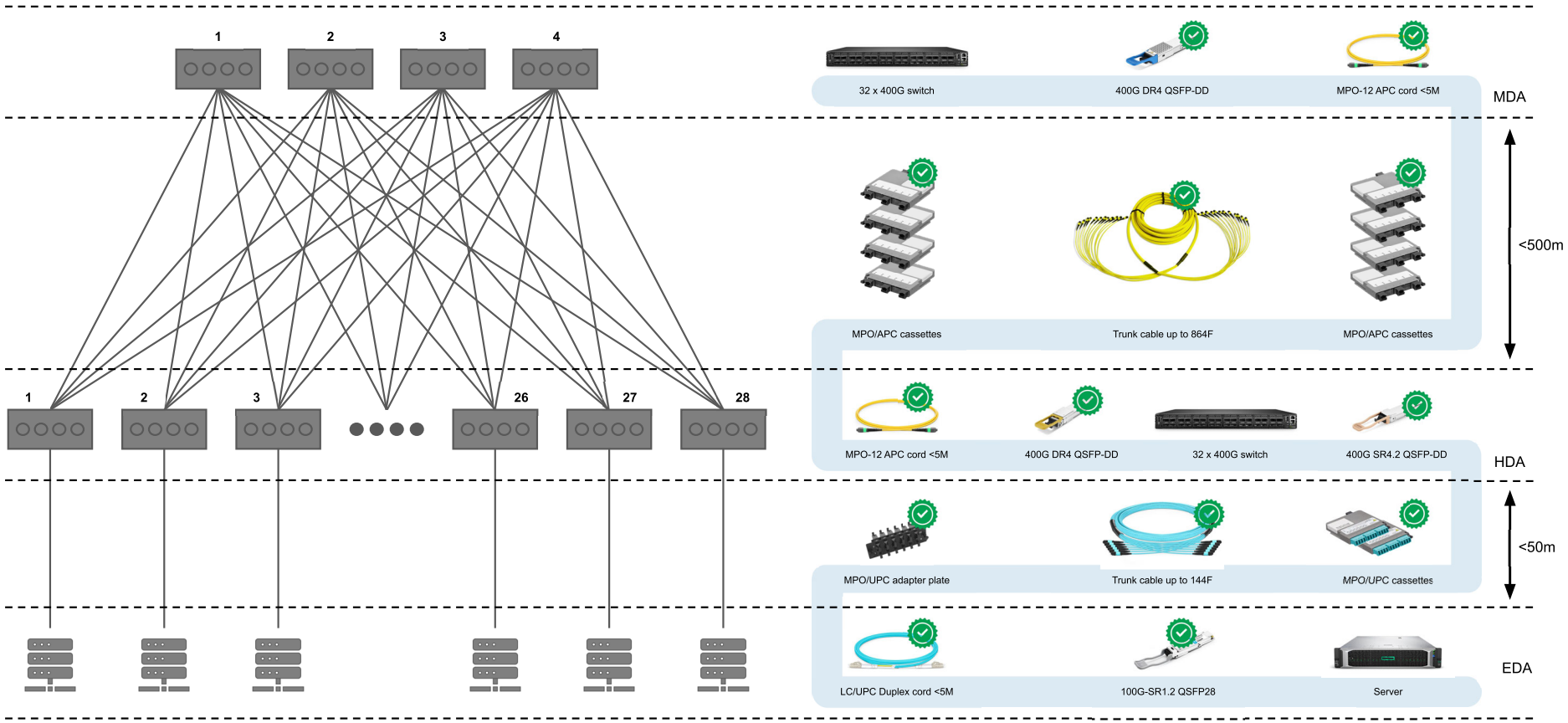
Network infrastructure



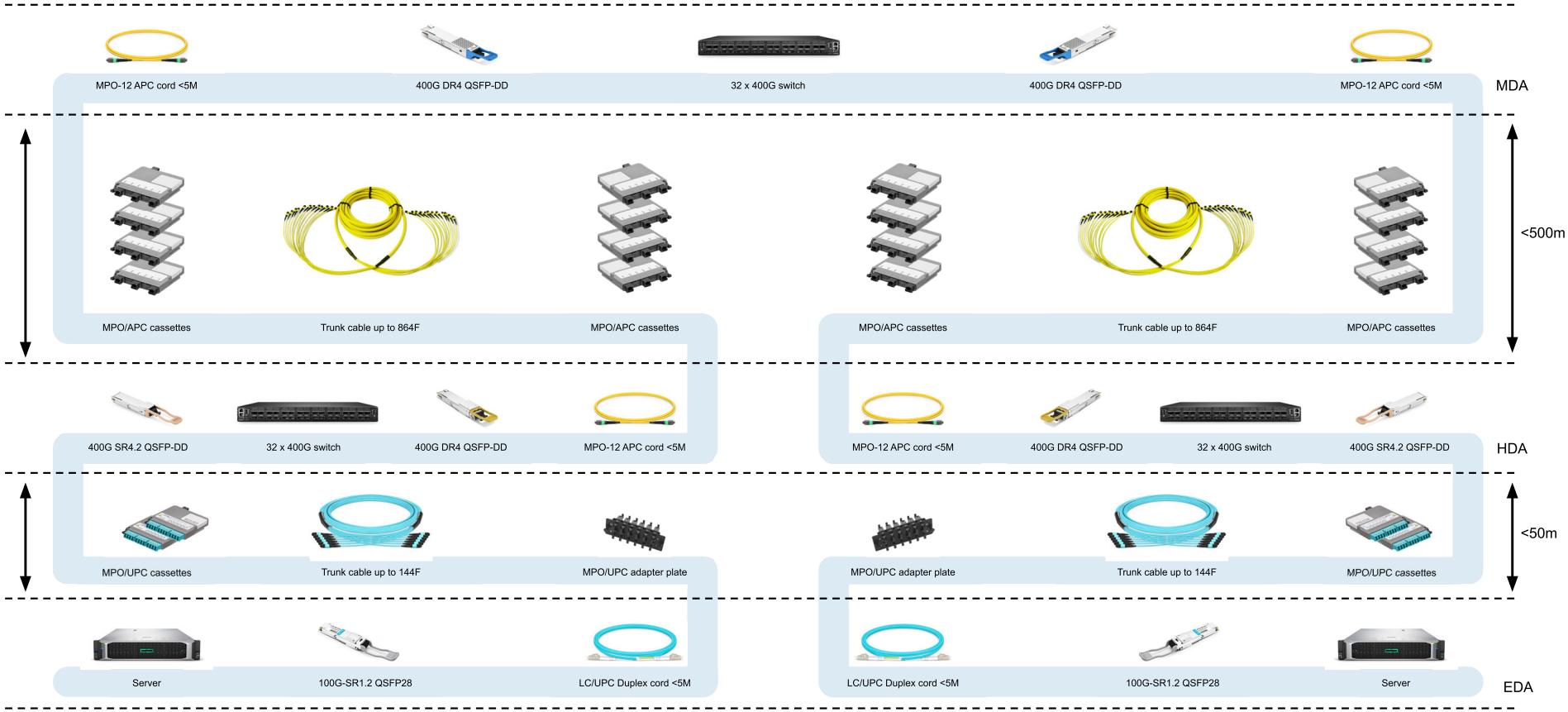
COMPONENT TESTING

Active and passive



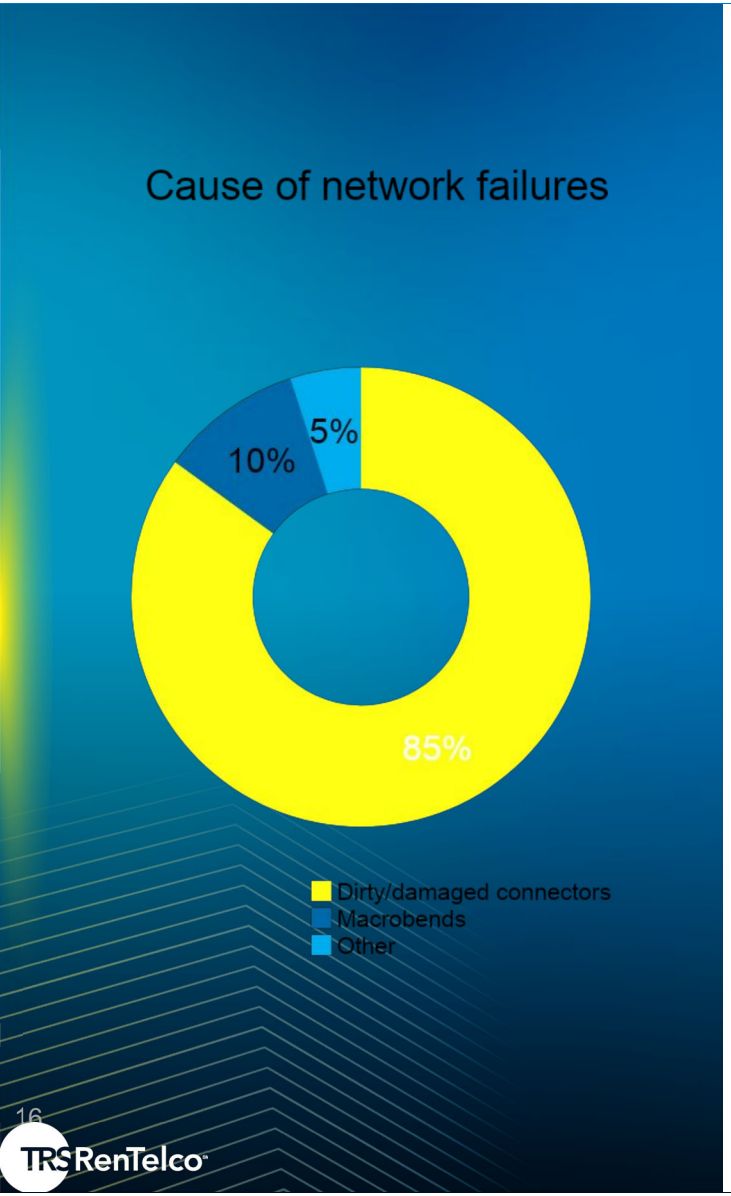
LINK TESTING

Active and passive

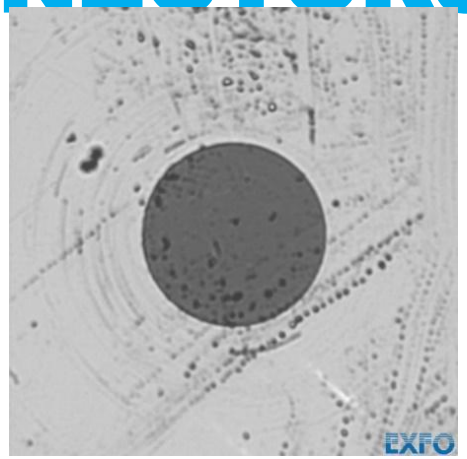


ESSENTIAL TOOLS AND TECHNIQUES

CONNECTOR INSPECTION



THE NUMBER 1 CAUSE OF NETWORK FAILURE IS **BAD CONNECTORS**



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WHAT IS A FIBER INSPECTION SCOPE (FIP)?

DEFINITION

A FIP is a specialized microscope that:

- Takes a picture of the small connector end-face
- Locates and measures all defect and scratches found on the connector end-face
- Applies industry standard thresholds
- Gives a clear Pass/Fail status on the quality of the connector end-face

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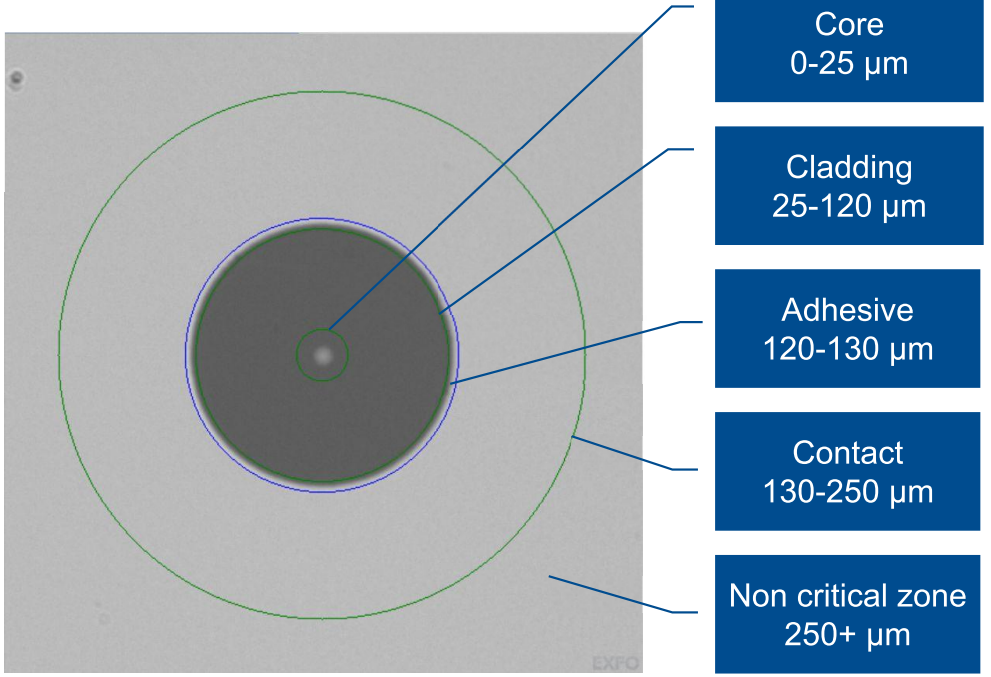
FIBER INSPECTION STANDARD

S ARE DIVIDED IN ZONES WITH DIFFERENT TOLERANCES

IEC 61300-3-35
Fiber-optic interconnecting devices and passive components—basic test and measurement procedures

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



Pass/Fail criteria example

INSPECT CLEAN – INSPECT CONNECT

CONNECTOR INSPECTION

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FIP-500

1

LC

CS SN MDC

2

MPO-8/12

3

MPO-16

SN-MT MMC

4

MPO-24

SN-MT MMC

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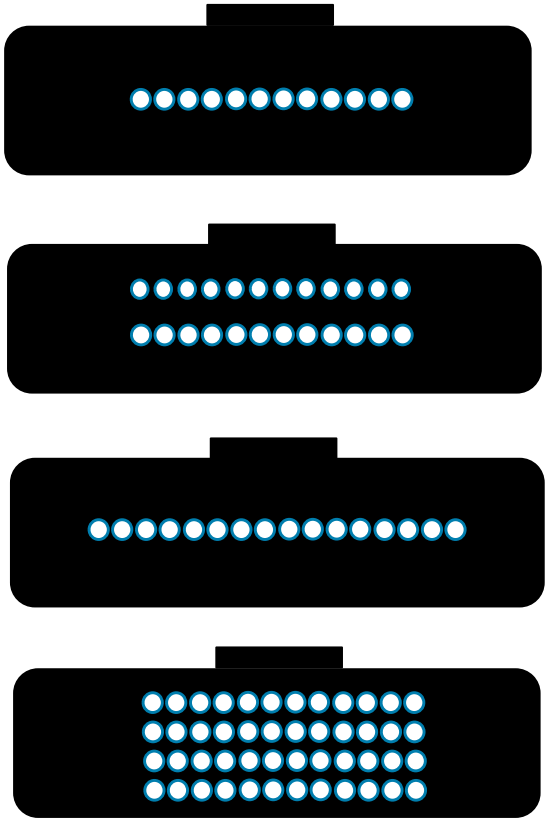
MPO CONNECTOR INSPECTION

Multiplies the occurrence of damaged or dirty fibers

Multiplies possibilities of a failing link/channel



CLEANING METHODS

DRY METHOD

- AN EFFICIENT TECHNIQUE FOR REMOVING LIGHT CONTAMINANTS
- OFTEN CONSIDERED THE TECHNIQUE OF CHOICE IN A CONTROLLED MANUFACTURING
- ENVIRONMENT WHERE SPEED AND EASE OF USE ARE IMPORTANT FACTORS

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

EXAMPLE OF DRY-CLEANING SUPPLIES:

- SPECIALIZED LINT FREE WIPES AND SWABS
- MECHANIC CLEANING DEVICES

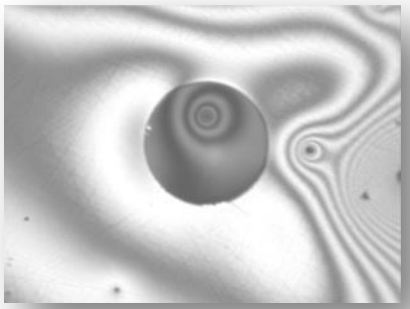


CLEANING METHODS

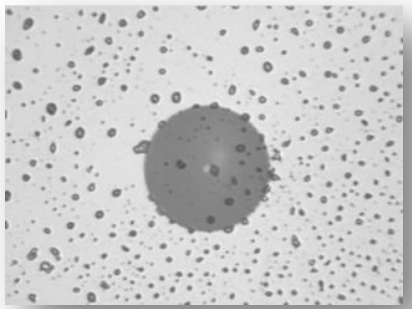
WET METHOD

- A COMMON MISTAKENLY USED METHOD BASED ON THE PROPERTIES OF THE SOLVENT
- MANY SPRAYS ARE AVAILABLE WITH DIFFERENT PROPERTIES (W/ ALCOHOL, W/O ALCOHOL, >70%, >95%, ETC…)

Advantages	Limitations
Fast and easy	Will false temporarily connector values as the solvent will act as an index matching gel
	If not dry, solvent will eventually evaporate but not completely. Leaving some impurities and the risk of gluing bigger debris.



After drying



CLEANING METHODS

COMBINATION METHOD (HYBRID)

- COMBINATION CLEANING IS A MIX OF THE WET AND DRY-CLEANING METHODS
- TWO STEP PROCESS: USE A SOLVENT AND DRY AFTER

Advantages	Limitations
Cleans most 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 procedure	
Not expensive	

EXAMPLE OF COMBINATION CLEANING SUPPLIES:

- SPECIALIZED WIPES AND SOLVENTS

OLTS = TIER 1

INDUSTRY COMPLIANCE

Ensures adherence to TIA, ISO, and IEC standards, which are critical for high-performance data center operations and securing manufacturers' warranty coverage.

PERFORMANCE VALIDATION

Verifies that polarity, insertion loss (IL) and optical return loss (ORL) meet required performance criteria.

SCALABILITY

Certifies links to support future data rates and technology upgrades.

TROUBLESHOOTING

Quickly detects installation issues (e.g., poor splices, dirty connectors), hence minimizing downtime.

TIER 1 TESTING

TIER 1 TESTING CERTIFICATION – OPTICAL LOSS TEST SET (OLTS)

- **Insertion Loss:** Using Light Source and Power Meter to measure the total light loss (attenuation) between two endpoints and determines pass/fail certification.
- **Length Measurement:** Verifies that the installed fiber length matches planned design or standards.
- **Polarity:** Verifies continuity between Tx and Rx. Essential for Multi-fiber connections and applications.

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WHY IS TIER-1 CERTIFICATION CHALLENGING?

CHALLENGES WE WANT TO SOLVE

TIME CONSUMING

Some solutions take several seconds to run a test, which becomes very cumbersome in diverse and high-density fiber environments.
Each second counts.

REFERENCING ERRORS

Referencing is one of the main causes of errors that result in bad measurements. Traditional two-cord referencing increases setup time, while being difficult to handle and not compliant with standards.

WRONG POLARITY TYPE

Determining polarity types across multiple fibers (duplex or base-8/12) is a challenge. Mismatches in polarity can disrupt light transmission and compromise network functionality.

CONNECTORS DIVERSITY

No solution available on the market to address multiple types of multi-fiber (8-12) and duplex fiber connector types (e.g., LC, SN, MDR and MPO).

CHALLENGES WE WANT TO SOLVE

TIME CONSUMING

Current solutions take several seconds to run a test, which becomes very cumbersome in diverse and high-density fiber environments.
Each second counts.

QTY	Fiber Count
4	6,912 Fibers

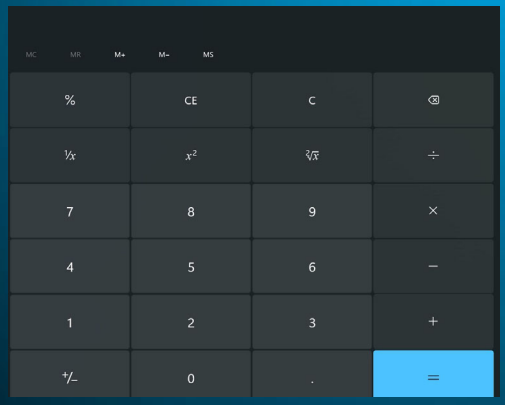
= 27,648 Fibers

MPO	Fiber Count
12F	27,648 Fibers

= 2,304 Connections

Each second counts!

Test time Per connection	Total Test Time
1s	38.4 min or 0.65 hours
4s	2.56 hours
6s	3.84 hours



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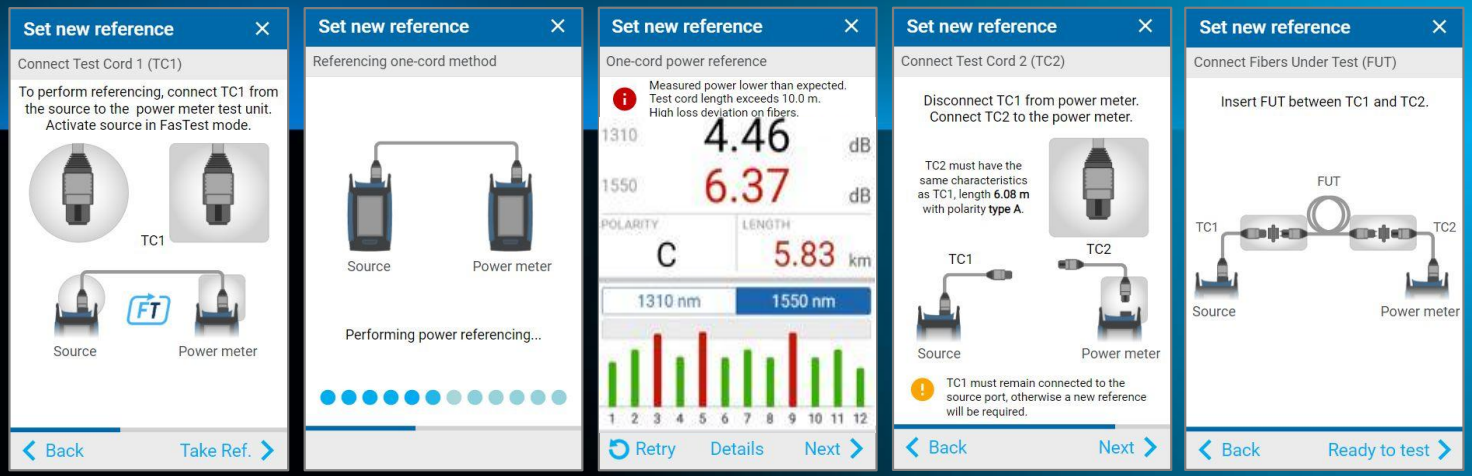
CHALLENGES WE WANT TO SOLVE

REFERENCING ERRORS

Referencing is one of the main causes of errors that result in bad measurements. Traditional two-cord referencing increases setup time, while being difficult to handle and not compliant with standards.

An onboard reference assistant will ensure the reference is done correctly.
A bad reference is the main cause of errors and incorrect measurements.



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CHALLENGES WE WANT TO SOLVE

One-CORD REFERENCING

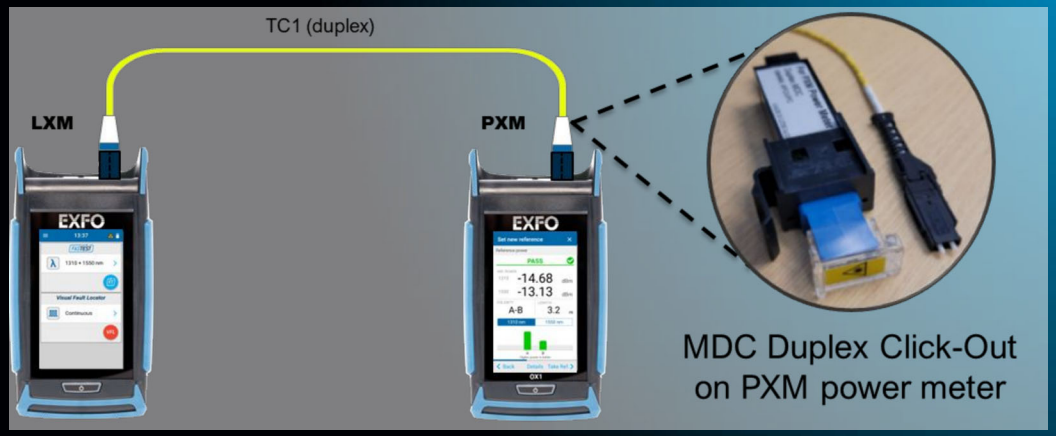
REFERENCING ERRORS

Referencing is one of the main causes of errors that result in bad measurements. Traditional two-cord referencing increases setup time, while being difficult to handle and not compliant with standards.

Perform one-cord referencing on:

- Duplex VSFF connectors (SN and MDC)
- Duplex LC uniboot test cords
- MPO pinned and unpinned connectors
- CommScope reversed polarity MTP

Compliant with standard recommendations



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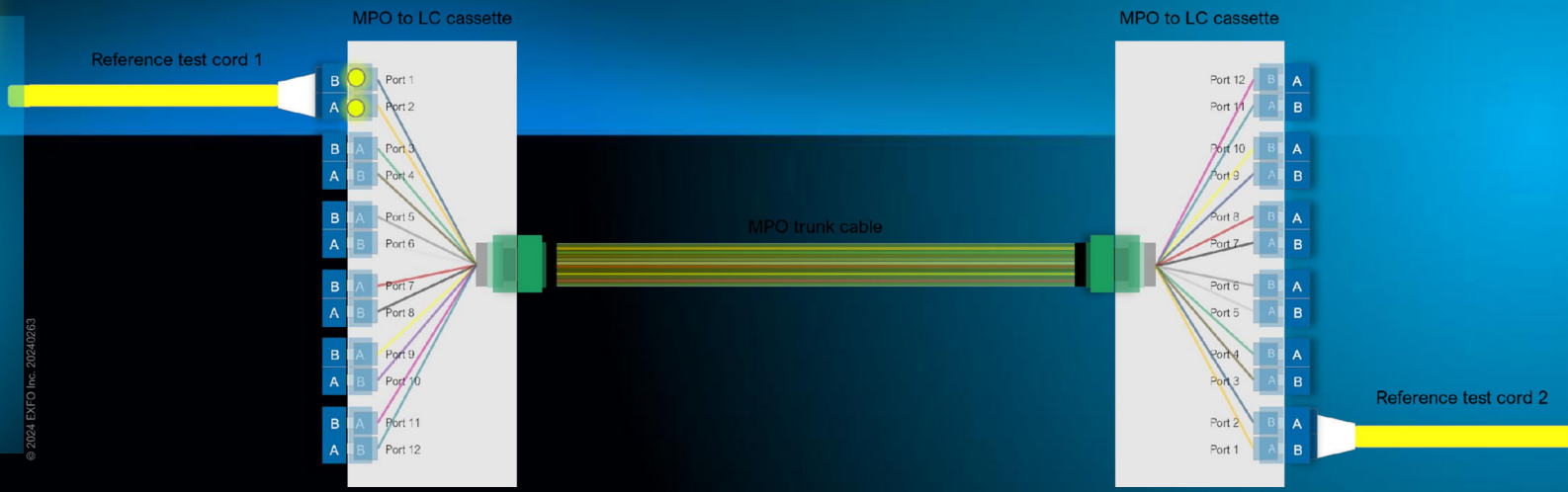
CHALLENGES WE WANT TO SOLVE

WRONG POLARITY TYPE

Determining polarity types across multiple fibers (duplex or base-8/12) is a challenge. Mismatches in polarity can disrupt light transmission and compromise network functionality.

Detect both duplex and base-8/12 polarity issues.



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TIER 1 TESTING

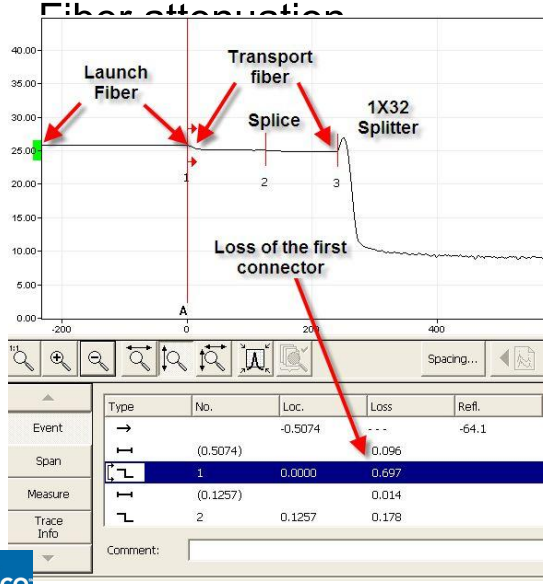
WHEN SELECTING AN OPTICAL LOSS TEST SET (OLTS) FOR TIER 1 DUPLEX AND MULTIFIBER TESTING IN A DATA CENTER, TWO KEY FACTORS SHOULD BE CONSIDERED:

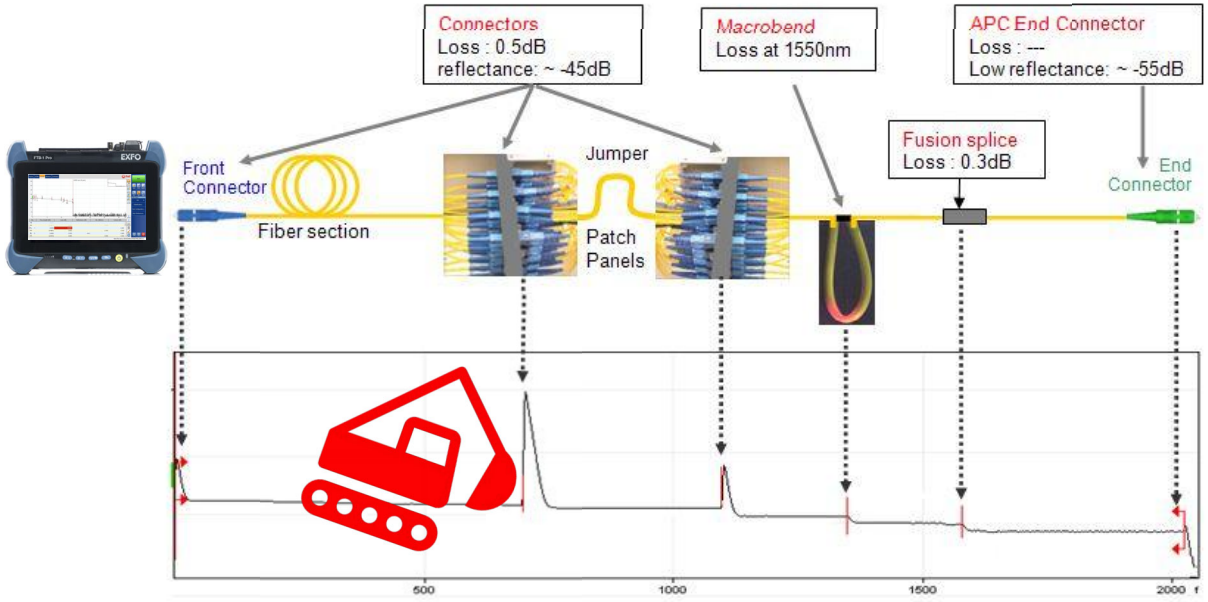
- Testing Speed and Efficiency: Look for an OLTS that offers fast and efficient testing capabilities, especially for multifiber links. In a high fiber count context, a fast instrument can save days and even weeks of testing in a single project.
- Connector Types: The OLTS should be compatible with the specific connectors used in your data center, such as LC, MPO/MTP and VSFF duplex and multifiber connectors.

OTDR/IOLM TIER 2 END-TO-END CERTIFICATION

WHAT DOES AN OTDR/IOLM DO?

- ✔ Break points
- ✔ Splice and connector losses
- ✔ Point-to-point distances
- ✔ Total cable length
- ✔ Connector quality (return loss)
- ✔ Fiber attenuation





When to use an OTDR/iOLM:

- ✔ Installation and commissioning
- ✔ Maintenance
- ✔ Emergency restoration
- ✔ Fiber identification
- ✔ Characterization

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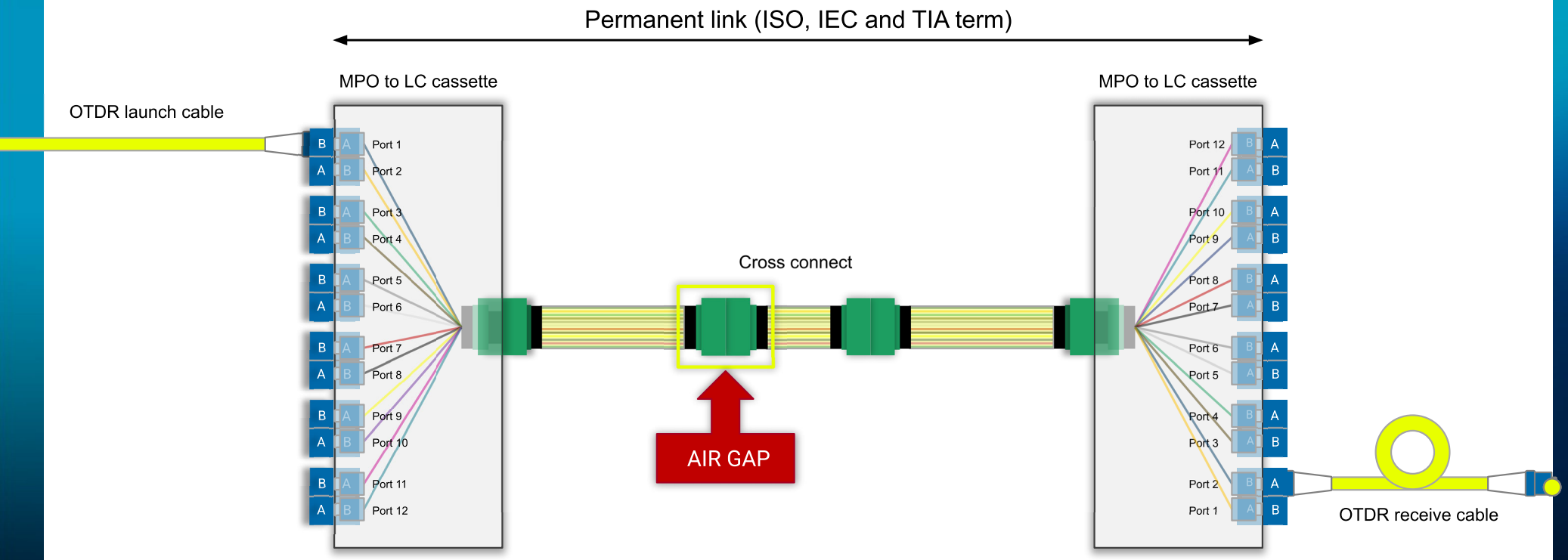
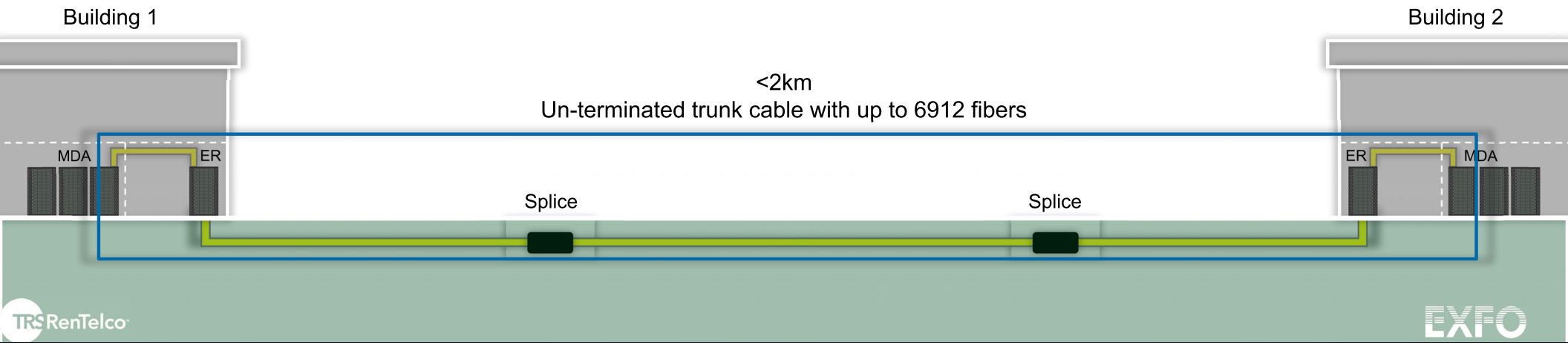
TROUBLESHOOTING USING AN OTDR



TRUNK CABLING EXTERNAL



TIER-2 LINK CERTIFICATION

TROUBLESHOOTING COMPLEX LINKS

TROUBLESHOOTING COMPLEX LINKS

TROUBLESHOOTING COMPLEX LINKS

FAULT RESOLUTION

BAD CONNECTION

GOOD CONNECTION

MEASURING LOSS WITH OTDR/iOLM

The uncertainty of IL measurements with OTDRs is dependent of the **methodology** as well as the **analysis**:

- Reflectometry vs. advanced reflectometry
- Using a launch fiber
- Using a launch and a receive fiber
- Uni-directional or bi-directional
- Central wavelength
- BAD SETTINGS = false measurements

MEASURING LOSS WITH OTDR/iOLM

LEGACY OTDRS

- OTDR's were designed to provide distance to the fault
- Traces used to be very noisy and slow
- Only knowledgeable user could use OTDRs:
  - Wrong settings = false measurement
  - Loss was measured manually using markers (not automated)

Tier 1 vs Tier 2

IDEAL FOR TIER 1 CERTIFICATION

STRENGTHS

- Automated IL + ORL + length
- Very fast
- Reference validation (EXFO)
- End-to-end loss measurement + polarity + continuity
- Bidirectional or unidirectional

WEAKNESSES

- Needs referencing
- Cannot pinpoint faults
- No distributed loss

IDEAL FOR CHARACTERIZATION AND TIER 2 CERTIFICATION

STRENGTHS

- No reference
- Accurate (end-to-end and events)
- Distributed loss measurement
- Mapping of event
- Full automation via iOLM
- End-to-end loss measurement + continuity using LF and RF
- Bidir or unidirectional

WEAKNESSES

- Test time longer than OLTS
- Not Tier 1
- Traditional OTDR complexity

CONCLUSION & KEY TAKEAWAYS

TAKE AWAYS

- A strong working relationship with your customer, vendor and contractor
- Have the right tools.
- Understand the features and functions of your test equipment.
- Quality vs Time
- Automated Job management and reporting

The TRS & EXFO Partnership

sales@trs-rentelco.com
800.874.7123

- *EXFO Rental Partner* with an expansive inventory and a full range of acquisition options:
  - Short and Long-Term, Full-Service Rentals (overnight exchanges available)
    - Minimize user downtime
  - Operating Leases
  - Sales of NEW equipment through distribution sales
  - 0% Financing for New and Certified Pre-Owned Equipment

Call us today for a free consultation to see how we can help!

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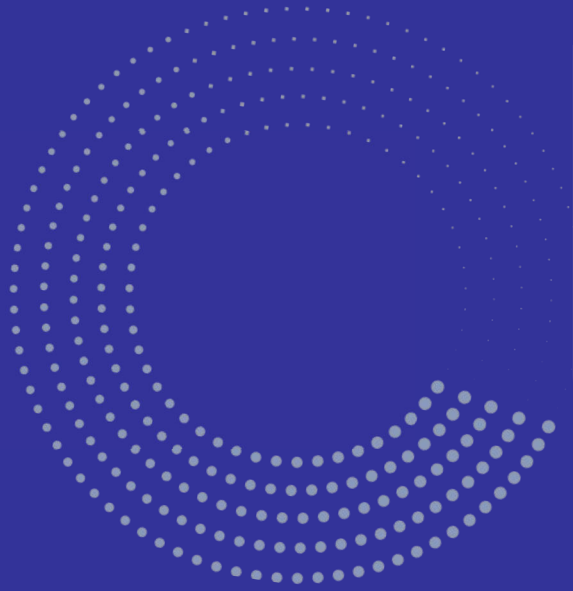
Questions?



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Thank you!