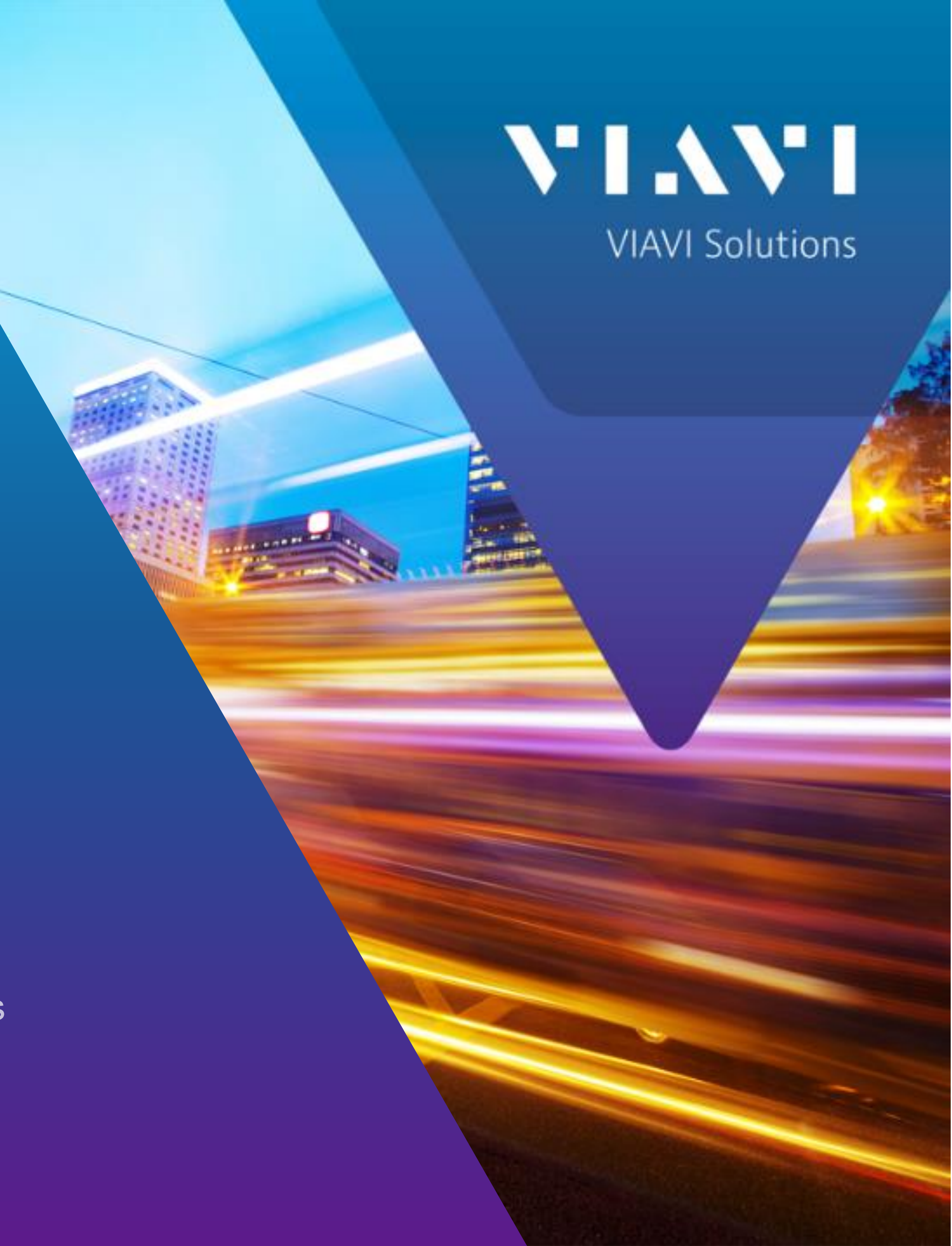



# RFOG/PON & WDM & Testing

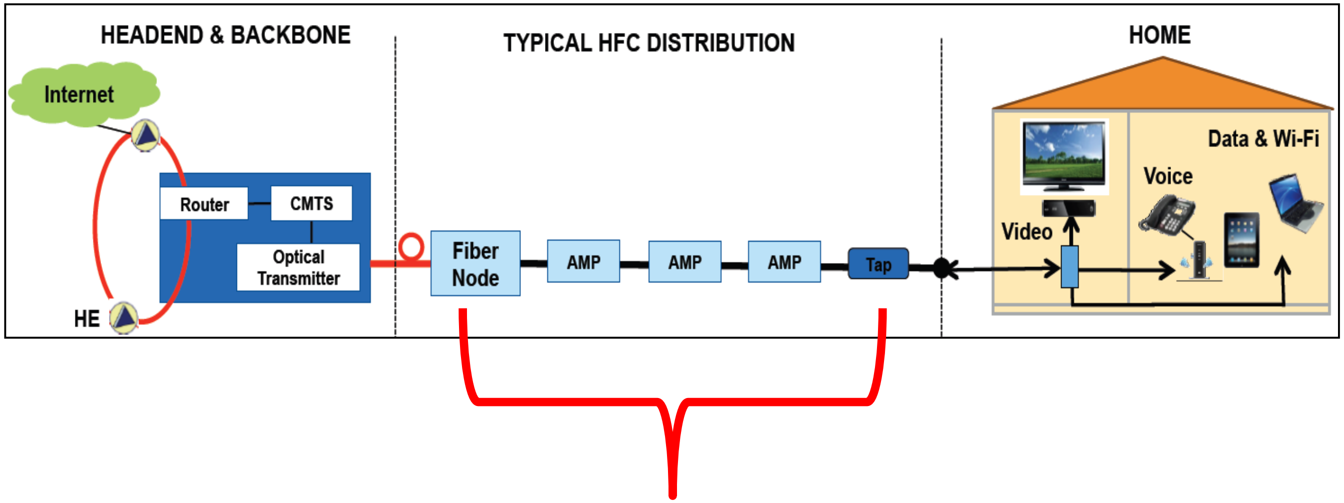
Mark Leupold
Business Development Manager-
Fiber & Metro Testing Solutions for MSOs

September 2019

# Agenda

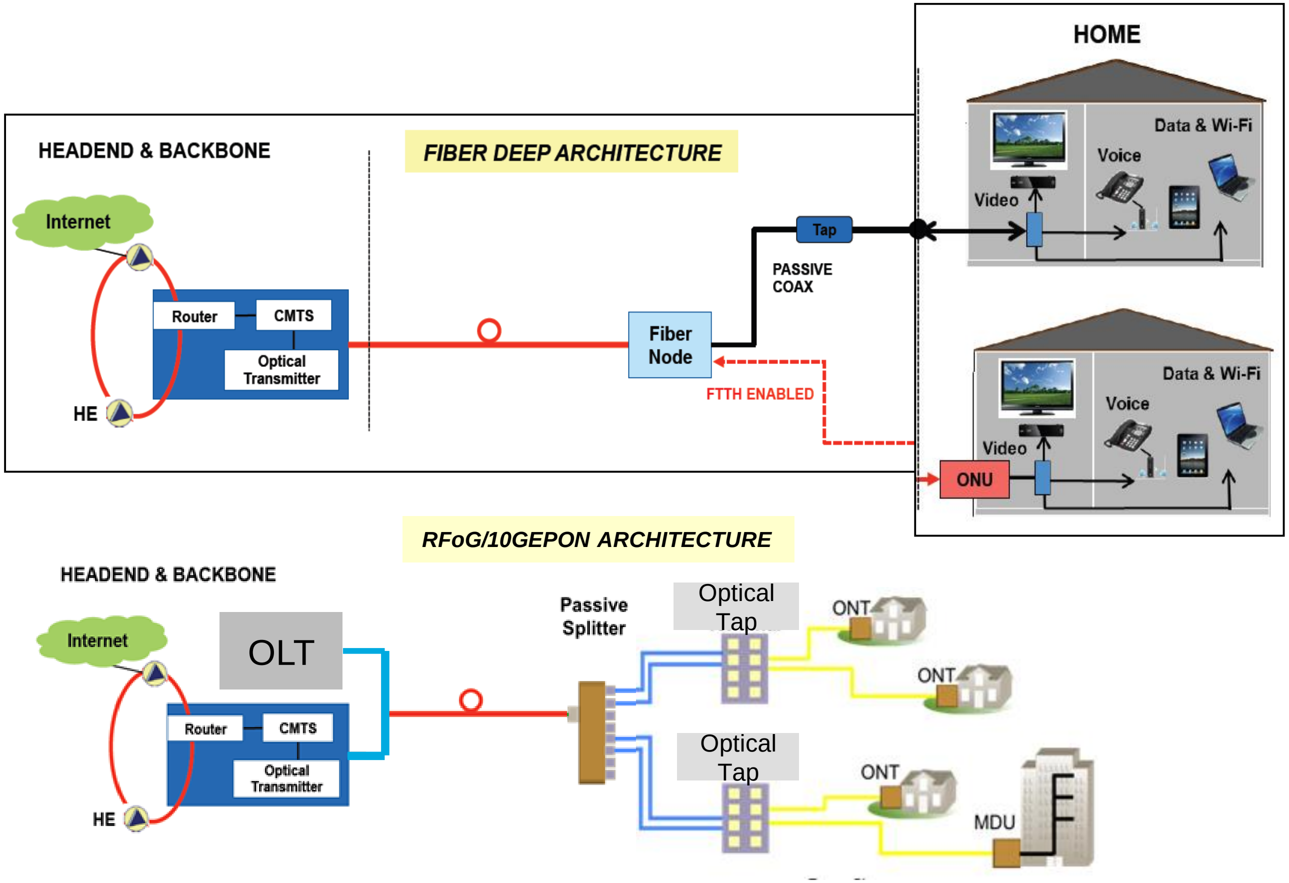
- Overview
  - RFOG/PON Networks
  - WDM networks
- Quick word on CD/PMD
- Fiber Testing
  - Optical Connector Inspection
  - Verifying wavelengths & Power Levels (Power Meters)
  - OTDR Testing
- Live Demo

# MSOs Access Network Topology Changes  From…




The "last mile"
(and shrinking)
is coax

# …And Transforms into…

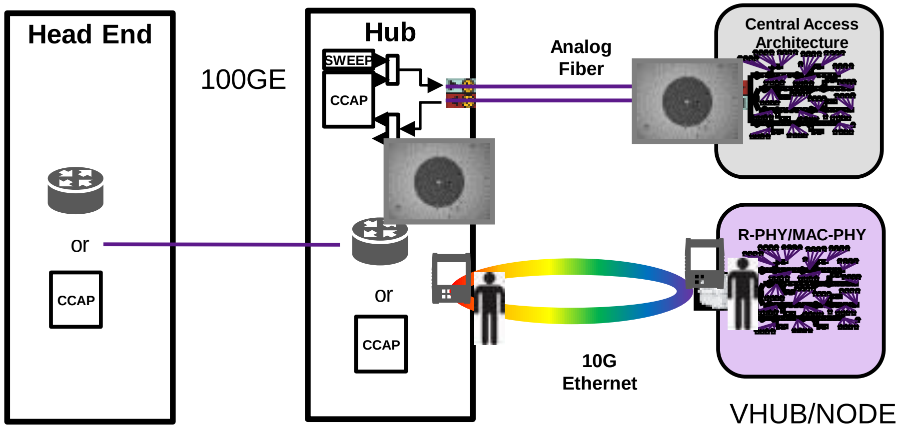


# Where are Things Headed?

## Distributed Access Architectures (DAA) & Remote PHY (R-PHY)

### Technology Shift

- DAA goes hand-in-hand with Fiber Deep
- HE to node changes from analog RF to 10G Ethernet
- Moves some HE functions to the node
- New node hardware (RPD) adds dynamic bandwidth allocation
- ***Ethernet over DWDM***




### What to Test?

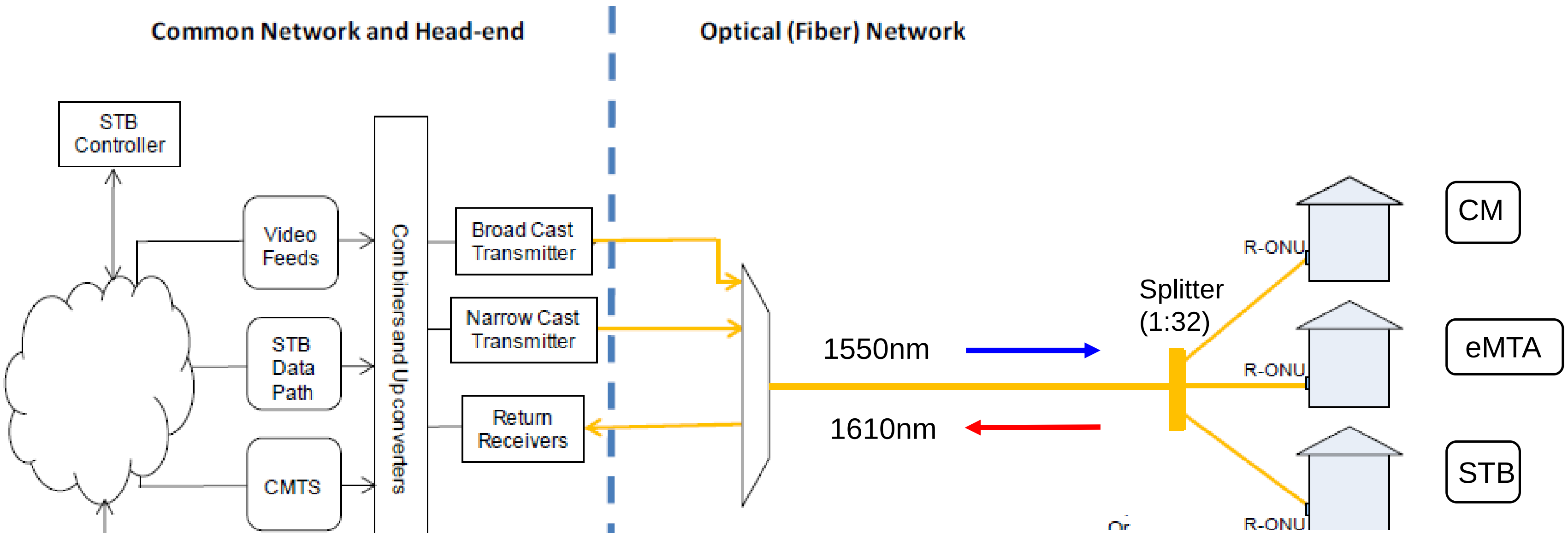
- Verify connector condition/cleanliness
- Fiber Characterization
  - IL,ORL & OTDR (Bi-directional)
  - Dispersion (CD/PMD)
- DWDM
- Pluggable optics (SFP+, QSFP28, AOC/DAC cables)
- Ethernet tests
  - RFC-2544, Y-1654


### Where to test?

- At Head End, Hub or Optical Node

# RFOG & PON

# RF over Glass (RFOG)- Transitioning to an "all fiber" plant





**Where?**
- Green Fields
- Competitive (MDU contracts)
- Rural settings

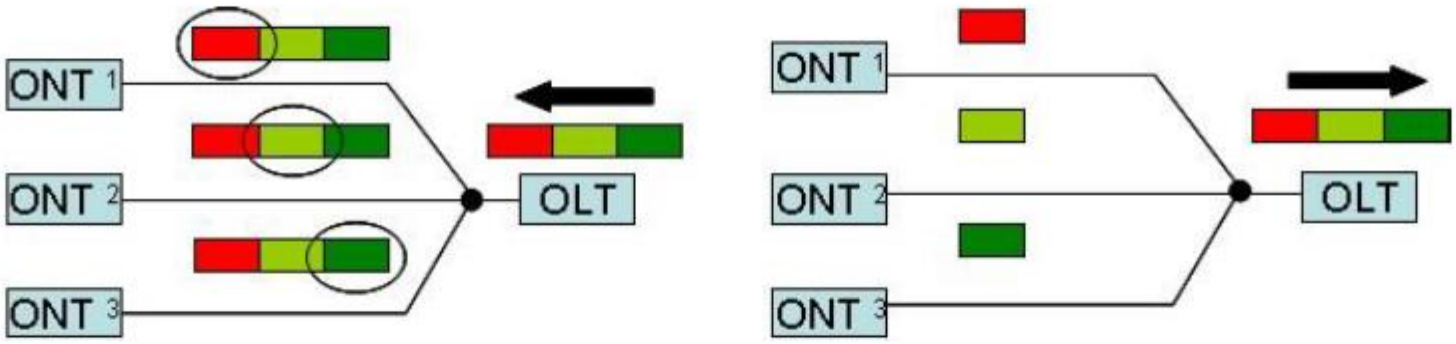
**When?- NOW**

**Why?**
- Minimal investment
  - Same HE & CPE equipment
  - Same OSS/BSS
- Easily deployable
- Easy transition to PON

**What?**
- Exact same speed/services as traditional Coax but **<u>on fiber</u>**
- Hand Fiber to customer
- Lower maintenance cost/ less noise

**How?**
- 1550nm down
- 1610nm up
- Add RFOG CPE device (R-ONU)
- Add splitter(s) (1:32 splitter)

# Passive Optical Network (PON) Network Architecture

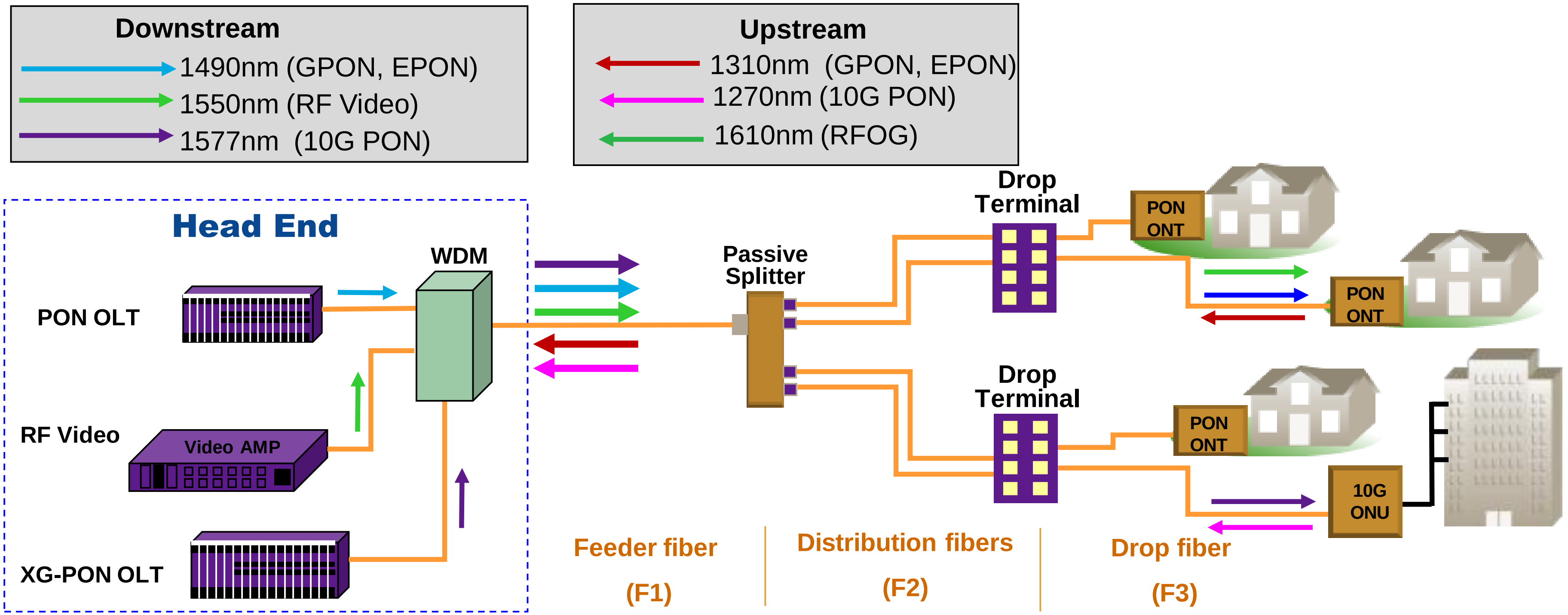


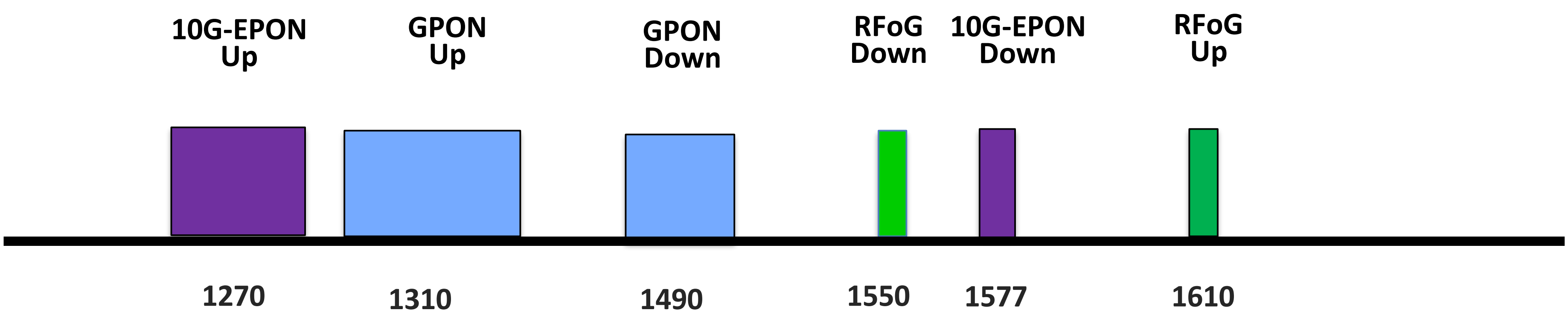

- Distributed system architecture (pt to multi-pt)
- Uses Time Division Multiplexing (TDM)
- Downstream data is transmitted to all ONTs
- Data is filtered based on port ID
- The OLT controls the upstream channel by assigning a different time slot to each ONT

OLT- Optical Line Termination
ONU- Optical Network Unit
ONT- Optical Network Terminal
BPON- Broadband PON
EPON- Ethernet PON
GPON- Gigabit PON
XG-PON- 10GigE PON

| | | Down (Gb/s) | Up (Gb/s) |
|---|---|---|---|
| FSAN (ITU-T) | GPON | 2.5 | 1.25 |
| | XG-PON1 | 10 | 2.5 |
| IEEE | EPON | 1.25 | 1.25 |
| | 10G-EPON | 10 | 1 or 10 |

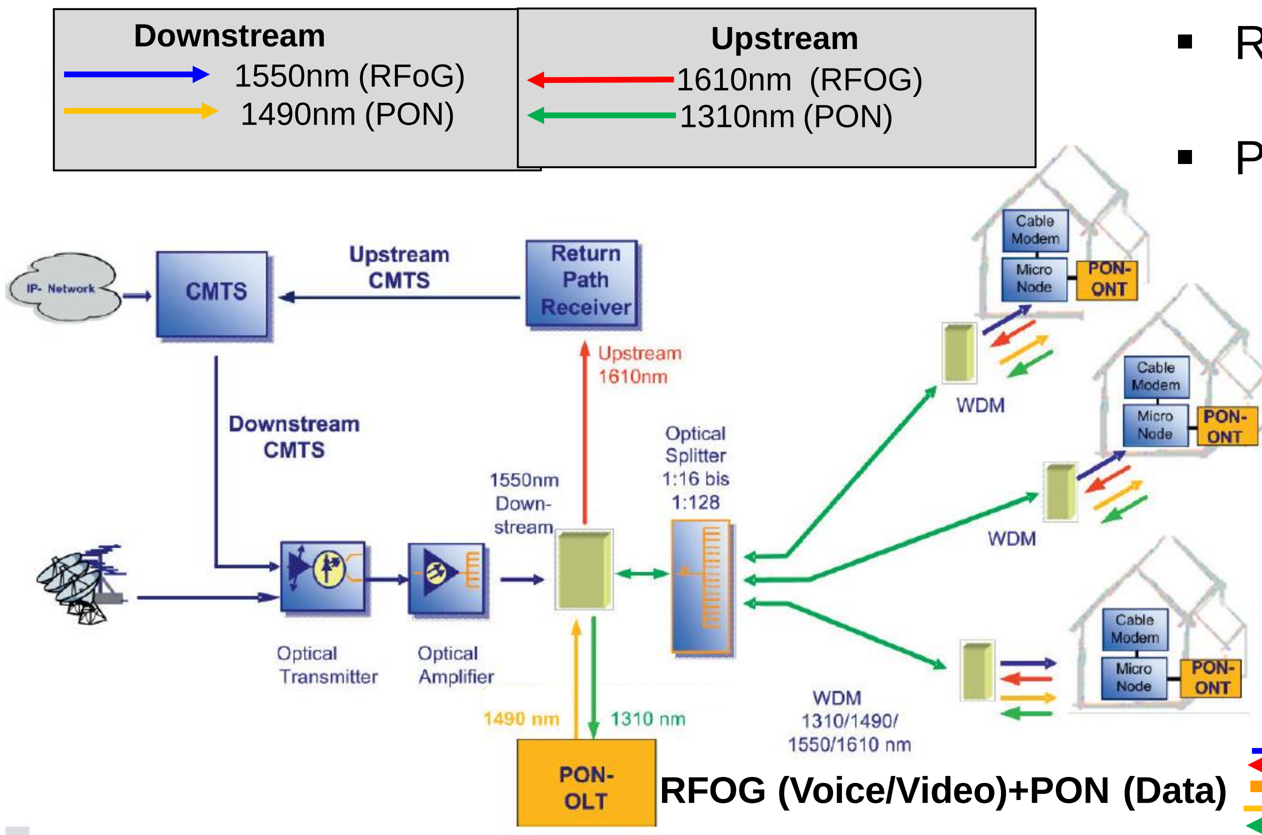
# FTTx/PON Networks



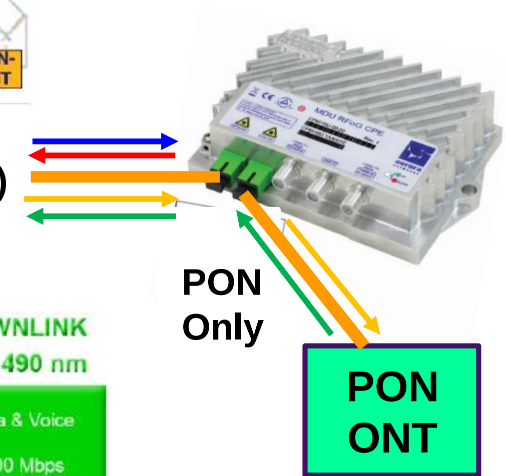




Source: FTTH EMEA D&O Committee FTTH Poland 2015

# Combos: RFoG with PON (RF-PON) Topology

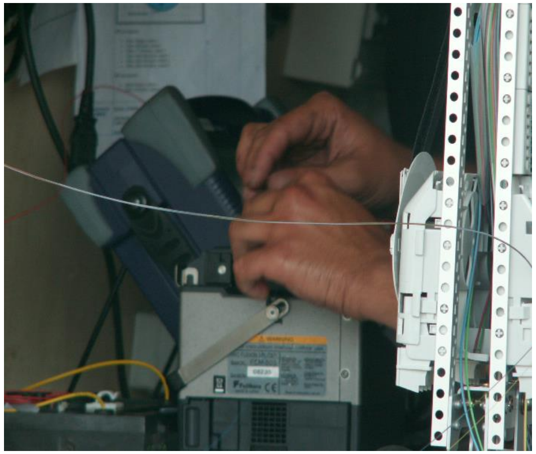



- RFOG
  - for voice/video
- PON
  - for customers demanding higher speed &/or symmetrical data speeds beyond what RFOG can offer




Some Vendors have OLT module for "RFOG Repeater"

# Distribution Installation Optimization
# Connectorized versus spliced network



- Connectorized network
  - Lower cost, fewer technicians to deploy
  - Easy testing with many test access points
  - Easier to maintain and evolve
- Spliced network
  - Lower losses
  - More rugged (connector is the #1 issue on FTTH)
  - More secure
  - More difficult to test with fewer test access points

➔**Both methods are valid and are used worldwide**

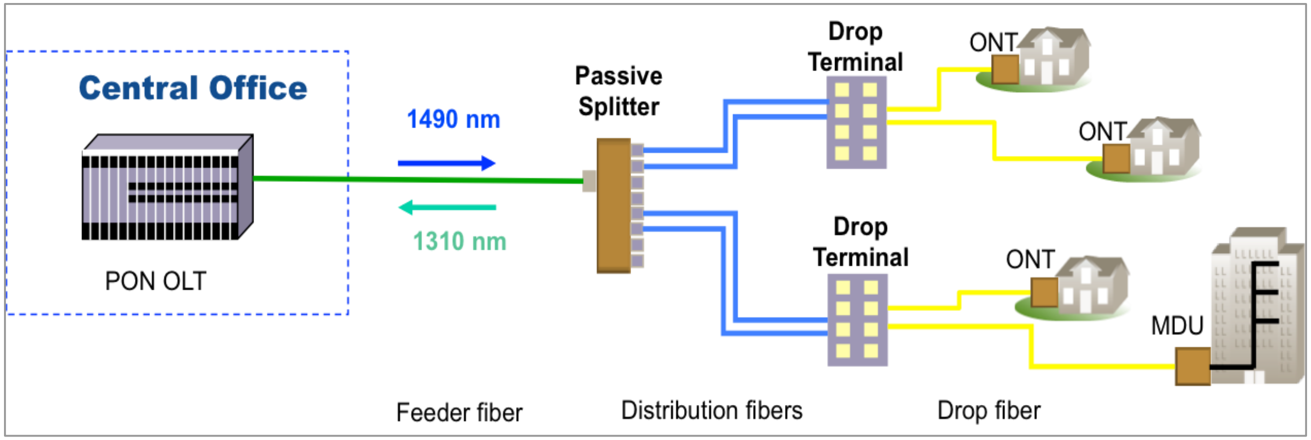
| Spliced Approach | | Hardened Drop Connector Approach | |
|---|---|---|---|
| Hand-Hole Costs | $ 10,000.00 | Hand-Hole Costs | $ 11,194.00 |
| Cable Costs | $ 15,000.00 | Cable Costs | $ 1,538.00 |
| Cable Placing Costs | $ 75,000.00 | Cable Placing Costs | $ 56,650.00 |
| Splicing Costs | $ 9,072.00 | Splicing Costs | $ 2,988.00 |
| Terminal Costs | $ 0.00 | Terminal Costs | $ 16,072.00 |
| **Total Costs** | **$109,072.00** | **Total Costs** | **$ 88,442.00** |
| **Cost/ Home Passed** | **$ 568.08** | **Cost/ Home Passed** | **$ 460.63** |

Specific cost model based on a phased project for a 192 home subdivision, featuring eight homes per block.

# FTTH Network Schematic

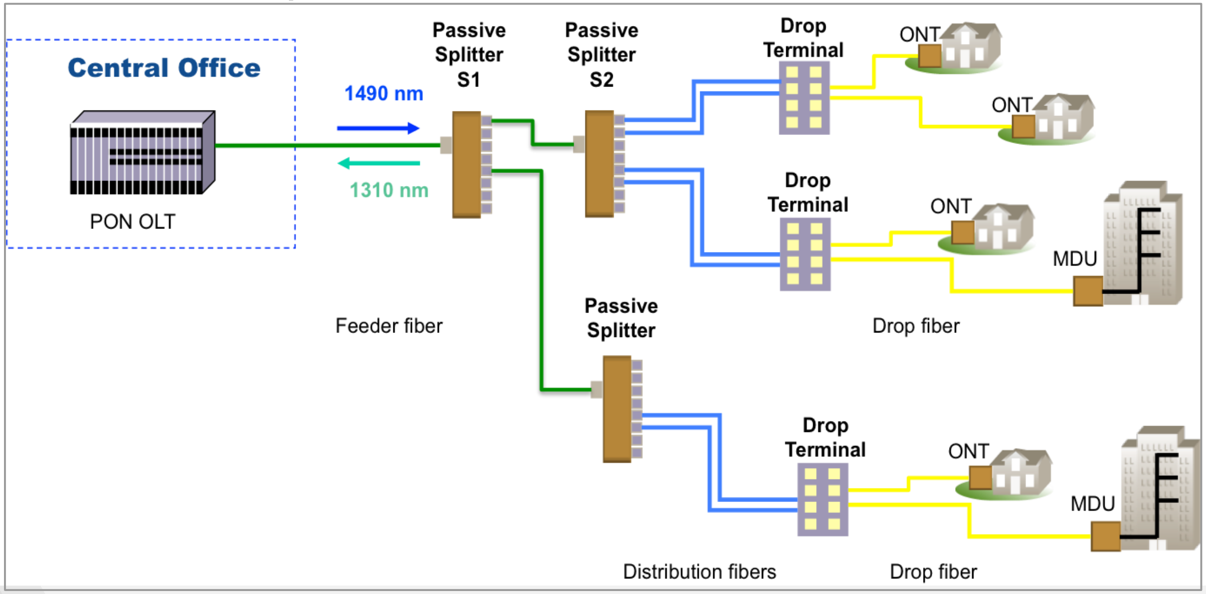
## Single Split

+ 1550nm if Video overlay




## Cascaded Split

+ 1550nm if Video overlay



# FTTH/PON Network Elements

Optical Line Terminal (OLT)


Optical Splitter


Fiber Distribution Hub (FDH)

**10G-EPON ONLY**: Direct connection from network
**RFoG + 10G-EPON**: Jumper from RFoG ONU (SC/UPC)


Optical Network Terminal (ONT) / Optical Network Unit (ONU)

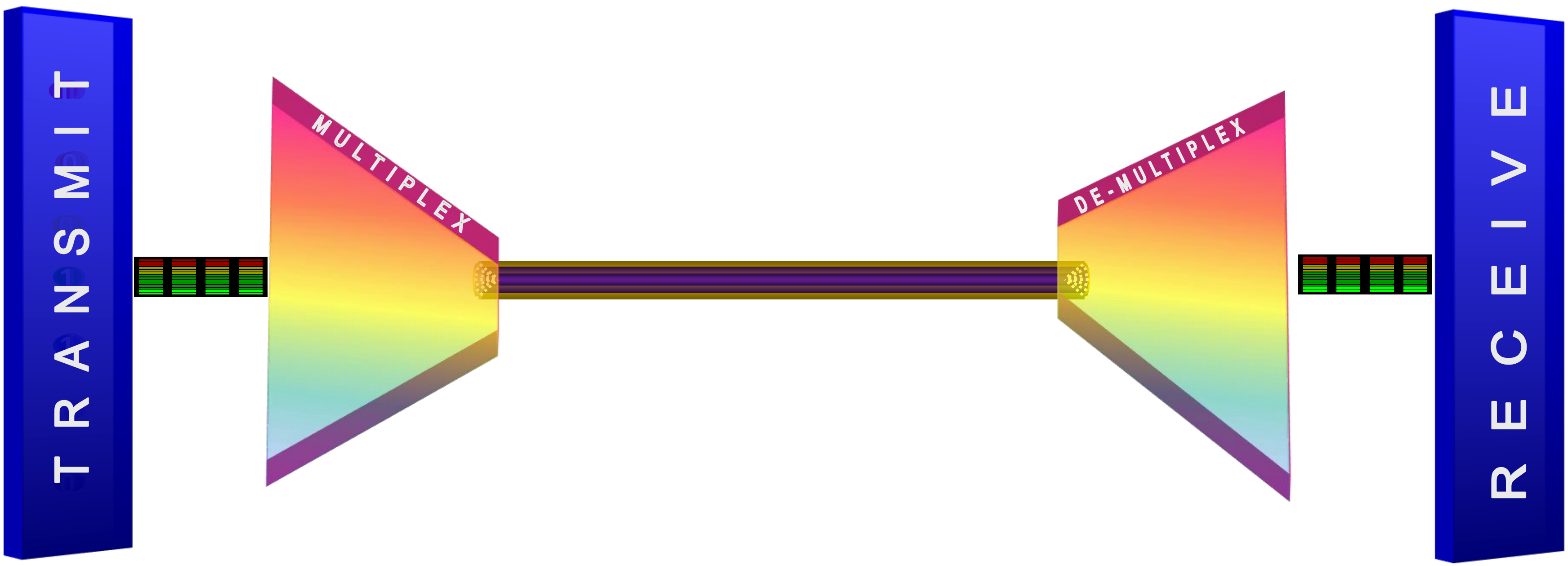

**Optical Input** is the fiber coming from MSO network which has RFOG+ 10GPON (1550/1577 nm) signals present

**PON Pass Thru** is for the fiber jumper to the PON ONT (1577 nm only)

# WDM Background, Components and Architectures

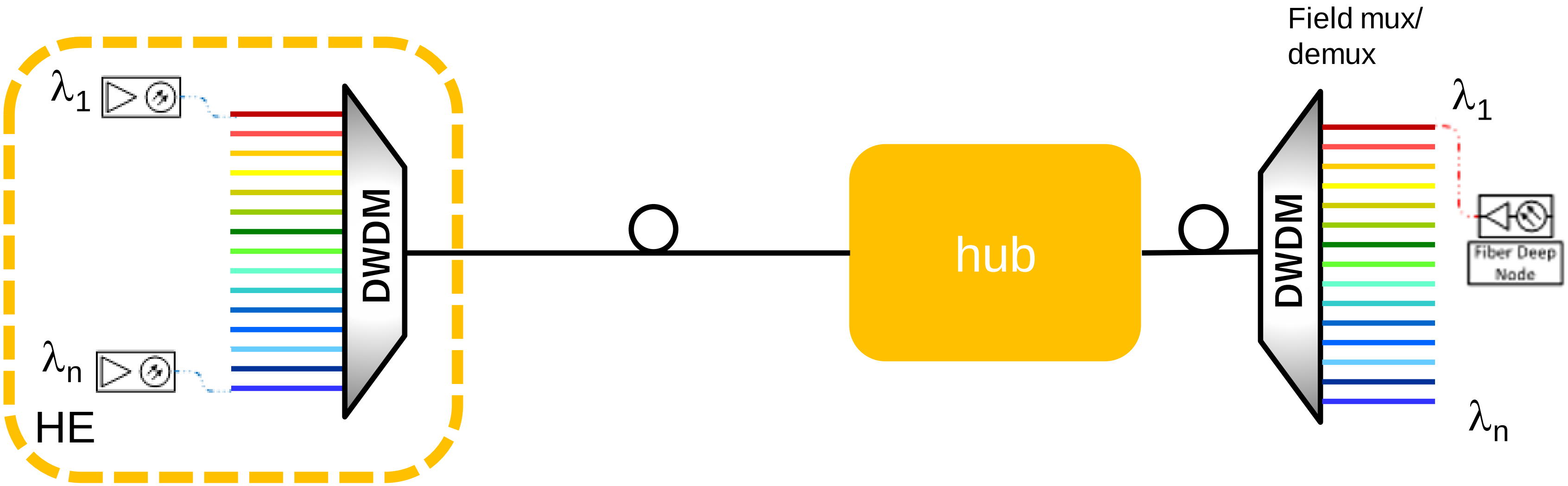
# Wave Division Multiplexing

**Wave Division Multiplexing or WDM combines <u>multiple optical signals</u>, at very high speeds, <u>onto one fiber</u>, significantly increasing bandwidth – without installing new fiber.**

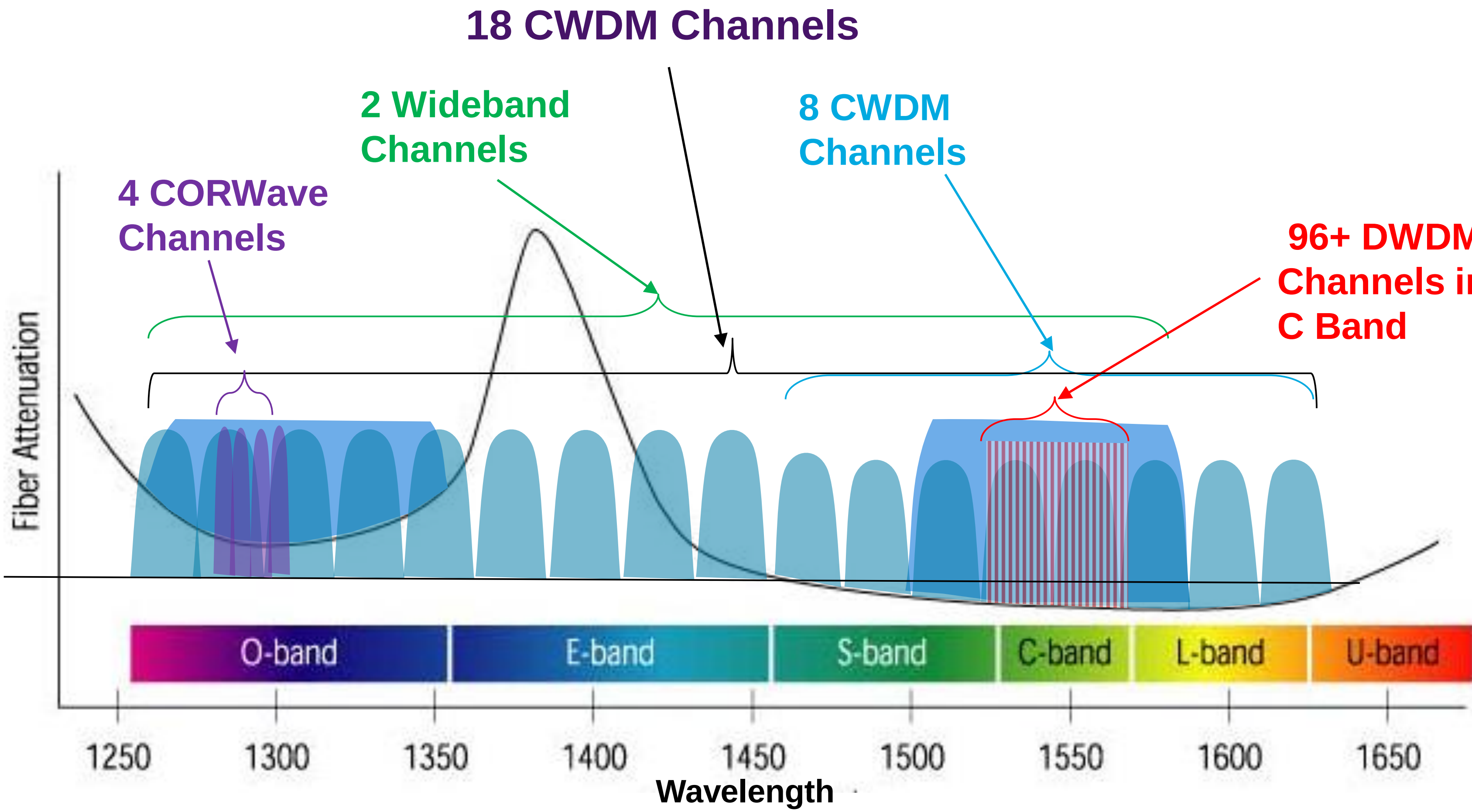


# Why Fiber/WDM?

- MSOs need more bandwidth per end user
- Node splits required, closer to end user
- Fiber being deployed deeper to support this
- Adding more $\lambda$s fully utilizes the potential of fiber
- *Expand the capacity of the network* ***without*** *laying more fiber!*
- Capacity of a given link can be expanded simply by upgrading the components at each end



# WDM Wavelength Allocation



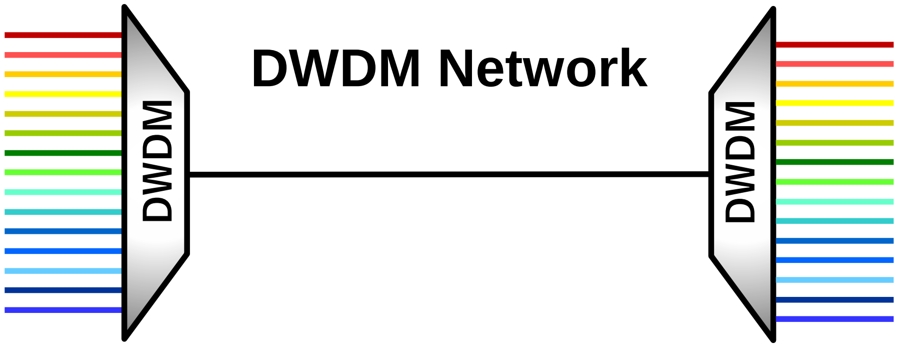

- **Wideband WDM** channels spaced ~100 nm apart
- **CWDM** channels are spaced 20 nm apart
- **DWDM** channels are spaced ~0.4 to 0.8 nm apart (50GHz vs 100GHz spacing)
  - much higher density, therefore a better usage of the fiber
- **CORWave** channels are spaced 1 to 2 nm apart

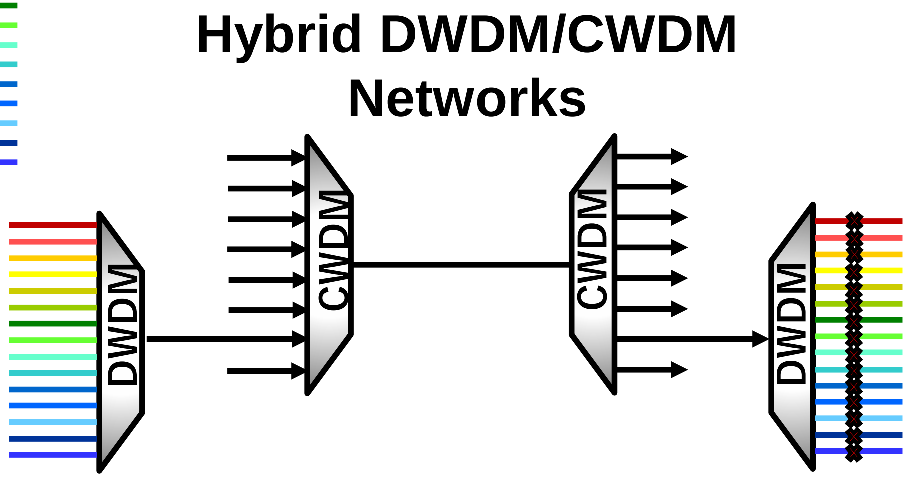
# WDM Standards

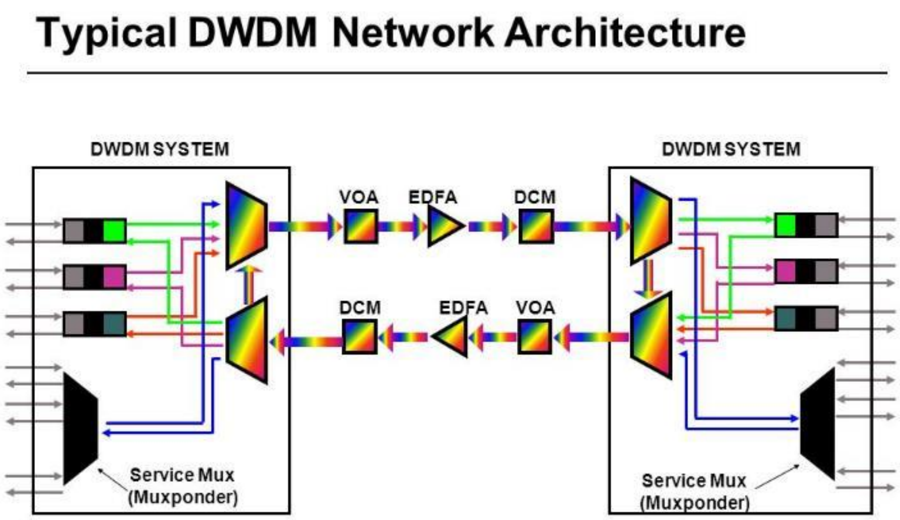
| Type | Standard | Wavelengths | Max reach | Max data rate | Channel Spacing |
|---|---|---|---|---|---|
| Normal | --------- | 1310nm, 1550nm | | | 200+ nm |
| **CWDM** Coarse Wave Division Multiplexing | ITU-T G.694.2 (2002) | 1271-1611 nm | ~60km (spacing to wide for EDFAs) | 2.5 Gb/s | 20 nm (18 channels) |
| **DWDM** Dense Wave Division Multiplexing | ITU-T G.694.1 (2002) | C-Band (1530 -1565 nm)<br><br>L-band (1565 – 1625 nm) | ~100 km (between amplifiers) | 100+ Gb/s | 100 GHz (~0.8nm, typical 40 CH)<br>50 GHz (~0.5nm, typical 80 CH)<br>12.5 GHz (ultra dense) |
| **CORWave** (Arris) | -------- | 1290, 1291, 1293, 1295 nm | | | 1 – 2 nm |

WDM, DWDM and CWDM are based on the same concept of using multiple wavelengths of light on a single fiber, but <u>differ in the spacing of the wavelengths, number of channels, and the ability to amplify</u> the multiplexed signals in the optical space.

# WDM Architectures



# Dense Wavelength Division Multiplexing (DWDM)

*ITU Grid: C-Band, 100 GHz Spacing*

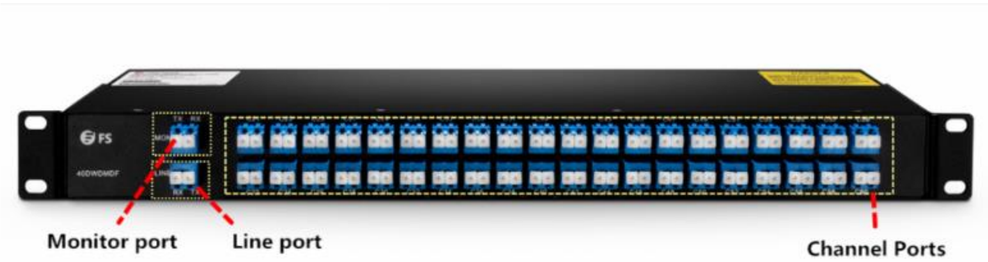
| Channel (#) | Frequency (GHz) | Wavelength (nm) |
|---|---|---|
| 1 | 190100 | 1577.03 |
| 2 | 190200 | 1576.2 |
| 3 | 190300 | 1575.37 |
| 4 | 190400 | 1574.54 |
| 5 | 190500 | 1573.71 |
| 6 | 190600 | 1572.89 |
| 7 | 190700 | 1572.06 |
| 8 | 190800 | 1571.24 |
| 9 | 190900 | 1570.42 |
| 10 | 191000 | 1569.59 |
| 11 | 191100 | 1568.11 |
| 12 | 191200 | 1567.95 |
| 13 | 191300 | 1567.13 |
| 14 | 191400 | 1566.31 |
| 15 | 191500 | 1565.5 |
| 16 | 191600 | 1564.68 |
| 17 | 191700 | 1563.86 |
| 18 | 191800 | 1563.05 |
| 19 | 191900 | 1562.23 |
| 20 | 192000 | 1561.42 |
| 21 | 192100 | 1560.61 |
| 22 | 192200 | 1559.79 |
| 23 | 192300 | 1558.98 |
| 24 | 192400 | 1558.17 |
| 25 | 192500 | 1557.36 |
| 26 | 192600 | 1556.56 |
| 27 | 192700 | 1555.75 |
| 28 | 192800 | 1554.94 |
| 29 | 192900 | 1554.13 |
| 30 | 193000 | 1553.33 |
| 31 | 193100 | 1552.52 |
| 32 | 193200 | 1551.72 |
| 33 | 193300 | 1550.92 |
| 34 | 193400 | 1550.12 |
| 35 | 193500 | 1549.32 |
| 36 | 193600 | 1548.52 |

| Channel (#) | Frequency (GHz) | Wavelength (nm) |
|---|---|---|
| 37 | 193700 | 1547.72 |
| 38 | 193800 | 1546.92 |
| 39 | 193900 | 1546.12 |
| 40 | 194000 | 1545.32 |
| 41 | 194100 | 1544.53 |
| 42 | 194200 | 1543.73 |
| 43 | 194300 | 1542.94 |
| 44 | 194400 | 1542.14 |
| 45 | 194500 | 1541.35 |
| 46 | 194600 | 1540.56 |
| 47 | 194700 | 1539.77 |
| 48 | 194800 | 1538.98 |
| 49 | 194900 | 1538.19 |
| 50 | 195000 | 1537.4 |
| 51 | 195100 | 1536.61 |
| 52 | 195200 | 1535.82 |
| 53 | 195300 | 1535.04 |
| 54 | 195400 | 1534.25 |
| 55 | 195500 | 1533.47 |
| 56 | 195600 | 1532.68 |
| 57 | 195700 | 1531.9 |
| 58 | 195800 | 1531.12 |
| 59 | 195900 | 1530.33 |
| 60 | 196000 | 1529.55 |
| 61 | 196100 | 1528.77 |
| 62 | 196200 | 1527.99 |
| 63 | 196300 | 1527.22 |
| 64 | 196400 | 1526.44 |
| 65 | 196500 | 1525.66 |
| 66 | 196600 | 1524.89 |
| 67 | 196700 | 1524.11 |
| 68 | 196800 | 1523.34 |
| 69 | 196900 | 1522.56 |
| 70 | 197000 | 1521.79 |
| 71 | 197100 | 1521.02 |
| 72 | 197200 | 1520.25 |

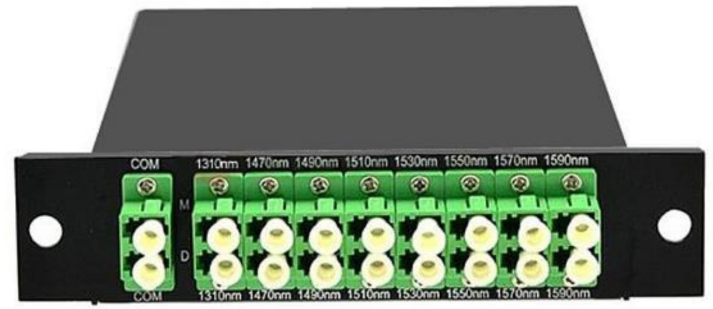
# WDM Components

- **WDM terminal multiplexer “MUX” (ISP)**
  - Contains wavelength-converting transponder for each data signal and an optical multiplexer
  - Combines individual signals together into a multi-wavelength optical signal
  - May or may not include an EDFA (DWDM)
- **Intermediate line repeater (DWDM) (OSP)**
  - Approximately every 80–100 km to compensate for the loss of optical power
  - EDFA - amplify any optical signal in their operating range, regardless of bit rate
- **Optical add-drop multiplexer “OADM” (OSP)**
  - Provides ability to remove (or add) specific wavelengths while passing others along
- **WDM terminal demultiplexer “DEMUX” (OSP)**
  - Separates multi-wavelength optical signals and outputs them on separate fibers
  - Originally entirely passively
- **Optical Supervisory Channel (OSC)**
  - Usually outside EDFA amplification band (1510 nm, 1620 nm, 1310 nm, proprietary wavelength)
  - Carries information about the multi-wavelength optical signal
  - Also used for remote software upgrades and Network Management information

# WDM Network Elements








Optical Mux / Demux

EDFA

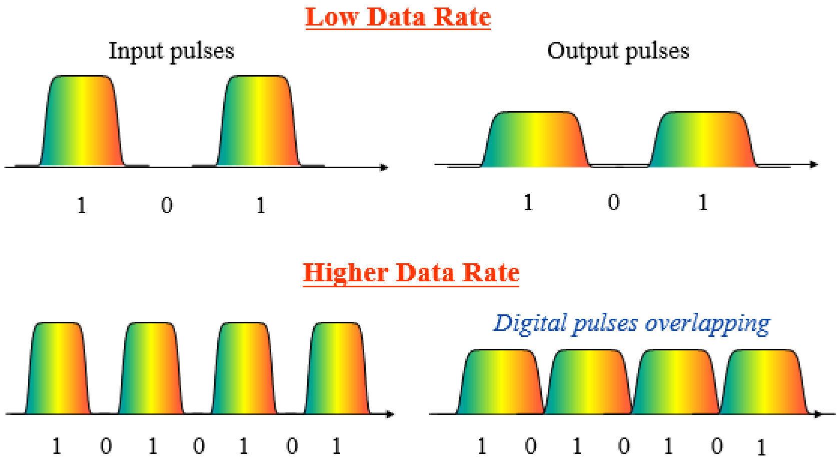


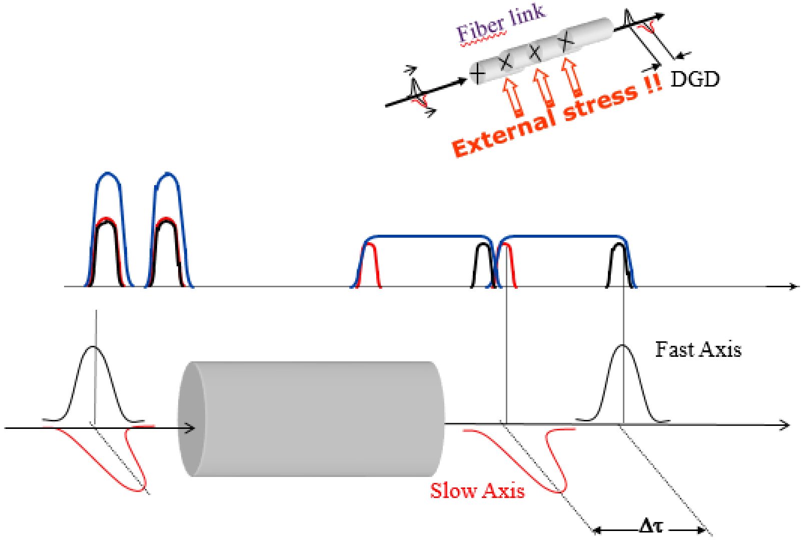
Fiber Distribution Hub (FDH)

# CD & PMD

# Dispersion Testing

**Ensuring the fiber is ready for higher speeds (10G+)**




Both CD & PMD can become an issue as you move to Higher Data Rates (10G+)

## Chromatic Dispersion (CD)

- Different wavelengths (colors) travel at different speeds down the fiber causing the pulse to spread out as it travels down the fiber
- 1x measurement (doesn't change)
- Use Dispersion Compensation (DC) modules

## Polarization Mode Dispersion (PMD)

- Different polarization modes travel at different velocities causing a Differential Group Delay (DGD)- end result is the pulse broadens
- PMD varies with λ, time, T°, movement
- May have to switch to another fiber
- 10G is more susceptible than 100G coherent

# Dispersion Testing Parameters

Fiber Characterization is simply the process of testing optical fibers to ensure that they are *suitable for the* ***type of transmission*** *(ie, WDM, SONET, Ethernet)* for which they will be used.

| Transport Type | Transport Speed | PMD Max | CD Max |
|---|---|---|---|
| **SONET** | OC-192/STS-64 | 10 picoseconds | 1176 ps/nm |
| **Ethernet** | **10 Gb/s** | **5 picoseconds** | **738 ps/nm** |
| **SONET** | OC-768/STS-256 | 2.5 picoseconds | 64 ps/nm |
| **Ethernet**<br>**Non coherent detection** | **100Gb/s**<br>**(4x25 Gb/s)** | **1 picoseconds** | **500 ps/nm** |
| **Ethernet**<br>**Coherent detection** | **100Gb/s** | **25 picoseconds** | **30000 ps/nm** |

# Fiber Characterization- Dispersion (CD/PMD/AP)

## Optical Dispersion Module (ODM)

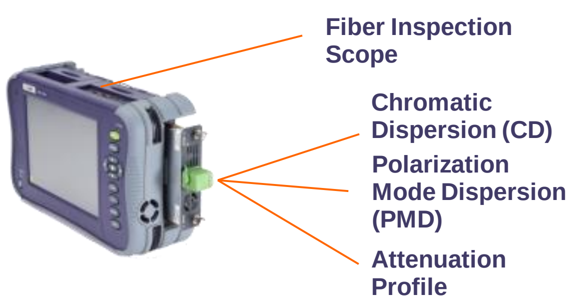
- CD
- PMD
- AP


## Broadband Source (BBS)

Far-end source functions

- ***PMD***
- ***Chromatic Dispersion***
- ***Attenuation Profile***

## Automation Script

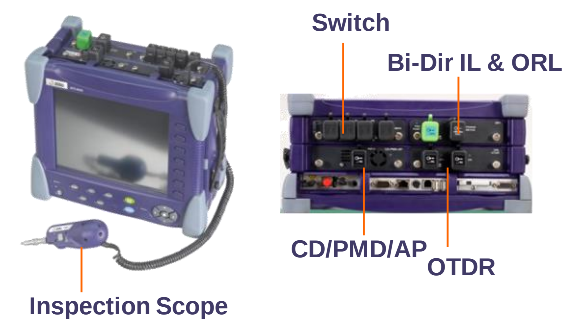

T-BERD 6000A Kits
(CD/PMD/AP)

## T-BERD 6000A

Lightest, smallest and fastest dispersion analyzer on the market

## T-BERD 8000

The only FULLY AUTOMATED link characterization solution on the market




T-BERD 8000 Kits
(CD/PMD/AP + IL/ORL + OTDR)

# Testing & Troubleshooting

Mark Leupold
Progarm Manager- Fiber & Ethernet Testing for MSOs

November 2018

# Agenda

- **Fiber Inspection**
  - Verify it's a clean network
- **Power Meters**
  - Verify Wavelength(s) and Power Levels
  - Traditional vs OCCs vs OSAs
- **OTDRs**
  - Verifying network & Locating Problems
- **Centralized Fiber Testing Solution**
  - 24/7 Monitoring

# CATV/MSO Fiber Tools Portfolio

- CWDM, DWDM, Fiber Deep, DAA
- FTTH, PON, EPON, RFoG
- Commercial/Business Services

## Fiber Inspection

**P5000i**
USB Fiber Inspection Probe

**FiberChek**
Fiber Inspection Probe

## VFL & Fiber ID

**FI-60**
Live Fiber Identifier

**FFL-050/-100**
Visual Fault Locator (VFL)

## Power Meters & Optical Channel Checkers (OCC)

**MP-60/80**
USB Broadband Optical Power Meter

**OLP-35/38**
Broadband Optical Power Meter

**OLP-82P**
Broadband Optic Power Meter

**OLP-87**
PON/XG PON Power Meter

**OCC-55/56C**
CWDM/ DWDM Power Meter

**OCC-4055/4056C**
CWDM/DWDM Power Meter/Tuning

## OTDRs

**4100 Series Modules**
OTDR, OCA, Fiber Complete

**SmartOTDR**
PON OTDR

**T-BERD/MTS-2000**
OTDR FiberComplete
CWDM/DWDM OTDR

**T-BERD/MTS-4000v2**
OTDR FiberComplete
CWDM/DWDM OTDR

**T-BERD 5800**
1/10/100G Ethernet VoIP PRI Transport Tester

## OSAs

**T-BERD 6000A & T-BERD 8000**
OSA-110 & OSCA-710

## MPO Testing

**SideWinder**
Fiber Inspection MPO/MTP®

**MPOLx**
MPO/MTP Loss Test Set

## Fiber Characterization

T-BERD/MTS-8000E or T-BERD/MTS-6000
Advanced Fiber Characterization Kit OTDR, PMD, CD, AP (Modules fit both T-BERD/MTS-8000 and T-BERD/MTS-6000)

## Cloud

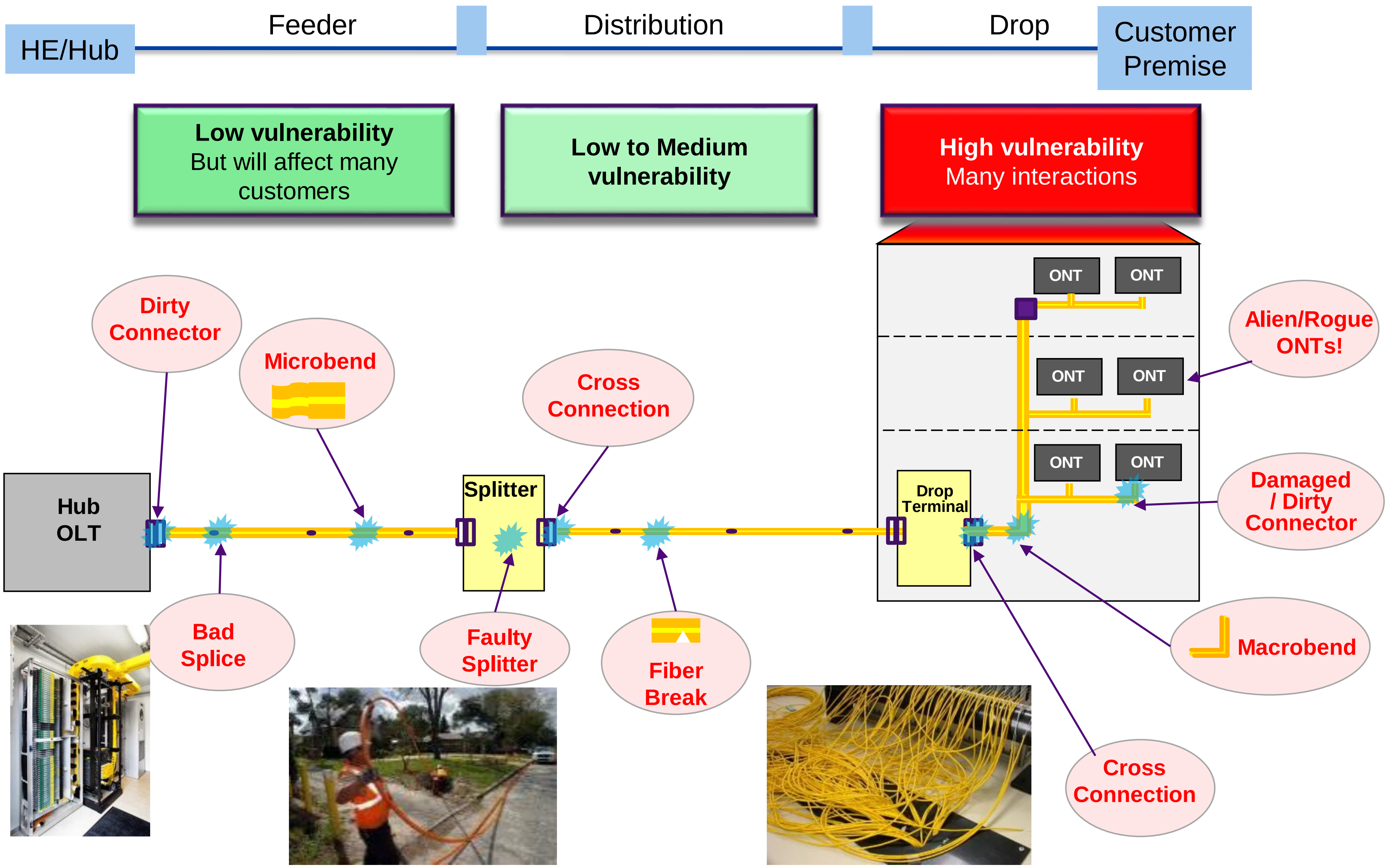

**StrataSync**
Cloud-based data and asset management

## Fiber Monitoring (24/7)

**OTU5000**
Fiber/Infrastructure Monitoring and Automated Testing

**SmartOTU / ONMSi**
Fiber/Infrastructure Monitoring and Automated Testing

# What Could Possibly Go Wrong?



# Fiber T&M Recommendations - What the Standards Say

**ITU-T G.984**

| | G-PON G.982, G.983.1, G.984.2, and G.652 Fiber Specs |
|---|---|
| Attenuation ranges | Class A: 5 to 20 dB<br>Class B: 10 to 25 dB<br>Class C: 15 to 30 dB<br>(Table 3/G.982) |
| Differential optical loss | 15 dB<br>(Table 4-a/G.983.1) |
| Maximum split ratio | 1x64<br>(Table 2a/G.984.2) |
| Minimum ORL of ODN | 32 dB, optionally 20 dB<br>(Table 2b/G.984.2) |
| Maximum reflectance of equipment, measured at receiver wavelength, for OLT receiver | Less than −20 dB<br>(Table 2b/G.984.2) |
| Maximum reflectance | −35 dB<br>(G.982 Chapter 11.4) |
| Reach | Up to 20 km<br>Up to 60 km logical reach<br>(Table 2a/G.984.2) |
| Fusion splice reflectance | −50 dB recommended<br>(G.982 Chapter 11.4) |
| Splitter loss | — |
| Connector loss | — |
| Cable attenuation | Example of G.652.B fiber (but other fiber types exist, with other specs):<br>0.4 dB/km max at 1310 nm<br>0.35 dB/km max at 1550 nm<br>(Table 3/G.652) |
| Concatenated cable attenuation (including typical splices and connectors) | Typical 0.5 dB/km at 1310 nm<br>Typical 0.35 dB/km at 1550 nm<br>(Table I.1/G652) |

| Fiber Network Element | Typical Loss (dB) | Maximum Loss (dB) | Typical ORL (dB) (or reflectance when applicable) | Min ORL (dB) (or reflectance when applicable) |
|---|---|---|---|---|
| Fiber attenuation | 0.35 dB/km at 1310 nm<br>0.2 dB/km at 1550 nm | — | 30 dB (long distance)/<br>40 dB (150 m) at 1310 nm<br>30 dB (long distance)/40 dB (150 m) at 1550 nm | 30 |
| Fusion splice | 0.1 | 0.2<br>0.3 (G.651) | None | None<br>−70 (G.671) |
| Mechanical splice | 0.2 | 0.5 (G.651) | None | −50<br>−40 (G.671) |
| Connector | 0.5 | 0.7<br>0.5 (G.671) | 65 (APC)<br>55 (UPC) | −50 (APC)<br>−40 (UPC)<br>−35 (G.671) |
| Splitter | 1x2 3.5<br>1x4 6.5<br>1x8 9.5<br>1x16 12.5<br>1x32 16<br>1x64 20<br>1x128 23 | (G.671)<br>1x2 4.2<br>1x4 7.8<br>1x8 11.4<br>1x16 15<br>1x32 18.6<br>1x64 22<br>1x128 25 | None | −55<br>−40 (G.671) |

**IEC 61300-3-35**

| Zone Name (diameter) | Scratches | Defects |
|---|---|---|
| A, Core Zone (0-25µm) | < 4 ≤3µm width | none |
| B, Cladding Zone (25-120µm) | none > 3µm width | no limit < 2µm<br>5 from 2 - 5µm<br>none > 5µm |
| C, Adhesive Zone (120-130µm) | no limit | no limit |
| D, Contact Zone (130-250µm) | no limit | none > 10µm |

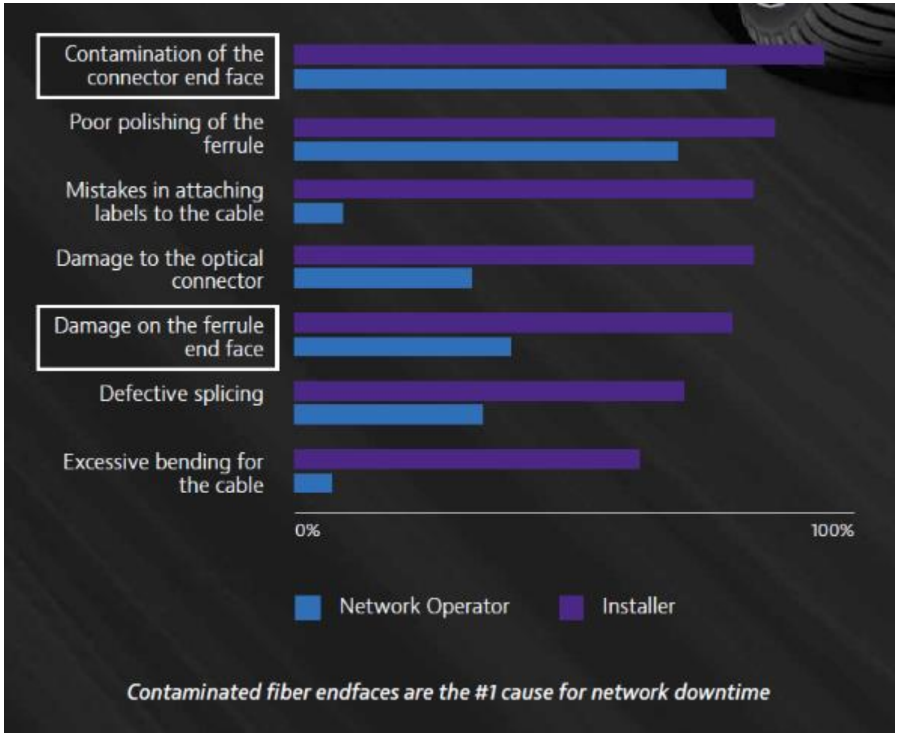
ITU & IEC standards provide specs & acceptance values guidance for fiber networkperformance:

- Maximum loss budget, splitter loss and minimum ORL crucial if video overlay
- A set of requirements for connector quality designed to guarantee loss and ORL perf.

# Optical Connector Inspection

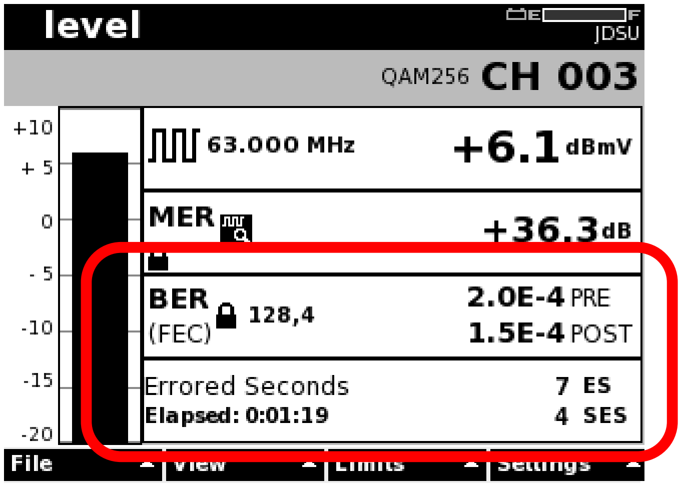
"Cheap Insurance for Network Reliability"

# Goal: Preventing Network Downtime



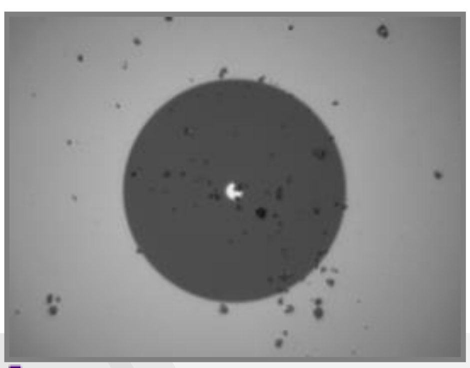

**In a study by NTT-Advanced Technology, 98% of installers (purple) and 80% of network owners (blue) reported that issues with connector contamination was the greatest cause of network failure.**

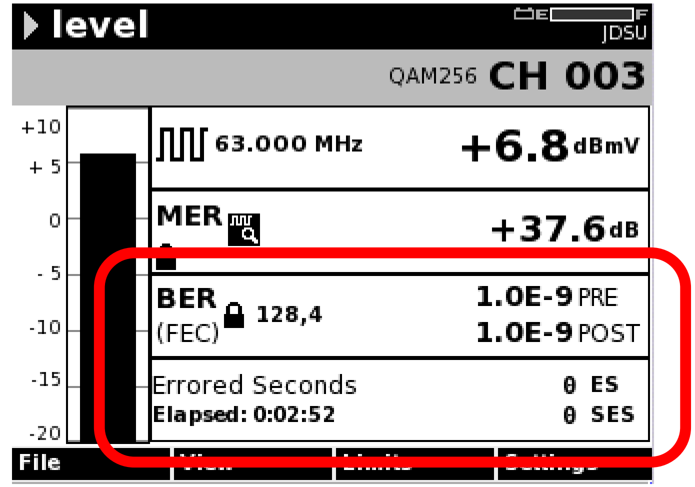
# Fiber Connector Cleaning Improves Plant Health Metrics




## Before Cleaning

- Level and MER okay
- Notice Bit Errors both pre and post
- Also shows errored seconds
- Definitely customer affecting



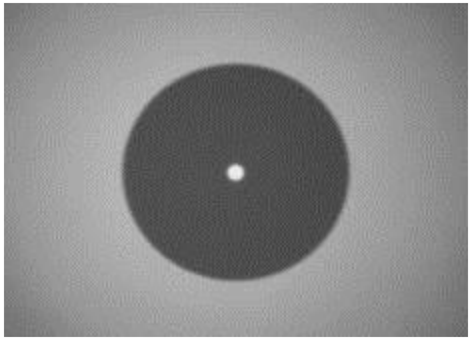



## After Cleaning

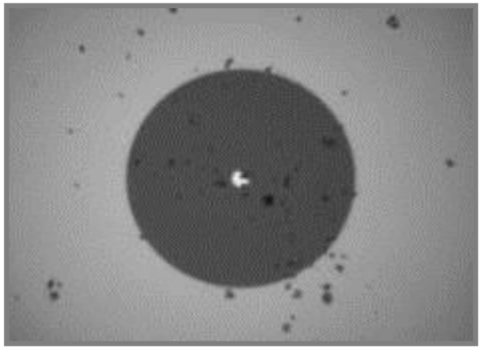
- MER and Level improvement
- Pre and Post Bit Error issue is corrected
- Errored Seconds corrected

# Contamination and Signal Performance

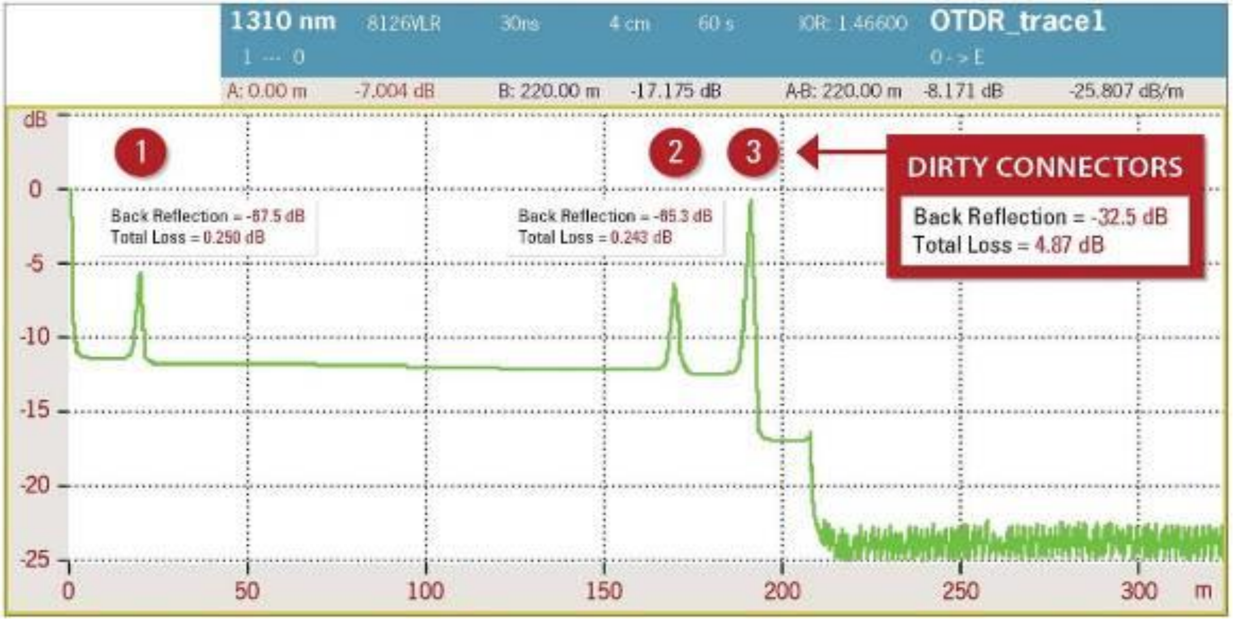
## Fiber Contamination and Its Affect on Signal Performance



Back Reflection = **-67.5 dB**
Total Loss = **0.250 dB**



Back Reflection = **-32.5 dB**
Total Loss = **4.87 dB**

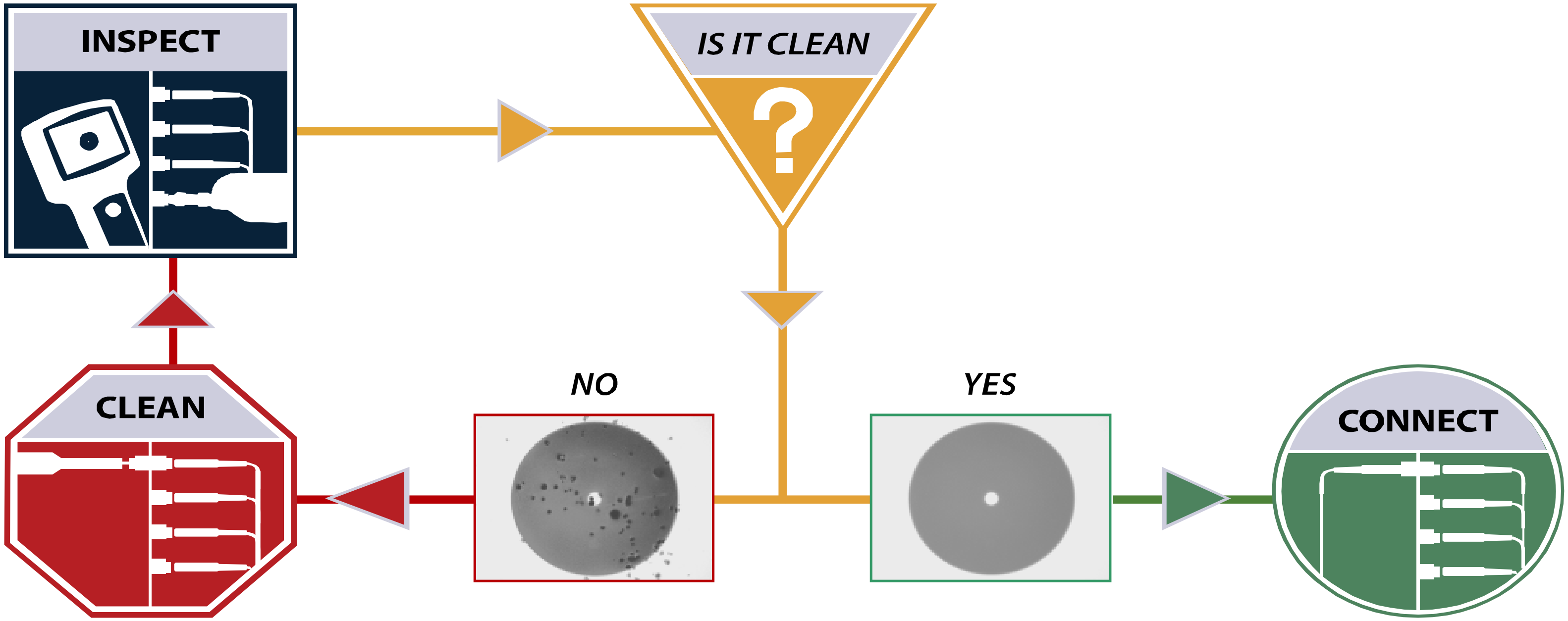



### Clean Connection vs. Dirty Connection

This OTDR trace illustrates a significant decrease in signal performance when dirty connectors are mated.

# Solution: Inspect ***Before*** You Connect

Follow this simple **"INSPECT BEFORE YOU CONNECT"** process to ensure fiber end faces are clean prior to mating connectors.

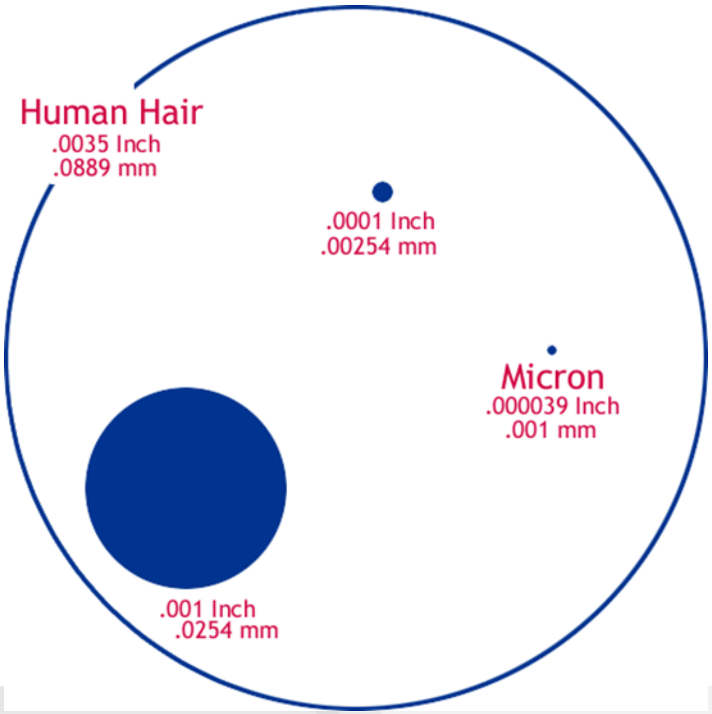


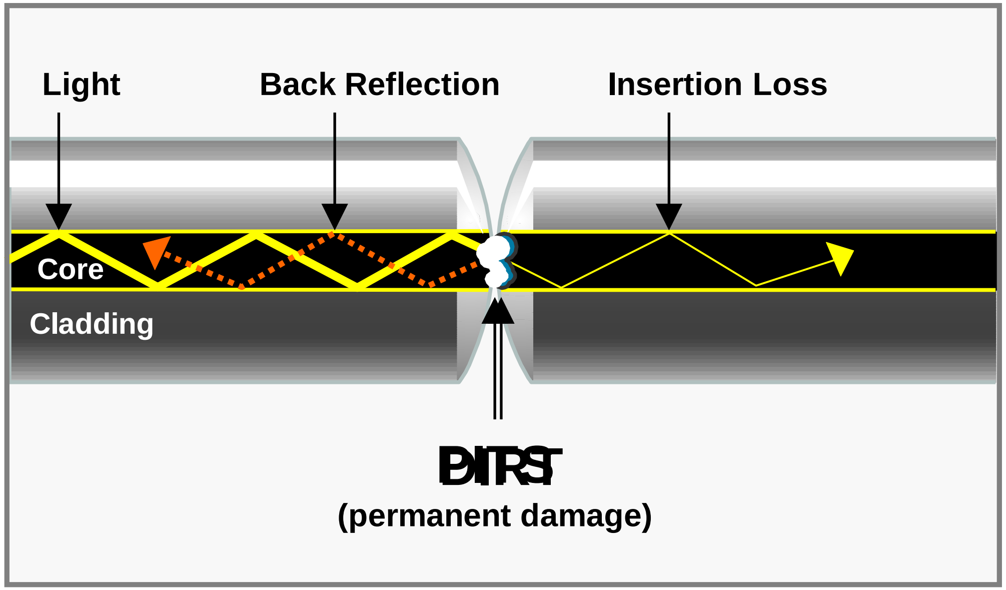

**Inspecting BOTH sides** of the connection is the **ONLY WAY** to ensure that it will be free of contamination and defects. A simple process with big benefits.

# Dirt Damages Fiber!

***Mating dirty connectors embeds the debris into the fiber.***

***Mating force of 2.2 lb over 200um diameter gives 45,000 psi.***

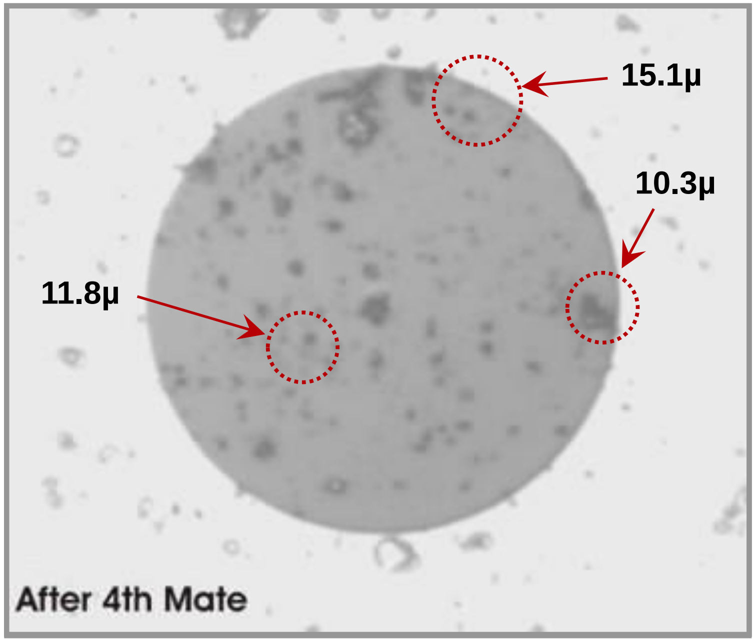


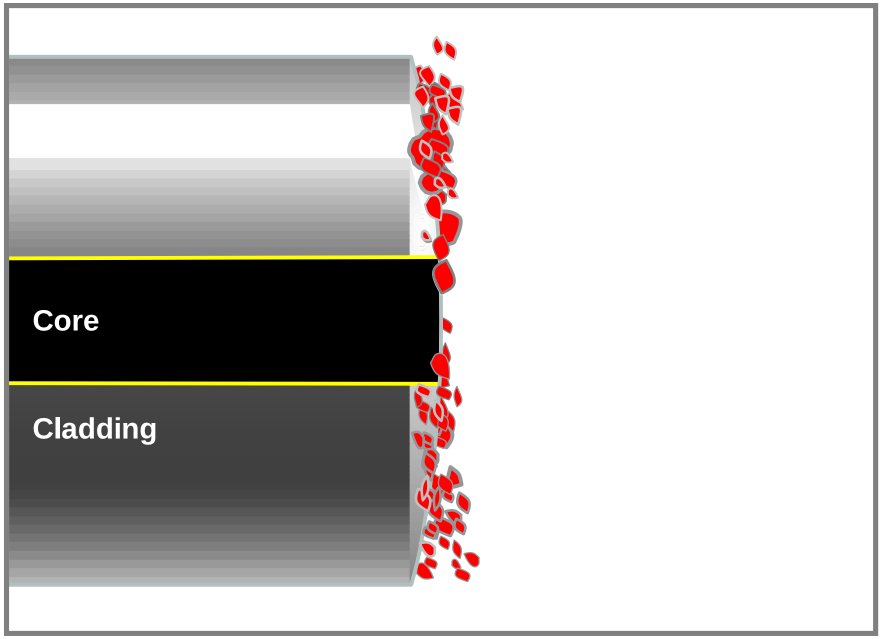




- Once embedded debris is removed, **pits and chips remain in the fiber.**
- These pits can also prevent transmission of light, causing **back reflection, insertion loss and damage** to other network components.

**Most connectors are not inspected until the problem is detected… AFTER permanent damage has already occurred.**

# Illustration of Particle Migration




***Actual fiber end face images of particle migration***

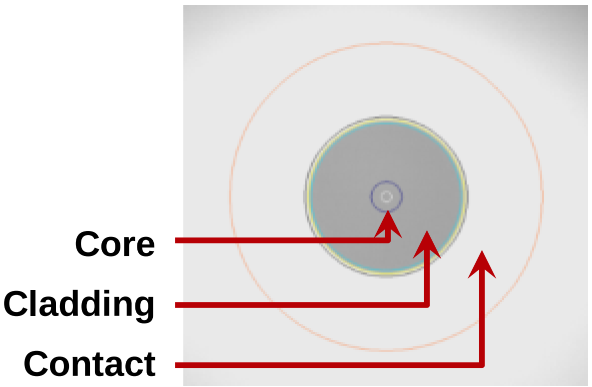
- Each time the connectors are mated, particles around the core are displaced, causing them to migrate and spread across the fiber surface.
- Particles larger than 5µ usually explode and multiply upon mating.
- Large particles can create barriers ("air gaps") that prevent physical contact.
- Particles less than 5µ tend to embed into the fiber surface, creating pits and chips.

# IEC 61300-3-35 Requirements for Connector Quality

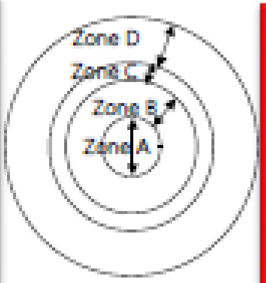
## SM-UPC Standard

* Separate criteria for different connector types

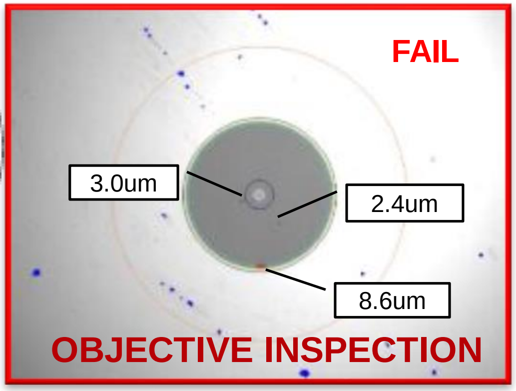
| ZONE NAME | SCRATCHES | DEFECTS |
|---|---|---|
| **A. CORE** (0–25µm) | None | None |
| **B. CLADDING** (25–120µm) | No limit <= 3µm<br>None > 3µm | No limit < 2µm<br>5 from 2–5 µm<br>None > 5µm |
| **C. ADHESIVE** (120–130µm) | No limit | No limit |
| **D. CONTACT** (130–250µm) | No limit | None => 10µm |





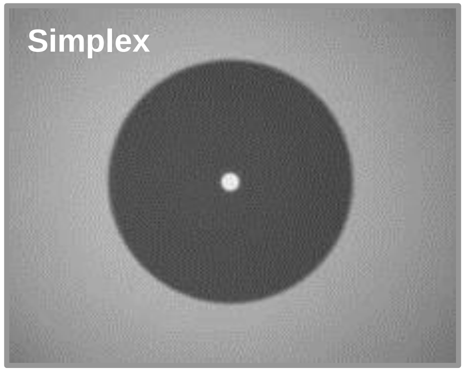


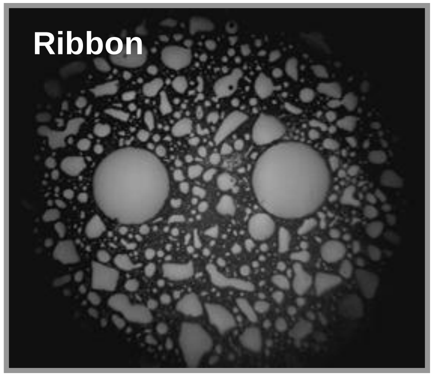

VS.



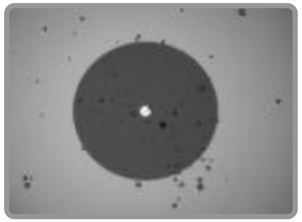
# Types of Contamination

A fiber end-face **should be free of any contamination or defects,** as shown below:

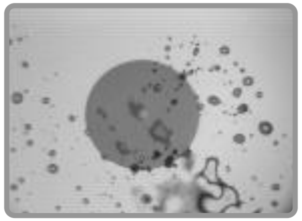



Common types of contamination and defects include the following:

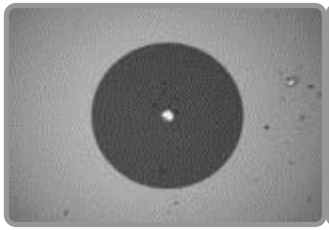


**Dirt**

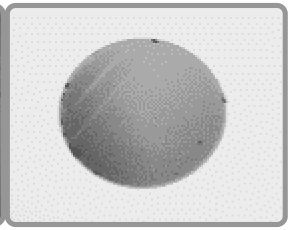


**Oil**

Can be proactively cleaned



**Pits & Chips**



**Scratches**

The damage is already done

# Proactive vs. Reactive Inspection

## PROACTIVE INSPECTION:

Visually inspecting fiber connectors at every stage of handling ***BEFORE*** mating them.

*Connectors are much easier to clean prior to mating, before embedding debris into the fiber.*

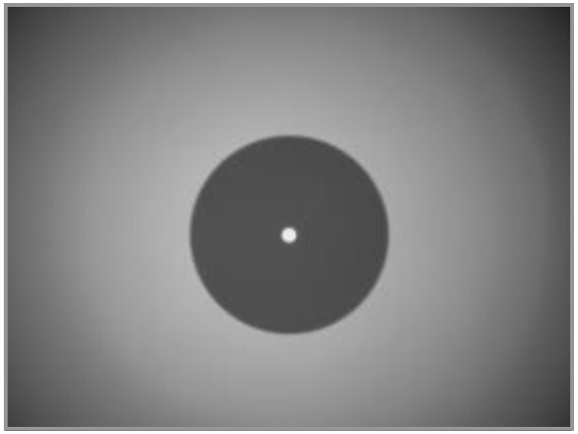

## REACTIVE INSPECTION:

Visually inspecting fiber connectors ***AFTER*** a problem is discovered, typically during troubleshooting.

*By this time, connectors and other equipment may have suffered permanent damage.*

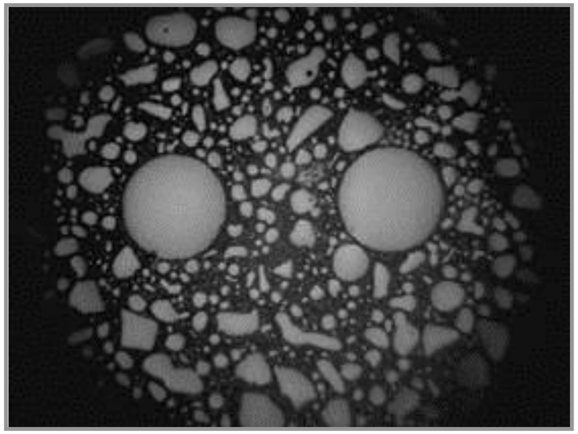
# Simplex vs. Multi-fiber Connectors

## SIMPLEX CONNECTOR



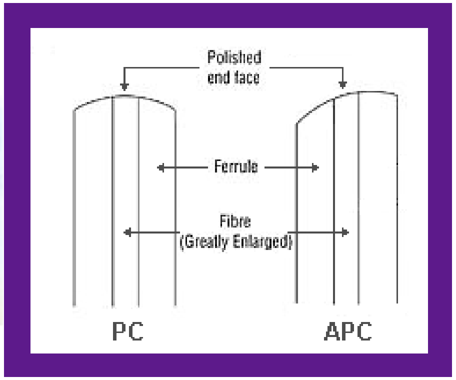
- White ceramic ferrule
- One fiber per connector
- Common types include SC, LC, FC and ST

## RIBBON CONNECTOR



- Multiple fibers in linear array (8, 12, 24, 48, 72, etc.) in single connector providing high-density connectivity
- Common type is MPO or MTP®

# Typical connectors for FTTx

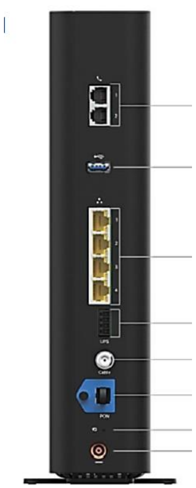



Blue = SC/UPC

Green = SC/APC

*Blue = Green!*

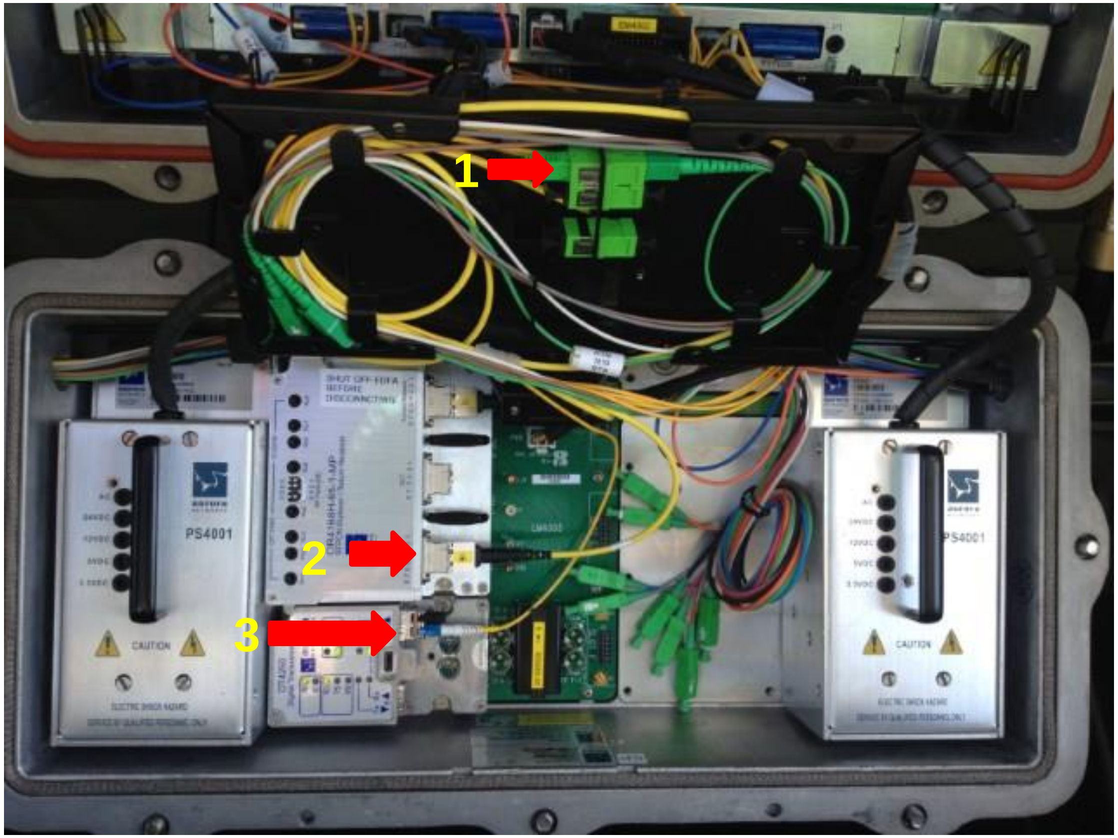
## CPE




SC/UPC

SC/APC

## FIELD

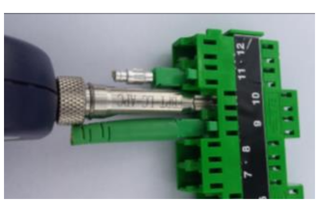


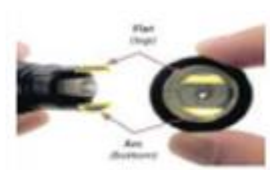

1. SC/APC connectors
2. MPO connectors
3. LC/UPC connectors

# Use the Correct Inspection Tip(s) for the Job

FiberChek Probe (FCP)

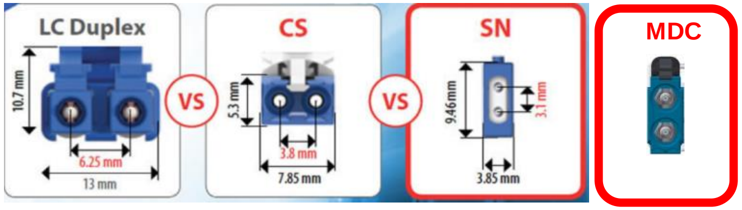

P5000i

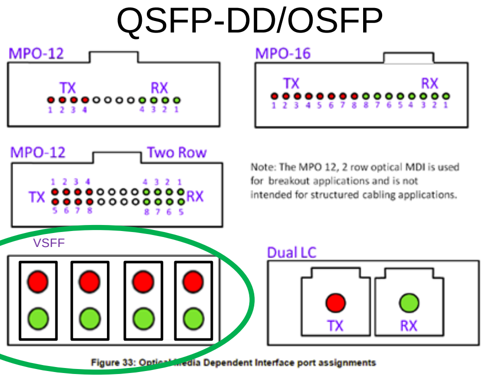




| Connector | Inspection Tip | FiberChek™ Probe (FCP) Settings | Application |
|---|---|---|---|
| SC | FBPT-SC | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| | FBPT-SC-A6 | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** FBPT-SC-A6 Tip | |
| | FBPT-U25M | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| SC-APC | FBPT-SC-APC | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| | FBPT-SCA-A6 | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** FBPT-SCA-A6 | |
| | FBPT-U25MA | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| LC | FBPT-LC | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| | FBPT-LC-L | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** Simplex Long Reach (-L) Tip | |
| | FBPT-ULC-A6 | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** FBPT-ULC-A6 for UPC | |
| | FBPT-U12M | **Profile:** SM UPC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| LC-APC | FBPT-LC-APC | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** FBPT-LC-APC (V2) | |
| | FBPT-ULC-A6 | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** FBPT-ULC-A6 for APC | |
| | FBPT-U12MA-SF | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** Standard Tips (with BAP1) | |
| MPO | FBPT-MTPA-L (for APC)<br>FBPT-MTP-L (for UPC) | **For FBPT-MTPA-L:**<br>**Profile:** Ribbon, SM APC (IEC- 61300-3-35)<br>**Tip:** Ribbon Tips - Long Reach | |
| | ZP-HW-00448 | **For FBPT-MTP-L:**<br>**Profile:** Ribbon, MM (IEC-61300-3-35)<br>**Tip:** Ribbon Tips - Long Reach<br>**To inspect patch cords:**<br>Attach bulkhead adapter (as shown in image to the right)<br>Note: Microscope Settings/Auto Center Settings: OFF | |
| OptiTAP | FBPT-COD-L | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** Simplex Long Reach (-L) Tip | Inspect Corning OptiTAP™ Simplex connectors |
| | FBPT-DLX | **Profile:** SM APC (IEC-61300-3-35)<br>**Tip:** FBPT-LC-APC (V2) | Alternate option for inspecting Corning OptiTAP simplex connectors |

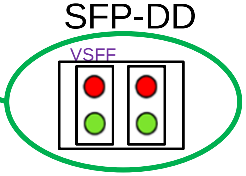
# A Very Small Form Factor (VSFF) connector …




QSFP-DD/OSFP 4:1 breakout:

SFP-DD 2:1 breakout:




… and could support future higher density applications!

Use of MT-style ferrule could increase fiber density by **8x** over current VSFF connector

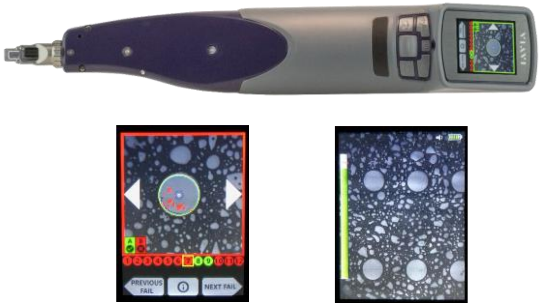
# Automated Fiber Inspection Probes

## FiberChek Probe (FCP)

- Integrated touch screen display (standalone testing)
- Auto everything:  focus,centering, pass/fail analysis, save, reports
- Wifi/BT
- FiberChek Mobile (free app-works w/ smartphone)
- 300+ inspection tips available

## P5000i (USB)

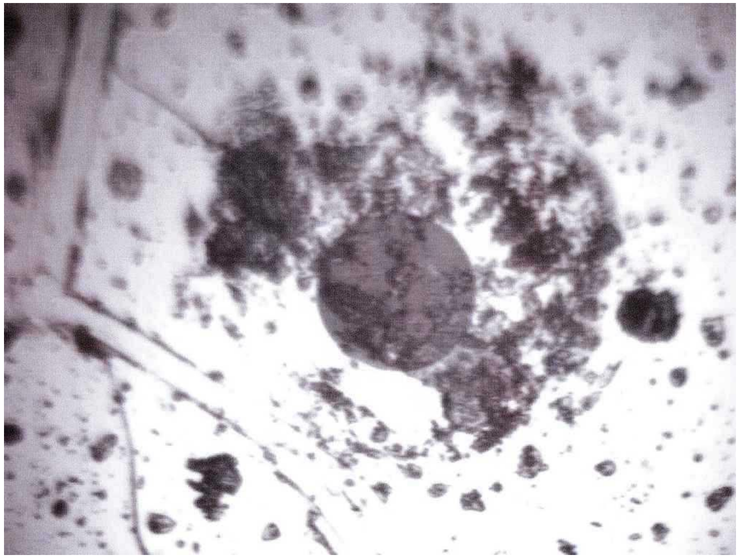
- USB port operation
- Software pre-installed on T-BERD,DSAM,ONX,OLP-8x
- Auto: centering, pass/fail analysis, save, reports
- 300+ inspection tips available (same tips as FCP)



## Sidewinder (MPO)

- 15-20 seconds to test MPO connector
- Auto locates and tests all fibers on MPO connector
- WiFi/BT
- Integrated touch screen display (standalone testing)
- FiberChek Mobile (free app- works w/ smartphone)

# Don’t forget about your test set ports (OTDR)

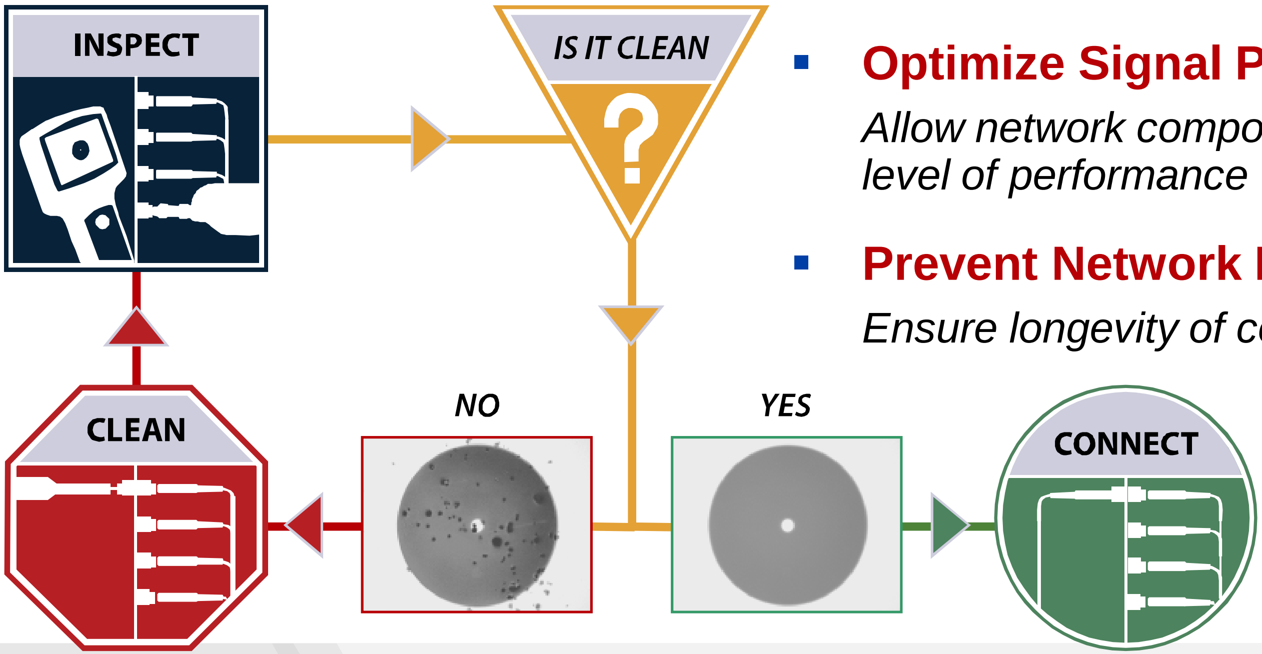


**Sent back for repair**
**Tech just cleaned it and sent it back**

# Inspect Before You Connect[sm]

Follow this simple **"INSPECT BEFORE YOU CONNECT"** process to ensure fiber end faces are clean prior to mating connectors.

- **Reduce Network Downtime**
  *Active network = satisfied customers*
- **Reduce Troubleshooting**
  *Prevent costly truck rolls and service calls*
- **Optimize Signal Performance**
  *Allow network components to operate at highest level of performance*
- **Prevent Network Damage**
  *Ensure longevity of costly network equipment*



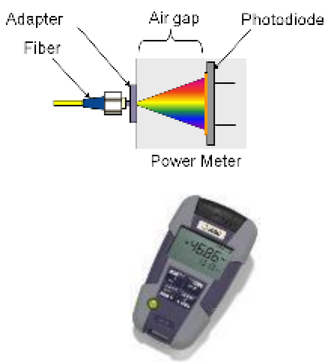
# Fiber Inspection Live Demo (FiberChek Pro)

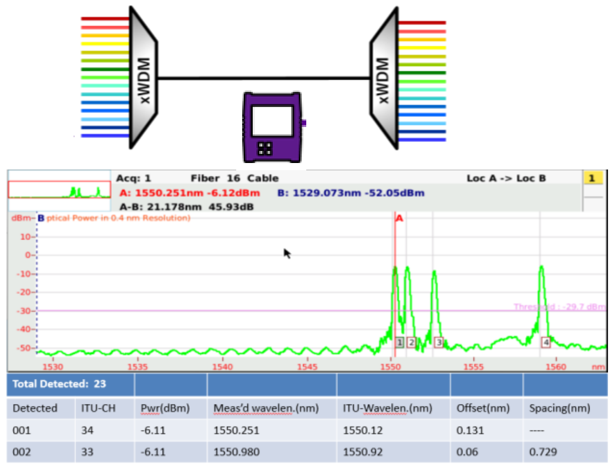
- Automated Pass/Fail example
- Cross contamination example
- Wrong tip example
- Dirt on fiber or scope (use SC/PC fiber)
- Improved workflow using a bulkhead adapter
- Save results/auto-generate report
- Use FiberChek Mobile (view/control from smartphone)

# Power Meters

"Verifying wavelength(s) and power levels"

# Selecting the Right Power Meter for the Job





- **Broadband Power Meter**
  - Measures average peak power of ALL wavelengths present
  - Uses a Photodiode
  - Only accurate if one wavelength is on fiber
  - User selects wavelength (no auto-id)
- **WDM Power Meter (Channel Checker)**
  - CWDM & DWDM versions
  - Auto-scan capability to identify every WDM wavelength on the fiber
  - Use on common fiber or drop fiber side
  - Provides power level (dBm) of each detected wavelength
  - May also provide wavelength drift (offset) and spacing information
- **FTTH/PON Power Meter**
  - Able to isolate and measure downstream PON wavelengths simultaneously
  - Able to be inserted in-series to measure downstream and upstream wavelengths
  - Upstream signal is TDM and requires BURST measurement capability

# Power Meters for….

## Broadband (Traditional)

**OLP-35**(+10dBm) & **OLP-38**(+26dBm)

- Ability to customize and store 5 wavelengths (in 1nm increments)
- AA batteries

**MP-60**(+10dBm) & **MP-80**(+26dBm)

- USB Power meter
- Connects to laptop, DSAM, ONX or T-BERD


## DWDM/CWDM OCCs

**Handhelds**

- OCC-56(DWDM)/OCC-55(CWDM)
- Displays CH, λ, Power Level

**T-BERD modules/kits**

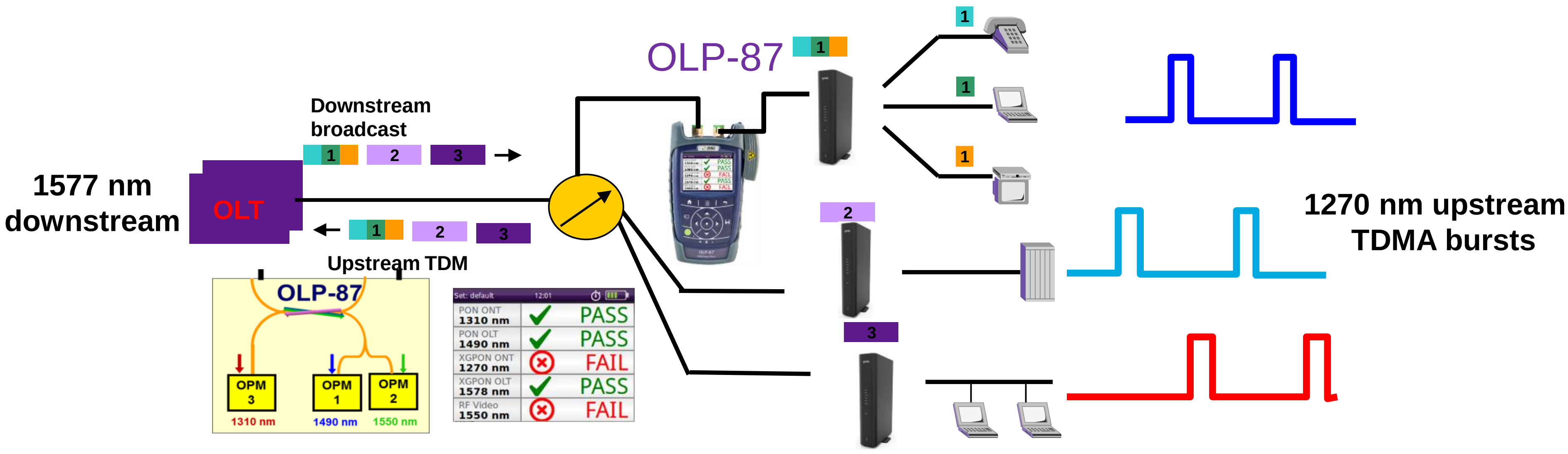
- **4056C**(DWDM)/4055(CWDM)
- Displays CH, λ, Power Level
- Offset/drift (detect optics going bad)
- SFP+ Tuning option (for DWDM)
- SFP bays (becomes light source)

## PON/ FTTx

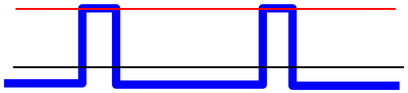
**OLP-87**

- Measures all downstream AND upstream PON wavelengths
- Broadband Power meter port
- Color Touchscreen display
- USB port (connect P5000i)
- Configurations for all PON types (RFOG,GPON,EPON,XGS PON, NG-PON2)

# Upstream Wavelengths for PON




- **The ONT MUST see the downstream 1577 nm wavelength <u>before</u> activating the upstream wavelength(s) at 1270nm**
  - A PON PM w/ through mode allows OLT ⇔ XF3 communication to be established so the upstream wavelength(s) will activate
- **Upstream signal active only in predefined time slots (framed)**
  - Must be able to accurately measure power level for a BURSTING upstream laser (intermittent on/off)



**FTTx power meter shows average peak level**

Standard power meter shows average level

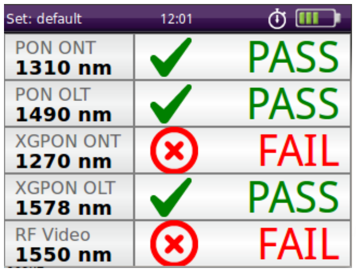
# Evolution of PON meters

***PON (1310/1490/1550nm)***



**OLP-87**

***PON+10G PON (1310/1490/1550 & 1270/1577)***

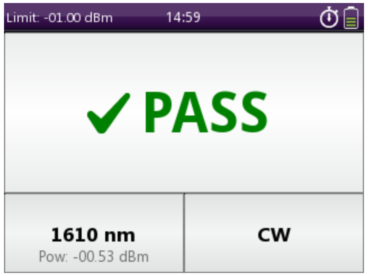




**BB-PM port**

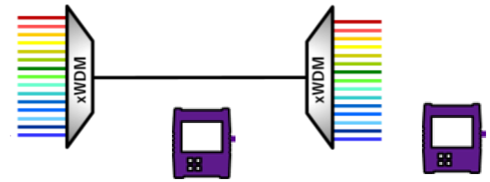
**Through Mode (OLT/ONT ports)**

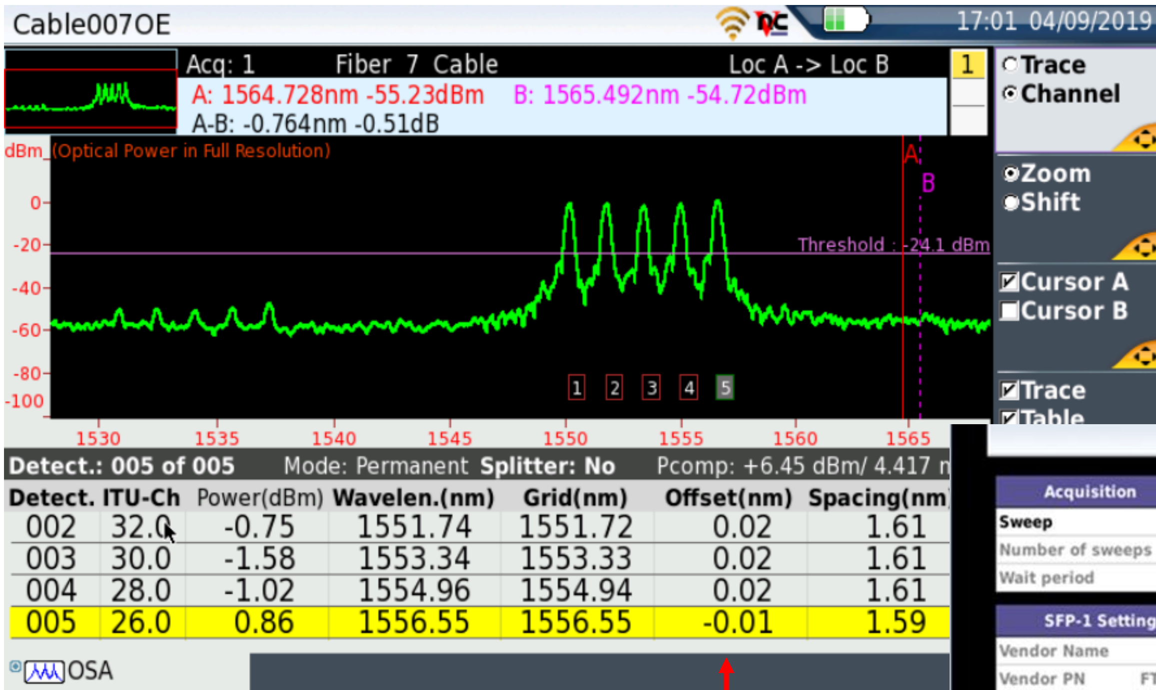
***Also Broadband PM***



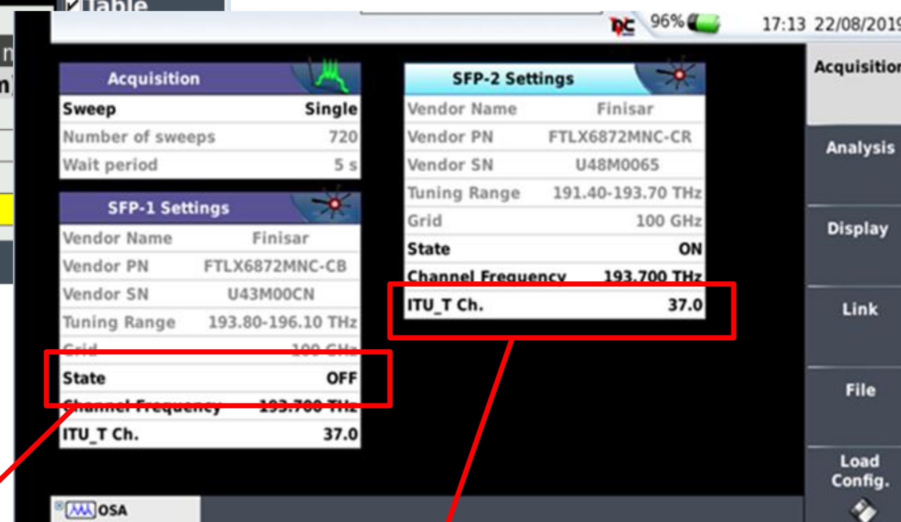

***Add Fiber Inspection***

# Optical Channel Checkers (OCCs)







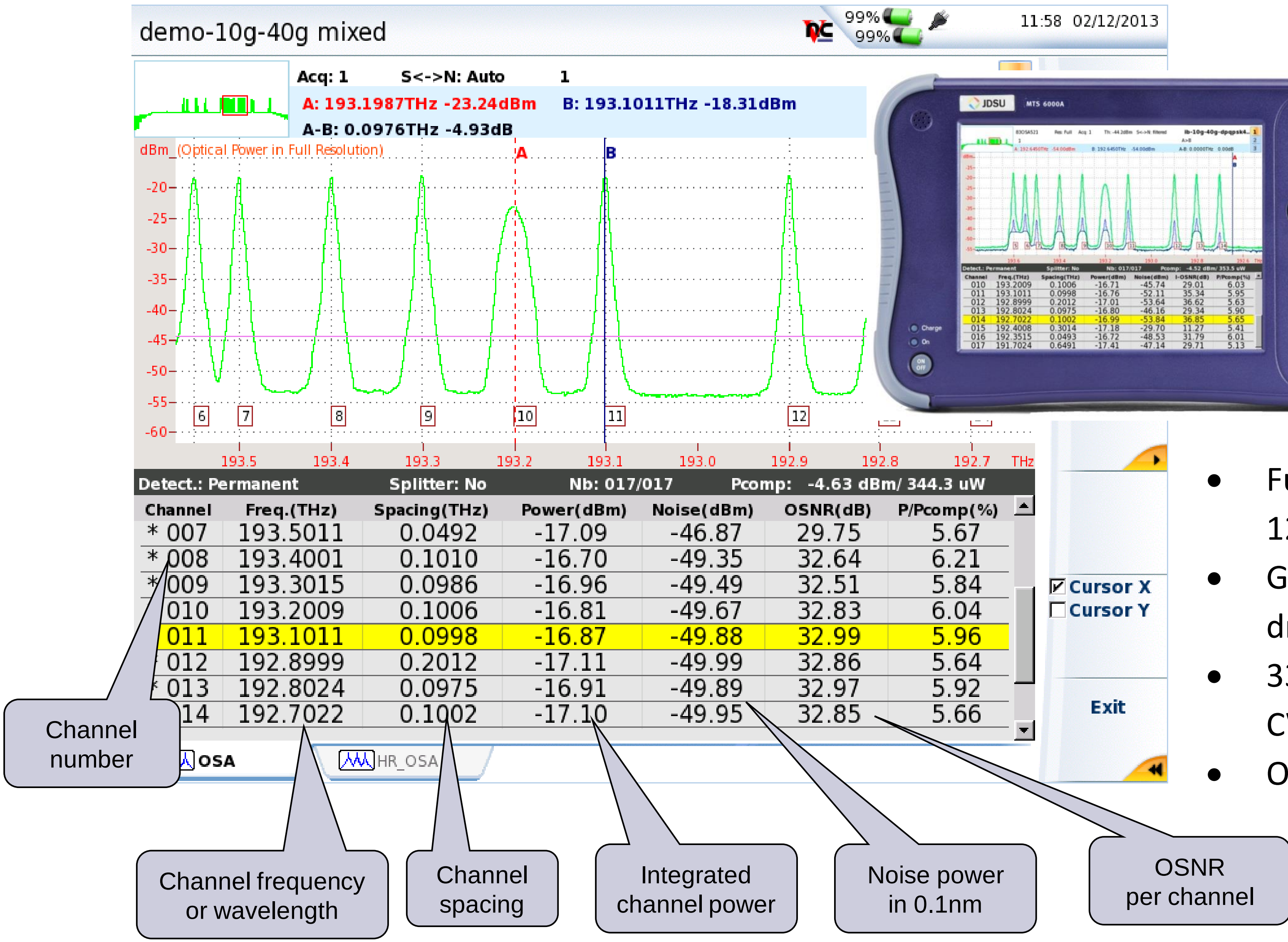

Verify Channels and Power Levels

Detect optics Going bad

Use SFP+ as Tunable Light Source

Tune SFP+'s from test set

# Optical Spectrum Analyzer (OSA)

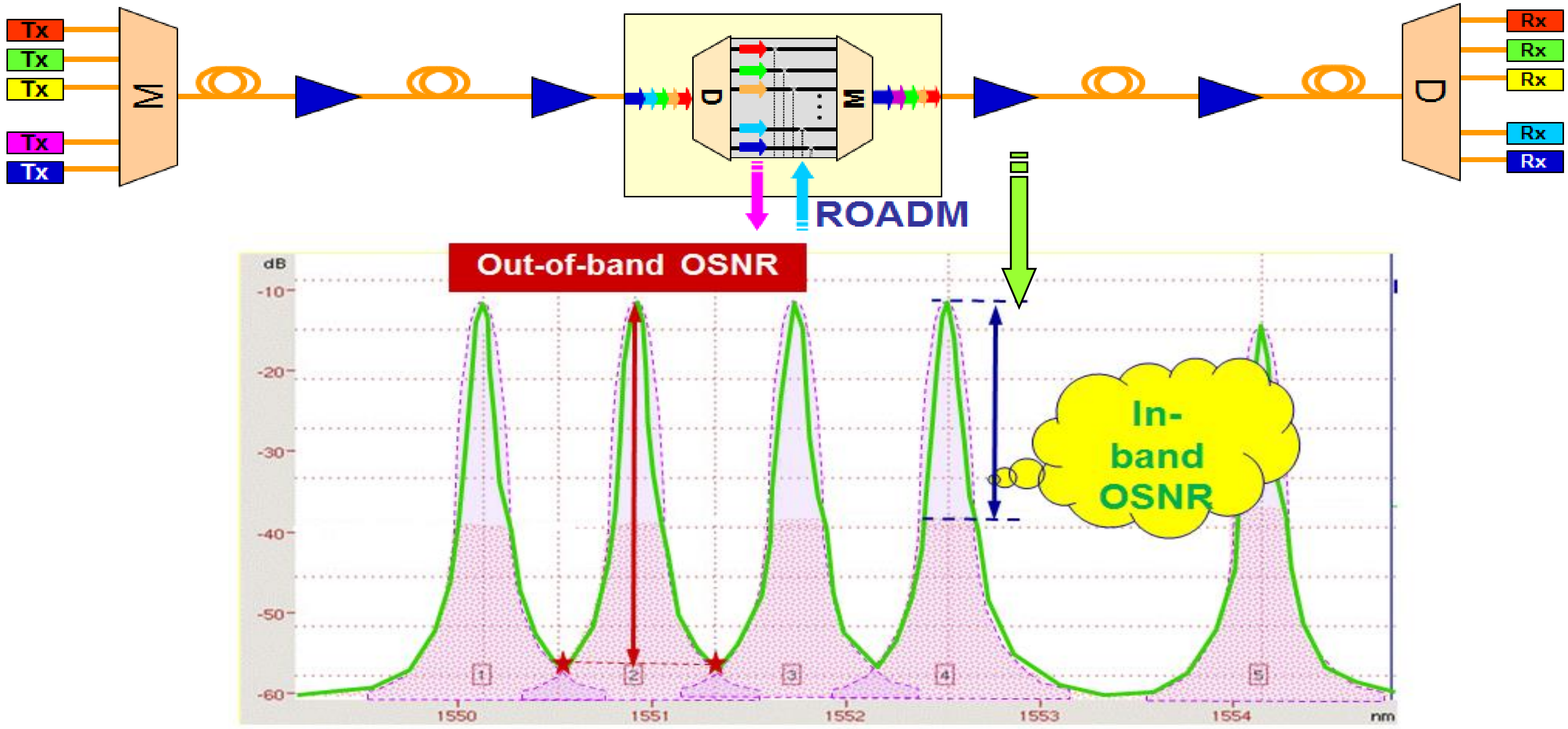



| Channel | Freq.(THz) | Spacing(THz) | Power(dBm) | Noise(dBm) | OSNR(dB) | P/Pcomp(%) |
|---|---|---|---|---|---|---|
| * 007 | 193.5011 | 0.0492 | -17.09 | -46.87 | 29.75 | 5.67 |
| * 008 | 193.4001 | 0.1010 | -16.70 | -49.35 | 32.64 | 6.21 |
| * 009 | 193.3015 | 0.0986 | -16.96 | -49.49 | 32.51 | 5.84 |
| 010 | 193.2009 | 0.1006 | -16.81 | -49.67 | 32.83 | 6.04 |
| 011 | 193.1011 | 0.0998 | -16.87 | -49.88 | 32.99 | 5.96 |
| 012 | 192.8999 | 0.2012 | -17.11 | -49.99 | 32.86 | 5.64 |
| 013 | 192.8024 | 0.0975 | -16.91 | -49.89 | 32.97 | 5.92 |
| 14 | 192.7022 | 0.1002 | -17.10 | -49.95 | 32.85 | 5.66 |

- Full spectral range: 1250 and 1650 nm
- Graph, table and drift display modes
- 33 to 200 GHz, CWDM & DWDM
- OSNR

# ROADM Networks

- ROADMs change the noise level due to filtering
- Testing before or after the ROADM will change the OSNR



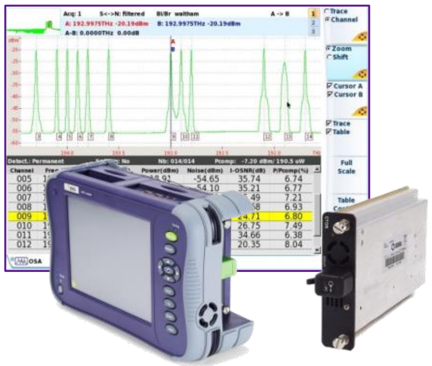

- The “true” OSNR is the “In-band” OSNR

A Conventional OSA cannot correctly detect the “true” OSNR

# OSA's:

## T-BERD 6000A w/ OSA-110M

**Standard OSA**



- Full spectrum OSA (1250 to 1650nm)
- 33 to 200GHz Channel Spacing
- +23dBm
- Traditional OSA (out of band OSNR)

Also available:

- OSA-110H (+30dBm)
- OSA-110R (in-band OSNR for ROADM networks)
- All OSA-110x modules also compatible w/ T-BERD 8000

**Coherent (≥100G) networks**

Standard OSAs X  Viavi OSCA-710 √

| OSNR Test | OSA-110M | OSCA-710 |
|---|---|---|
| Legacy ≤10G | √ | √ |
| ROADM | OSA-110R | √ |
| Coherent (≥ 100G) | out-of service (On/Off method) only | in-service |
| Chromatic Dispersion (CD) | | √ |

Standard OSAs

- canNOT provide accurate In-service OSNR for these networks

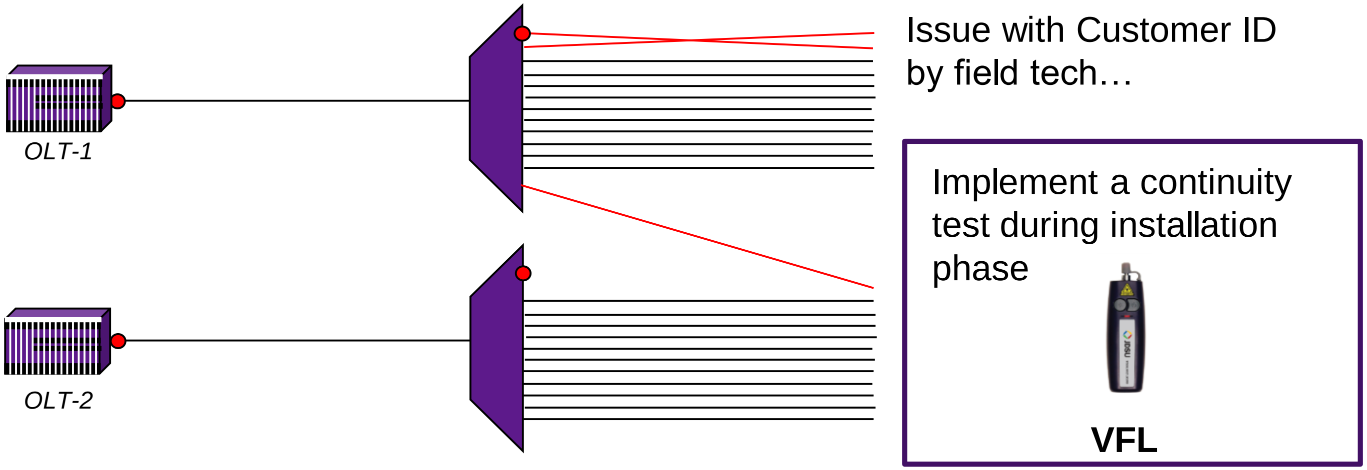
OSCA-710

- Able to provide accurate In-Service OSNR for these networks

## T-BERD 8000 w/ OSCA-710


- Only solution on market able to provide In-Service OSNR for all deployed DWDM networks (legacy, ROADM, Coherent (100G+) w/ pol-mux)
- Patented SCorM method
- In-Service per channel CD measurement
- Commission & troubleshoot w/out shutting down the network or individual channels
- Uses coherent receiver

# Patching Customers Correctly

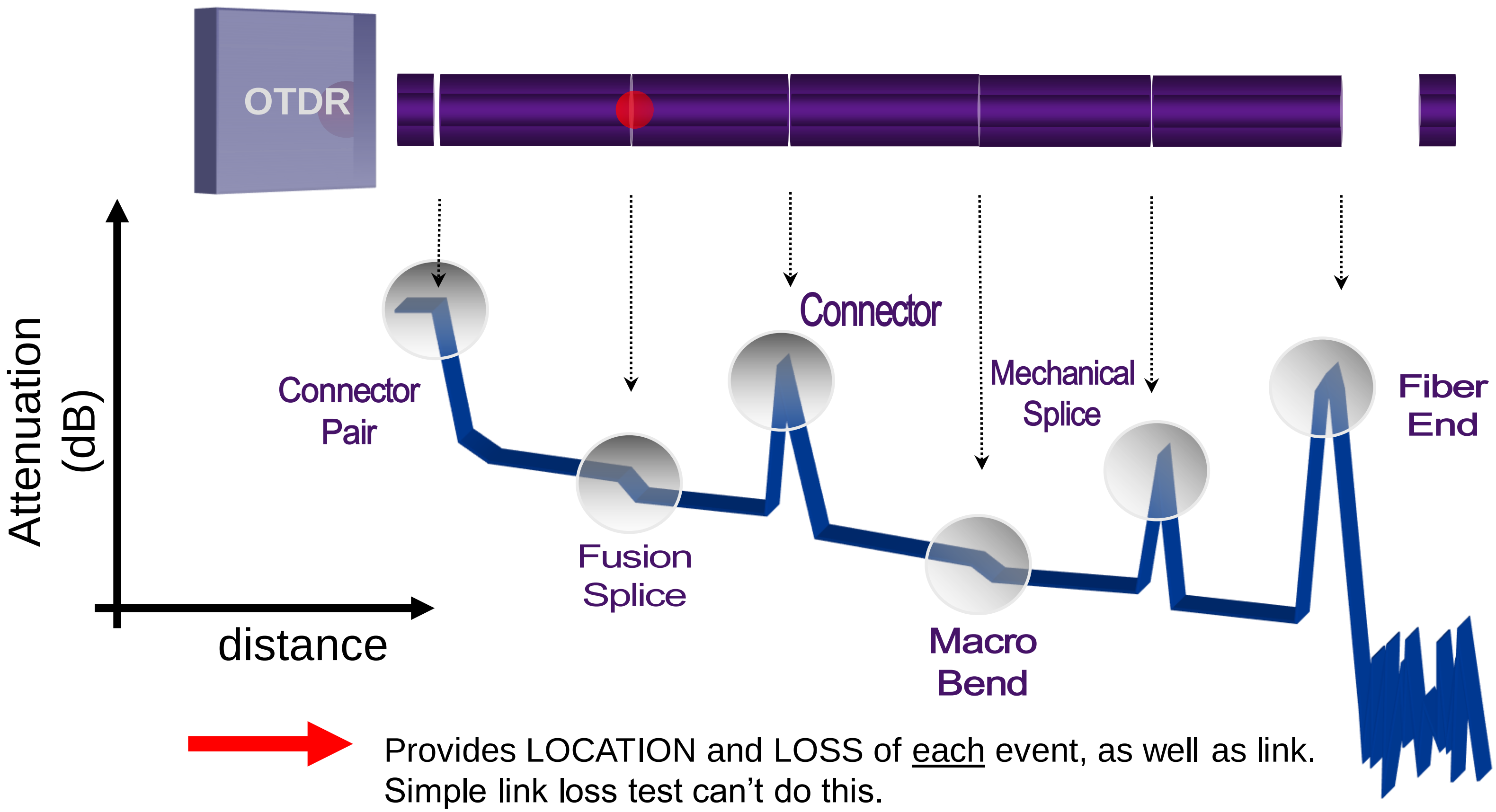



- If continuity is not checked during installation phase:
  - Incorrect connections will not be found until ONT is turned-up -> dispatch
  - A customer who has been patched incorrectly might be brought down-> customer dissatisfaction
- Continuity tests reduce OPEX and customer dissatisfaction
- Use a **Visual Fault Locator (VFL)** for quick verification of continuity during installation (avoid cross connects)

# OTDR Testing

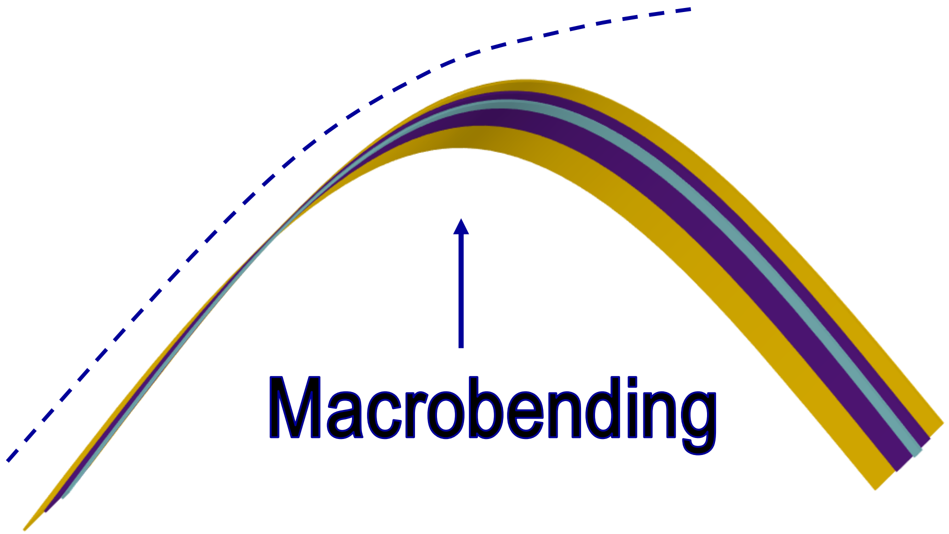
"Verify the fiber network and locate/fix problems"

# OTDR Trace

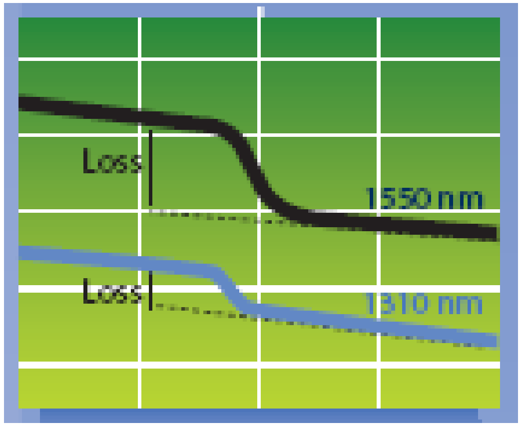



Provides LOCATION and LOSS of each event, as well as link.
Simple link loss test can't do this.

# Detecting Bends w/ an OTDR




- Higher wavelengths are more susceptible to bending than lower wavelengths
  (1550nm more susceptible than 1310nm)
- Therefore to distinguish a bend from a splice, two wavelengths are used (typically 1310 & 1550nm)



# Understanding OTDR Specs

## Dynamic Range

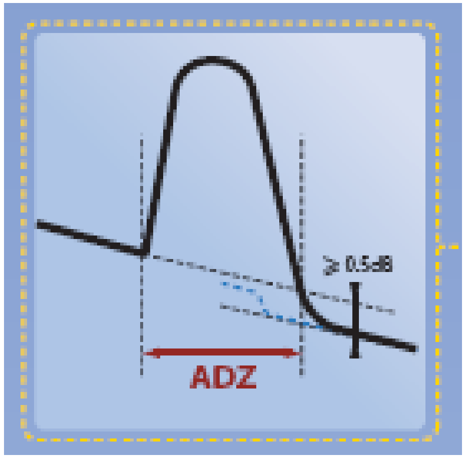
- The “dB rating” of the OTDR
- Measured in dB (typical range is 20-50dB)
- Describes how much loss an OTDR can measure in a fiber, which in turn describes how long of a fiber can be measured
  - The higher the dB rating of the OTDR module the farther it can shoot
- Directly related to Pulse Width: larger pulse widths provide larger dynamic range
  - OTDR spec is based on the longest pulsewidth
- Select an OTDR that provides testing capabilities beyond the longest fiber to be tested.

## Understanding OTDR specs

# Dead Zones

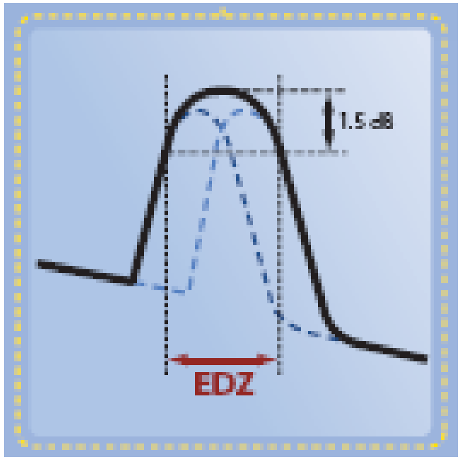
- Specified as a DISTANCE
- Determines how CLOSE to OTDR you can detect and measure a splice loss
- Determines how CLOSE TOGETHER two events (splices) can be measured
- Directly related to PULSE WIDTH: larger pulse widths produce larger dead zones
  - OTDR specs are based on the shortest pulsewidth

# Dead Zone Types




**Attenuation Dead Zone (ADZ)** is the minimum distance after a reflective event that a non-reflective event can be measured (0.5dB)

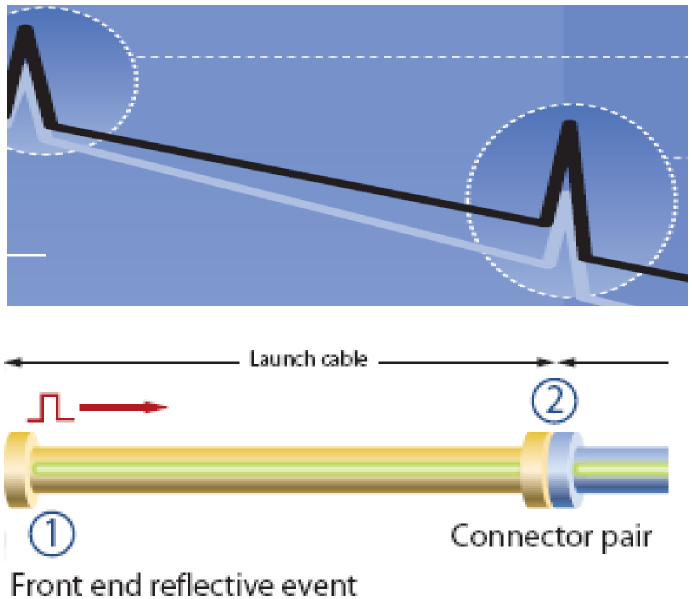
- In this case the two events are more closely spaced than the ADZ, and shown as one event
- ADZ can be reduced using shorter pulse widths




**Event Dead Zone (EDZ)** is the minimum distance where 2 consecutive unsaturated reflective events can be distinguished

- In this case the two events are more closely spaced than the EDZ, and shown as one event
- EDZ can be reduced using shorter pulse widths

# Tools to Optimize OTDR testing




## Launch Cable

- Using a launch cable allows the characterization of the connector at the origin of the link.
- This shifts the first connector outside the dead zone of the OTDR connector
- The last connector can also be measured by using a receive cable

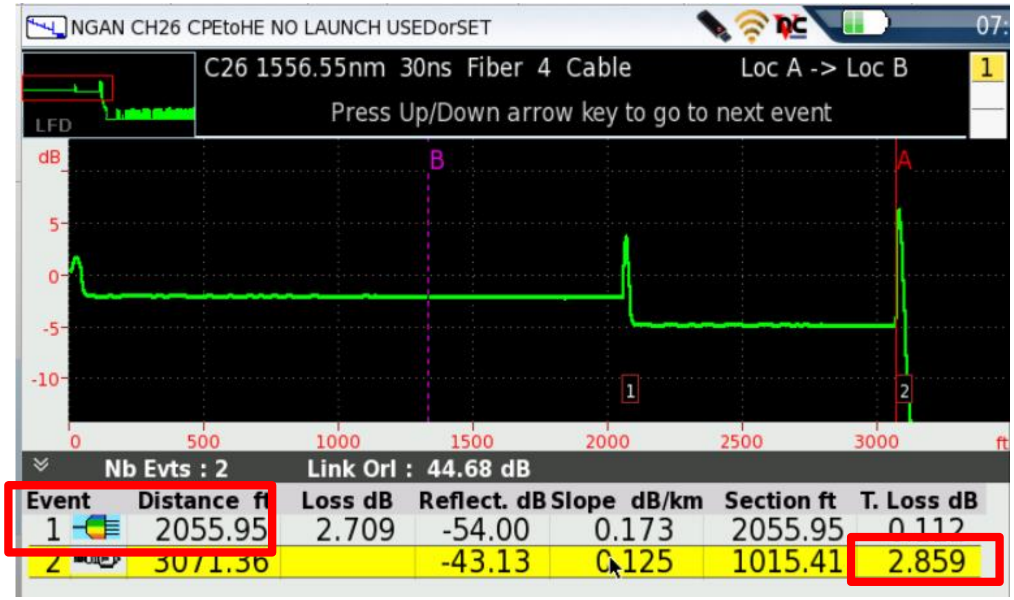
## About Launch Cables

- Launch cables are typically 100 – 1,000 meters in length.
- *VIAVI T-BERD OTDRs only require 20m!*

# Launch Cable Example

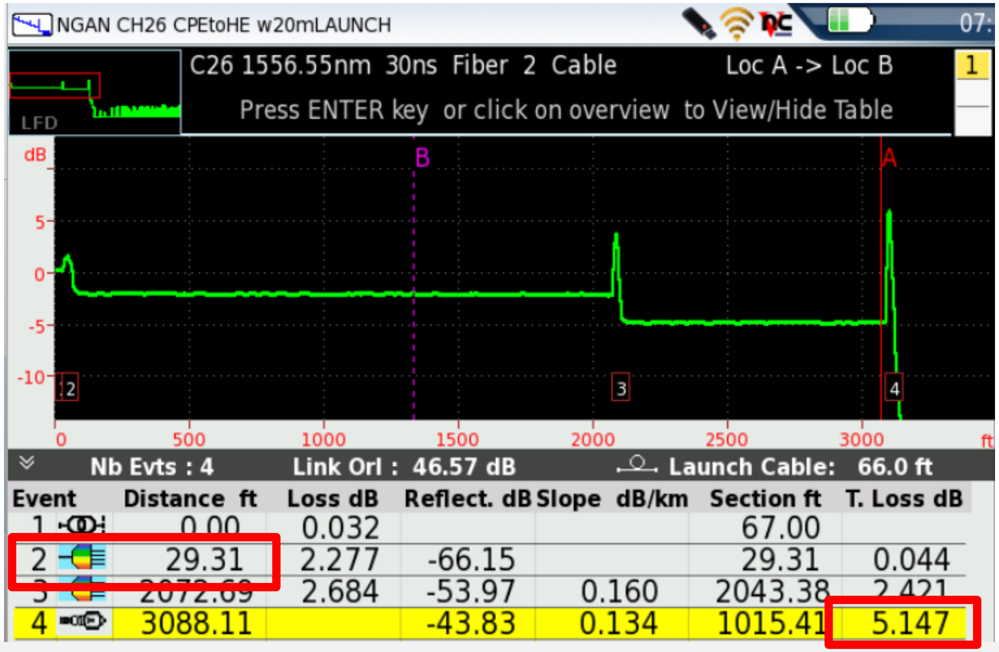
### No Launch Cable Used:

- 1 mux detected at 2055ft
- Total loss on span 2.859dB




### 20m Launch Cable Used:

- Additional mux detected at 29ft
- Total loss on span 5.147dB

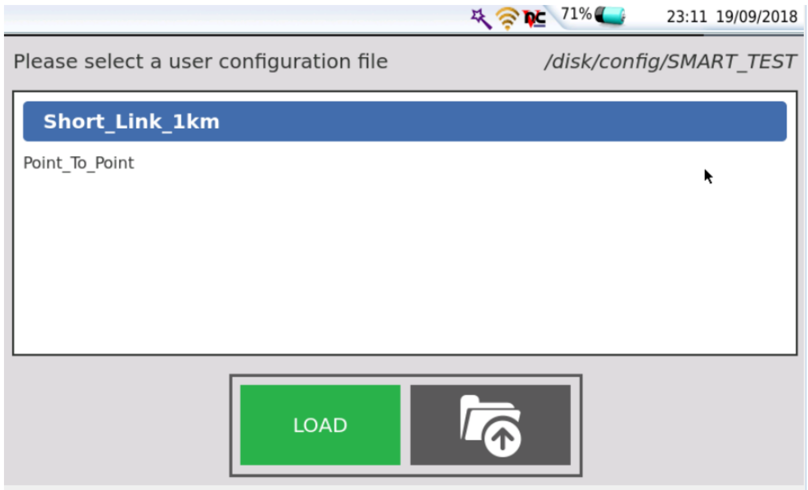



Always use a Launch Cable!

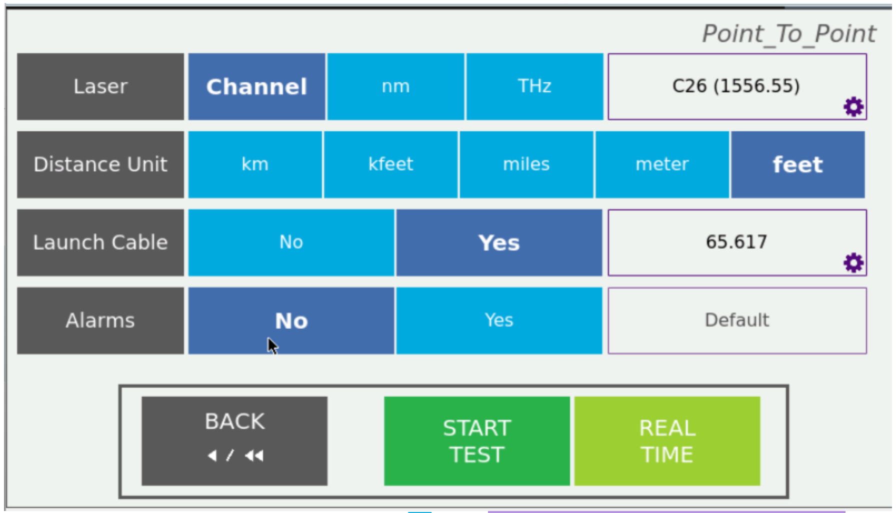
OTDR Made Easy!

# Setting up & Running a Test
## SmartTEST Assistant

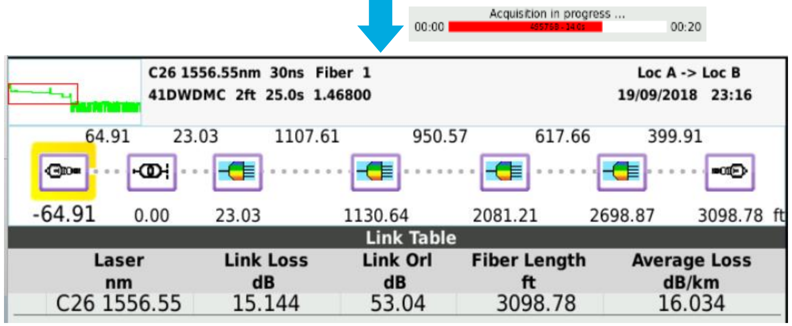
1. Load a test config



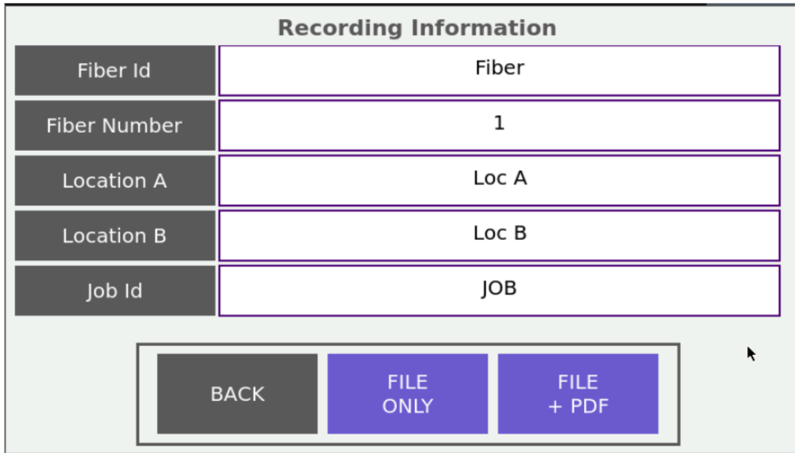

2. Set basic parameters




3. START acquisition




4. Read pass/fail results



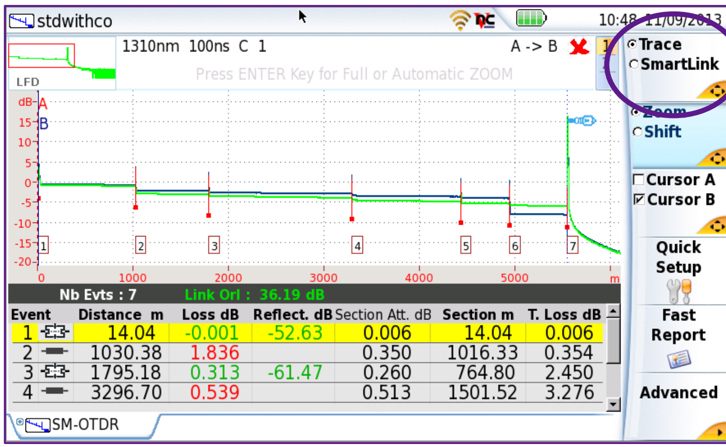

5. Save results report

OTDR Made Easy!

# Simple Viewing & Understanding of Results

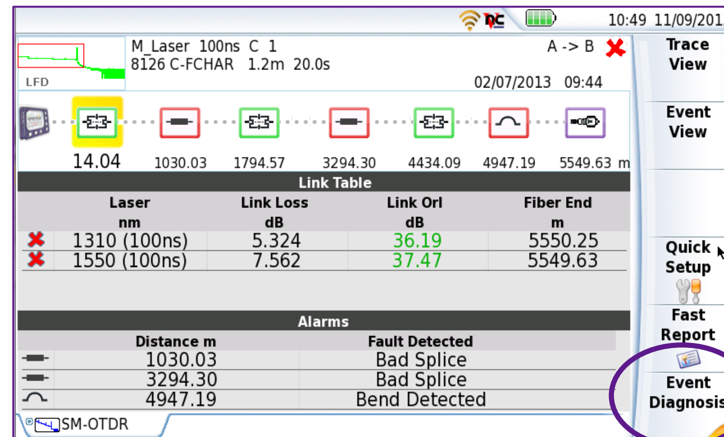
## SmartLink Mapper (SLM)

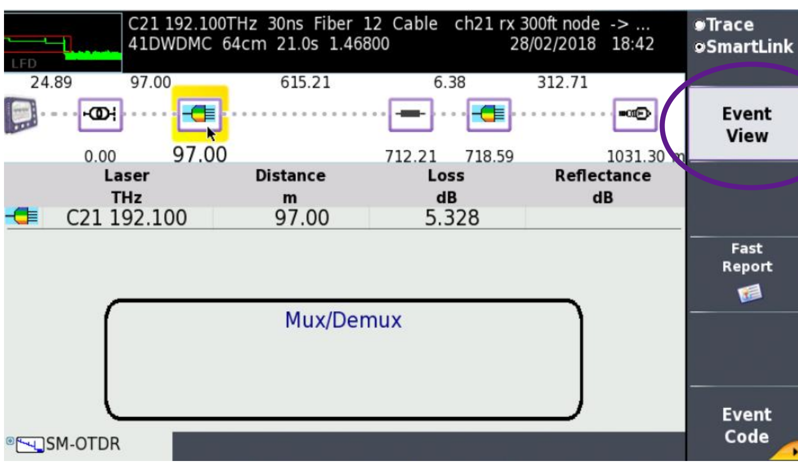
### Trace View

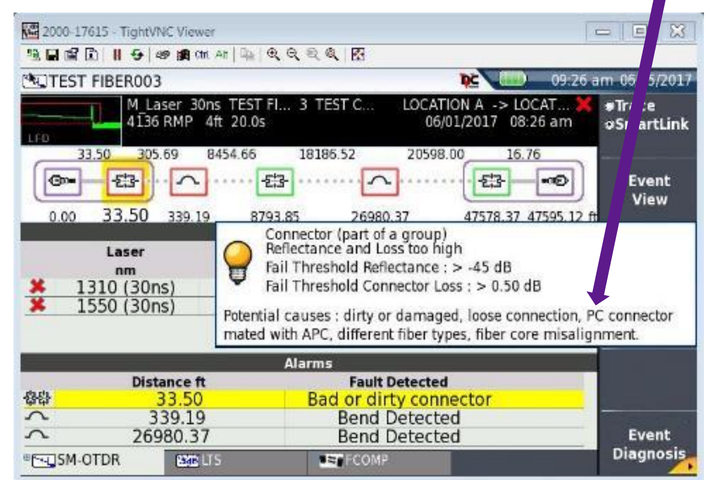



### Toggle between

### SmartLink View



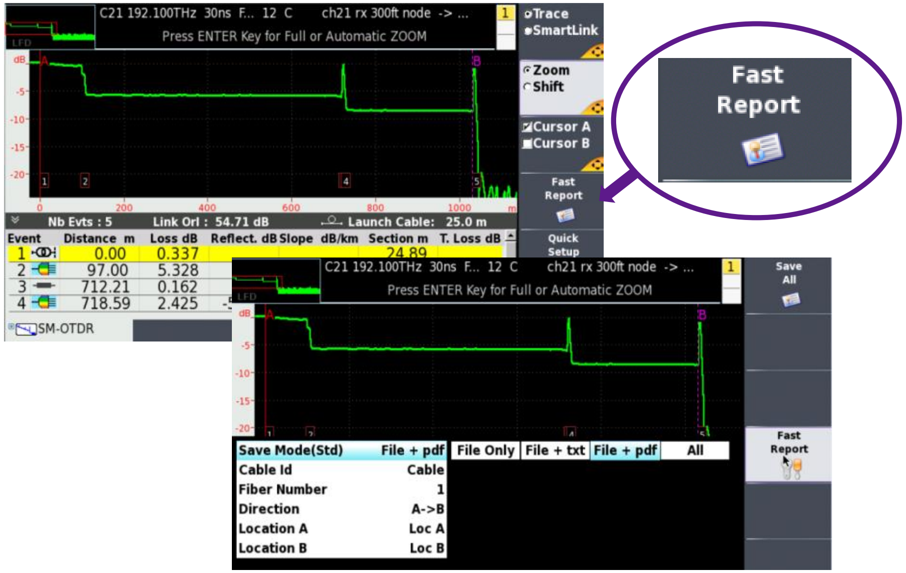



OTDR Made Easy!

# Documentation:
# Easy Results Reports Generation

## FastReport

1. Tap Fast Report icon from Results screen




2. Select the format (.sor, .pdf, .txt)

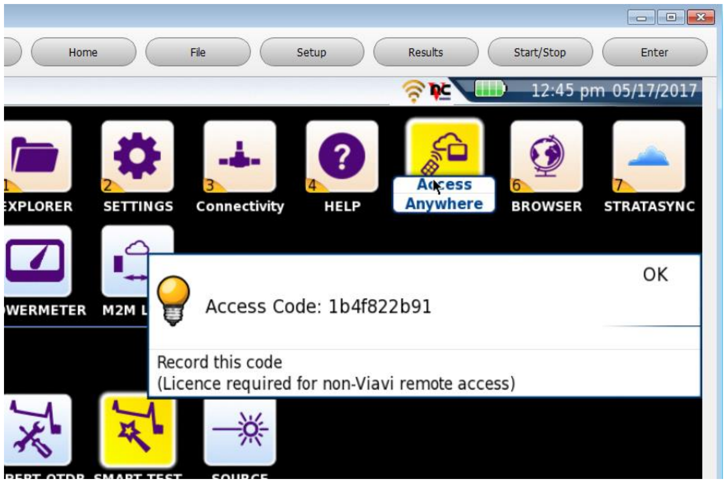

| Event | | Distance | Loss | Reflect. | Slope | Section | T. Loss |
|---|---|---|---|---|---|---|---|
| | | ft | dB | dB | dB/km | ft | dB |
| 1 | | 0.00 | 0.001 | -62.03 | | 0.00 | 0.000 |
| 2 | | 23.03 | 2.787 | -65.20 | | 23.03 | 0.001 |
| 3 | | 159.13 | 2.203 | -66.39 | | 136.10 | 2.799 |

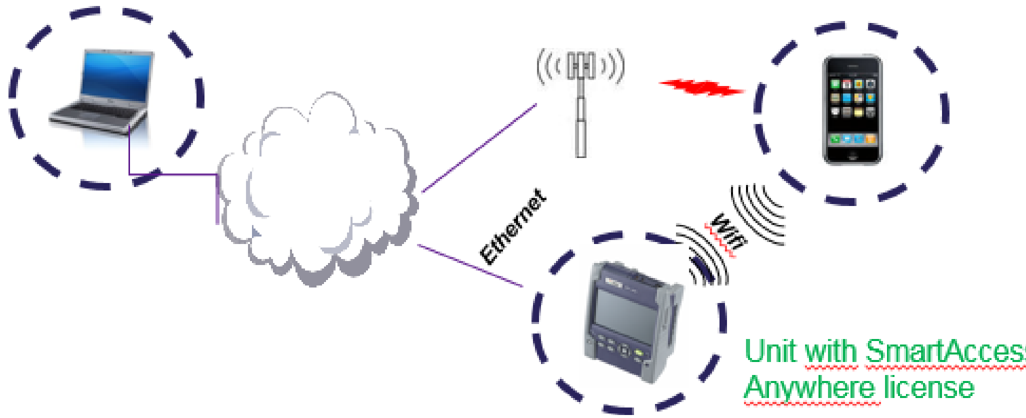
3. Results Report automatically generated

# Remote Viewing/Control

## Smart Access Anywhere (SAA)

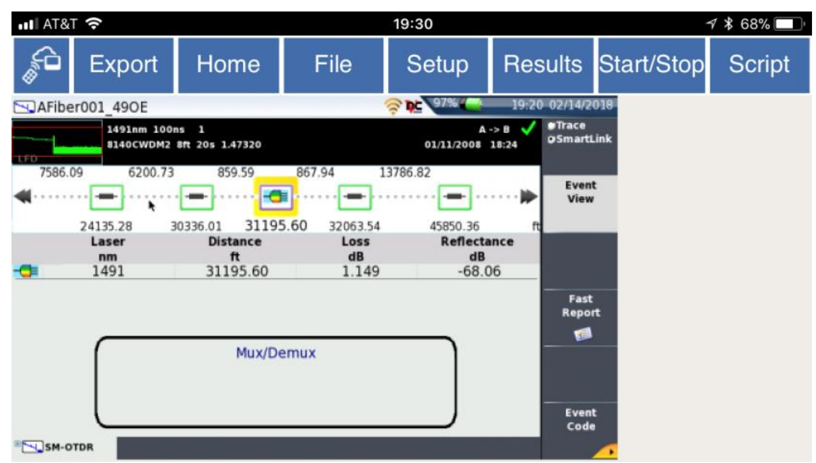
From the T-BERD:




From smartphone/tablet:



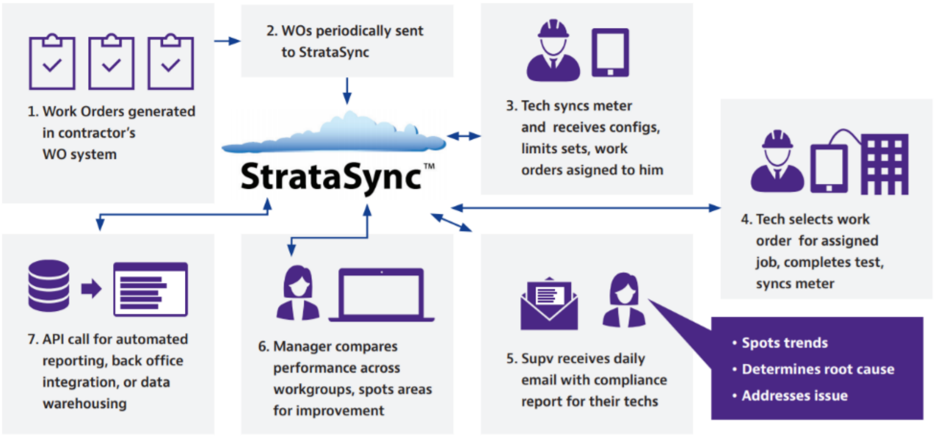


OTDR Made Easy!

# Workflow Efficiency

## StrataSync

- CWDM, DWDM, Fiber Deep, DAA
- FTTH, PON, EPON, RFoG
- Commercial/Business Services




Key Features

- Cloud-enabled architecture provides secure, easy network access from anywhere
- Complete asset management also tracks non-VIAVI instruments
- Automation simplifies update of instrument firmware, options, and configuration files
- No charge for StrataSync Core functionality

Applications

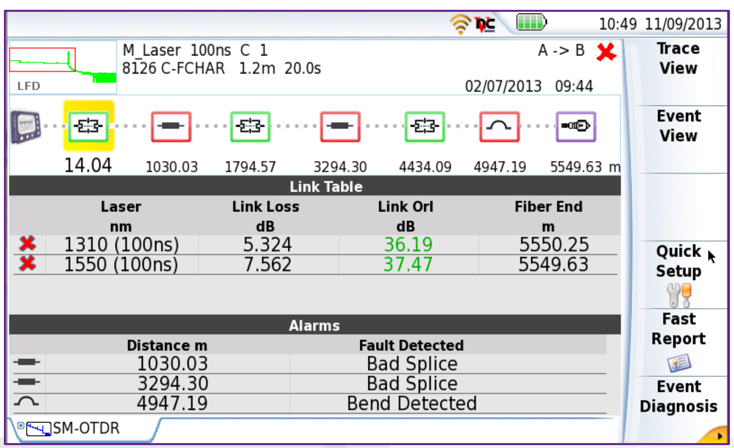
- Instant test data transfer for invoicing
- Centralized management of field instrument software, configuration, and test data
- Floating SW license and option management
- Self admin of instruments (Tech Portal)
- Tech performance tracking

# Selecting an OTDR

- Fiber type- SM or MM
- Wavelength(s) needed
- Dynamic Range (max length)
- Dead zones
- Connector Type (UPC or APC)
  - SC, LC, ST, FC,….
- Form Factor
- Options (VFL, PM, Lightsource,…)
- Ease of Use/ Automation
- Quality
- Training/Support
- Cost

**4100 Series Modules**




OTDR Modules (typical at 25°C)

| | Central Wavelength[5] | RMS Dynamic Range[6] | Event Dead Zone[7] | Attenuation Dead Zone[8] |
|---|---|---|---|---|
| MM | 850/1300±30 nm | 26/24 dB | 0.8 m | 4 m |
| Quad | 850/1300 ± 30 nm<br>1310/1550 ±20 nm | 26/24 dB<br>37/35 dB | 0.8 m<br>0.9 m | 4 m |
| LA | 1310/1550/1650 ±20 nm | 35/33/30 dB | 1.5 m | 6 m |
| MA2 | 1310 ±20 nm<br>1550 ±20 nm<br>1625 ±10 nm | 40 dB<br>40 dB[9]<br>38 dB | 0.7 m | 3 m |
| MA3 | 1310 ±20 nm<br>1550 ±20 nm<br>1625 ±10 nm<br>1650 +10/–5 nm | 43 dB<br>41 dB<br>41 dB<br>41 dB | 0.7 m | 3 m |
| MP2 | 1310 ±20 nm<br>1550 ±20 nm<br>1625 ±10 nm<br>1650 ±10 nm | 45 dB<br>43 dB<br>43 dB<br>42 dB | 0.65 m | 2.5 m |

**SmartOTDR**

Non-modular

**T-BERD 2000**

One-slot handheld modular platform for fiber network testing

**T-BERD 4000**

Two-slot handheld modular platform for fiber/copper and multiple services testing

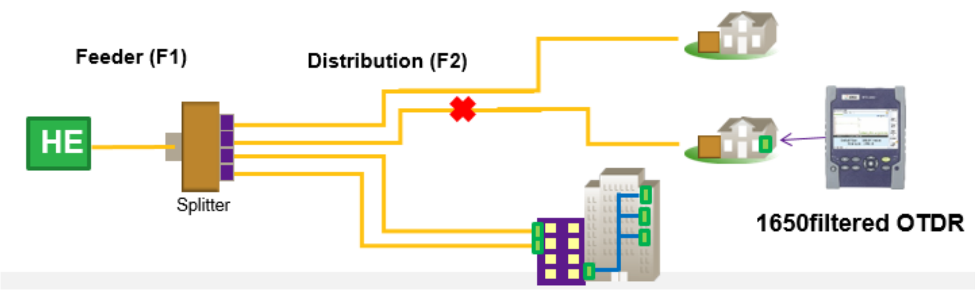
**T-BERD 5800**

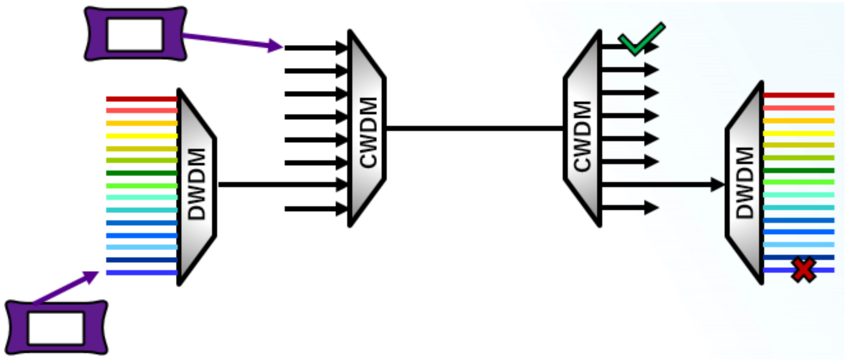
Platform compatibility

# PON & xWDM OTDR Testing

# Certifying & Troubleshooting the Fiber

**Selecting the right OTDR for the job**




## "PON Optimized" OTDR

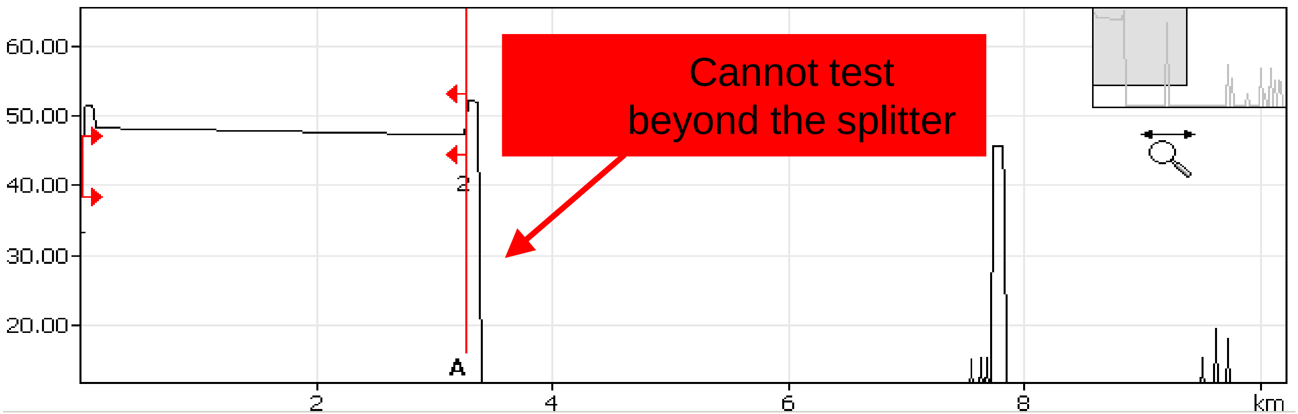
- Able to test thru splitters (30dB minimum)
- Short Dead Zones (id closely spaced events)
- Recovery (must be able to see after the splitter- a high loss event)
- Automatic Splitter ID (vs calling it fiber end)
- 1650nm Filtered for live network troubleshooting

## WDM OTDR

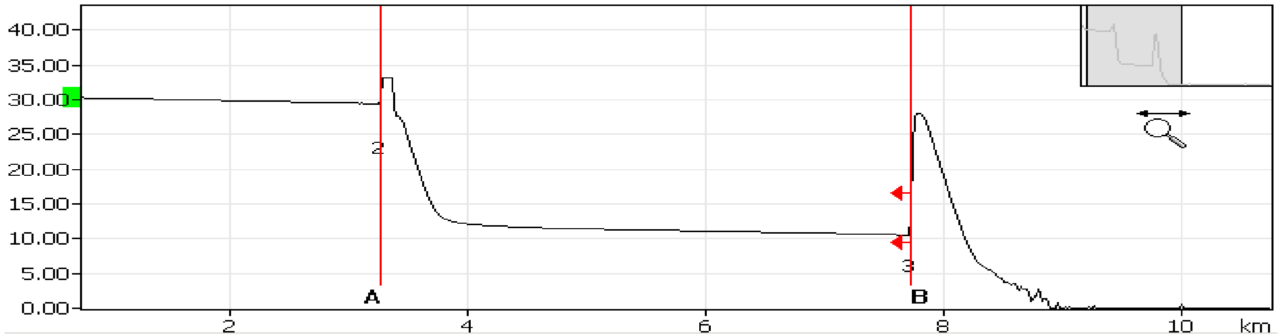
- Uses narrow-band lasers that can be set to a specific CWDM or DWDM wavelength/Channel to allow **testing thru a Mux/Demux**
- Able to troubleshoot a specific wavelength/channel **while live traffic is running** on other wavelengths/channels

# OTDRs: Are not all created equal!

**Standard OTDR:**




**PON-optimized OTDR:**



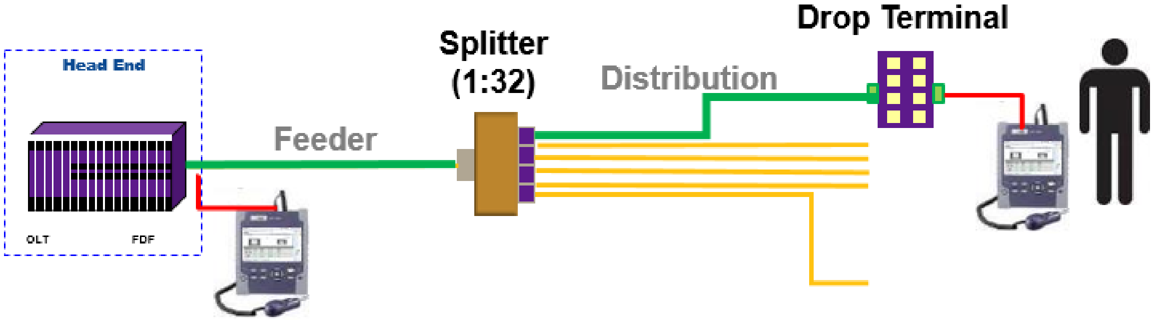
# Is 1490nm needed for testing?

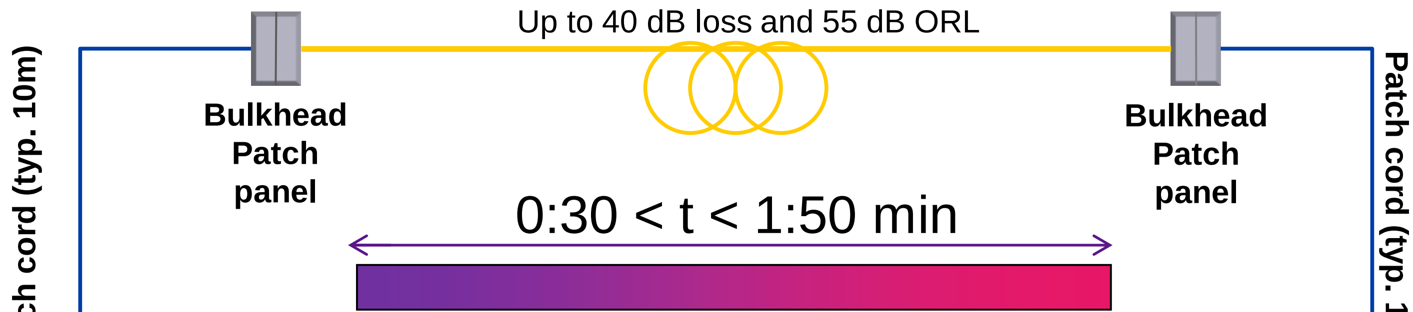
- Recommended for IL/ORL but not essential.
  - Some Service providers take IL values 1550nm for 1490nm (loss in 1490 is typically < 0.2dB higher)

- Absolutely not needed for OTDR.
  - Although there are OTDRs with 1490nm, this laser is more expensive and…
    - Optical budget is equivalent to 1550nm
    - 1490nm is not bend sensitive, so can´t be detected so its better to user 1550nm
    - **OTDR trace with 1490nm does NOT provide additional data or parameters to the ones measured with 1310/1550nm**

# Construction Acceptance Testing

## Automated IL,ORL, OTDR





Location A

When used in pair, FiberComplete allows automatic testing of:

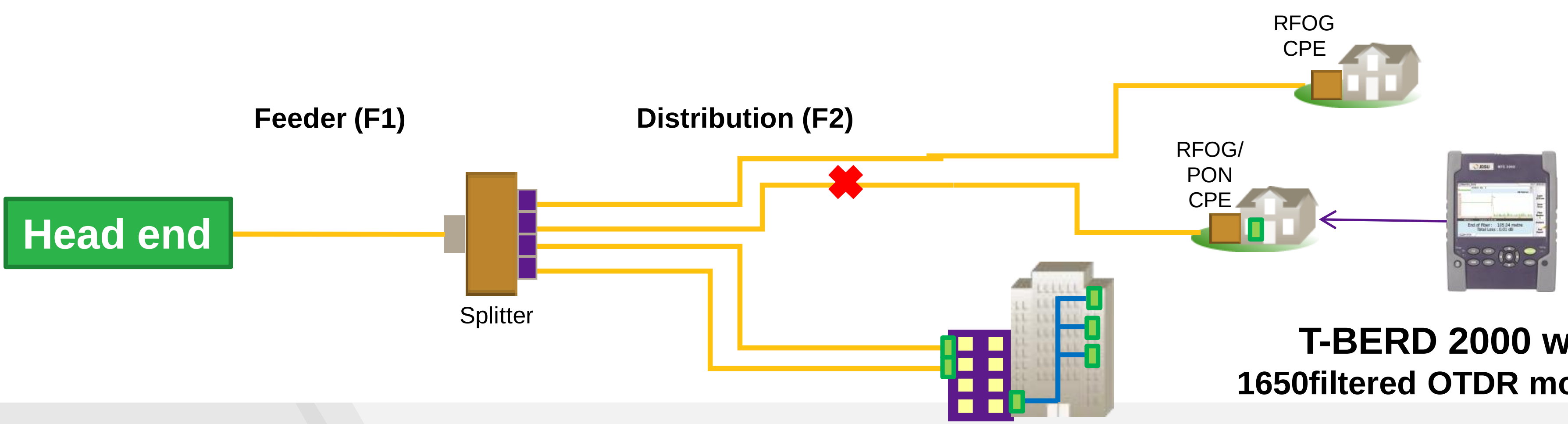
- Bidirectional insertion loss
- Bidirectional optical return loss
- Distance
- Bidirectional OTDR


Location B

# OTDRing on a Live FTTx/PON Network

- If entire Feeder (F1) fiber down
  - standard OTDR testing applies
- If one customer or partial splitter is effected….
  1. If connectorized splitter
     - Isolate F2 from F1 at splitter & OTDR
  2. If spliced splitters, multiple splitters (cascade) or need/desire to take OTDR trace without disconnecting fiber from network
     - shoot upstream (from CPE towards splitter) using a **filtered 1650nm* OTDR** (allows OTDR testing without taking other customers down)

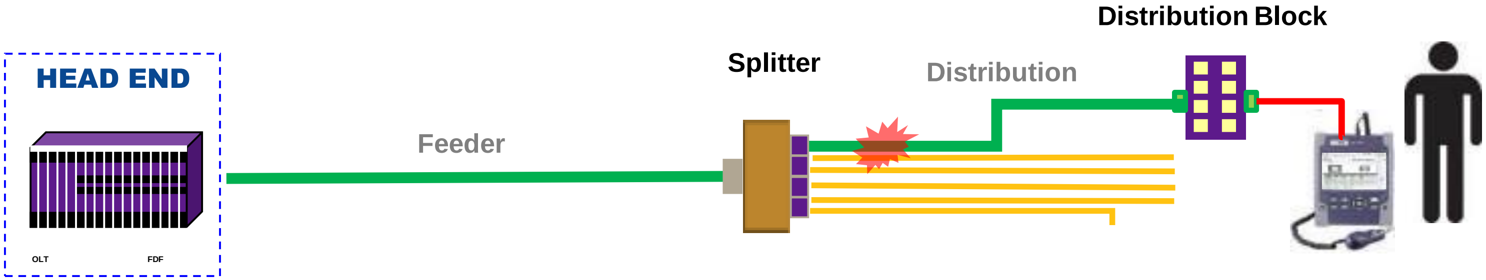
- *1625nm filtered OTDR modules are available (traditionally used for PON) but is to close to the 1610nm upstream for use in RFOG. 1650nm filtered can be used for BOTH RFOG and PON troubleshooting




**T-BERD 2000 w/ 1650filtered OTDR module**

# FTTx/PON (Splitter) Networks

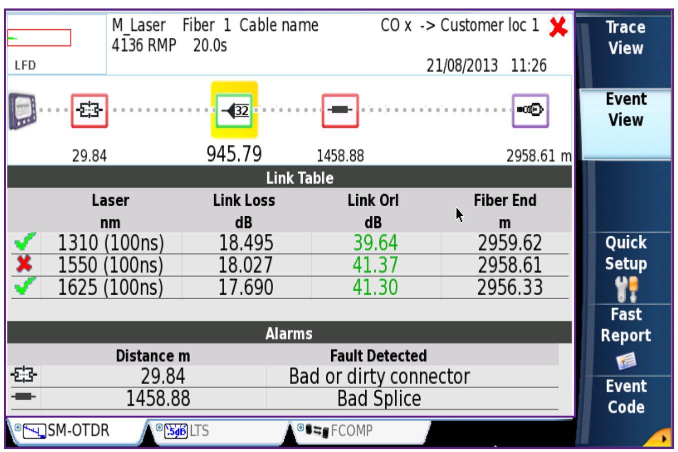
Splitters pass ANY wavelength but you take a dB hit.




## FTTH-SLM:

FTTH-SLM

- Tailored to PON testing through splitters (from ONT to OLT)
- Multiple pulses smart acquisition to discover any FTTH topologies and measure all their sections
- Automatic identification of PON splitter types
- Pass/Fail thresholds per PON standards




## Testing to the splitter

**E4126LA Module**
1310/1550nm (35/33 dB)

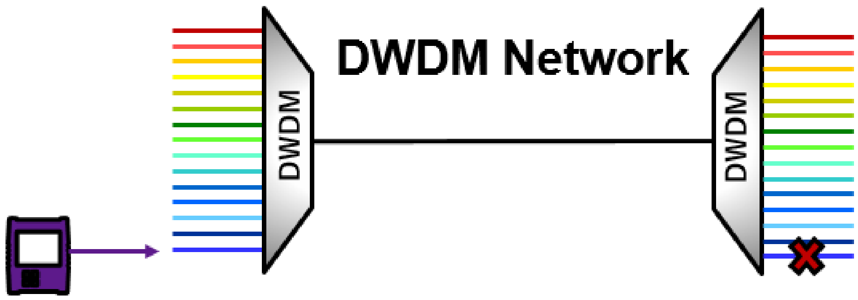
## Testing thru the splitter

**E4118FMA365-APC Module**
1650nm Filtered (41 dB)
(testing on live network)

**E4138FMA365-APC**
1310/1550nm + 1650nm Filtered (43/41/41 dB)
(testing on live network)

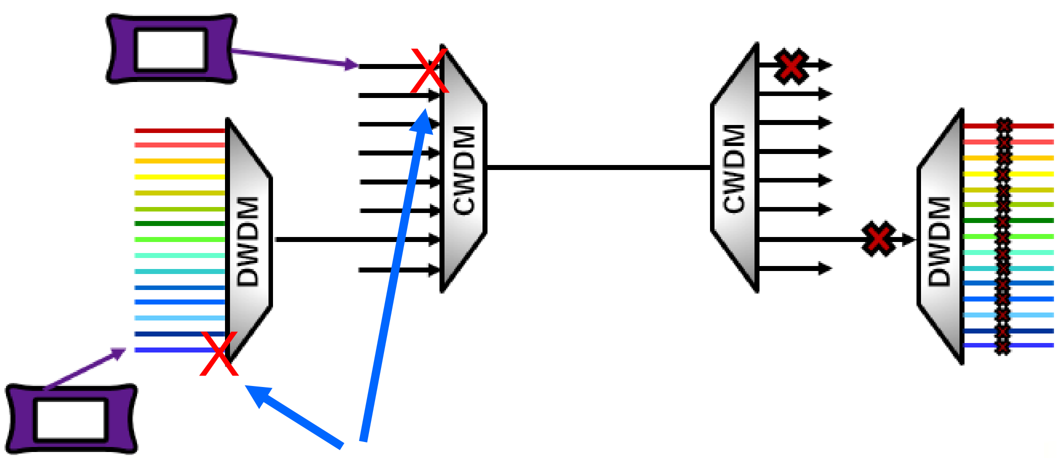
# WDM Mux/Filter Networks Require WDM OTDRs

- Requires specific wavelength OTDR in order to pass thru Mux/Filter (CWDM and DWDM OTDRs)





## Hybrid DWDM/CWDM Networks




A traditional wideband OTDR signal would be blocked here

**DWDM OTDR Module**

C-Band tunable 1528.77-1563.86 nm ITU Channels (C62 to C12)

**CWDM10U OTDR Module**

10 CWDM wavelengths from 1431 to 1611nm

T-BERD 2000

T-BERD 4000

T-BERD 5800

# Understanding OTDR Specs- Buyer Beware

## Does the DWDM OTDR cover your network needs?

| OTDR and Light Source | |
|---|---|
| Wavelengths[1] | C-band tuning – C62 to C12 (1527.99nm – 1567.95nm) @ 100GHz |
| Channel spacing | 50/100/200GHz |
| Pulsewidth | 10 ns to 20 µs |
| Dynamic range[2] | 44 dB |
| Event dead zone[3] | 1.5 m |
| Attenuation dead zone[4] | 4 m |
| Light source Wavelengths | Same as OTDR |
| Light Source Output Power | 0 dBm |
| Light Source Operating Modes[5] | CW, 270 Hz, 330 Hz, 1 kHz, 2 kHz |
| Automatic traffic detection | Yes |
| In-service testing | Yes |

Channel #'s being deployed today (and tomorrow) covered?

Channel spacing covered?

Dynamic Range good? (higher will shoot farther)

Dead Zones good?

Can it double as a Light Source?

Can it be used on a live network?

# Typical Values

- **Attenuation Loss (dB/km)**
  - 1310nm (single mode) 0.35 dB/km
  - 1550nm (single mode) 0.2 dB/km
  - 1625nm (single mode) 0.25 dB/km

- **Event Loss (dB)**
  - Fusion splice 0.05 dB
  - Mechanical splice 0.3-0.5 dB
  - Connector pair (FOTP-34) 0.3-0.5 dB

- **Reflectance (dB)**
  - PC connector -55 dB
  - APC connector up to -65 dB
  - Remember -50dB is better (smaller spike) than -20 dB (larger spike)

- **ORL (dB)**
  - 20's are bad
  - >30dB ok,
  - often >40 to 45dB

- **Macrobend**
  - Varies w/ degree of bend and wavelength
  - Higher wavelengths are more sensitive to macrobends (1550nm more susceptible to bends than 1310nm)
  - OTDR must shoot 2 wavelengths (typically 1310/1550) to detect macrobends

- **Muxes**
  - Typical value 2.5-3.5 dB
  - 40 channel has higher loss than 8 channel

- **Typical Splitter Losses**

| Split | Typical Insertion Loss |
| --- | --- |
| **1 : 2** | **3-4 dB** |
| **1 : 4** | **8-9 dB** |
| **1 : 8** | **10-11 dB** |
| **1 : 16** | **12-13 dB** |
| **1 : 32** | **16-17 dB** |

* Values listed above are approximate- for precise values you must check the spec sheets for the actual equipment (fiber, muxes, splitters, ….) being deployed in your specific network

# Live OTDR Demo

# Live Demo

- **SmartTest**
  - Setup (4 menu items to select)
    - Run Launch Cable Measurement
  - Run Test
  - Good/Bad connection bar
  - Walk thru trace results
  - **SLM results**
  - **Save Report (show pdf)**

- **FTTx SLM**
  - **Setup specific for PON**
    - Acquisition- ONT/OLT, Discover mode
    - Alarms- PON standards, set splitter thresholds
  - **Run Test**
    - **OPTIPULSES**

- **Expert OTDR**
  - Setup Menus quick run thru
  - Acquistion
    - Auto vs Manual
    - Manually adjust pulse width
    - Enter Launch Cable distance
  - Analysis
    - IOR
  - Run SLM and then Change Event ID

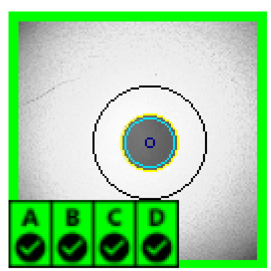
- **Real Time Mode**
  - Id the fiber
  - Localize the fault
  - Can remote into OTDR to do this!

- **Launch Cable vs no Launch Cable**

Show **SmartTest on DWDM module**
- Select a Channel and go

# OTDR Testing Tips

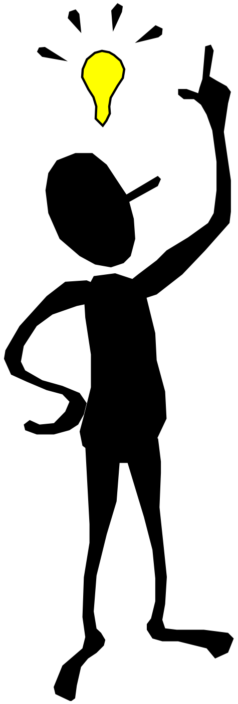
- Step 1 is Inspect Before You Connect (IBYC):
  - Eliminate the #1 cause of fiber issues- dirty fiber connections
  - Always inspect BOTH sides of the connection
  - OTDR ports are also a fiber connection
  - Use the correct inspection tips for clear viewing of fiber
  - Never connect UPC (blue) to APC (green)
  - Utilize built in pass/fail software for objective inspection
  - Carry a plastic bulkhead sleeve to speed testing (no tip swaps)


**Helpful Tip:**
Test faster by using plastic bulkhead sleeve to allow testing of patchcord side using bulkhead tip (avoid tip swapping delays)

# OTDR Testing Tips

- Always use a Launch Cable (20m)



- Enter Launch Cable length into OTDR settings so it subtracts out the Launch Cable from the results
- Carry Hybrid Launch cables to cover different fiber connections (SC/APC to SC/APC, SC/APC to LC/UPC,…)
- Keep Launch Cable attached to OTDR port (after proper cleaning) after testing is completed
  - Saves time for next use
  - Helps preserve OTDR port

# Setting Up The OTDR

- OTDR Setup Tips

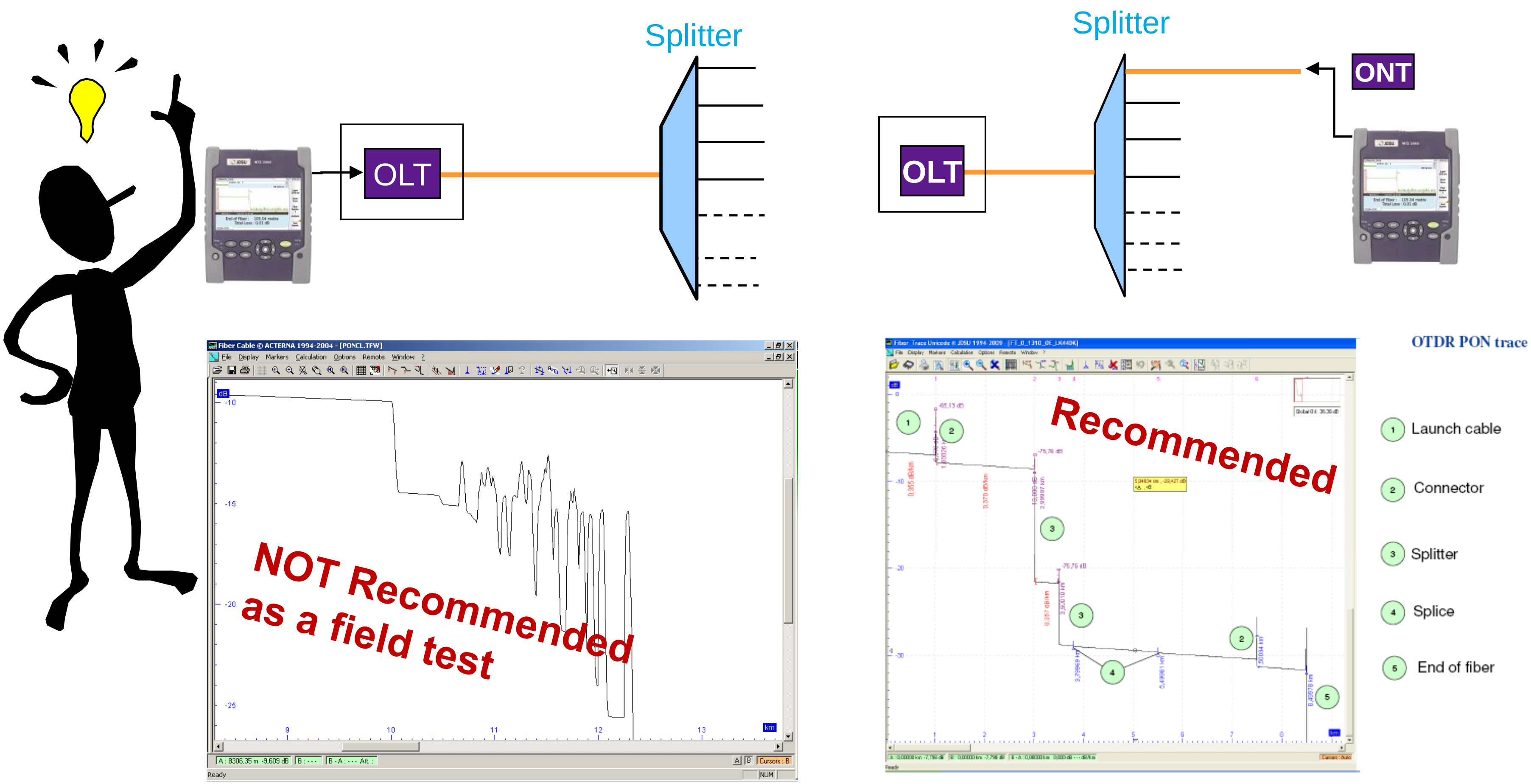
- Ensure clean connectors for maximum dynamic range and testing range


- Start with the “Auto test” settings and “tweak” parameters from there.

- Increase dynamic range by increasing number of averages or increasing the pulsewidth.
- Begin with low resolution and increase resolution as needed.

# OTDR Testing Tips

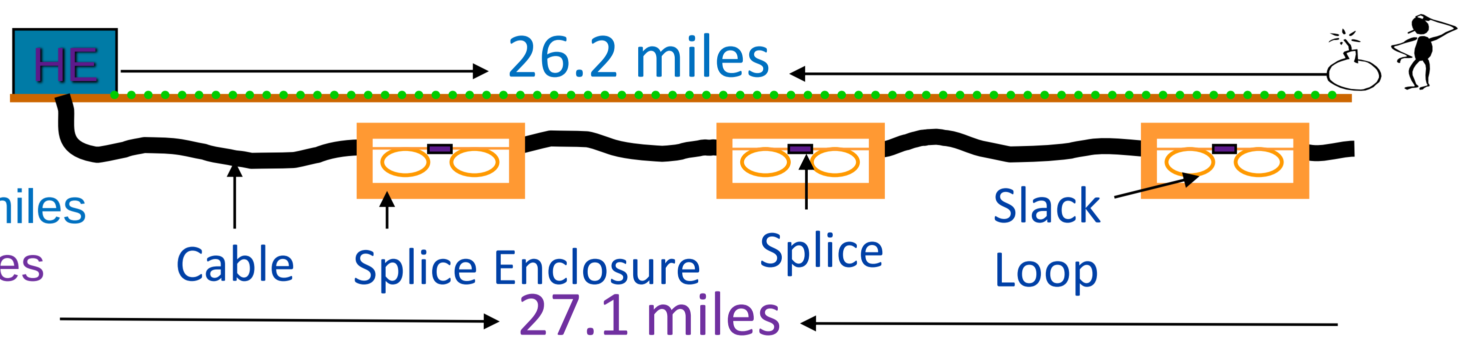
- For FTTx/PON take OTDR shot from ONT (field) side of splitter:



# OTDR Testing Tips

- For accurate **distance** measurements:
  - Make the measurement from the closest access point on the fiber
  - Lower the pulse width for increased resolution of up close events
  - Apply correction factor (OTDR distance vs physical distance)
    - Takes Helix factor, slack loops,… into account
    - Shortest distance: Physical length, along the ground
    - Next longest distance: Cable sheath length
    - Longest distance: Optical fiber length
    - If you don't know the correction factor than talk to the fiber expert in your area (what do they use)
  - Measure to the break from both ends of the fiber to ensure there is only one fault.
  - If span is all the same fiber (a rarity) enter correct Index of Refraction (IOR) into OTDR settings (IOR provided by fiber manufacturer)

Physical = 26.2 miles
OTDR = 27.1 miles

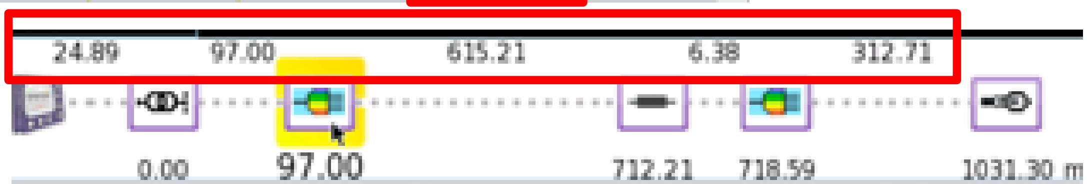


# OTDR Testing Tips

- For locating hard to find events:
  - Real Time mode is your friend
    - Place bend on fiber to:
      - confirm you have the correct fiber
      - Localize to the event (is your bend before our after the event)
    - Use SmartAccess Anywhere
      - Allows for remote viewing/control of OTDR from smartphone/tablet/laptop
      - 1 tech troubleshooting
  - Use section distance from a known event/location

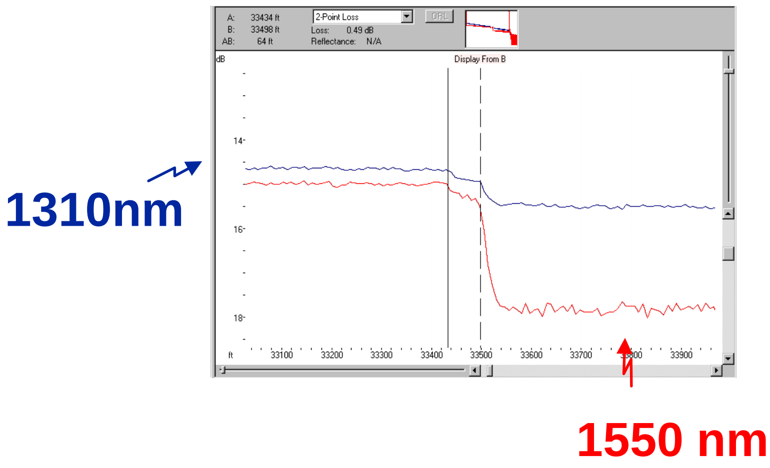
Nb Evts : 4 Link Orl : 46.57 dB Launch Cable: 66.0 ft

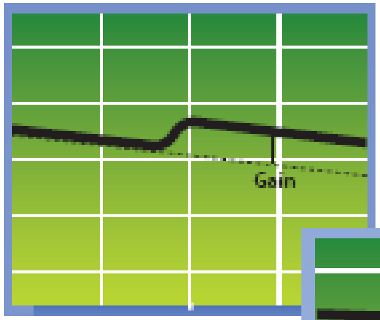
| Event | Distance ft | Loss dB | Reflect. dB | Slope dB/km | Section ft | T. Loss dB |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.032 | | | 67.00 | |
| 2 | 29.31 | 2.277 | -66.15 | | 29.31 | 0.044 |
| 3 | 2072.69 | 2.684 | -53.97 | 0.160 | 2043.38 | 2.421 |
| 4 | 3088.11 | | -43.83 | 0.134 | 1015.41 | 5.147 |



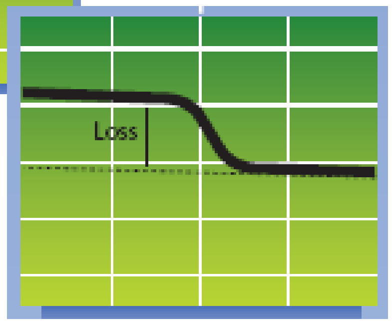
# OTDR Testing Tips

- For accurate **loss** measurements:
  - Test with the same wavelength at which the system will operate.
  - Remember- Macrobend detection requires you to run 2 wavelengths (typically 1310/1550)
  - Use bi-directional averaging for most accurate splice loss results (gainer vs excessive loss scenario)




Direction A to B




Direction B to A

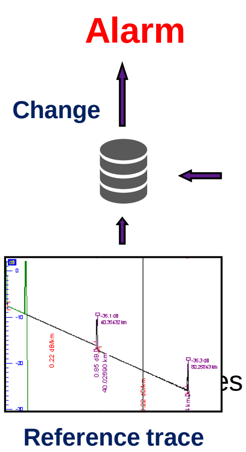
# Two Fiber Monitoring Coverage Models

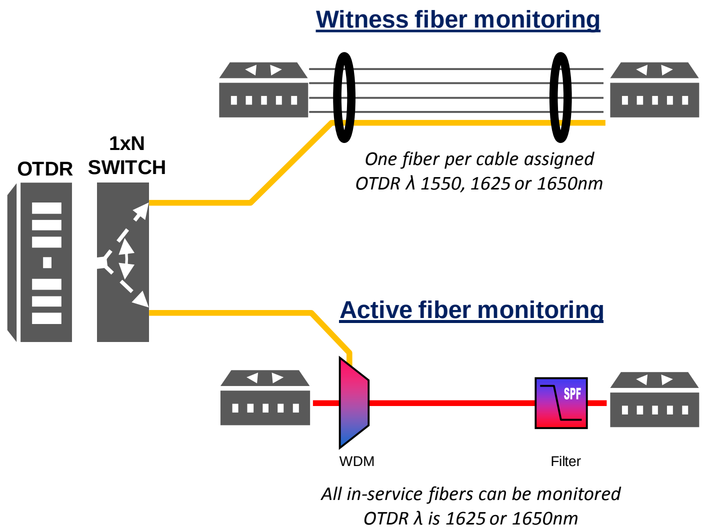
## Witness Fiber Monitoring

- Visibility to 80% of issues
- Monitor sample fibers - All fibers in cable mostly experience identical damage events
- Ideal for bundles with one path
- Lowers cost of monitoring
- Witness fiber can be dark or lit

## Direct Fiber Monitoring

- Visibility to 100% of issues
- Monitor every fiber to detect individual fiber specific issues
- Required to see fiber tapping or to verify construction and service activation
- May be necessary if highly dense, highly split architecture with varying fiber paths

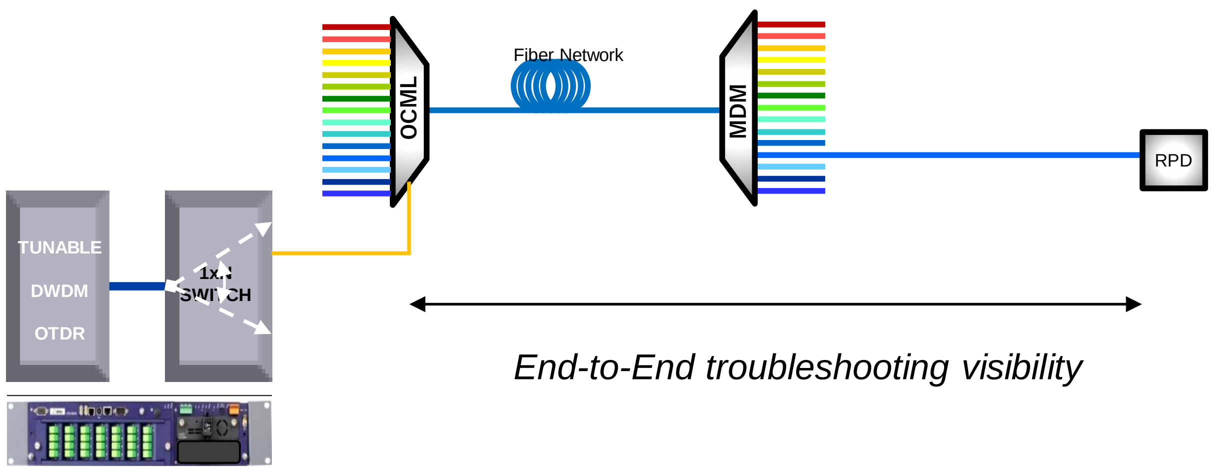


# New In-Service Monitoring Solution based on Tunable DWDM OTDR

***Troubleshooting application***

- Lock DWDM OTDR to channel in trouble.
- Test and locate problem up to end point (RPD, Node, cell tower…)



# Questions?