# From Glitches to Glory:

# OTDR Problem-Solving Strategies

Apr-2024

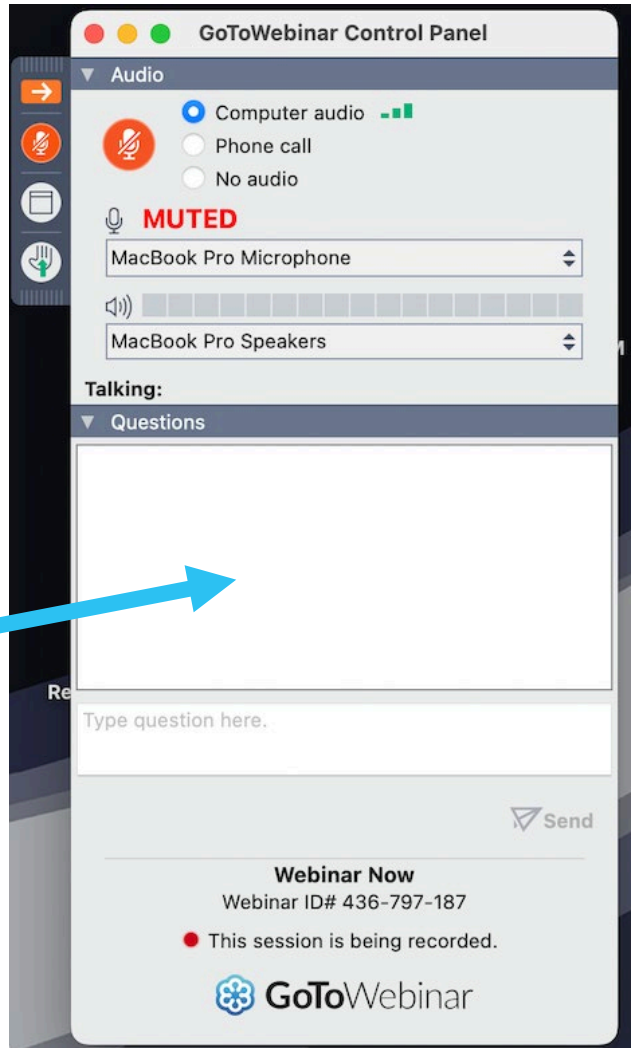
# Before we Begin . . .

- **Webinar Replay – PT1**
  - “***Fiber Optics Demystified: OTDR Fundamentals***”
  - https://learn.aflglobal.com

- Slides available under the “**Handouts**” tab on the control panel

- If you have a question, please submit it in the “Questions” box in your control panel

- Today's webinar is being **recorded** and will be available after the forum is over.



# Overcoming OTDR Test Issues – Presentation Outline

- **Common OTDR Test Setup Errors**
  - Distance Range Too Long or Too Short
    - Ghosts
    - Echoes
  - Pulse width Too Long or Too Short
  - Averaging Time Too Short or Too Long
  - Misconfigured Launch or Tail Cords
  - Incorrect Index of Refraction
  - Incorrect Pass/Fail Limits
  - Incorrect Event Detection Thresholds
  - Multi-pulse SmartAuto vs. Single Pulse Expert Mode
- **Common Network Issues**
  - Poor Launch Quality
  - Dirty, Damaged or Mismatched Connectors
  - Poor Splices & Macro-bends
  - Misinterpreted Events
- **Common Reporting Errors**
  - Auto-save
  - Naming
  - Adding & correcting events
  - Deleting false events

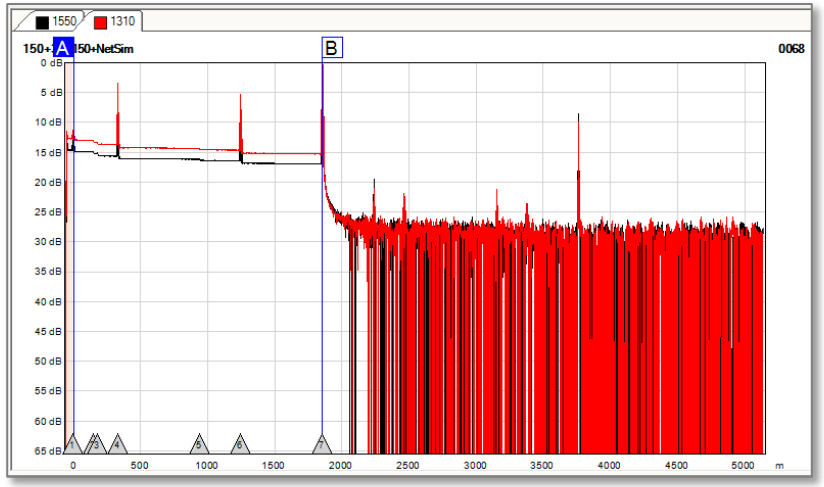
# Common OTDR Setup Errors

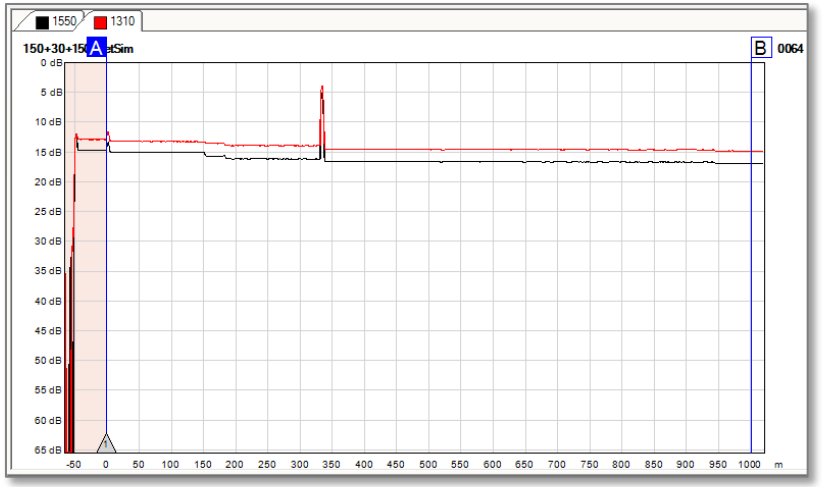
# Distance Range Too Long or Too Short

## Symptoms / Root Cause

- Range too Long: Fiber Portion of the Trace compressed; Most of the trace is just noise
- Range too Short:  Backscatter continues to end of the trace; No end found

**Range Too Long**




**Range Too Short (End not found)**

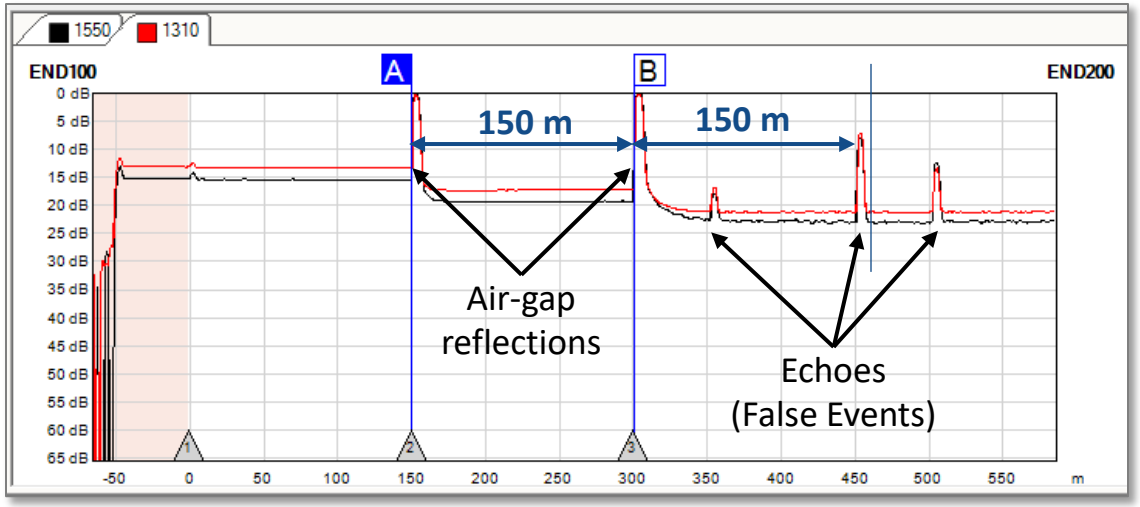
## Corrective Actions

- Distance Range setting should be at least 20% longer than tested network
- If using Launch and/or Tail Cords, include length of each when estimating expected fiber length
- Range too Long:  Reduce the Test Distance Range setting
- Range too Short:  Increase the Test Distance Range setting

# Echo Events (Re-reflections in network-under-test)

## Symptoms / Root Cause

- Reflective events shown where none are expected
- May be fiber break, or an echo (false event) due to re-reflection from other strong reflections
  - Fiber breaks will have loss at the reflection; Echoes typically have no loss
  - Strong reflections may re-reflect off OTDR internal optics creating echo at 2x distance to initial reflection
  - Echoes may occur following 2 large reflections; Spacing to echo same as spacing between large reflections




## Corrective Action

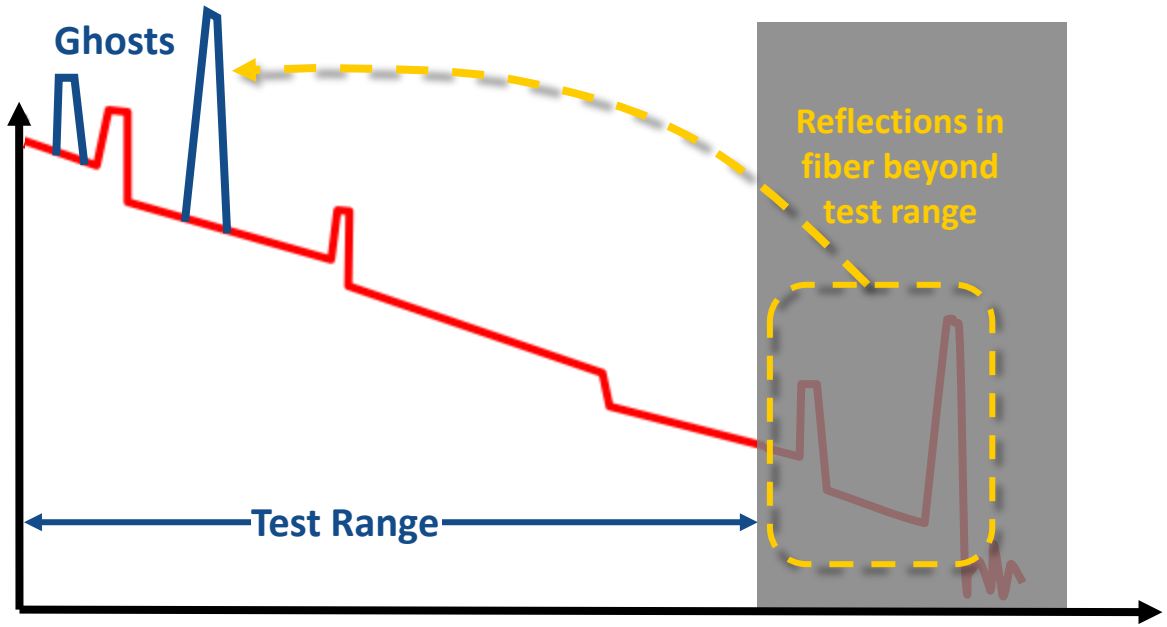
- Ignore echoes beyond end of fiber
- Automatic event analysis may report echoes as ghosts or may recognize as non-event & ignore
- Identify echoes based on spacing after large reflections

# Ghost Events (Range too short; Events aliased into Trace)

## Symptoms / Root Cause

- Test Range shorter than fiber; OTDR transmits 2nd pulse before first pulse has exited fiber
- Reflections from fiber beyond the configured test range are “aliased” into displayed portion of fiber
- Aliased reflections appear as events where no event actually exists

If OTDR launches 2nd pulse before 1st pulse exits the fiber, reflections at the end of the fiber are aliased back into the start of the displayed trace creating “ghost” events.



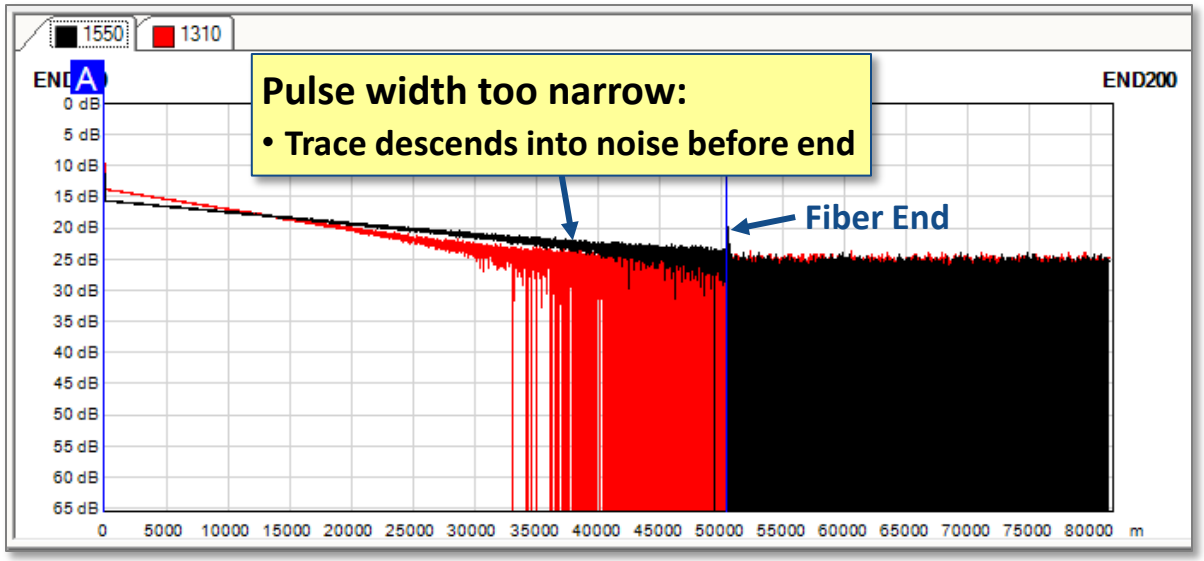

## Corrective Action

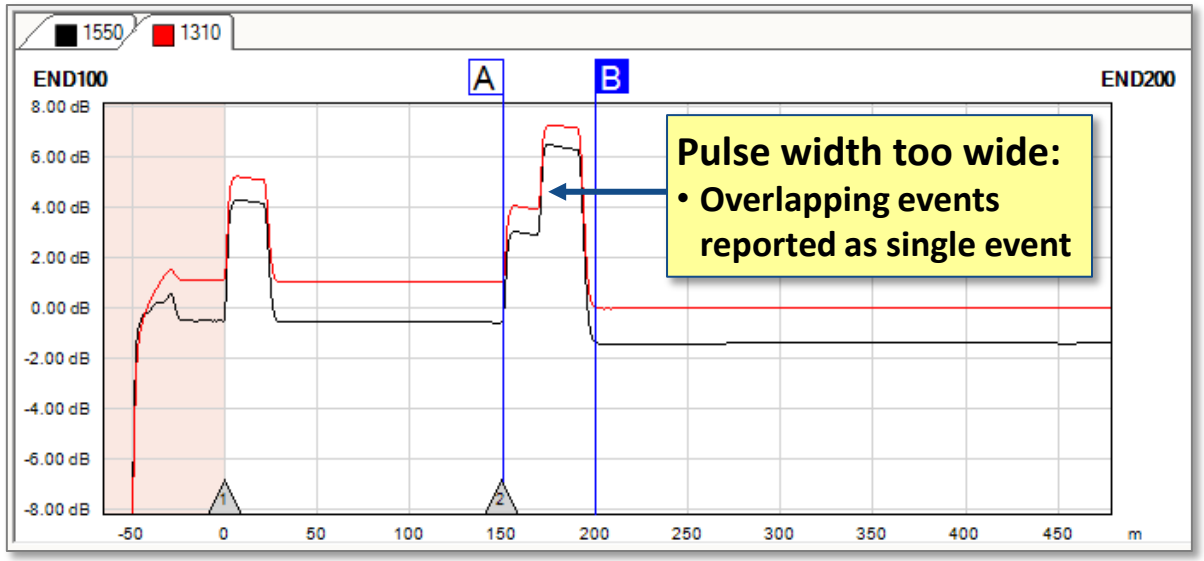
- Select an OTDR which auto-selects an appropriate pulse repetition rate even if short range selected
- If reflections appear at unexpected locations, do they disappear or move if longer range selected?
  - Ghosts will disappear or move if range is changed;  Echoes and real events will not

# Pulse Width Too Long or Too Short

## Symptoms / Root Cause

- Pulse Too Short:  Backscatter descends into noise before end;  Trace too noisy to detect small events
- Pulse Too Long:  Events overlap and cannot be independently detected and measured



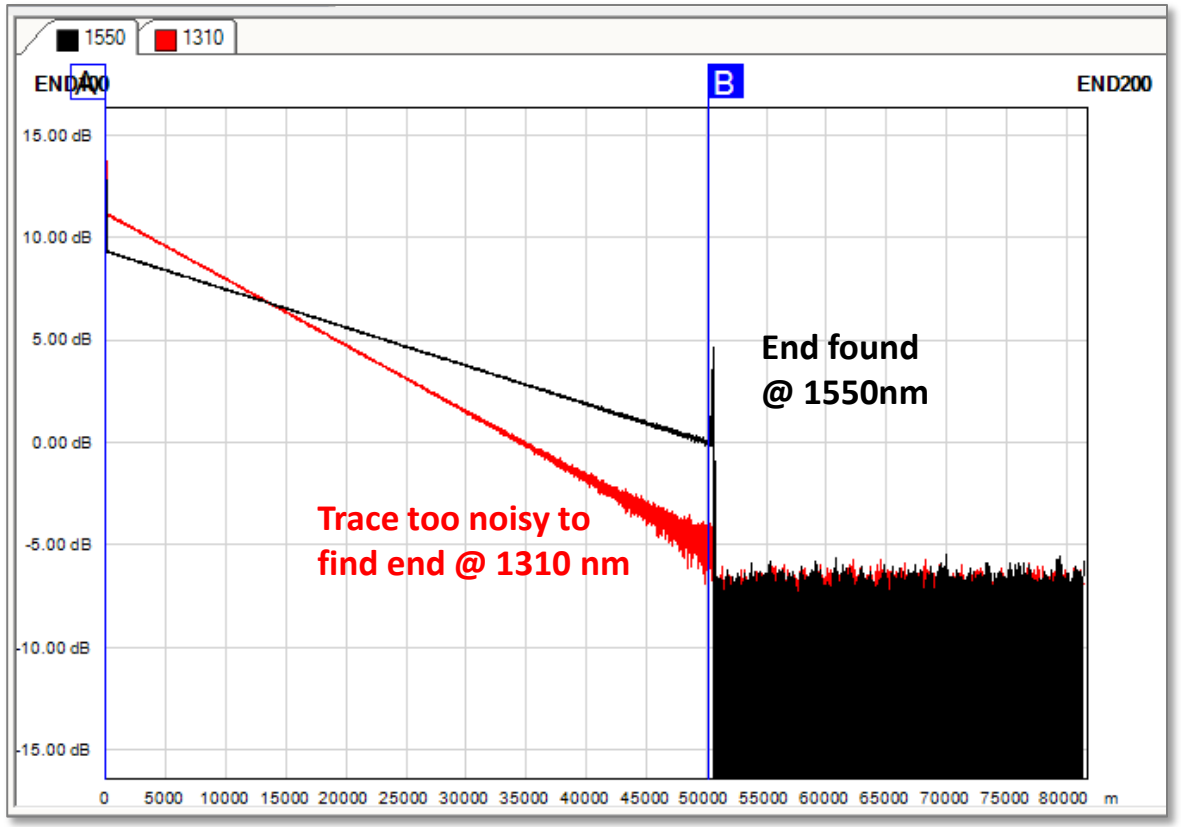

## Corrective Actions

- Use Automatic test settings, preferably multi-pulse if available ☺
  - If multi-pulse test not available, may need to perform multiple tests with different pulse settings ☹ $
- Expert mode: Select longer pulse width if unable to reach end of fiber with current pulse width
- Expert mode: Select shorter pulse width to prevent closely-spaced events from overlapping

# Averaging Time Too Short

## Symptoms / Root Cause

- Trace descends into noise before end of fiber
- Trace too noisy to detect some events of interest



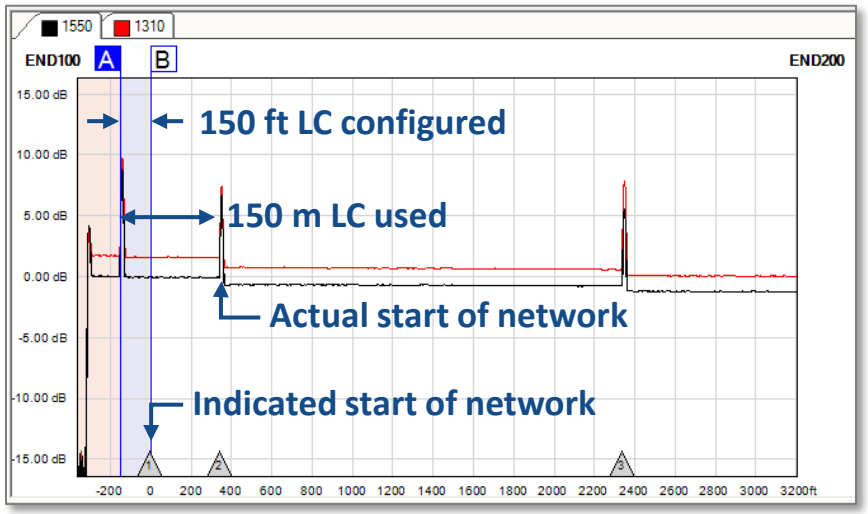

## Corrective Actions

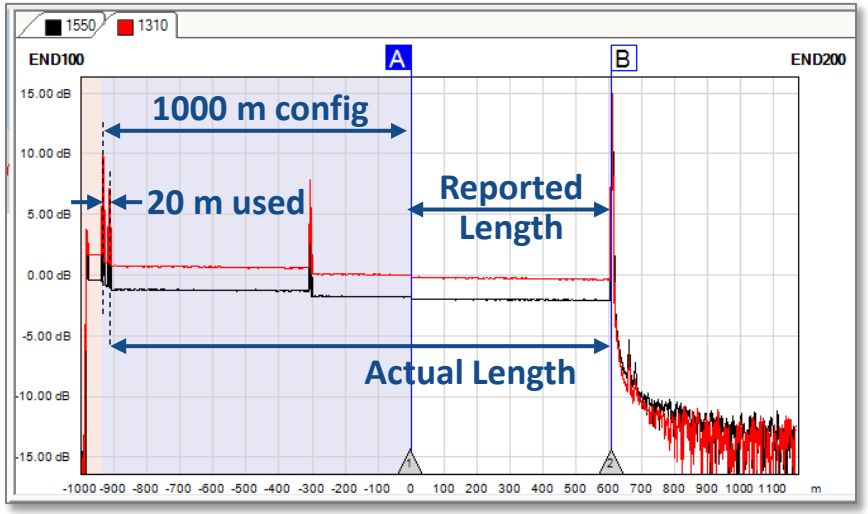
- Increase Averaging Time to reduce noise
- Law of diminishing returns applies (each doubling of Avg Time improves Dynamic Range by ~0.75 dB)
- Wider pulse width more effectively reduces noise, but results in longer dead zone after reflections

# Misconfigured Launch Cable (LC)

## Symptoms / Root Cause

- Actual launch cable length > configured launch cable length (or configured length = 0)
  - Fiber length appears too long; Known splices & connectors reported beyond known locations
- Actual launch cable length < configured launch cable length (or configured launch cable missing)
  - Fiber length appears too short; Network connection and nearby events appear to be inside the launch cable



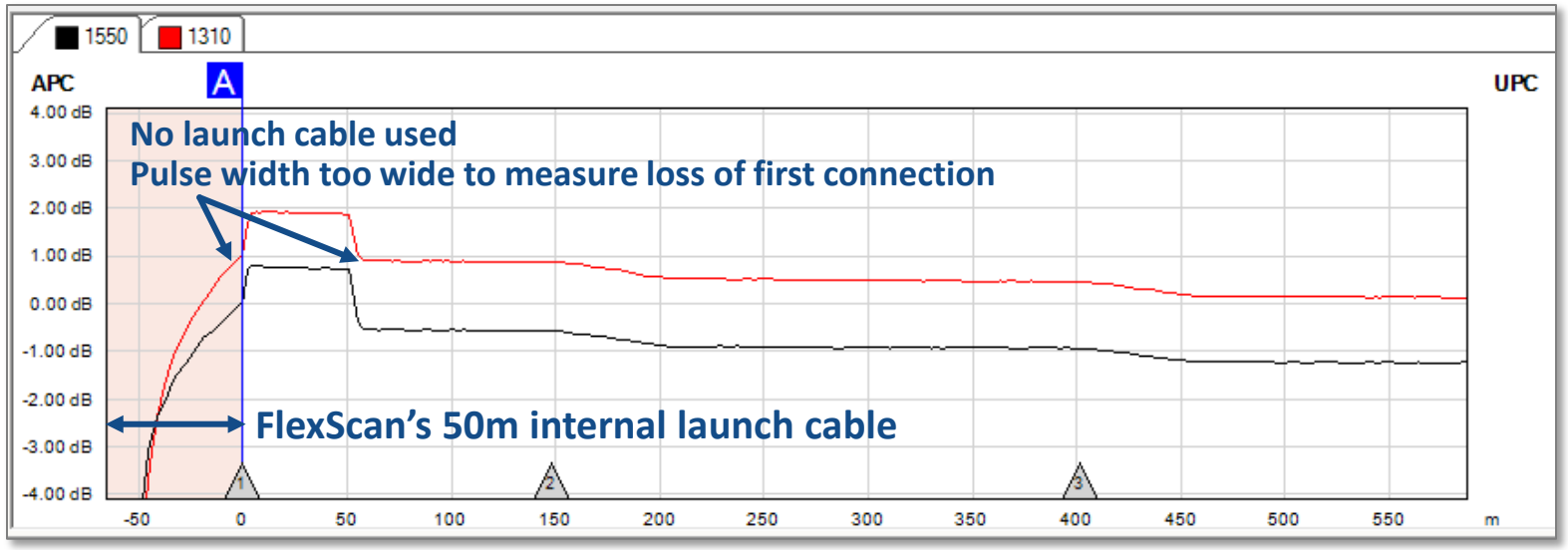

## Corrective Actions

- Use OTDR to measure launch cable length before connecting to network-under-test
- Verify OTDR's configured launch cable length matches actual launch cable length
- Correct mis-configured launch cable length in reporting software to avoid having to retest fibers

# Failed to Use Launch Cable or Launch Cable Too Short

## Symptoms / Root Cause

- Loss and reflectance of network start cannot be measured
- Connection to network-under-test in dead zone of OTDR connection
- Launch cable too short for selected pulse width



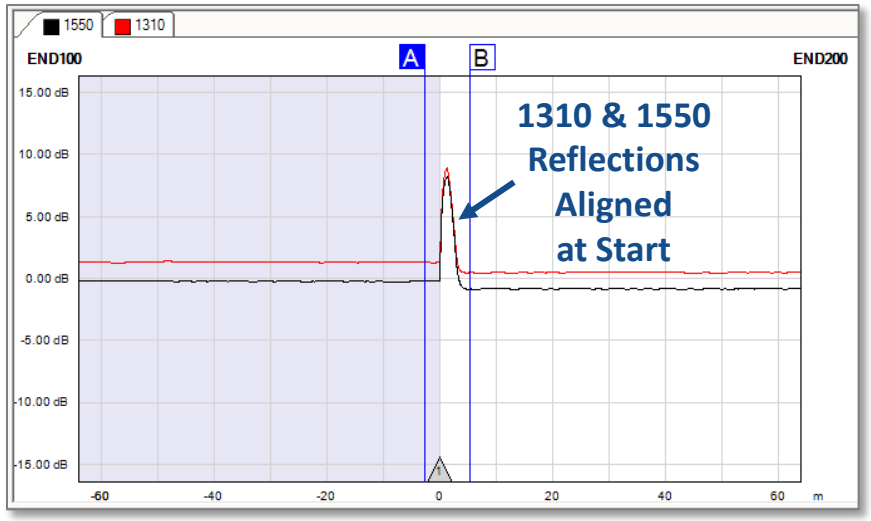

## Corrective Actions

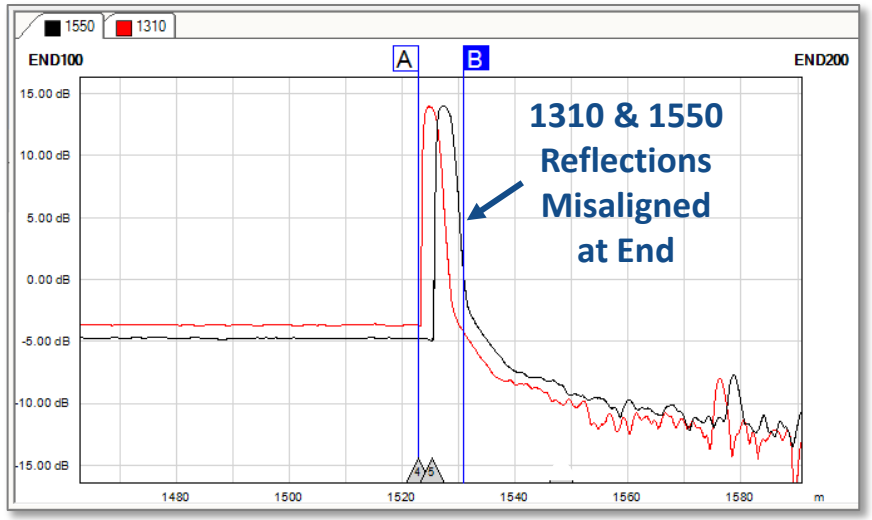
- Use launch cable which is longer than the pulse widths you expect to use
- ***Note***: Multi-pulse OTDRs always use short pulse widths at start of fiber, so shorter launch cable OK

# Incorrect Group Index of Refraction (GIR or IOR)

## Symptom / Root Cause

- Start event aligns at 1310 & 1550, but subsequent events and end are increasingly offset in distance
- IOR setting is wrong for one or both wavelengths
- OTDR uses IOR settings to convert round-trip time-of-flight into distance




## Corrective Actions

- Use default settings for known fiber types
- Review and correct IOR settings
- Reducing IOR lengthens distance reported for that λ

| Fiber Type | 1310 nm IOR | 1550 nm IOR |
|---|---|---|
| G.652.A/B/C/D (most common SMF) | 1.4677 | 1.4682 |
| G.655.C/D/E (1550 nm disp. comp.) | 1.4710 | 1.4690 |
| G.657.A1/A2 (G.652-compatible BIF) | 1.4676 | 1.4682 |
| G.657.B2/B3 (better BIF) | 1.4670 | 1.4680 |

# Wrong Pass/Fail Limits

## Symptom / Root Cause

- Good connectors and acceptable splices reported as failing:  Pass/fail limits too tight
- Failing connectors and poor splices reported as passing:  Pass/fail limits too loose
- OTDR failed to evaluate pass/fail of splices and connectors:  Pass/fail limits disabled

| Recommendation | Splice Loss | Connector | |
|---|---|---|---|
| | | Loss | Reflectance |
| TIA 568.3 | 0.3 dB | 0.5 dB | Conn. Dependent |
| ITU-T G.671 | 0.3 dB | 0.75 dB | Conn. Dependent |
| Service provider | Service provider specific | | |

| Typical Connector Reflectance Limits | | |
|---|---|---|
| PC | UPC | APC |
| -35 dB | -45 dB | -55 dB |

## Corrective Actions

- Review and adjust pass/fail limits to customer's standards
  - Pass/fail limits may be connector- or application-specific
- ***Note***:  OTDRs cannot detect connector types (UPC vs. APC vs. MPO)
- ***Note***:  Loss of an open connector at end cannot be evaluated
- Can correct and re-apply pass/fail limits in offline reporting software (such as AFL FlexReports)

# Wrong Event Detection Thresholds

## Symptom / Root Cause

- Visually obvious events not detected even with low-noise trace;  Detection threshold set too high
- Many false events reported, especially towards end of trace;  Detection threshold set too low

## Corrective Action

- With older OTDR, adjust event detection thresholds to find small events without too many false events
- Use newer OTDR which automatically adjusts event detection thresholds based on backscatter SNR to prevent reporting false events

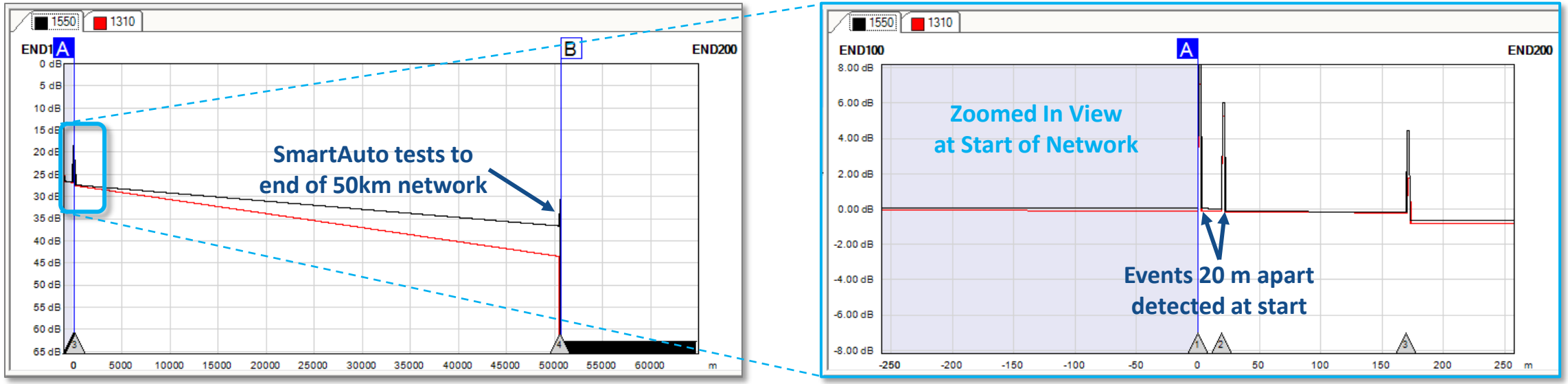
# Multi-pulse SmartAuto vs. Single Pulse Width Expert Mode

## Symptom / Root Cause

- Expert mode requires multiple tests to detect closely-spaced events at start and to test reliably to end

## Corrective Action

- Use an OTDR with multi-pulse acquisition (e.g., FlexScan FS200 or FS300)
- FlexScan's SmartAuto® mode combines short and wide pulse widths in a single test to detect closely-spaced events at start without sacrificing dynamic range needed to test longer fibers



# Common Network Issues

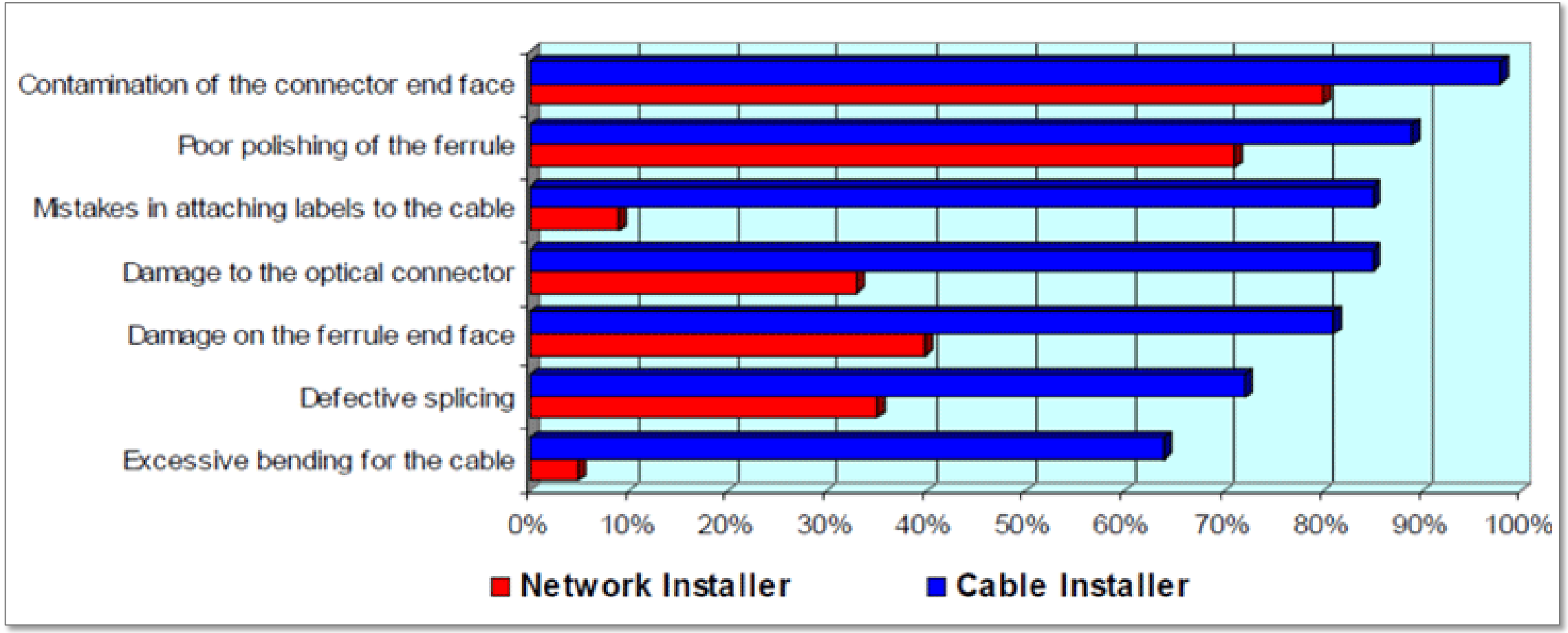
# Key Factors Affecting Fiber Optic Network Performance

- What are **Key Optical Network Factors** affecting fiber optic system performance?
  - **RX Power Level / Optical Loss** through the network
  - **Reflections** in the network
  - Chromatic Dispersion / Polarization Mode Dispersion (**CD/PMD**)
- How do low power, excess loss, reflection and dispersion impact performance?
  - Optical System performance degrades
    - Bit Error Rate increases
    - Packet loss & retransmission increases in packet-based networks (IP, Ethernet)
  - Communication fails (signal lost) when RX power too low (too much optical loss)

- What to do when system performance degrades or fails?
  - **Check System Power Levels**
    - Check TX Power Level – If absent or too low, replace optical TX
    - Check RX Power Level – If absent or too low and TX power OK, check for excess loss in optical network
  - If RX Power OK, **check for excess reflections** in optical network
  - If no excess reflections, possibly **check CD/PMD** (for networks operating at 10 Gb/s or higher)

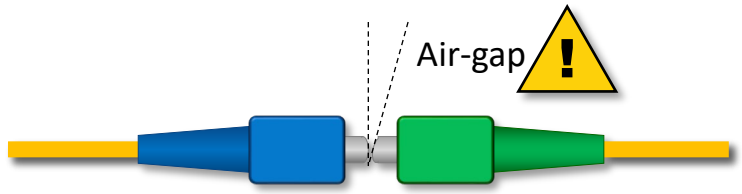
# Primary Causes of Optical Network Failures

## Poor connections & splices are the primary causes of optical network failures




***Source***: NTT Advanced Technology

# Causes of Optical Loss in Fiber Networks

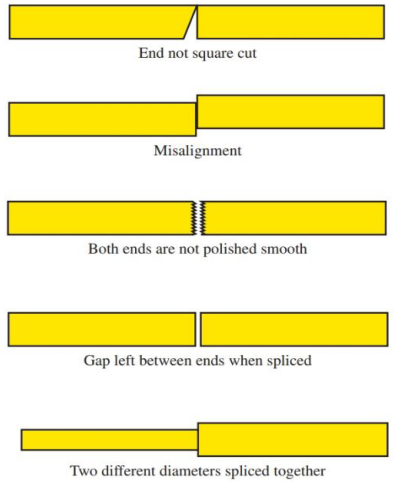



- **Dirty, Damaged, or Mismatched Connectors**
  - Always clean connectors before mating
  - Never mate PC (blue) to Angled PC (APC; green)
  - Fully seat connectors in bulkhead adapters
  - Replace damaged connectors with factory-polished connectors

FUSEConnect®

FASTConnect®

- **Poor Splices**
  - Strip, clean, cleave in that order
  - Clean and maintain fusion splicer
  - Rotate cleaver blade when worn
  - Core alignment machines produce better splices than cladding alignment

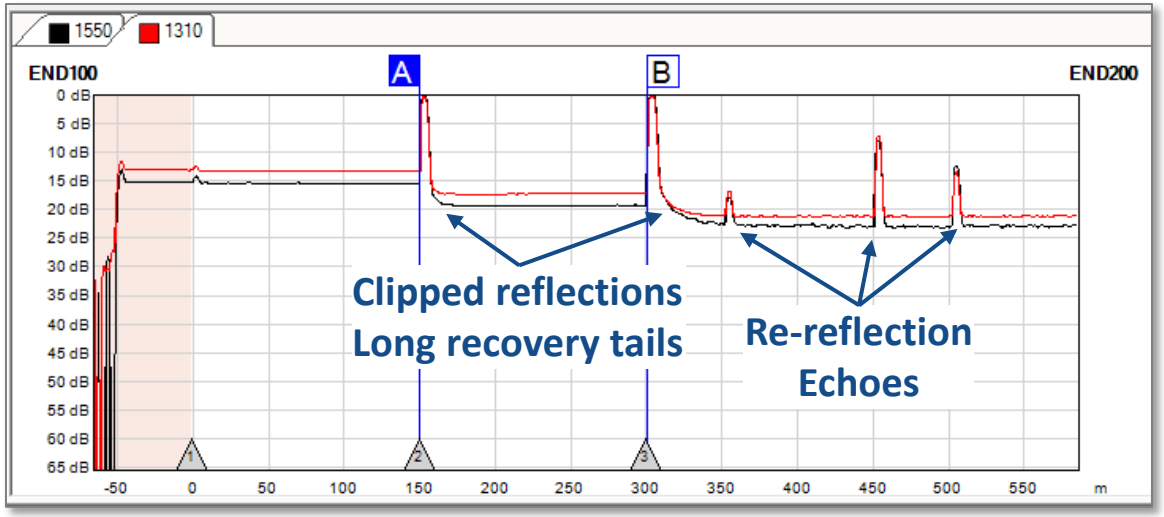


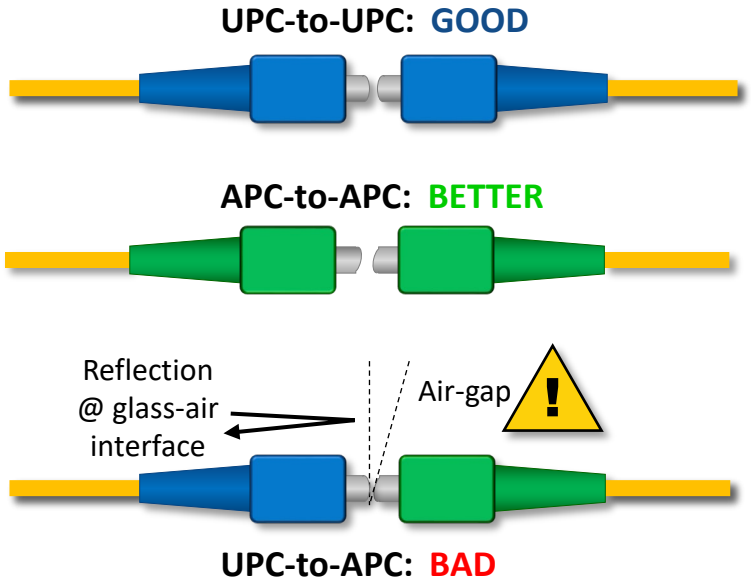

- **Fiber Breaks**
  - “Backhoe fade”
  - Rodents
  - Maintenance activity / unintended disconnect

# Dirty, Damaged or Mismatched Connectors

## Symptoms / Root Cause

- Poor launch quality reported by OTDR
- High-loss, saturated/clipped reflections in trace;  Trace shows long recovery tail after reflection
- End reported at high-loss, saturated/clipped reflection



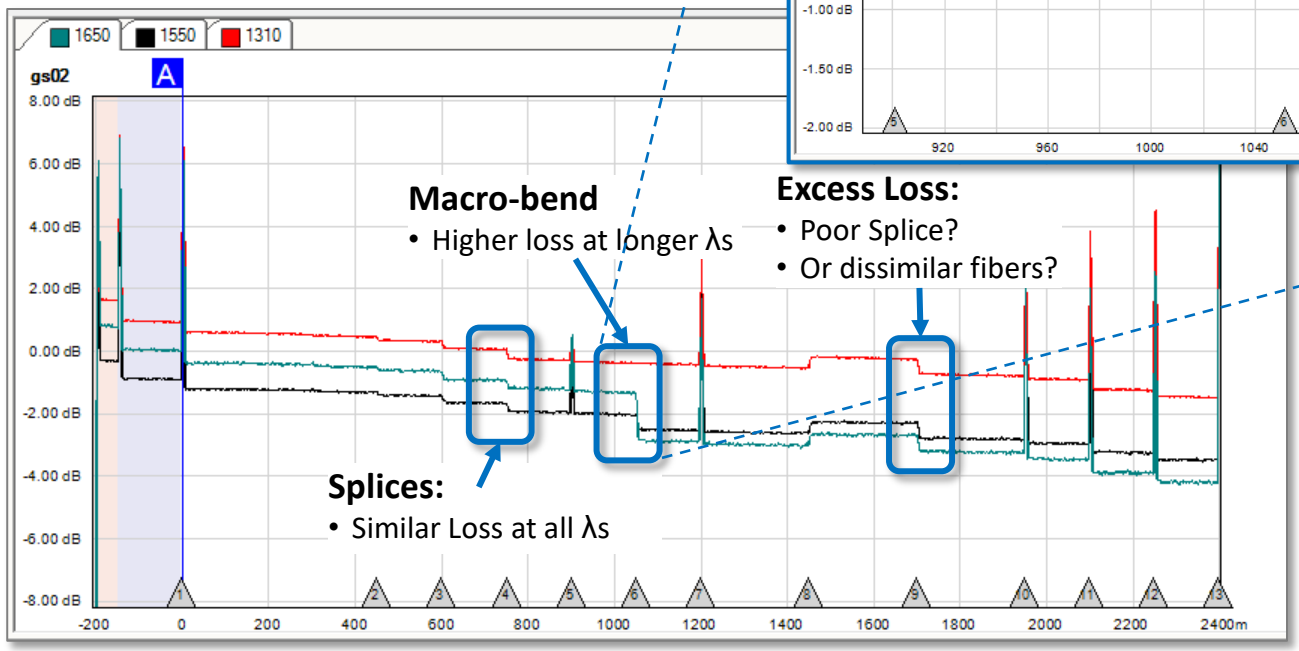

## Corrective Actions

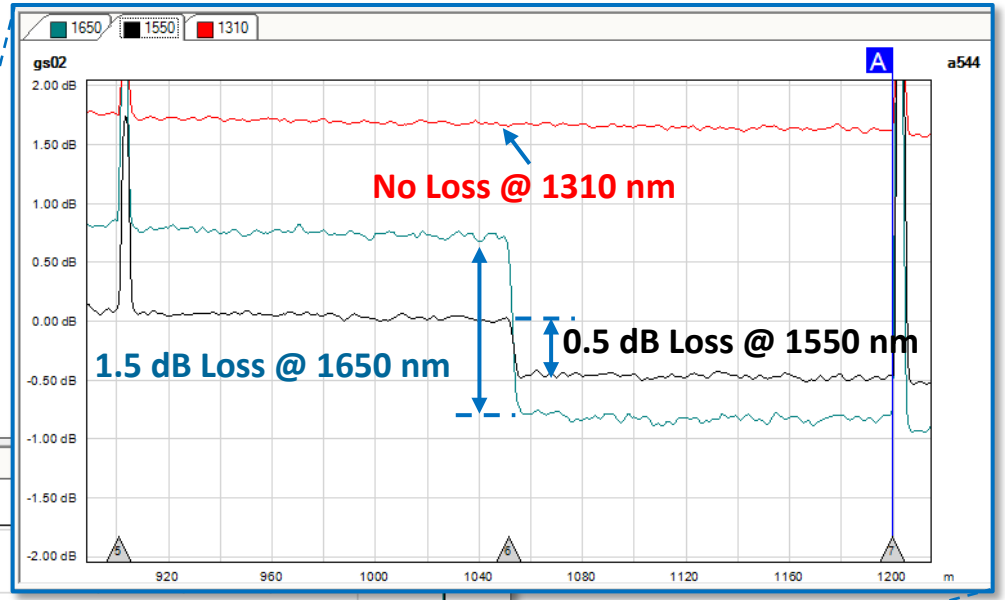
- Inspect and clean OTDR and launch cable connections & other failing connections
- Replace damaged connectors using factory-polished, field-installable splice-on connectors
- Replace mismatched connectors (UPC-to-APC)
- Mate UPC to UPC (blue to blue);  Mate APC to APC (green to green)

# Poor Splices and Macro-bends

## Symptoms / Root Cause

- Excess loss at splice:  Poor splice or different fiber types?
- Excess loss at splice:  Poor splice or macro-bend?




## Corrective Actions

- Re-splice and retest
- Test at short (1310 nm) and long (1550 nm) wavelengths to detect macro-bends
- Test in both directions and bidirectionally average to determine if fiber dissimilarity is root cause
- Use VFL (red laser) to pinpoint poor splices and macro-bends in closures and cabinets

# Misinterpreted Events

## Symptoms / Root Cause

- Good APC connector displayed as passing or failing splice
  - OTDR cannot determine if non-reflective event is splice or APC connector
- Mechanical splice displayed as passing or failing connector
  - OTDR cannot determine if reflective event is mechanical splice or connector

## Corrective Actions

- APC connector IDed as splice: Correct event type using OTDR or reporting software
- P/F limits similar for mechanical splice and connector, so typically no need to correct

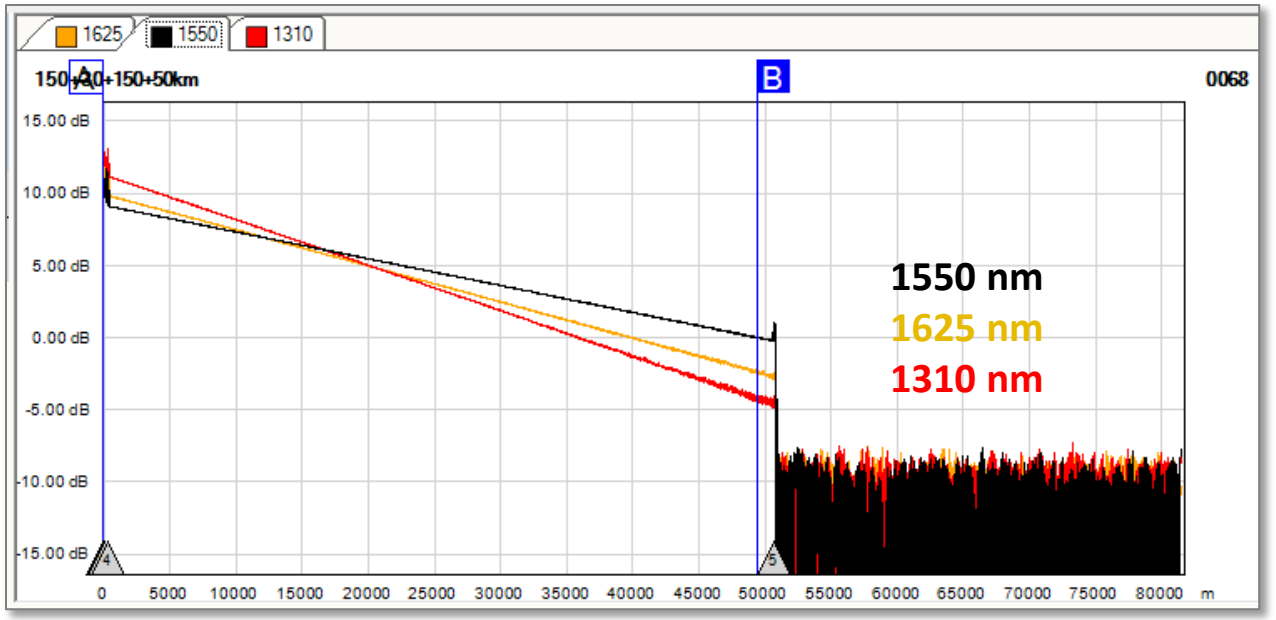
# Network Too Long to Test at 1310 nm

## Symptoms / Root Cause

- Unable to test long-haul DWDM networks at 1310 nm
  - Trace falls to noise floor even with long pulse widths and long averaging time
  - Some long-haul networks are too long to be operated (and tested) at 1310 nm
  - Fiber loss-per-distance higher at 1310 than at 1550 or 1625 nm
- Could test at 1550 nm only, but wouldn't detect macro-bends

## Corrective Action

- Test long-haul DWDM networks using 1550 & 1625 nm



# Common Reporting Issues

# Common Reporting Issues

- Likely to forget to save results?
  - Enable auto-save on test complete if OTDR includes that feature
- Failed to name results correctly?
  - Know your naming requirements:
    - Project or Job name
    - Near-end & Far-end location names
    - Fiber number
  - Software may be able to correct naming
- Misconfigured launch or receive cable settings?
  - Offline reporting software may be able to correct launch & receive cable settings
- Missed, misinterpreted or false events?
  - Use OTDR or reporting software to:
    - Add missed events
    - Correct misidentified event type or mislocated event distance
    - Delete false events

# And now a word from our sponsor…

# Industry Challenge:  Improve Test Productivity & Efficiency

- Industry experiencing shortage of skilled fiber technicians
- At same time, competing service providers racing to deploy FTTH and 5G fiber backhaul
- New crop of technicians must be productive (1st time right diagnosis and repair)
- Look for OTDRs which are:
  - ✓Easy to Configure
    - Simple, intuitive controls
    - Seldom-used control buried or hidden to prevent misconfiguration or confusion
    - Large controls which don't require a stylus to operate
  - ✓Easy to Understand
    - Provides icon-based LinkMap® and Event Table in addition to trace display
    - Evaluates event pass/fail to industry- or user-configurable pass/fail limits
    - Recommends corrective actions for detected failures
  - ✓Reduce Test Time
    - Instant On
    - SmartAuto® multi-pulse acquisition
  - ✓All-in-one OTDR, Source, Power Meter and VFL
  - ✓Small (handheld, even pocket-sized), rugged, weather-resistant
  - ✓Fast, comprehensive reporting software (AFL FlexReports)


# AFL Test & Inspection Product Lines

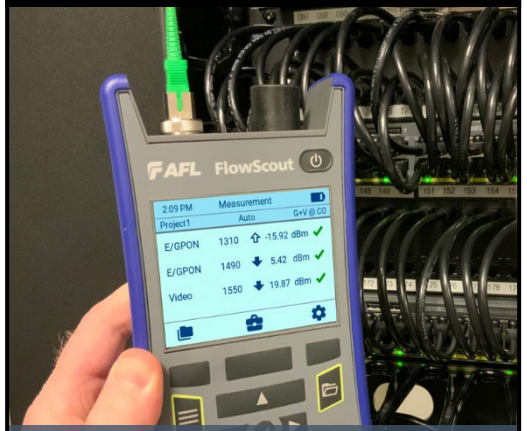
## OTDRS & OPTICAL TROUBLESHOOTERS

FlexScan FS200 OTDR
FlexScan FS300 OTDR
TS100 Troubleshooter
Port Saver

## FIBER INSPECTION & CLEANING

FOCIS Flex
FOCIS Lightning2
One-Click Cleaners

## OPTICAL LOSS TESTING



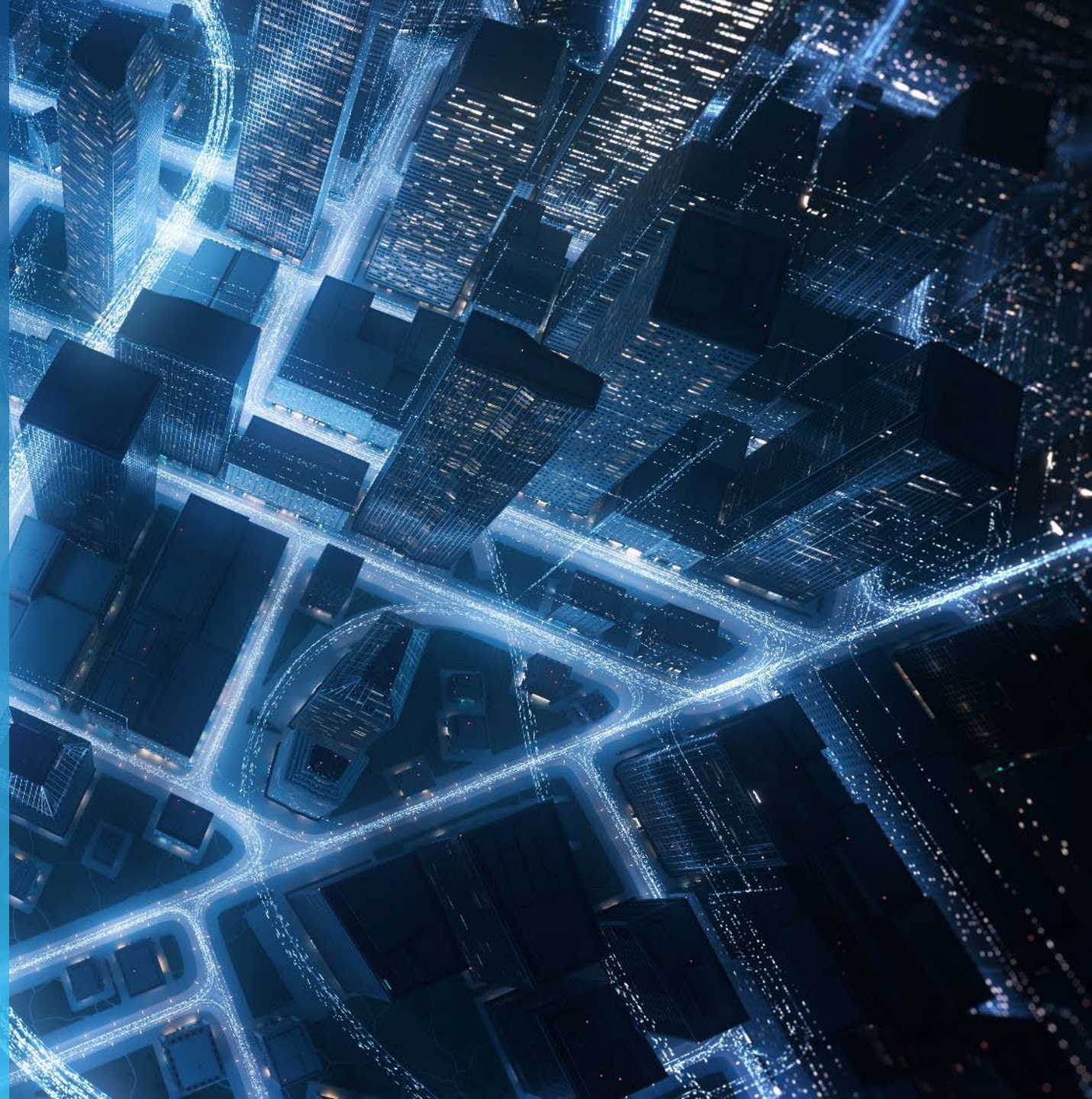

Handheld OLS/OPM
FlowScout PON OPM

## FIBER IDENTIFICATION

OFI -200D & OFI-400
OFI-BIPM / OFI-BIPMe
VFI4

## REPORTING SOFTWARE

FlexReporter
FlexApp



# Thank You

Please feel free to ask any questions