BCNET

Shared IT Services for Higher Education & Research

Conference 2017

Network Testing (OTDR and Ethernet-Based Services)

Format for workshop

- Slide deck presentation on OTDR Testing
- Move to equipment for Hands On to look at OTDR and apply what you learned
- Refreshment Break
- Slide deck presentation on Testing Ethernet-Based Services (EtherSAM)
- Move to equipment for Hands On to look at EtherSAM and apply what you learned

OTDR Testing Fundamentals

Presenter Shawn Tang

Shawn is the Territory Manager at EXFO Inc. for Western Canada.

He brings over 20 years of experience in the Telecommunications industry.

He received his Masters degree from Wuhan Research Institute in Electrical Engineering and a Bachelor degree from Beijing University in Computer Science.

Ethernet-Based Services Testing

Presenter François Marcotte

François is a senior engineer currently working for EXFO in Montreal.

He brings over 28 years of experience in the Telecommunications industry.

He graduated from the Electrial Engineering program from Ecole Polytechnique of Montreal.

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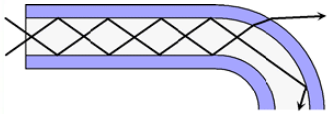
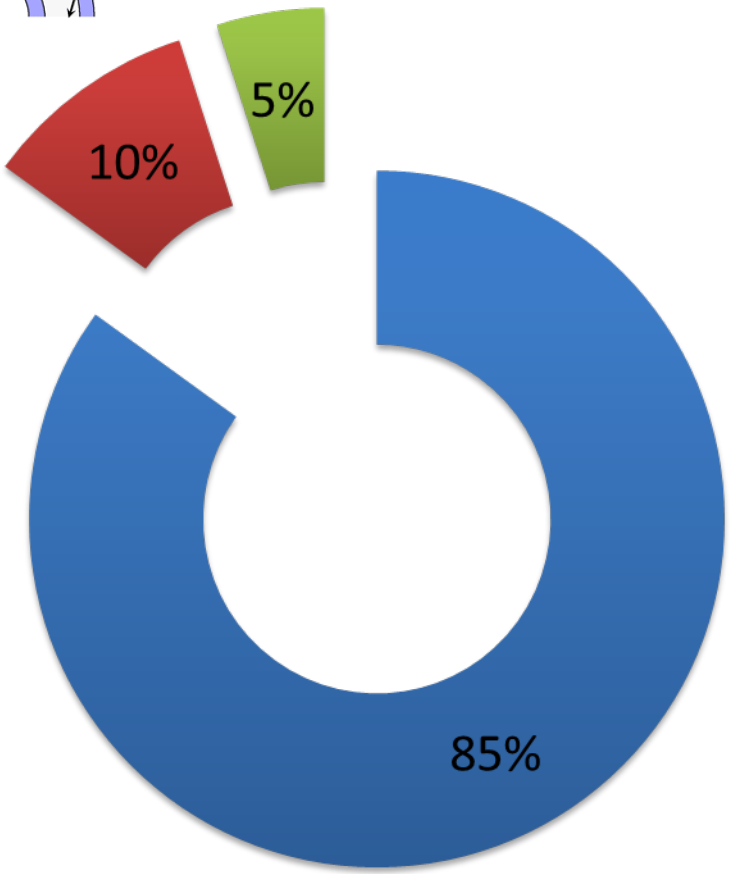
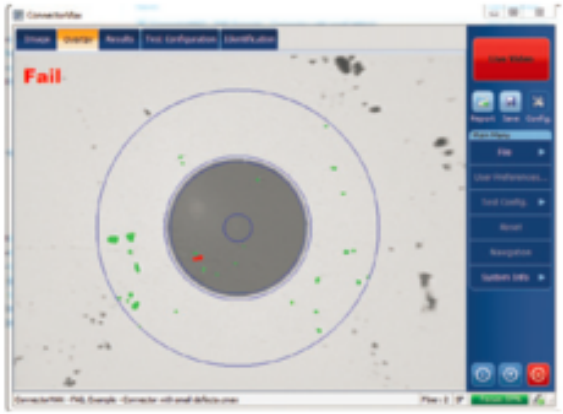
From OTDR 101 to Intelligent Optical Link Mapper IOLM

Installation best practices





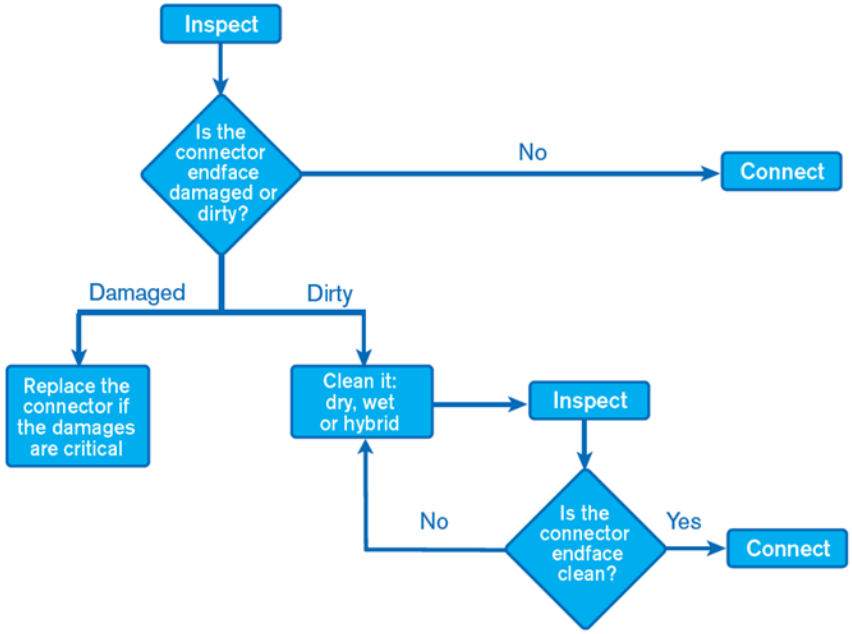
- Dirty/damage optical connection
- Macrobends
- Other



Defective connector failing acceptance criteria.

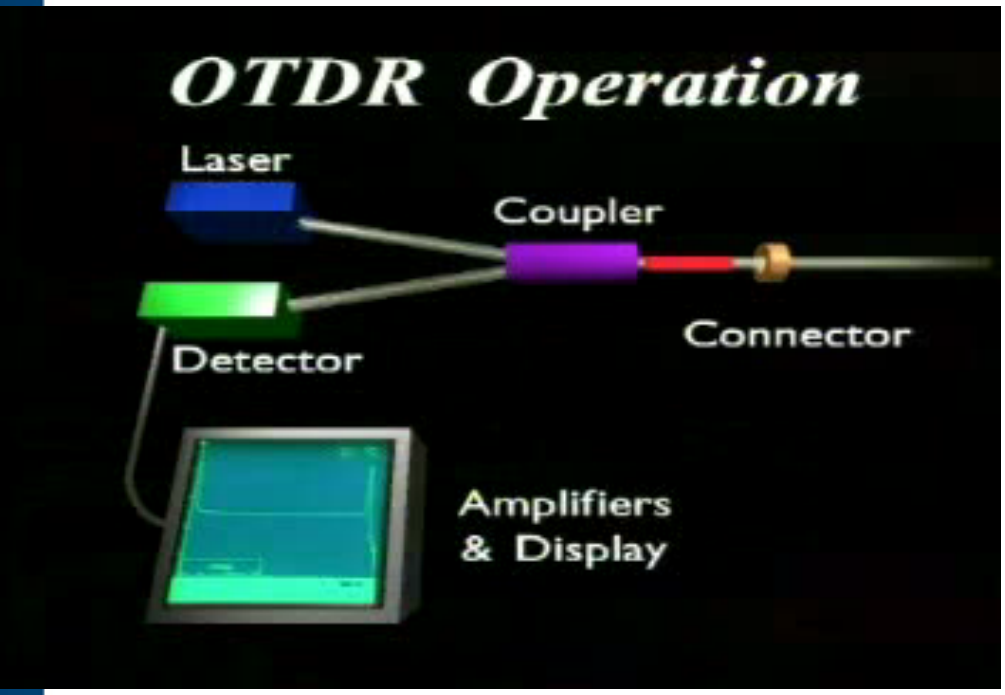
Installation best practices

Connector cleaningness



How Does an OTDR Work?

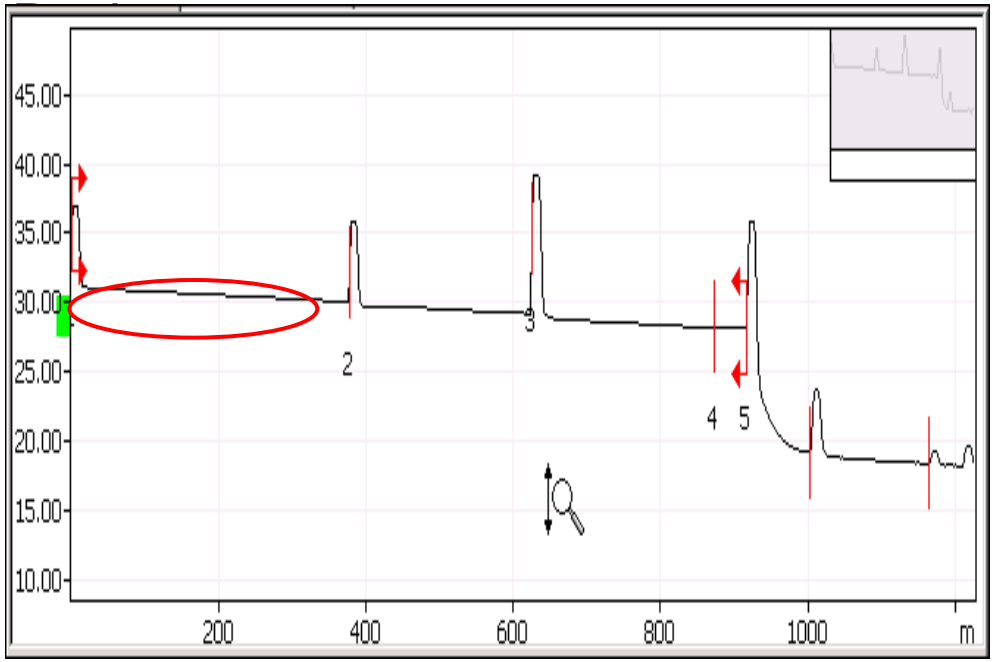
- **Laser / Coupler / Photodetector**
  - **Fresnel Reflections along the fiber are measured**
  - **Rayleigh Backscatter along the fiber is measured**

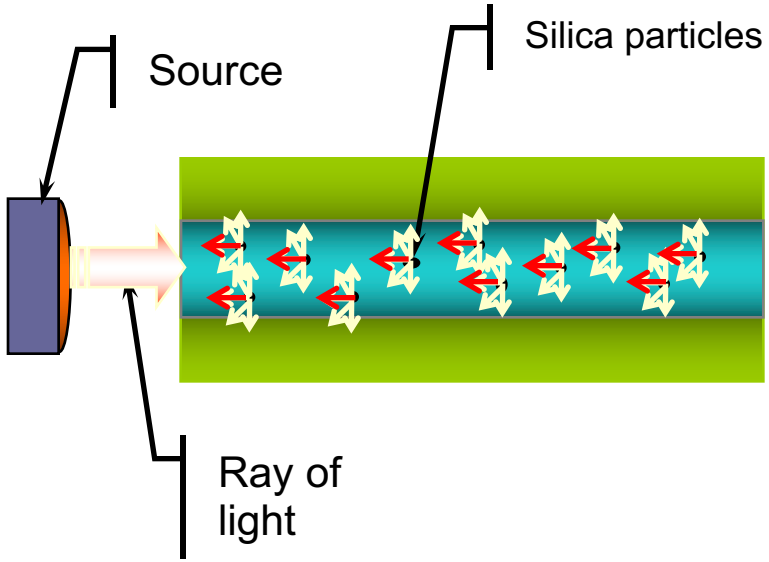


Reflectometry theory

Rayleigh Backscattering

- Comes from the “Natural” reflection of the fiber
- The OTDR will use the Rayleigh back reflections to measure fiber’s attenuation (dB/Km)
- Back reflection level around -75 dB
- Higher wavelength will be less attenuated by the Rayleigh

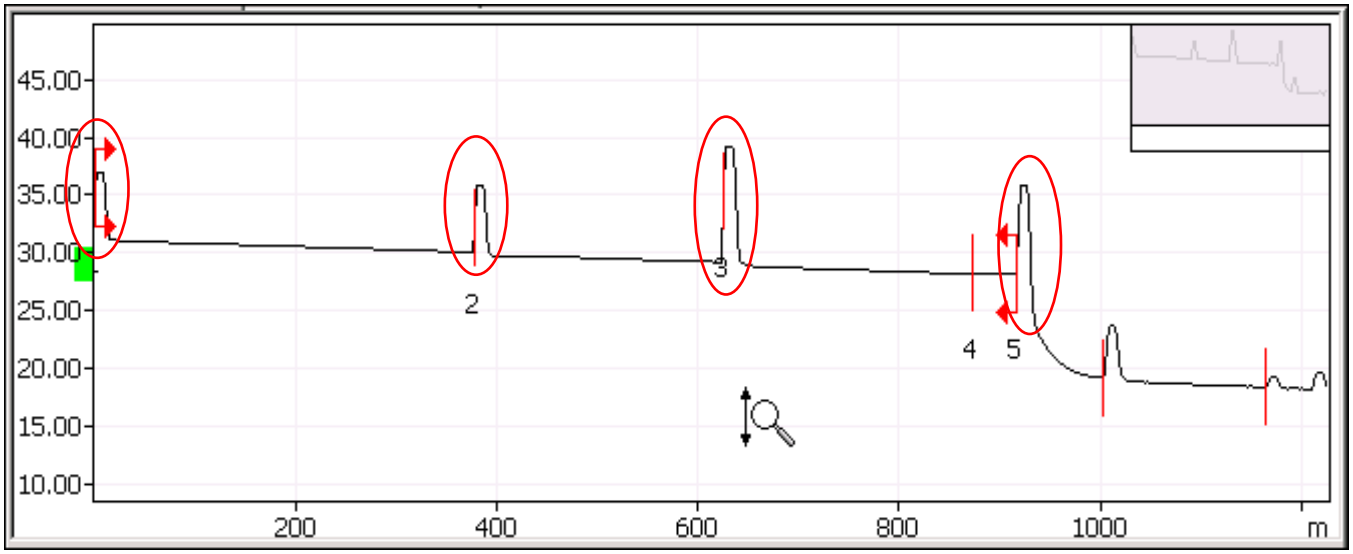




Reflectometry theory

Fresnel back reflections

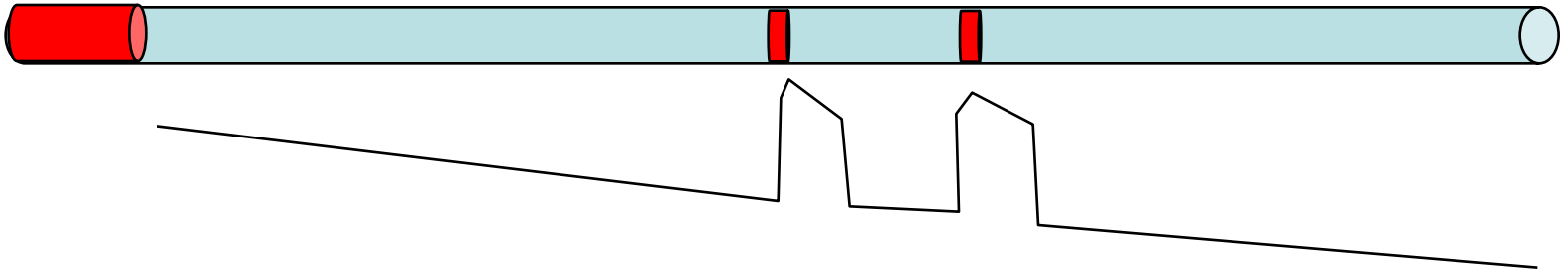
- Will come from abrupt changes in the IOR, ex: (glass/air)
  - **Fiber break, mechanical splice, bulkheads, connectors**
- Will show as a “spike” on the OTDR trace
- UPC reflection is typically -55dB and APC -65dB (as per ITU)
- Fresnel reflections will be approximately 20 000 times higher than fiber’s backscattering level
- Will create a « Dead Zone » after the reflection



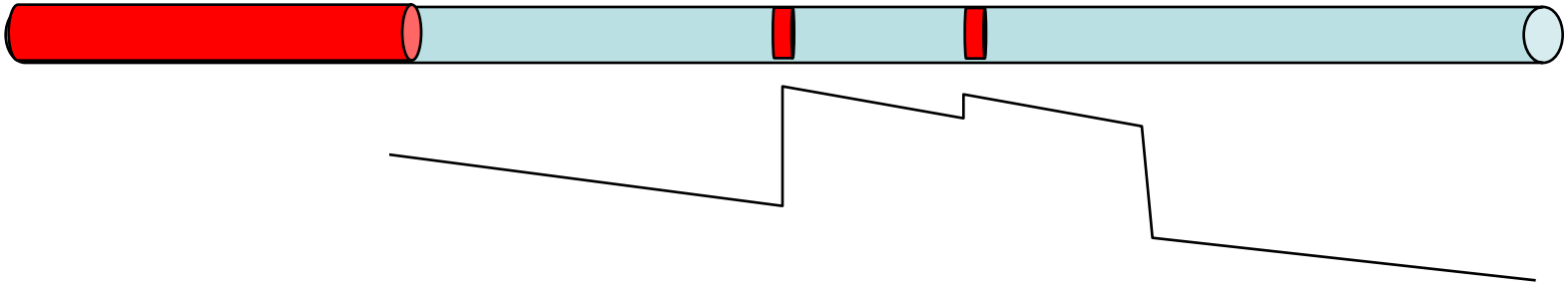
How does an OTDR Work?

Pulse versus resolution and dynamic range

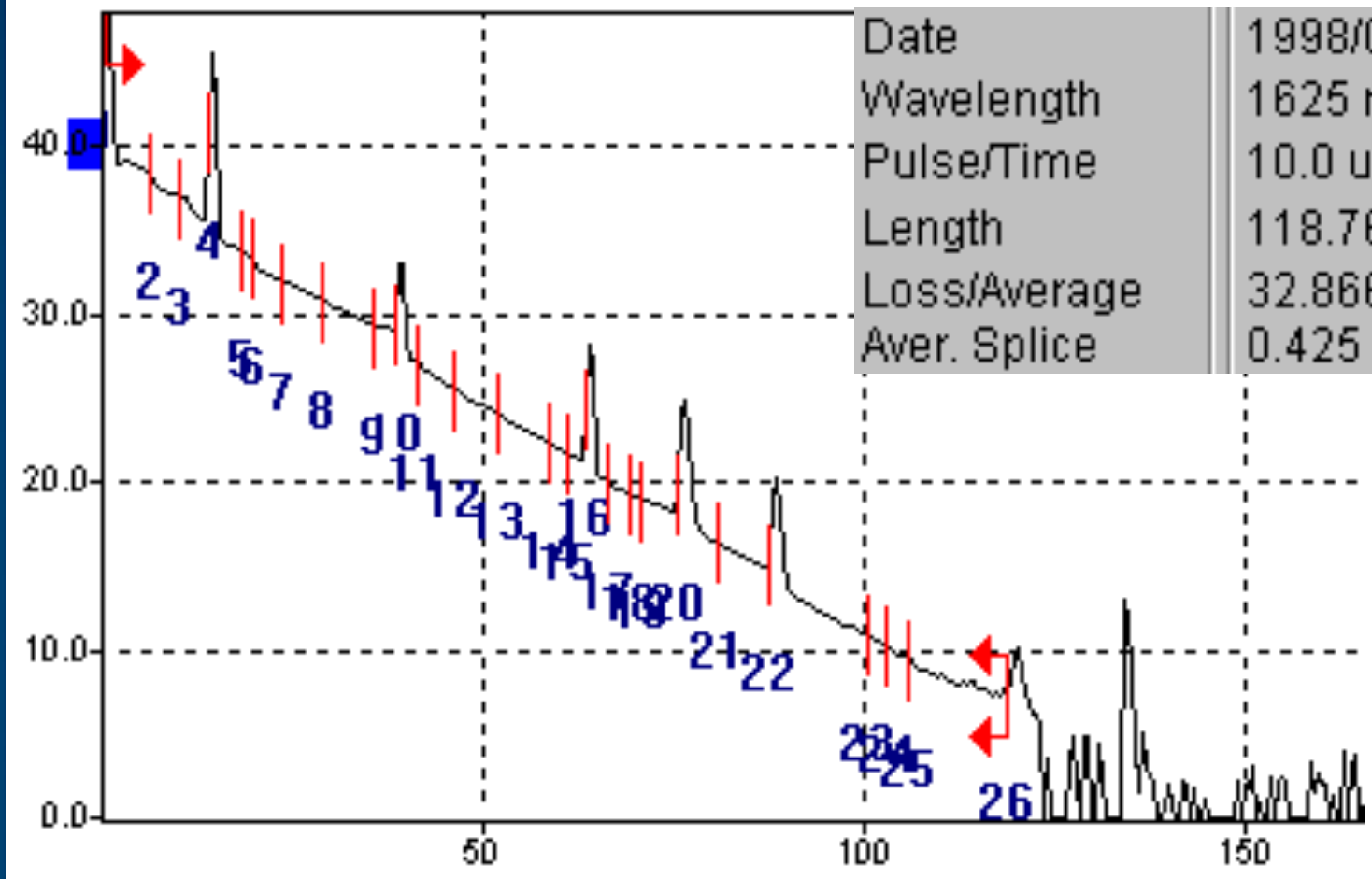
Short Pulse : more resolution but less energy



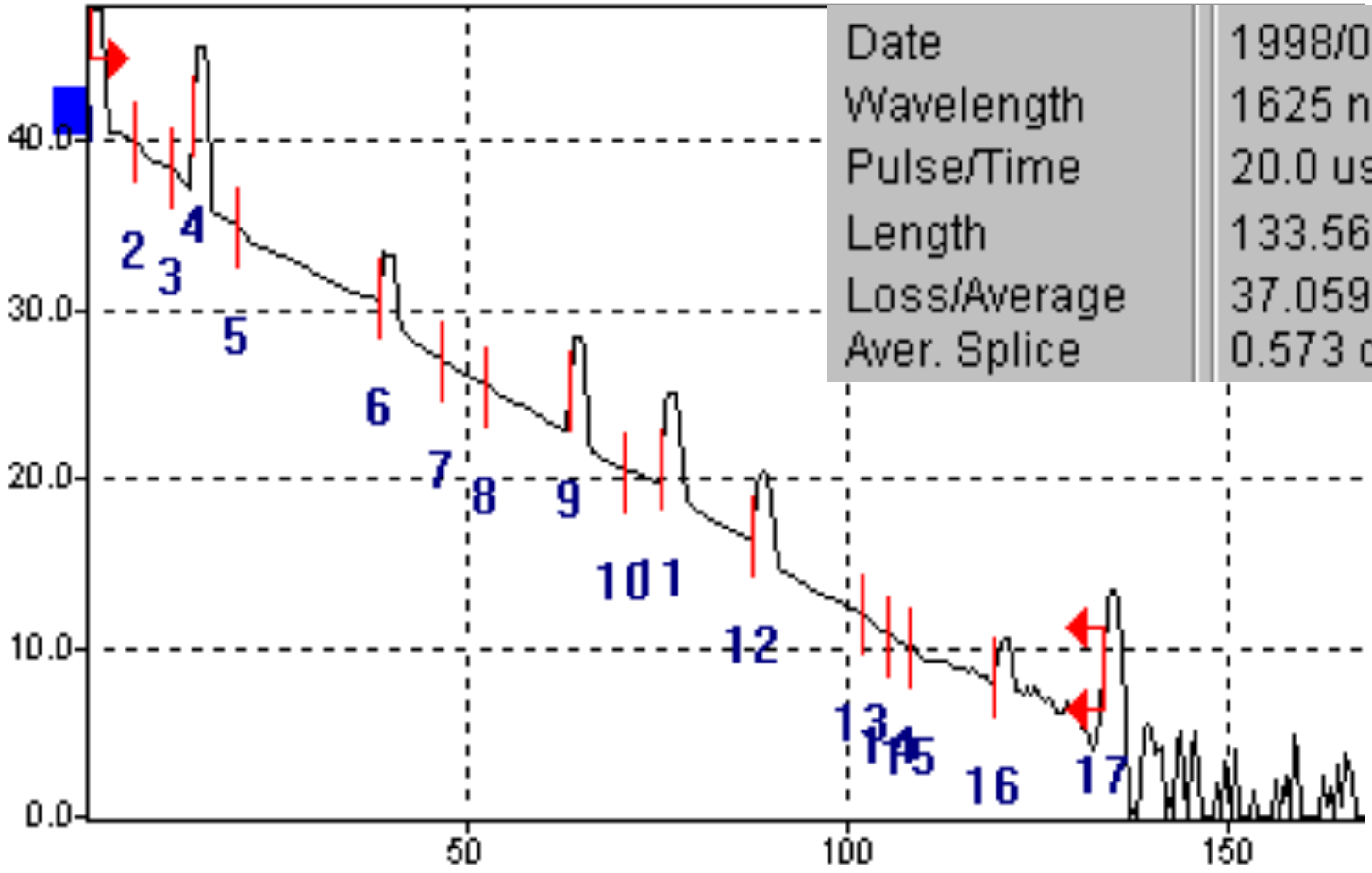
Long Pulse width: more energy but less resolution



10 us pulse

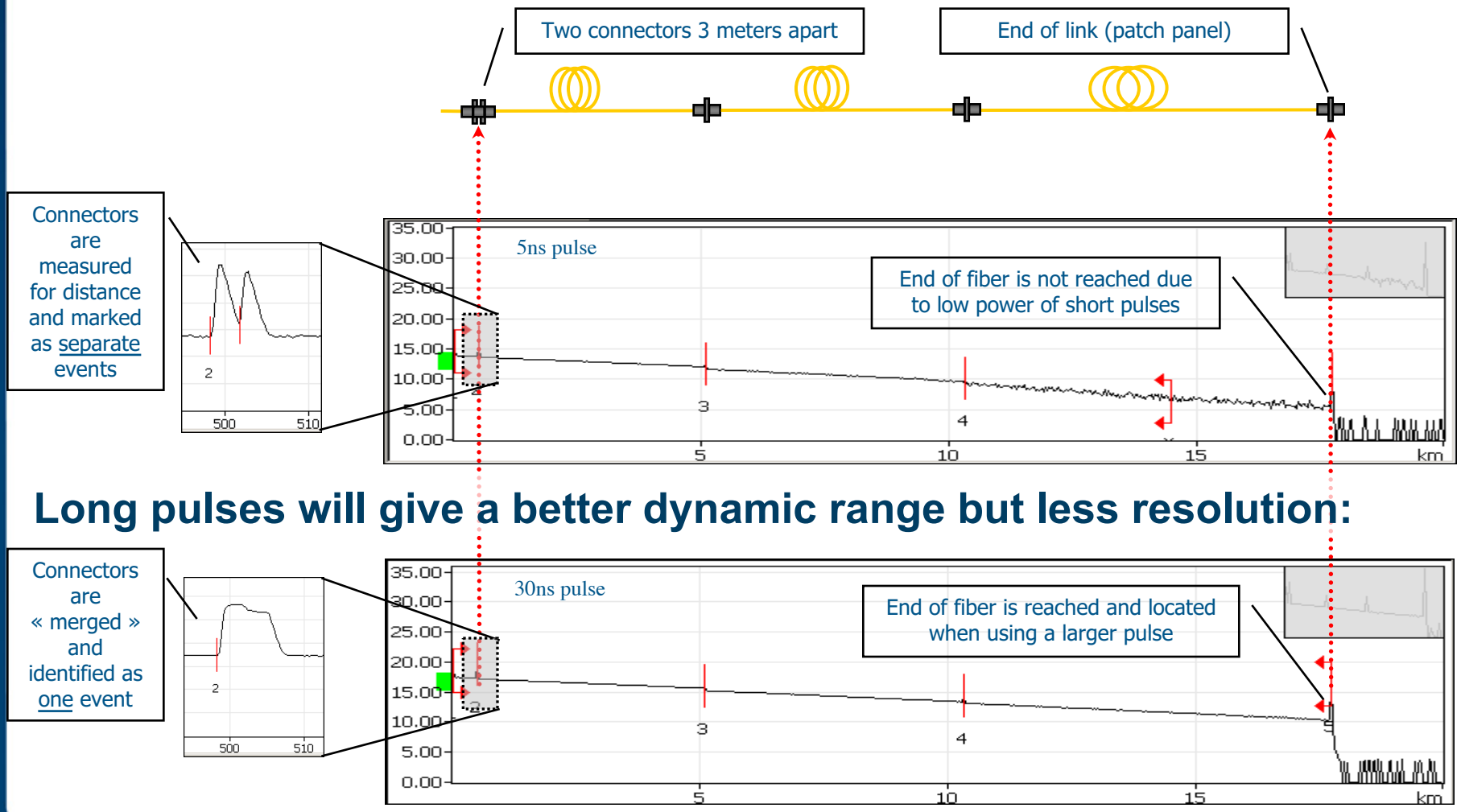


20 us pulse



OTDR specifications & limitations

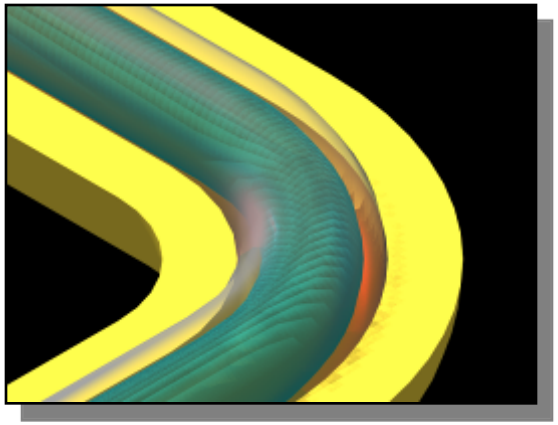
- Pulse width vs. Dead zones and Dynamic range

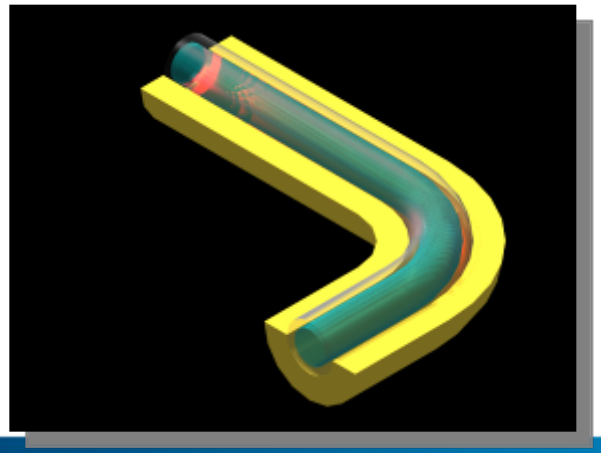


Long pulses will give a better dynamic range but less resolution:

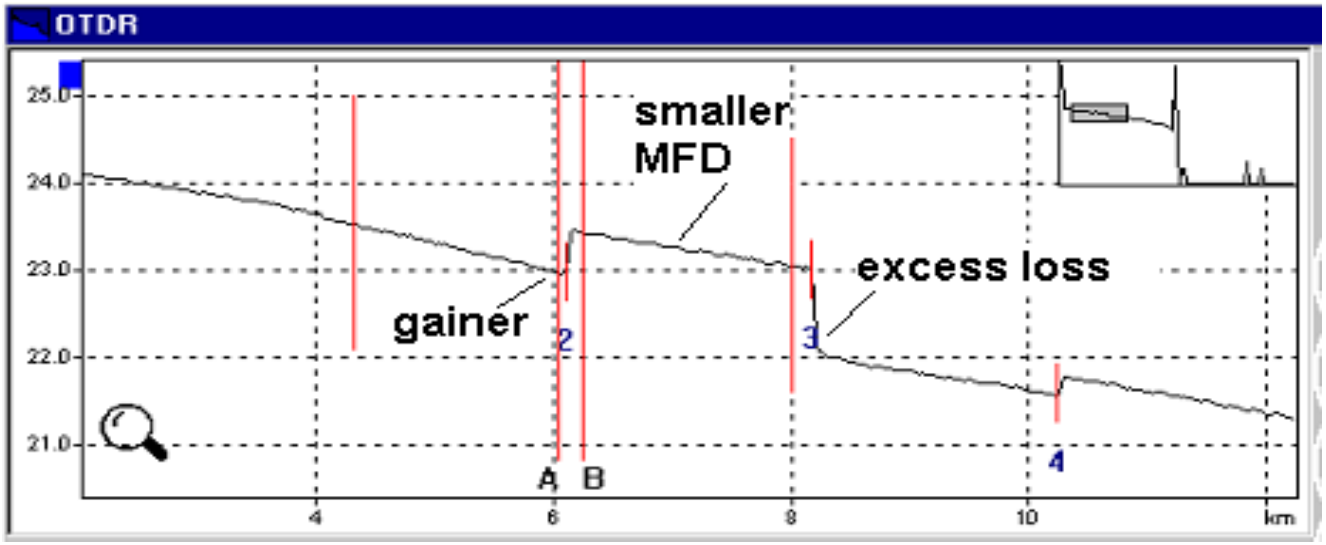
Macrobending

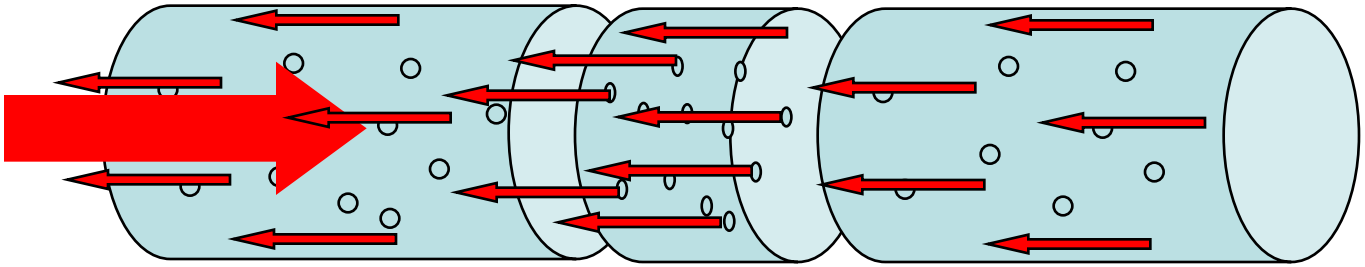
A fiber curvature that causes loss of light



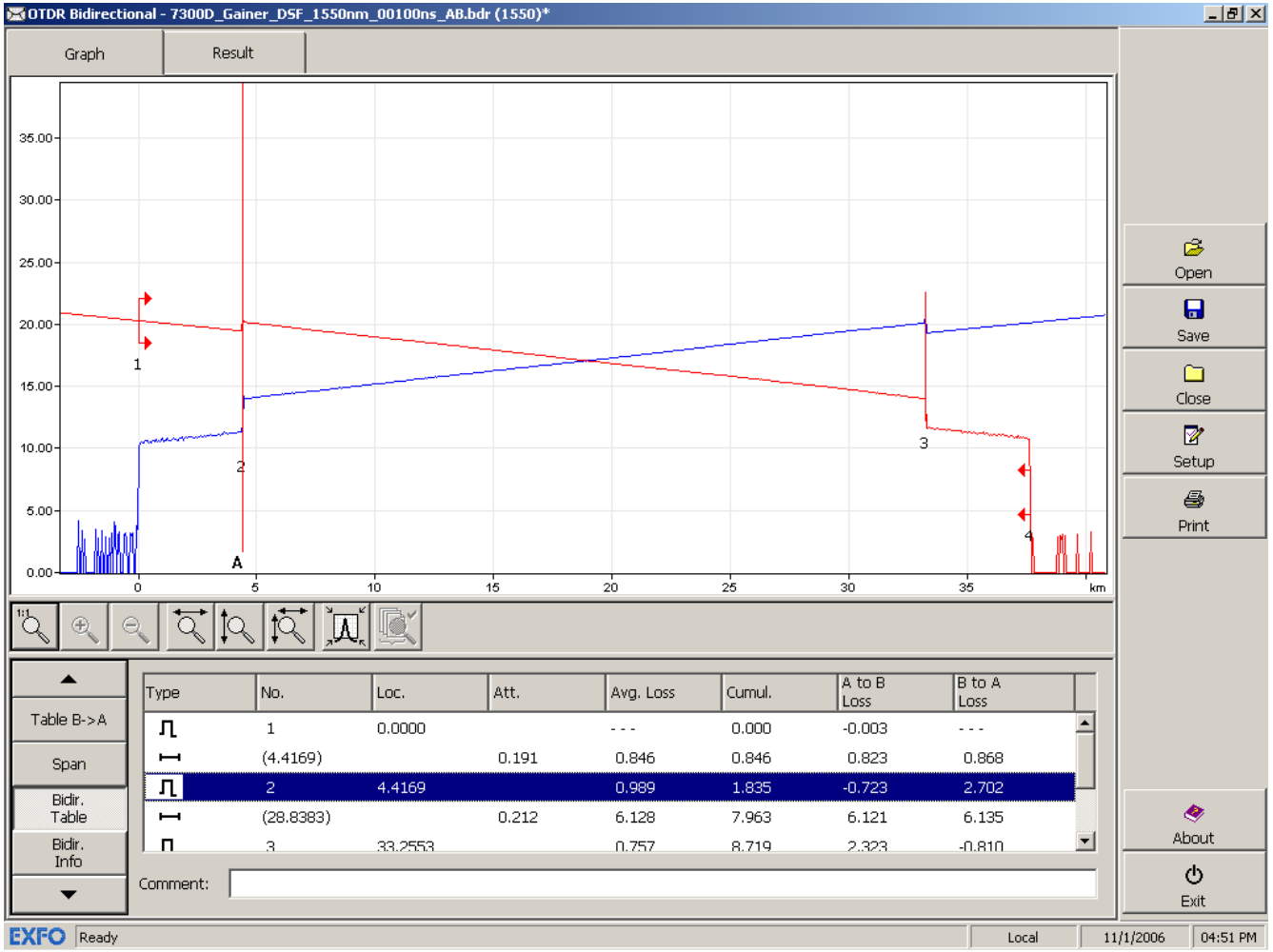


Singlemode gainers

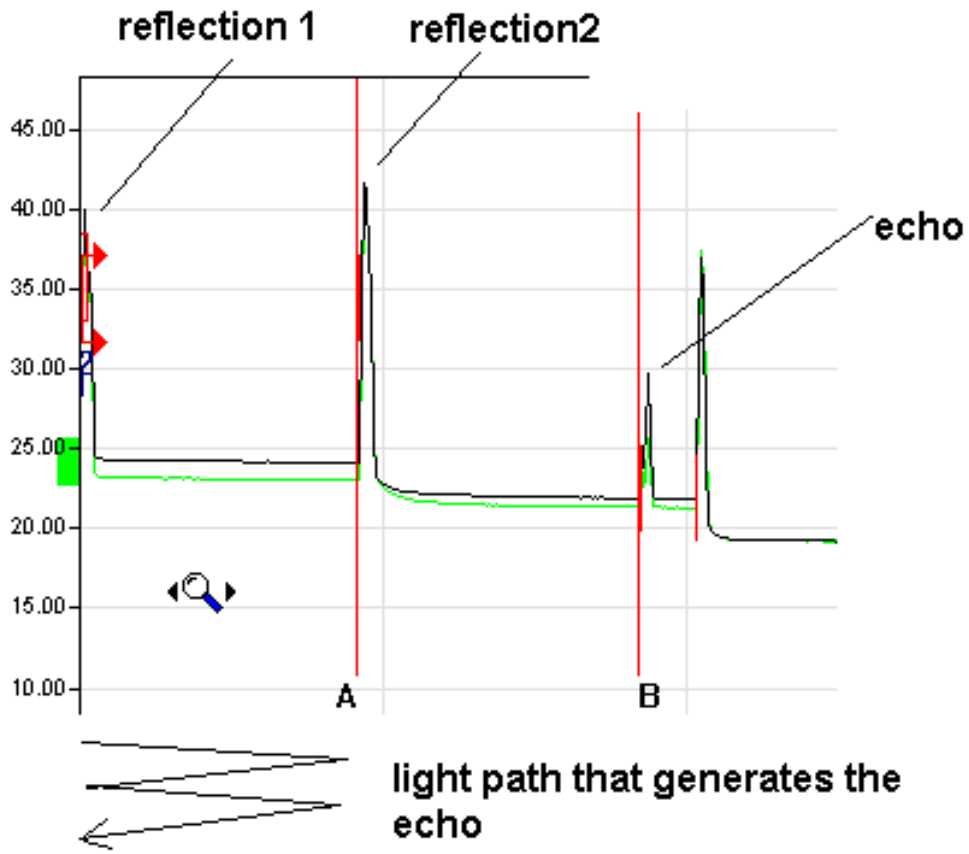




Bi-directionnal traces



Echos on OTDR traces

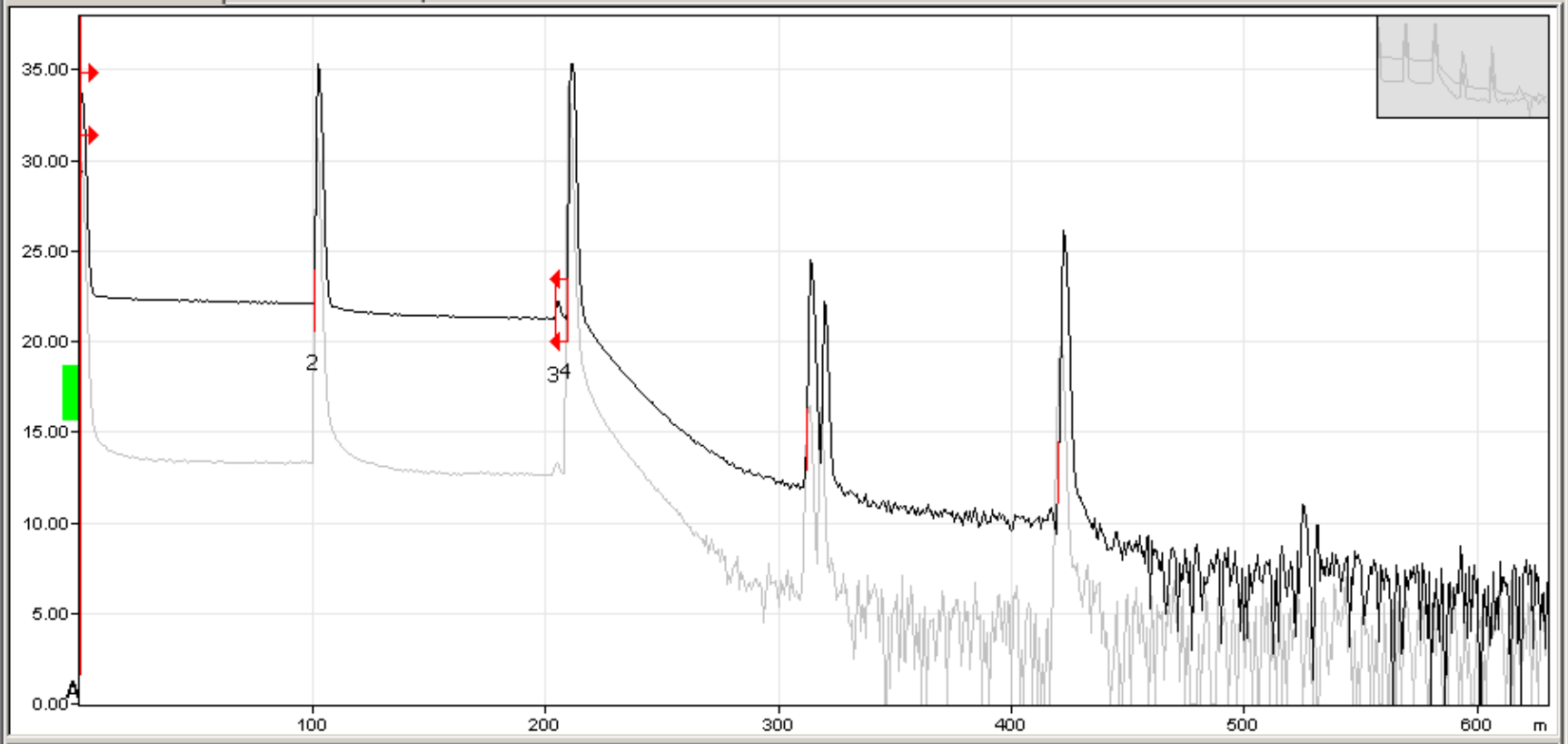


Echos are more frequent in multimode because of high reflectance connectors.

In this example the echo is located at twice the distance of reflectance 2.

OTDR Advanced - File0001.trc (850 nm)

Graph | Result



Spacing...

Type	No.	Loc.	Loss	Refl.	Att.	Cumul.
→	1	0.0000	- - -	>-41.9	@22.4dB	0.000
⊢	(0.1010)		0.372		3.687	0.372
⎍	2	0.1010	0.258	>-38.2		0.631
⊢	(0.1030)		0.524		5.092	1.155
⎍	3	0.2040	0.017	-66.5		1.172

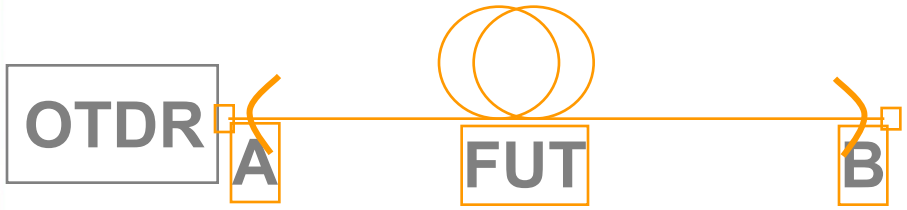
Change...
Insert...
Delete
Analyze

Event
Span
Measure
Trace Info

Comment:

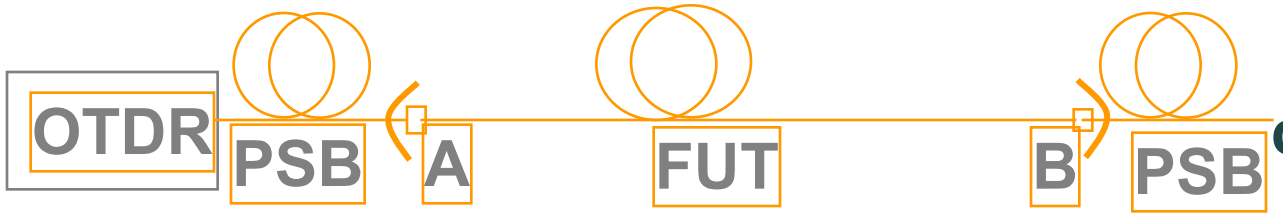
Open
Save
Close
Setup
Print
About
Exit

Pulse suppressor box (PSB)



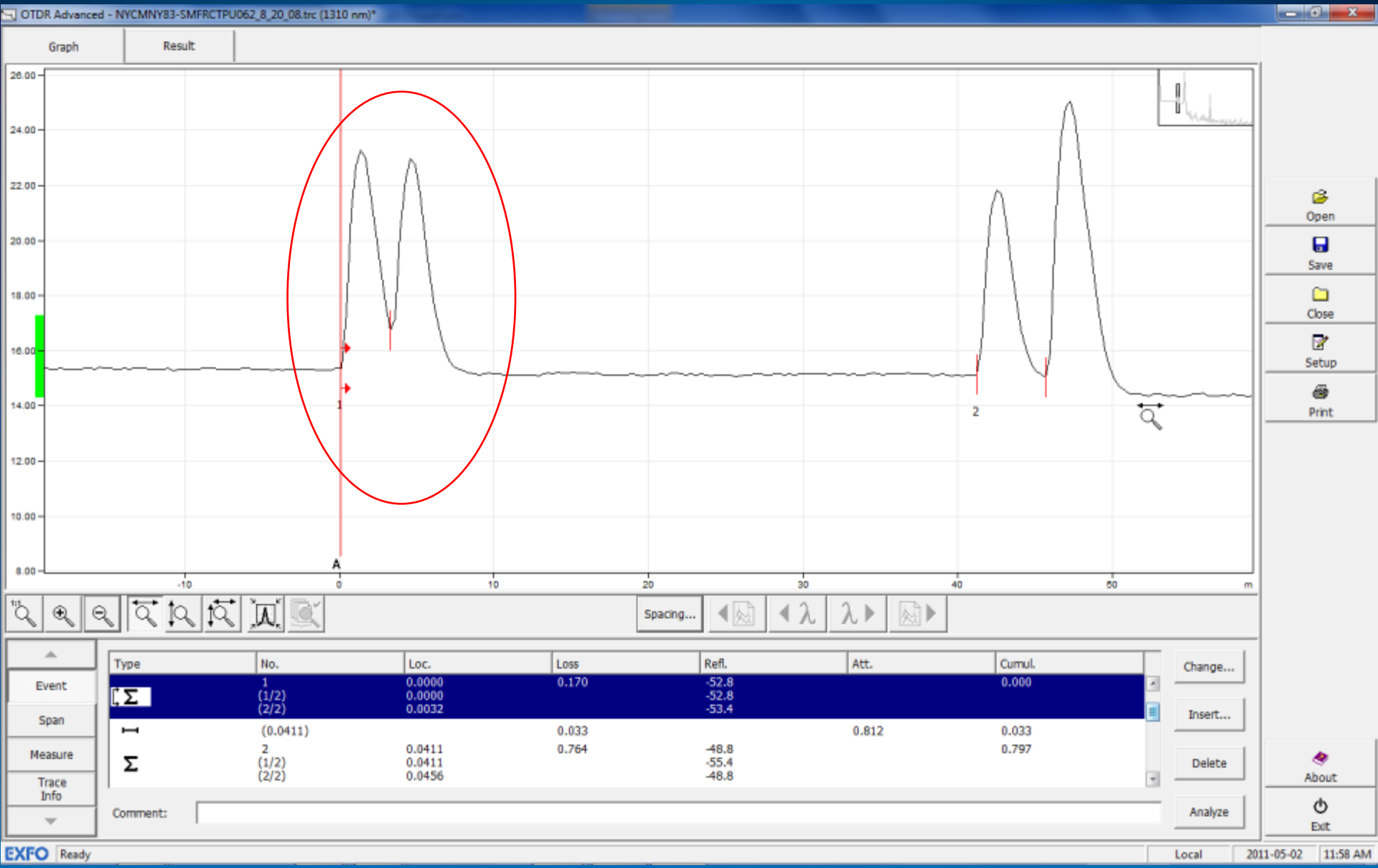
Link budget = FUT (excluding connectors A and B)

Link budget = connector A +FUT

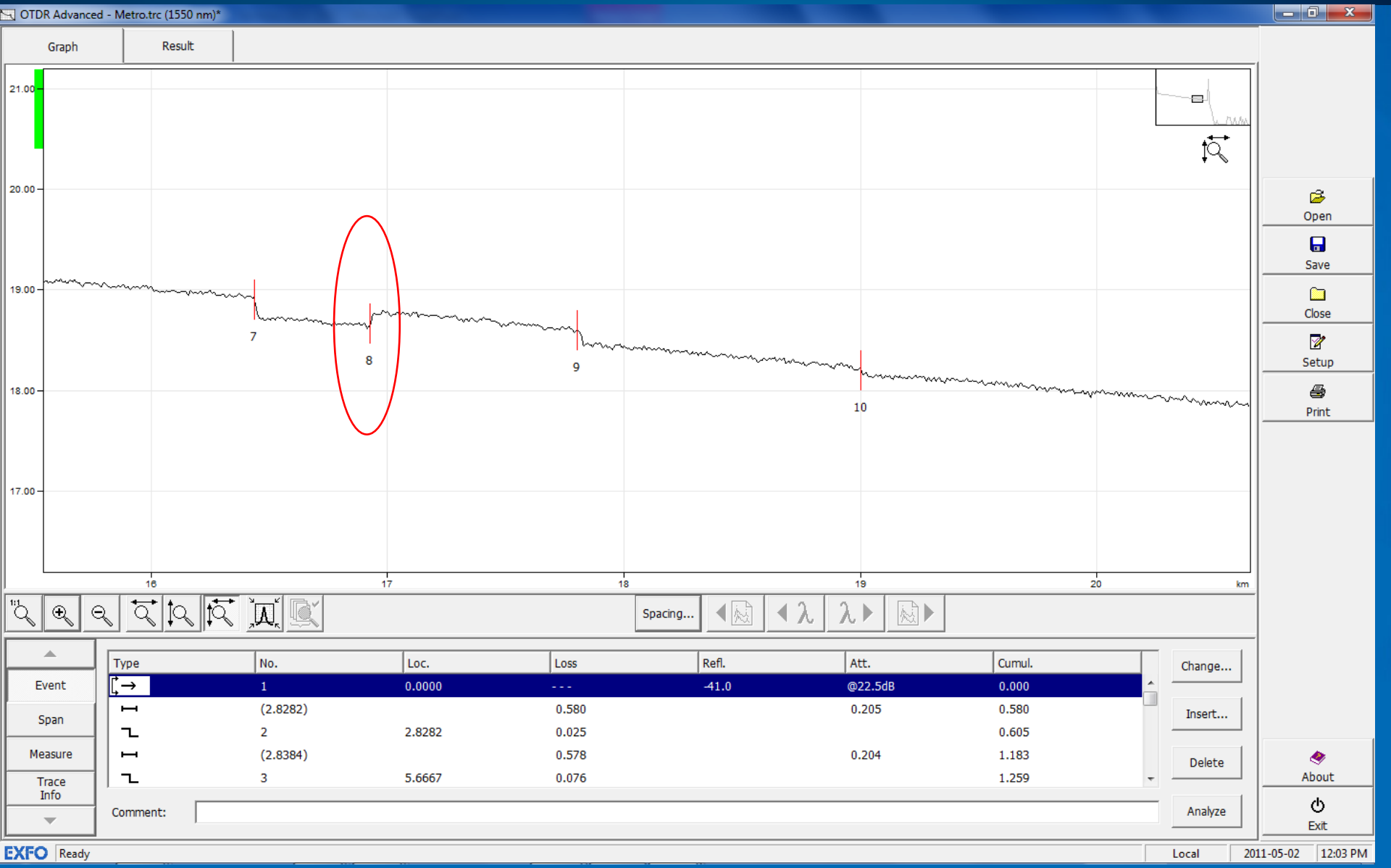


Link budget = connector A + FUT + connector B

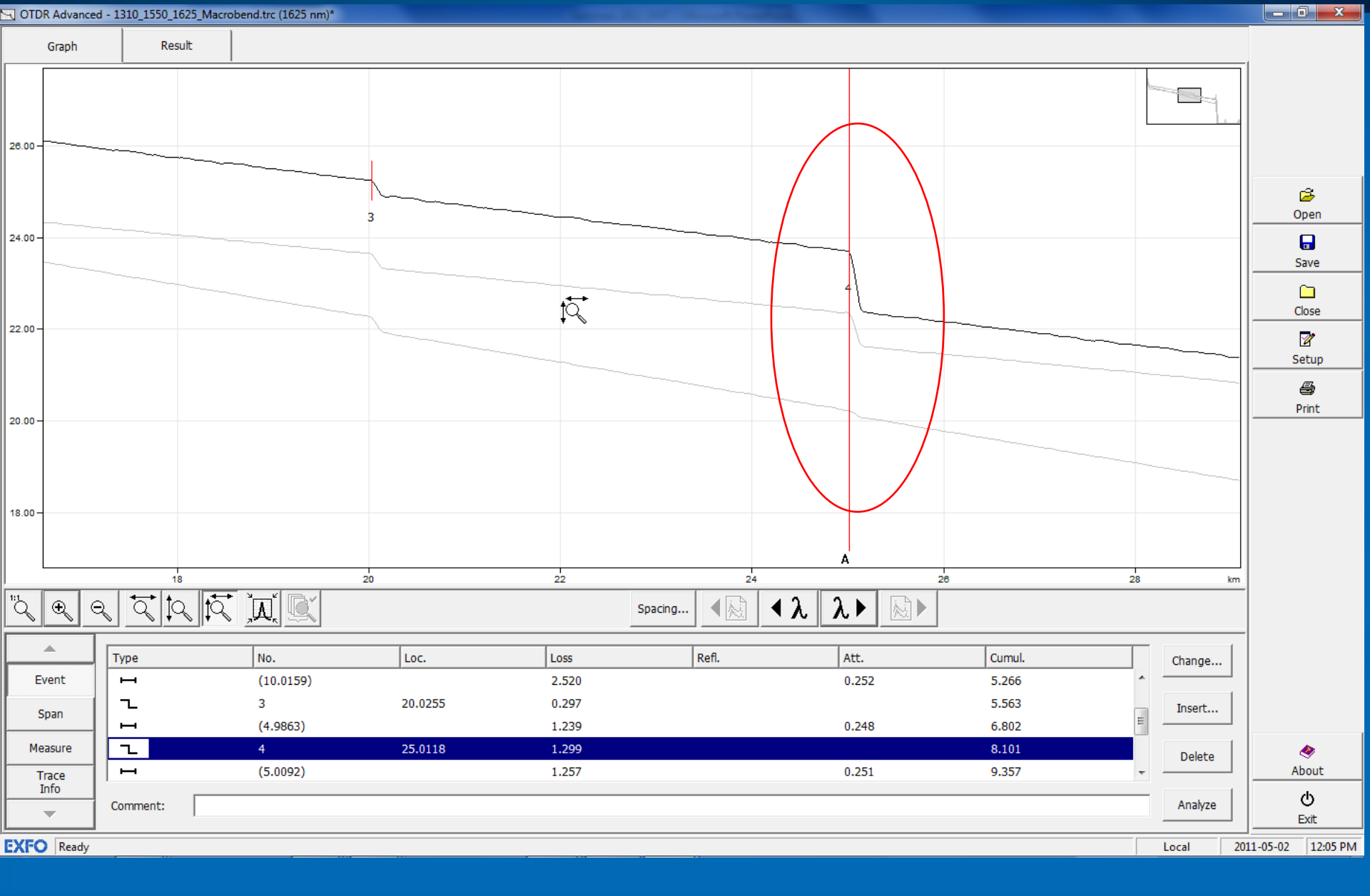
What is this?


OTDR Advanced - NYCMNY83-SMFRCTPU062_8_20_08.trc (1310 nm)*
Graph
Result
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
-10
0
10
20
30
40
50
m
A
1
2
Open
Save
Close
Setup
Print
Spacing...
Type
No.
Loc.
Loss
Refl.
Att.
Cumul.
1
(1/2)
(2/2)
0.0000
0.0000
0.0032
0.170
-52.8
-52.8
-53.4
0.000
(0.0411)
0.033
0.812
0.033
2
(1/2)
(2/2)
0.0411
0.0411
0.0456
0.764
-48.8
-55.4
-48.8
0.797
Event
Span
Measure
Trace Info
Change...
Insert...
Delete
Analyze
Comment:
About
Exit
EXFO
Ready
Local
2011-05-02
11:58 AM

What is this?


OTDR Advanced - Metro.trc (1550 nm)*
Graph
Result
21.00
20.00
19.00
18.00
17.00
7
8
9
10
16
17
18
19
20
km
Spacing...
Open
Save
Close
Setup
Print
About
Exit
Event
Span
Measure
Trace Info
Type
No.
Loc.
Loss
Refl.
Att.
Cumul.
1 0.0000 - - - -41.0 @22.5dB 0.000
(2.8282) 0.580 0.205 0.580
2 2.8282 0.025 0.605
(2.8384) 0.578 0.204 1.183
3 5.6667 0.076 1.259
Change...
Insert...
Delete
Analyze
Comment:
EXFO
Ready
Local
2011-05-02
12:03 PM

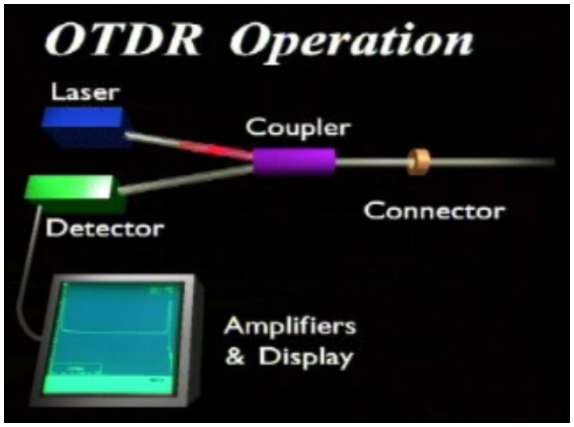
What is this?

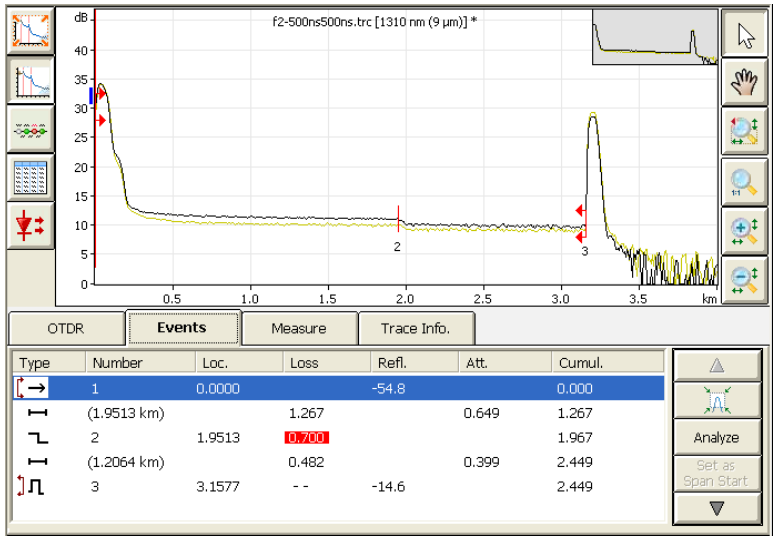

OTDR Advanced - 1310_1550_1625_Macrobend.trc (1625 nm)*
Graph
Result
26.00
24.00
22.00
20.00
18.00
18
20
22
24
26
28
km
3
4
A
Spacing...
Open
Save
Close
Setup
Print
About
Exit
Event
Span
Measure
Trace Info
Type
No.
Loc.
Loss
Refl.
Att.
Cumul.
(10.0159) 2.520 0.252 5.266
3 20.0255 0.297 5.563
(4.9863) 1.239 0.248 6.802
4 25.0118 1.299 8.101
(5.0092) 1.257 0.251 9.357
Change...
Insert...
Delete
Analyze
Comment:
EXFO
Ready
Local
2011-05-02
12:05 PM

Installation best practices

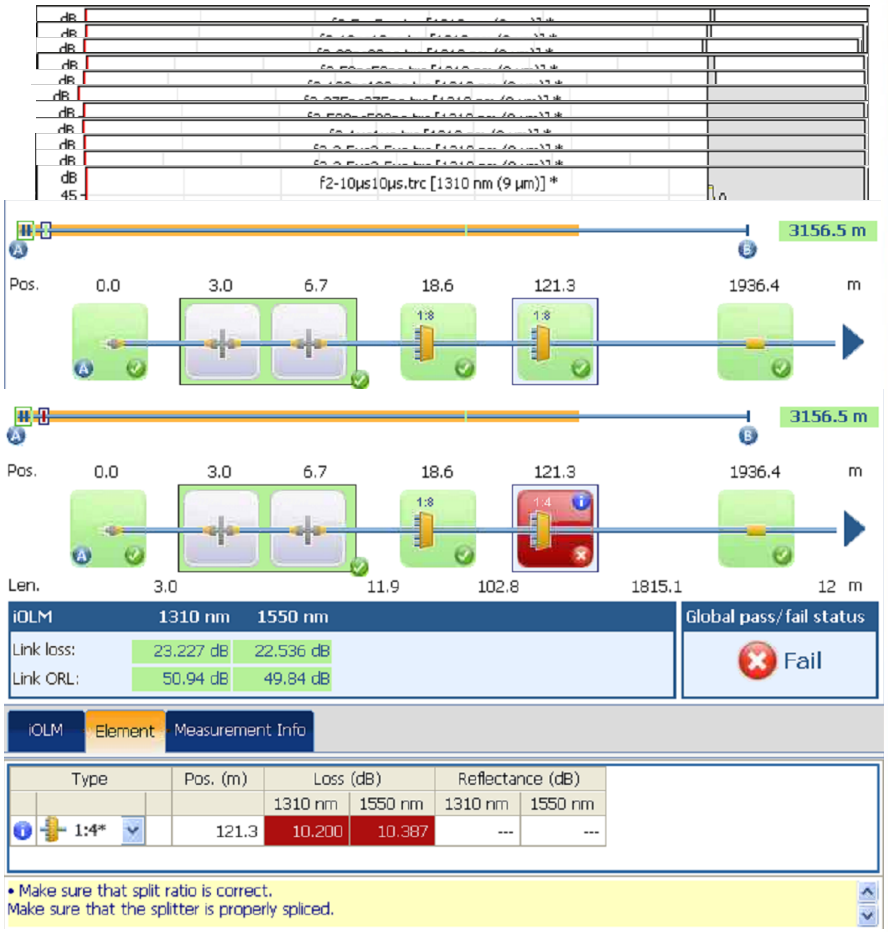
Using Intelligent optical link mapper IOLM™ instead of the good old OTDR

OTDR: Single pulse

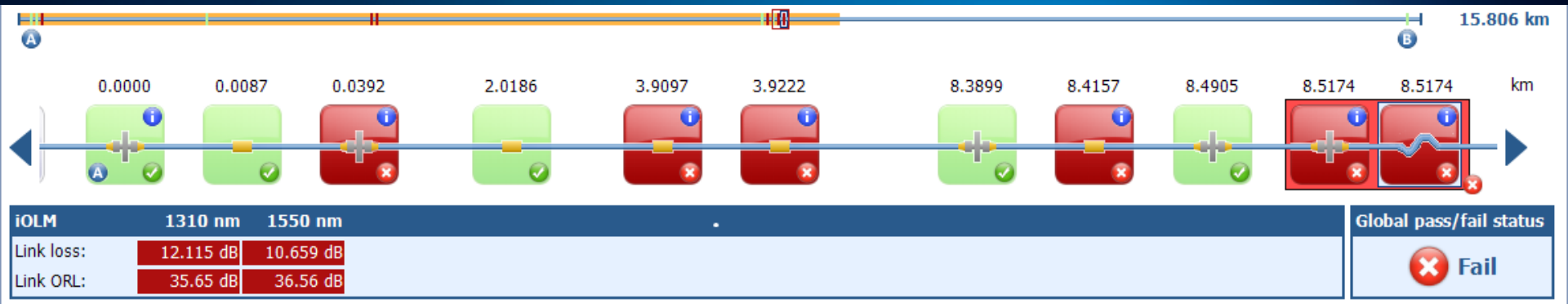




IOLM™: Multipulses with smart recognition and diagnostic



iOLM results



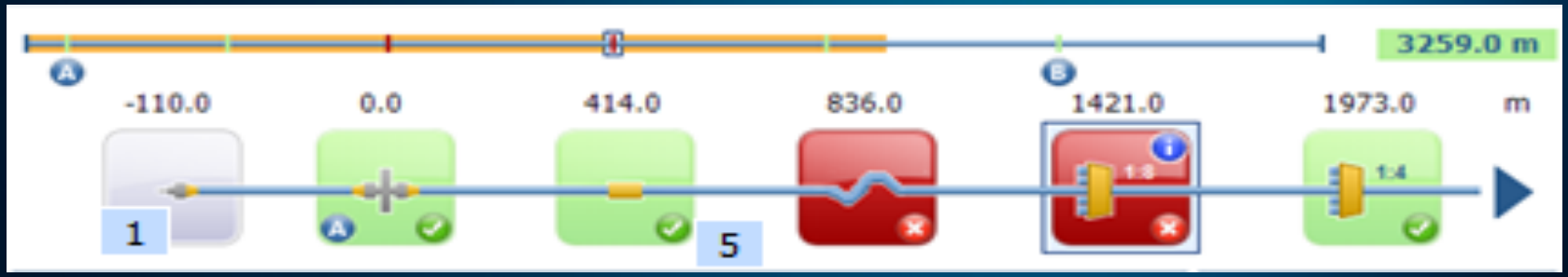
iOLM	1310 nm	1550 nm
Link loss:	12.115 dB	10.659 dB
Link ORL:	35.65 dB	36.56 dB

Global pass/fail status: Fail

iOLM | Element | Measurement Info

Type	Pos. (km)	Loss (dB)		Reflectance (dB)	
		1310 nm	1550 nm	1310 nm	1550 nm
Σ	8.5174	1.855	3.629	-37.0	-41.5
~	8.5174	---	---	---	---

• Inspect the fiber in this area to search for excessive bending or cable compression.



Troubleshooting with OTDR/IOLM on live fiber

› A filtered out of band OTDR/IOLM is able to test a live fiber showing stress or excess loss.

› An optional Power measurement is also available on the live Port

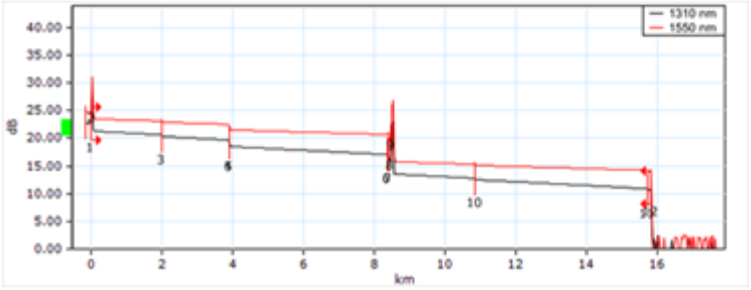
iOLM report now includes real OTDR trace

Link View

Element Table

Type	No.	Pos. (km)	Loss (dB)		Refl. (dB)		Diagnostic
			1310 nm	1550 nm	1310 nm	1550 nm	
Connector		-0.1581	0.124	0.097	-67.5	-69.6	
Connector	1	0.0000	0.047	0.048	-77.8	---	• The connection between the launch fiber and the tested link was not found. Make sure that the specified length corresponds to the launch fiber used. Use measure functionality to get the exact length of the launch fiber.
Group	2	---	1.351	1.058	-48.1	-48.8	
+ Connector		0.0316	---	---	-48.1	-48.9	
+ Connector		0.0346	---	---	-41.7	-42.9	
Splice	3	2.0092	0.303	0.238	---	---	
Splice	4	3.9008	0.558	0.482	---	---	• Make sure that the fiber is properly spliced. The loss could due to a low-reflectance (APC) connector.
Splice	5	3.9146	0.614	0.537	---	---	• Make sure that the fiber is properly spliced. The loss could due to a low-reflectance (APC) connector.
Connector	6	8.3828	0.387	0.257	-61.6	-62.0	
Splice	7	8.4076	0.960	0.860	---	---	• Make sure that the fiber is properly spliced. The loss could due to a low-reflectance (APC) connector.
Connector	8	8.4826	0.305	0.237	-45.9	-46.9	
Group	9	---	1.820	3.546	-35.2	-39.7	
+ Connector		8.5097	1.820	3.546	-35.2	-39.7	• The connector or bulkhead is damaged, dirty or not well connected. Inspect and clean as needed.
+ Macrobend		8.5097	---	---	---	---	• Inspect the fiber in this area to search for excessive bending or cable compression.
Splice	10	10.843	0.205	0.184	---	---	
Splice	11	15.705	0.225	0.198	---	---	
Connector	12	15.805	---	---	-57.4	-62.1	• To characterize loss and include the element in link loss and ORL, a receive fiber is required.

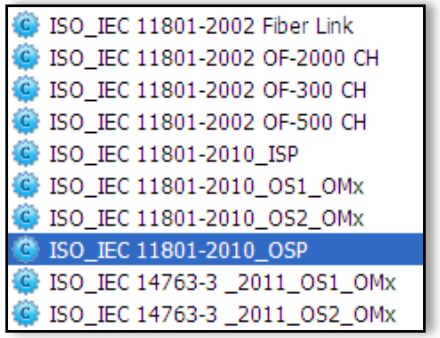
OTDR Graphic



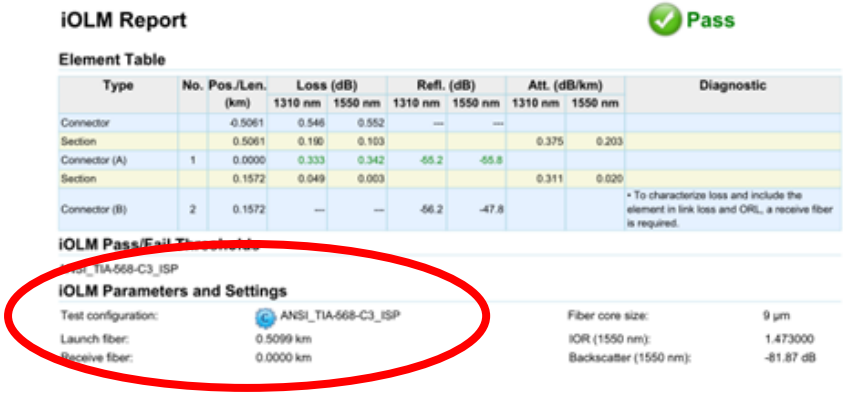
Certification using iOLM

Certified configurations

Preset test configs

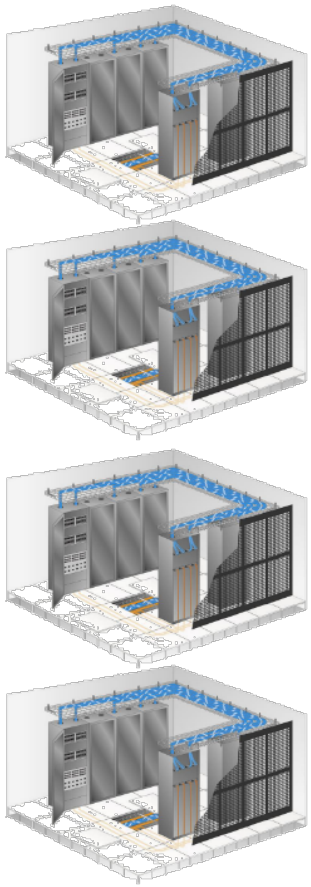


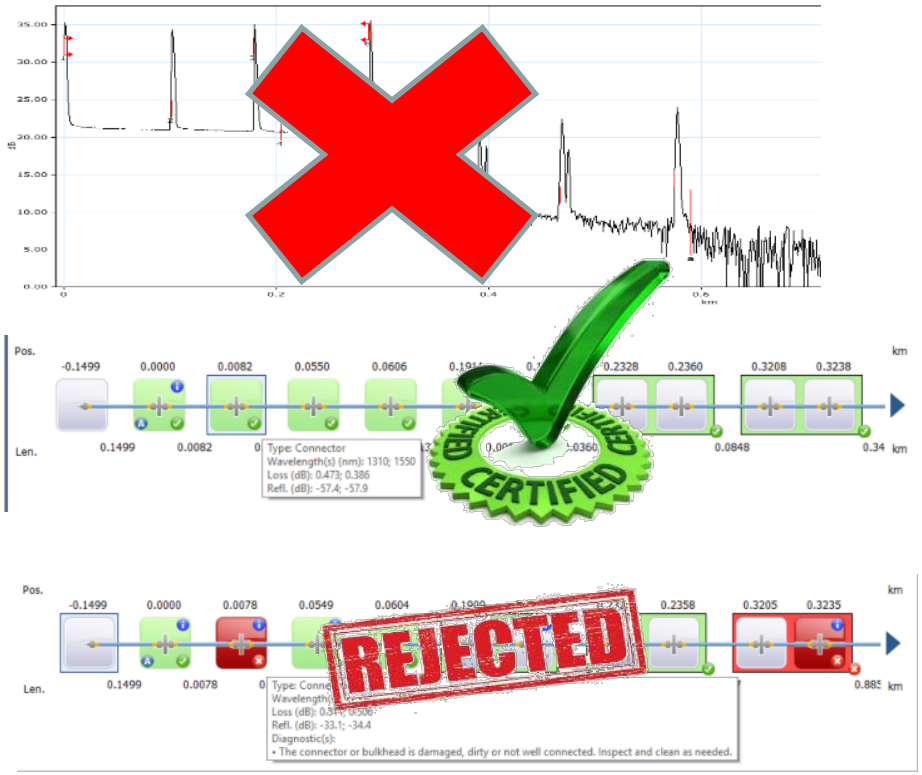
Complete report with selected standard



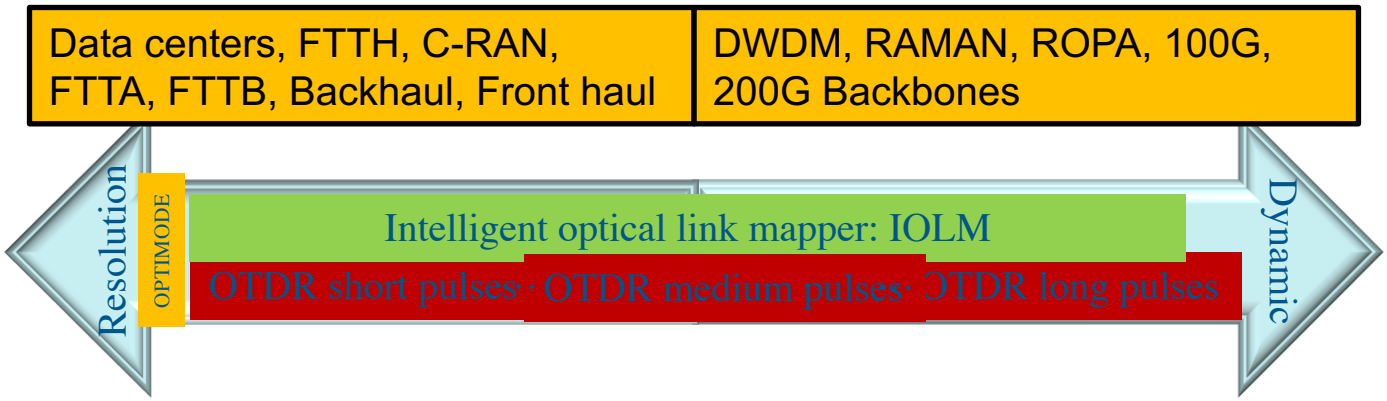
Thresholds values on report – Jan15

Intelligent Optical link mapper





New challenges for the OTDR



Short links requirements:

- High resolution
- Fast acquisition time
- Length measurement accuracy
- Loss accuracy
- Close events
- Macro bend detection

Long links requirements:

- High Dynamic range
- High sensitivity
- First 10Km high res
- Macro bend detection
- Loss accuracy
- ORL accuracy

QUESTIONS?

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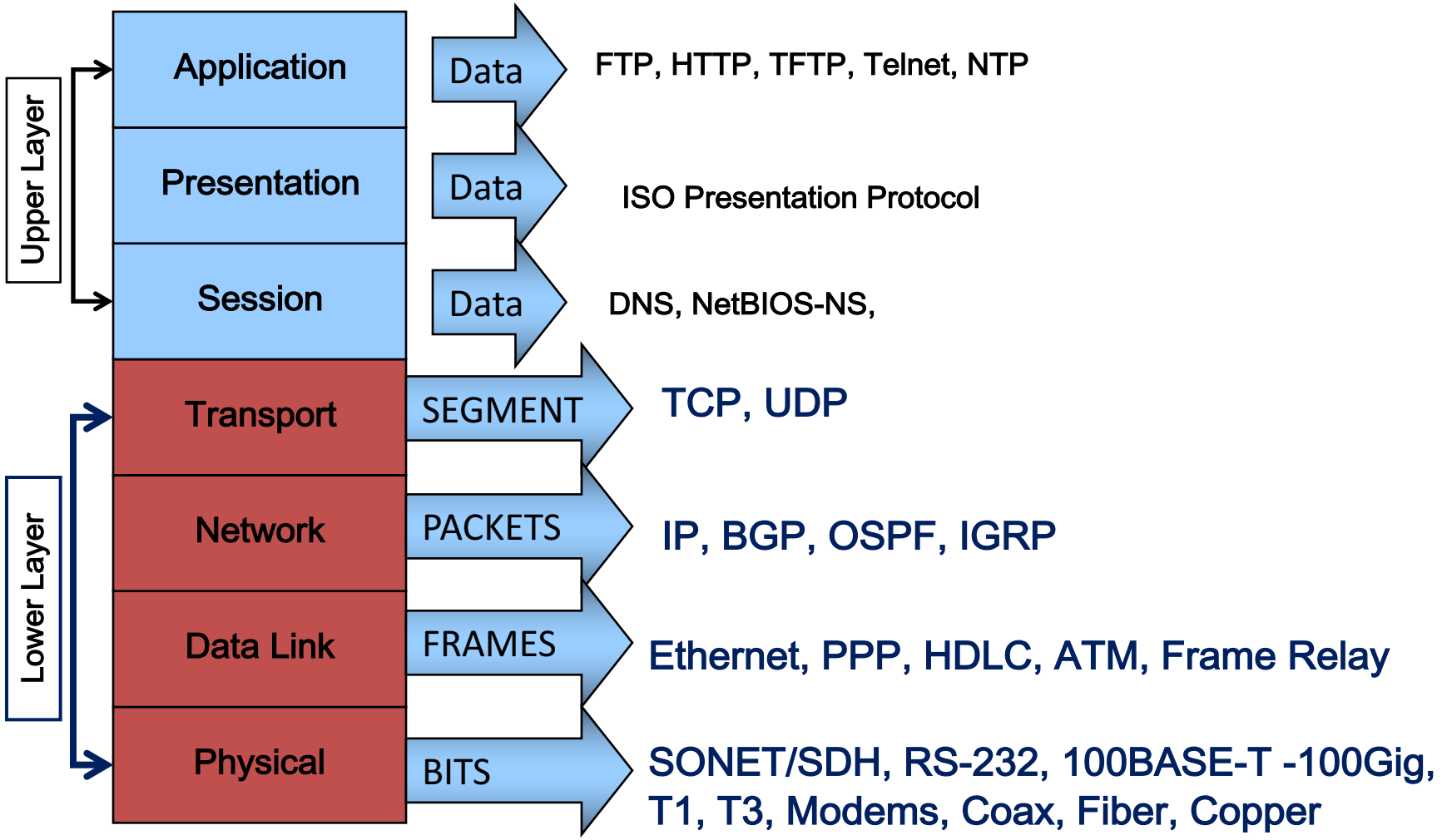
Shared IT Services for Higher Education & Research

Conference 2017

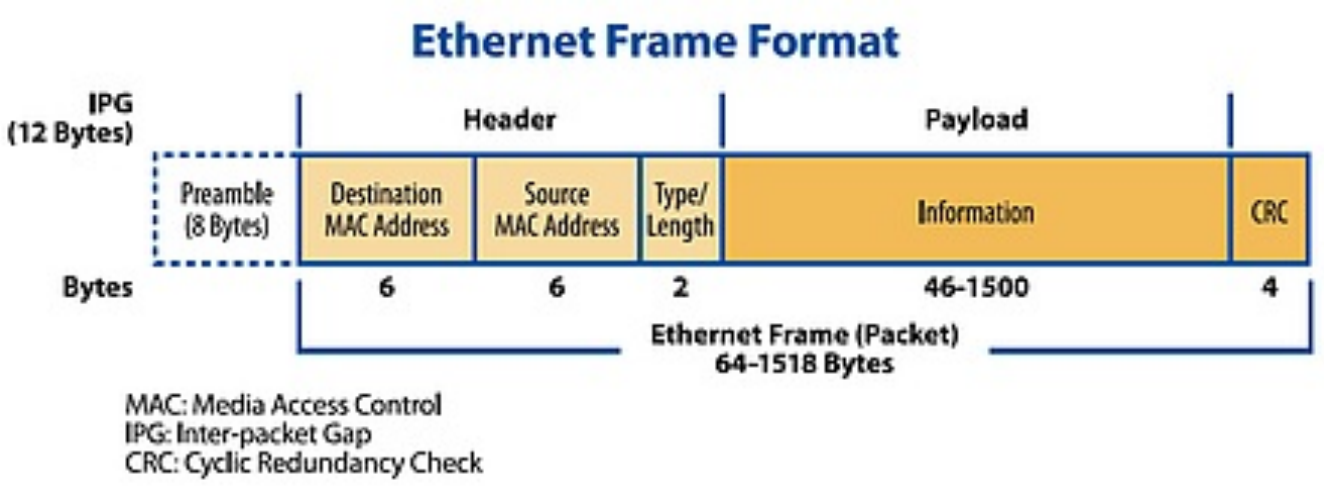
Ethernet Technology Review and EtherSAM

OSI Reference Model Popular Protocols



IEEE 802.3

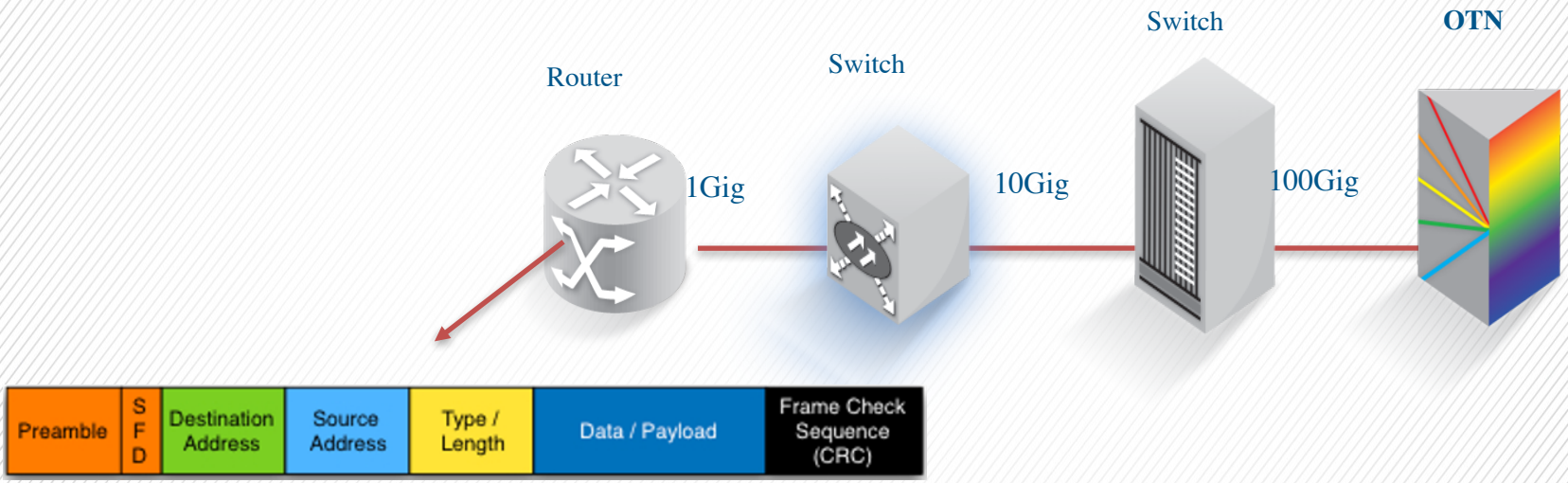
- Support Full Duplex
- Frame structure preserved accros all 802.3 standard
  - Interconnexion from 100Mbps to 100 Gig
- Frame size minimum to maximum
  - 64 Bytes to 1518 Bytes
- Bit Error Rate (BER) objective
  - Better than 10^{-12} for L1 (Physical) and L2 (MAC)
- Support for Optical Transport Network (OTN)



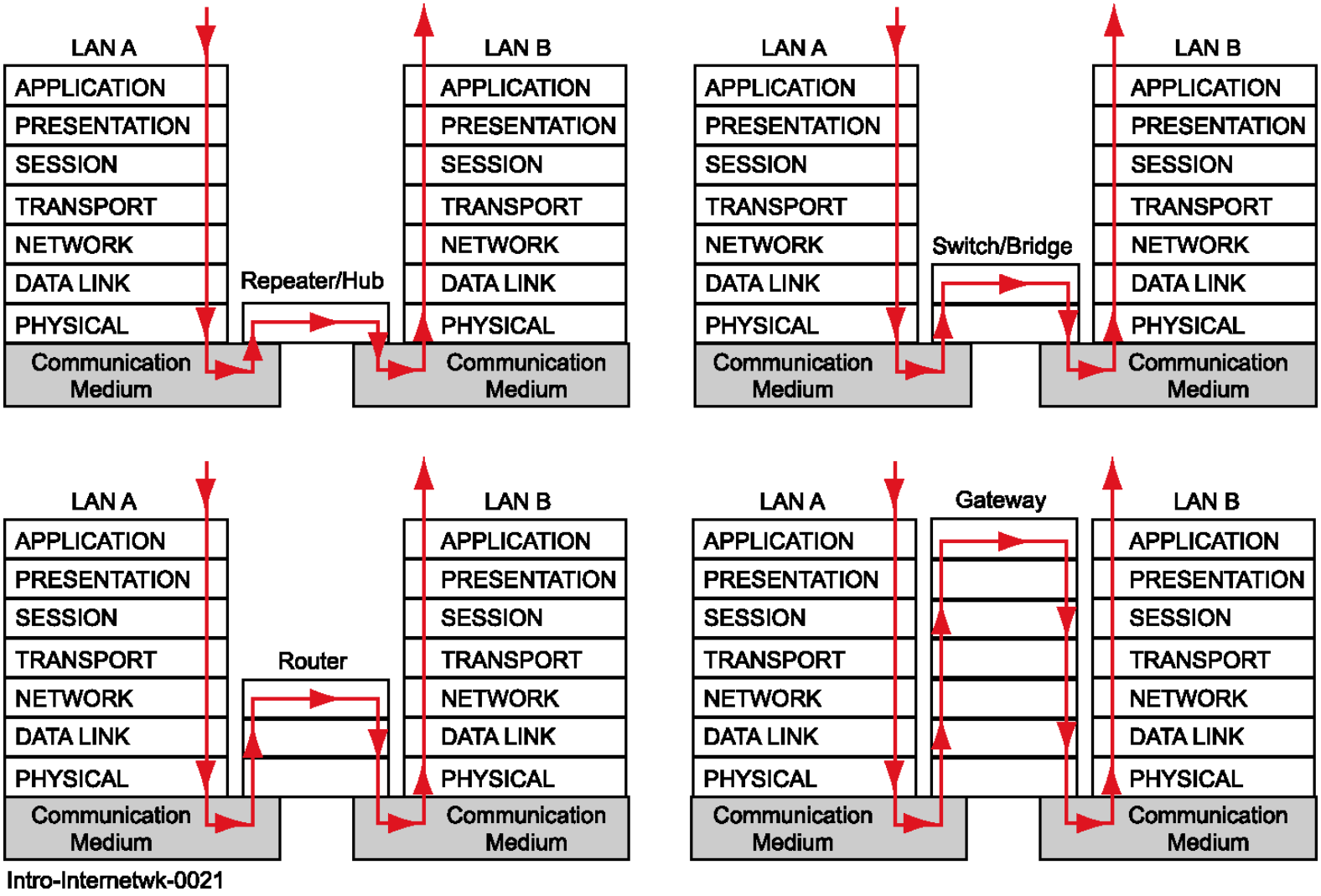
OH:18B

802.3 Interconnection

Interconnects all ethernet type system

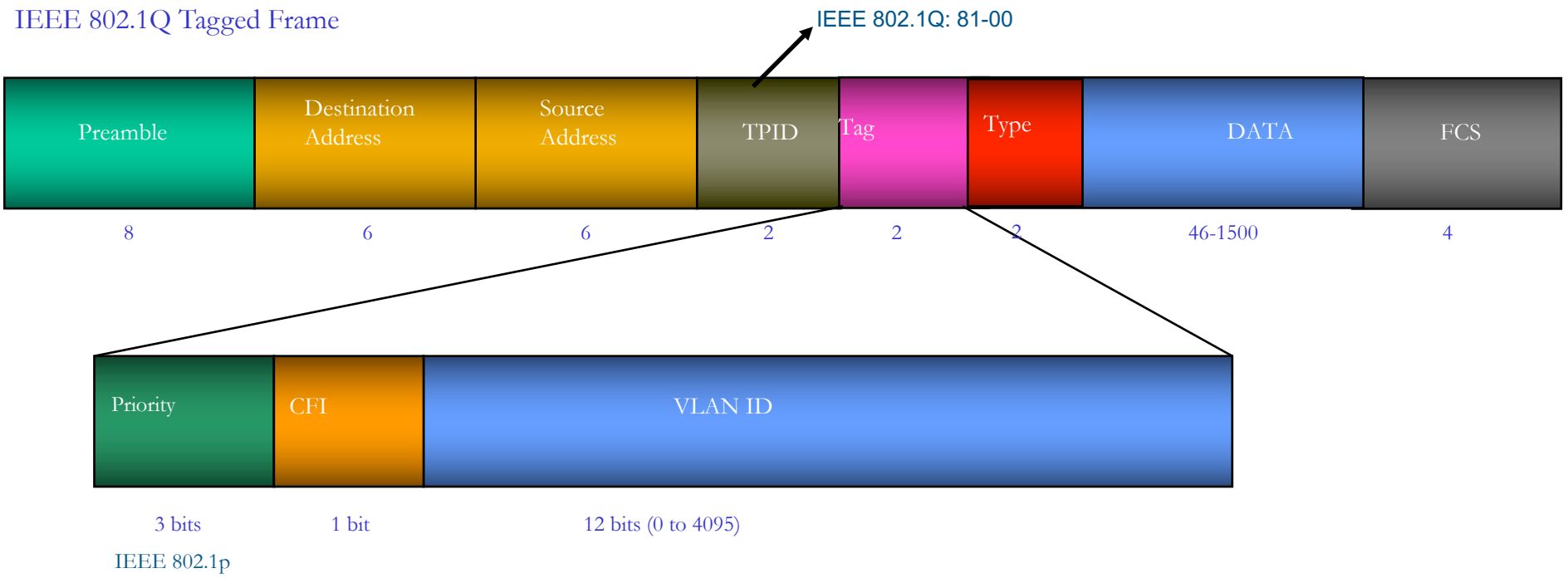


Internetworking Devices



Intro-Internetwk-0021

IEEE 802.1 Q/p


IEEE 802.1Q Tagged Frame
IEEE 802.1Q: 81-00
Preamble
Destination Address
Source Address
TPID
Tag
Type
DATA
FCS
8
6
6
2
2
2
46-1500
4
Priority
CFI
VLAN ID
3 bits
IEEE 802.1p
1 bit
12 bits (0 to 4095)

Ethernet Test Requirements

The services

Typical SLA for Ethernet-Based Services

SLA Parameter	Services			Comments
	Ethernet Services	Mobile Backhaul Services	Legacy TDM Services	
Frame Delay (Latency)	typical 5 ms - best effort up to 30 ms	5 ms (max 8ms)	50-60 ms	MEF 3 <25 ms
Frame Delay Variation - FDV (Jitter)	2 ms		-	MEF 3 <10 ms Service dependant
Frame Error rate	Better than $1x10^{-6}$ (0.0001%)		-	Service dependant
Bit Error Rate	-	From $1x10^{-9}$ to $1x10^{-11}$	From $1x10^{-11}$	-
Service Disruption	50 ms			From a Layer 1 perspective
Network Availability (Protected Core)	From 99.995 to 99.999%			26.28 to 5.26 min. per year

MEF: Performance Guide for Metro Ethernet

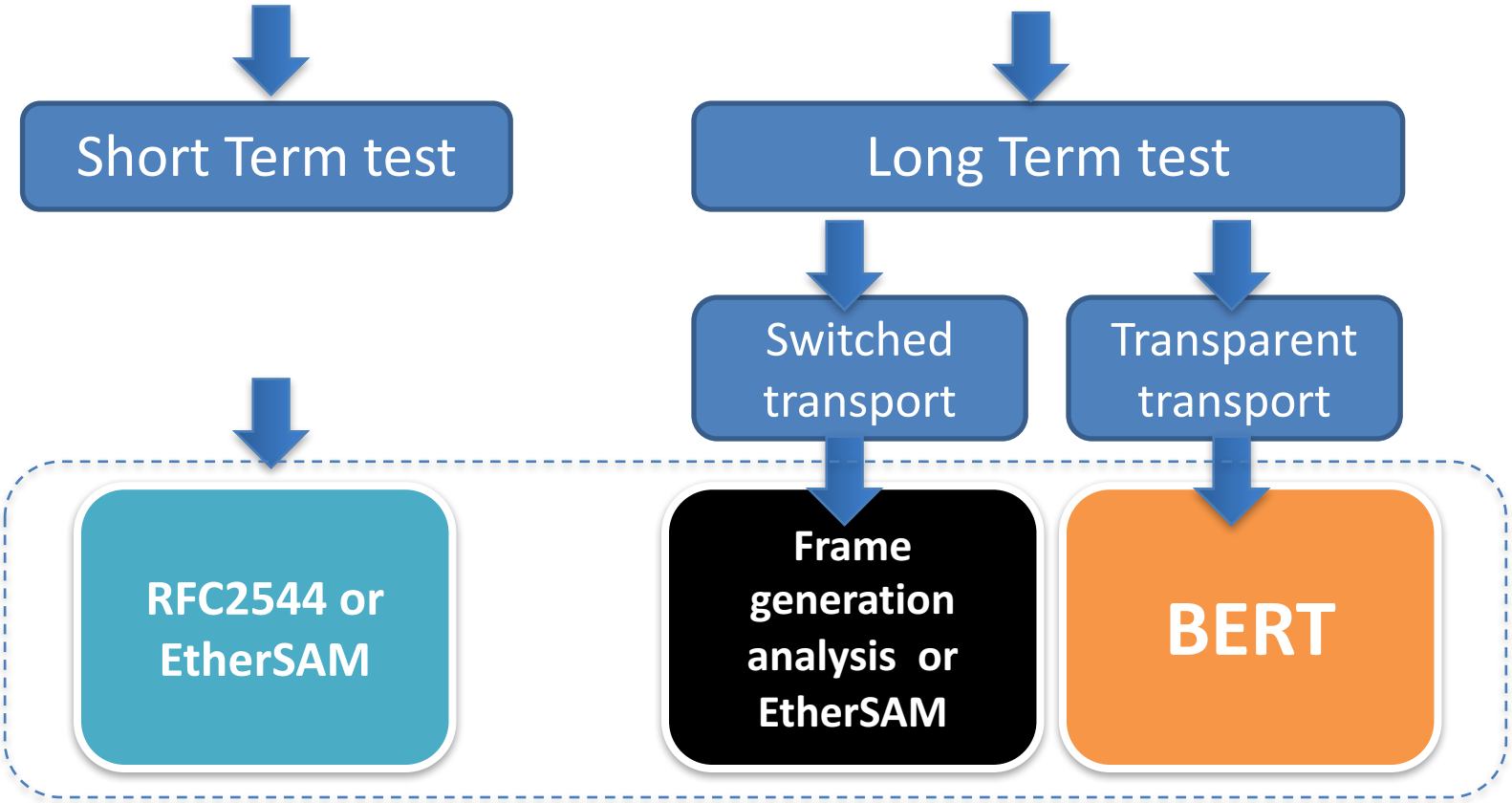
Performance Attributes	Real time application Ie: VOIP	High priority data	Lower priority data
	Pt-Pt	Pt-Pt	Pt-Pt
Latency one way (ms)	≤ 8	≤ 20	≤ 37
Packet delay variation, Jitter (ms)	≤ 2	≤ 8	N/S
Frame Loss Rate (ratio)	≤0.001% i.e. 10^{-5}	≤0.001% i.e. 10^{-5}	≤0.1% i.e. 10^{-3}

MEF: Performance Guide for Regional Ethernet

Performance Attributes	Real time application Ie: VOIP	High priority data	Lower priority data
	Pt-Pt	Pt-Pt	Pt-Pt
Latency one way (ms)	≤ 25	≤ 75	≤ 125
Packet delay variation, Jitter (ms)	≤ 8	≤ 40	N/S
Frame Loss Rate (ratio)	≤0.001% i.e. 10^{-5}	≤0.001% i.e. 10^{-5}	≤0.1% i.e. 10^{-3}

Test Scenario

Is the Ethernet test a short term performances assessment or a long term acceptance test?
Is the service delivered via a switched transport or via transparent transport?



Framing representation

Framing Representation	Framing Layer	OSI Equivalent
IFG | MAC Header | IP Header | UDP Header | Test Pattern | CRC	FL4	Transport
IFG | MAC Header | IP Header | Test Pattern | CRC	FL3	Network
IFG | MAC Header | Test Pattern | CRC	FL2	Data Link
IFG | Test Pattern	FL1	Physical

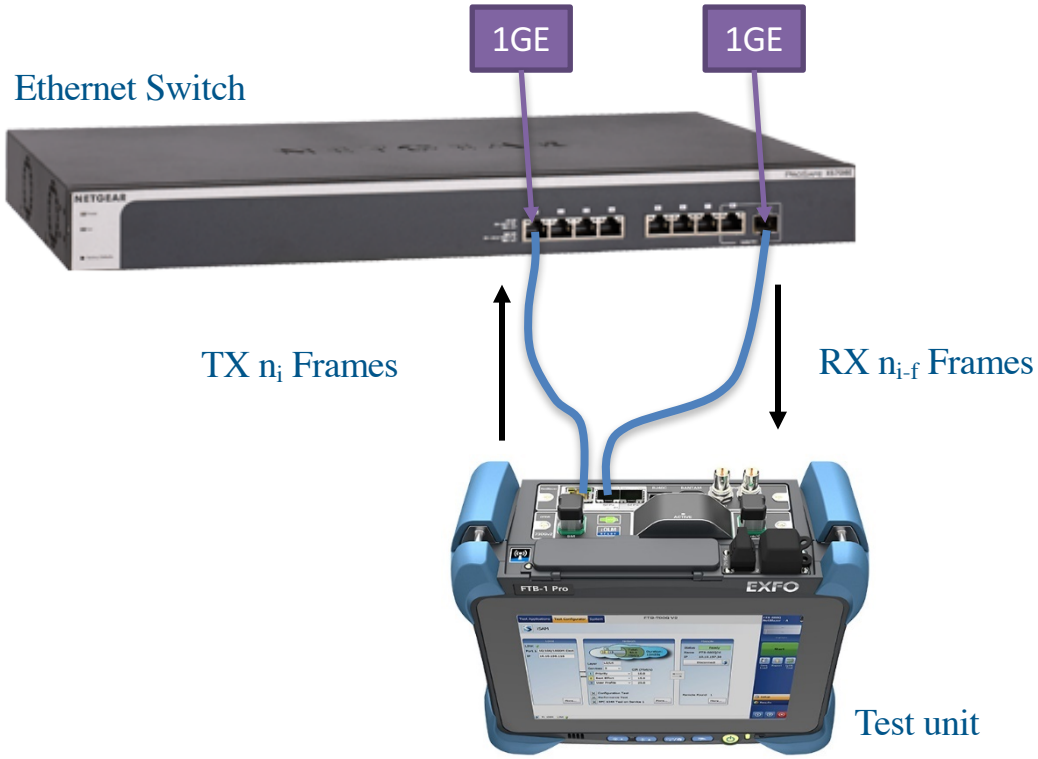
Frame from 64B to 1518B


EtherSAM

RFC-2544

- Defined in 1999
- Specific set of test to measure the performances of network device
- Not all test apply to all type of device
- The ideal test is using one port to transmit and one port to receive the frames

RFC-2544 test example



RFC-2544 Characteristics

4 tests defined in the RFC

- Throughput - Bandwidth
- Back-to-back
- Frame Loss
- Latency

Each test will use the following frame distributions

- 64B,128B, 256B, 512B, 1024B, 1280B, 1518B
- A test time will be define for every test

Performance Tests

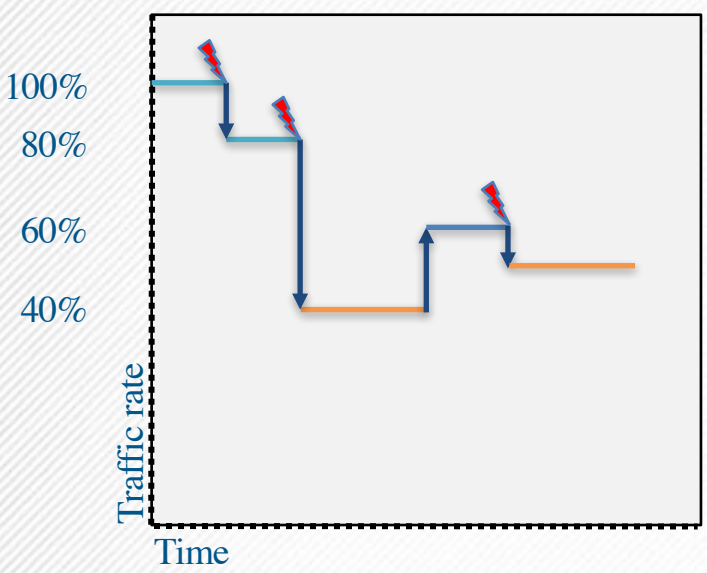
Throughput (Bandwidth Verification)
Maximum rate of transmitted frames through the network.
Test Objective: to find the throughput of the device under test with no frame loss.

Back to Back (Burstability Bandwidth)
Maximum burst of traffic through network where Burst = the max number of bytes at full line rate before a packet is dropped
Test Objective: to find the Maximum number of frames that can be sent at the max throughput without frame loss.

Frame Loss - Measure network ability to handle overload.
Test Objective: % of frames lost due to the lack if resources

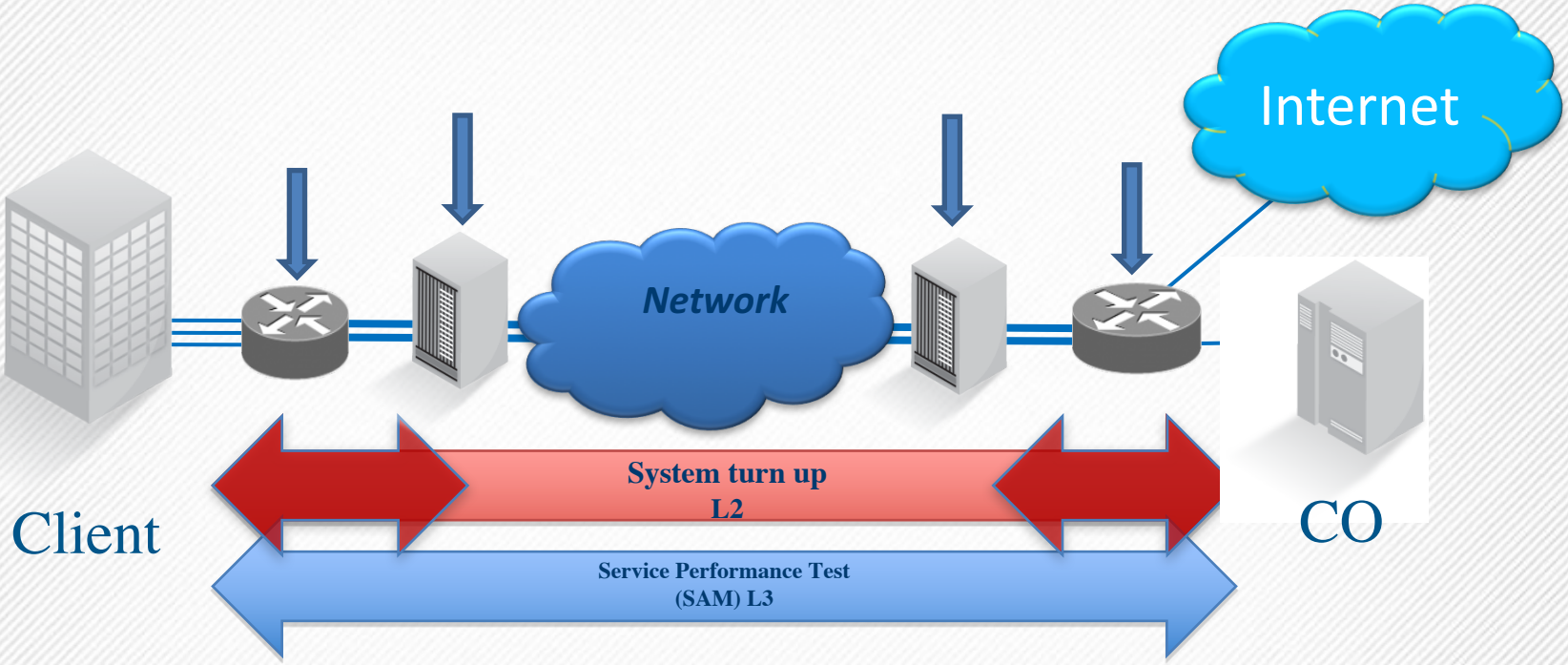
Latency - Round Trip delay of frames through network
Test Objective: to find the time required for a sent frame to go through the device under test and return to the test set.

RFC-2544 Process



Frame Loss

Turning up service



Y.1564 SAM (Service Activation Methodology)

Automatic test

Phase 1 – **Network Configuration Test (Ramp Test)**

Objective: ***Validate the network configuration***	**Methodology: RAMP**

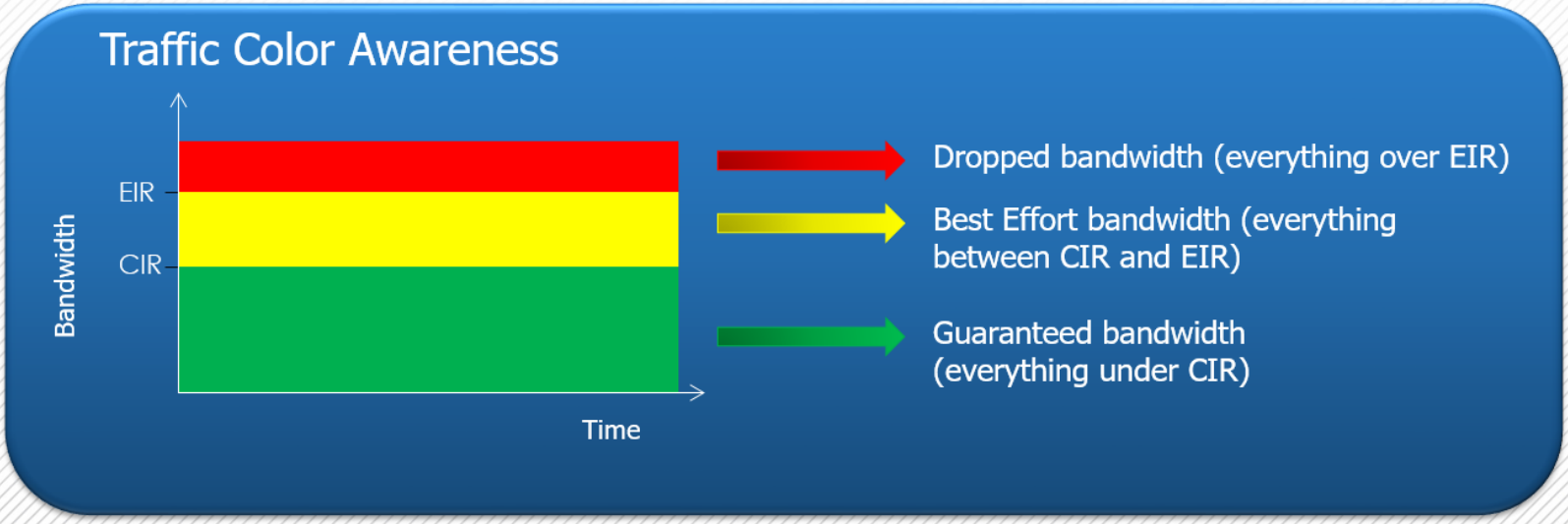
Phase 2 – **Performances Test**

Objective: Validate the quality of service of each defined service and prove SLA conformance	**Methodology: All services are generated** at once to their CIR and all KPIs are measured for all services

CIR = Bandwidth

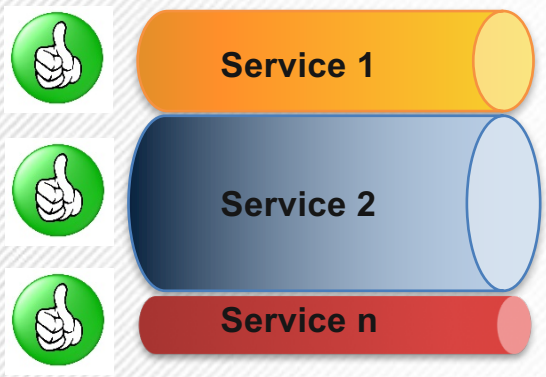
CIR: ***Committed Information Rate***: Guaranteed bandwidth. Service Frames rate to meet the performance objectives defined by the CoS Service Attribute.

EIR: ***Excess Information Rate***: Best effort bandwidth. Service Frames rate capable without any performance objectives.



ITU-T Y.1564 Phase 1: Service Configuration

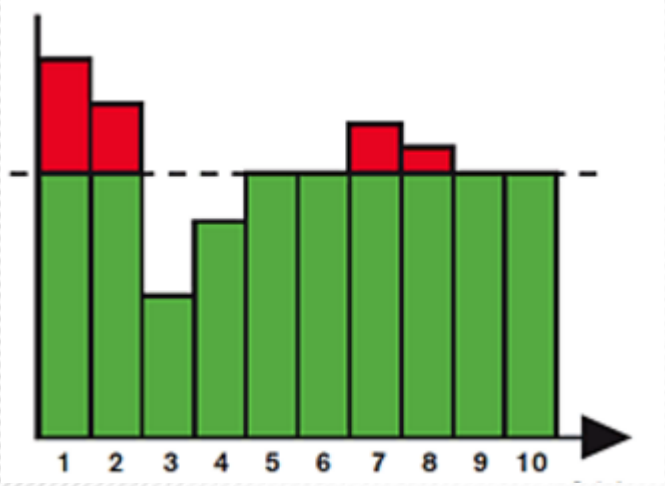
Phase 1: **Service Configuration Test**	
Objective: Service validation	**Methodology:** Individual test



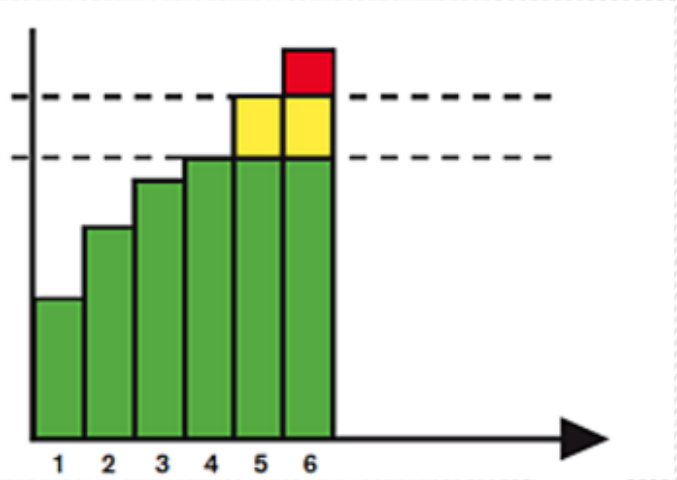
Test objective

- throughput,
- frame delay,
- frame loss,
- frame delay variation (Jitter)
- OOS

RFC 2544 vs Y.1564



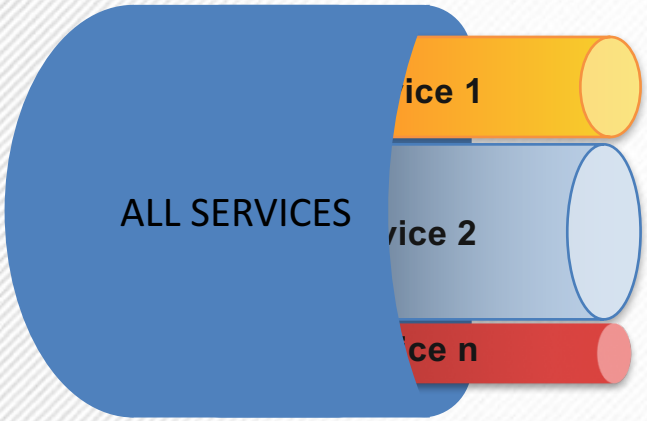
RFC process



Y.1564 process

ITU-T Y.1564 Phase 2: Performances

Phase 2: **Performances Test**	
Objective: Test all performances	**Methodology:** All services are tested

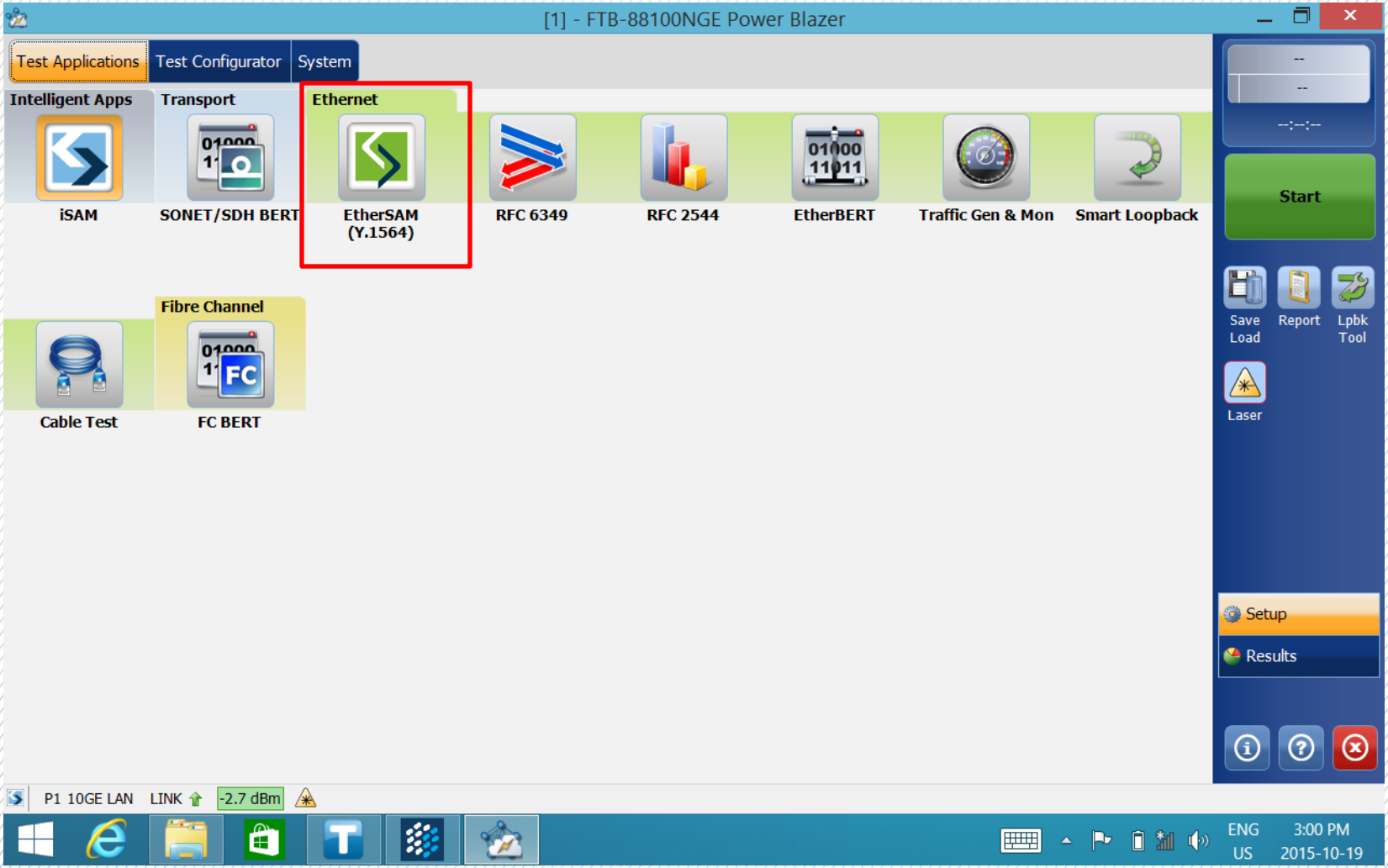


Test objective

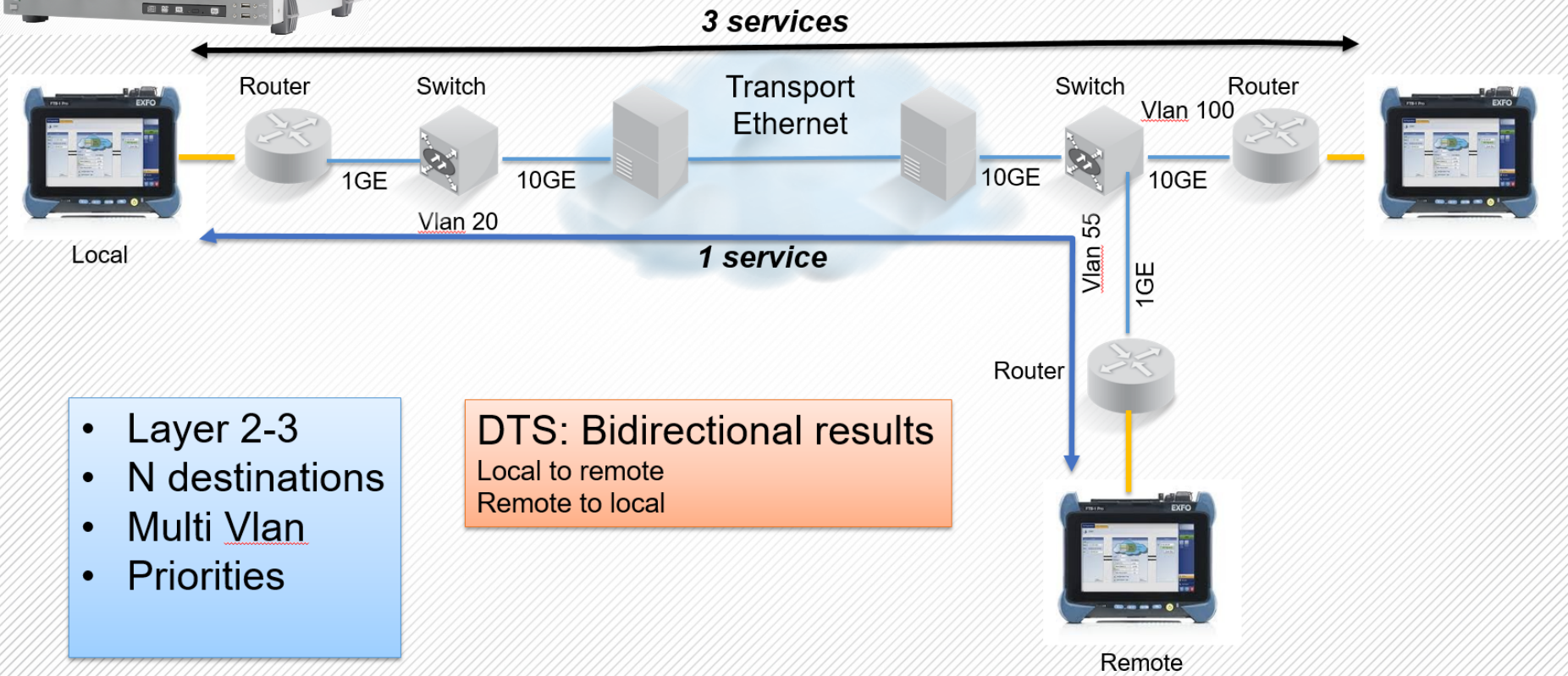
- throughput,
- frame delay,
- frame loss,
- frame delay variation (Jitter)
- OOS

Demonstration on unit

Test applications



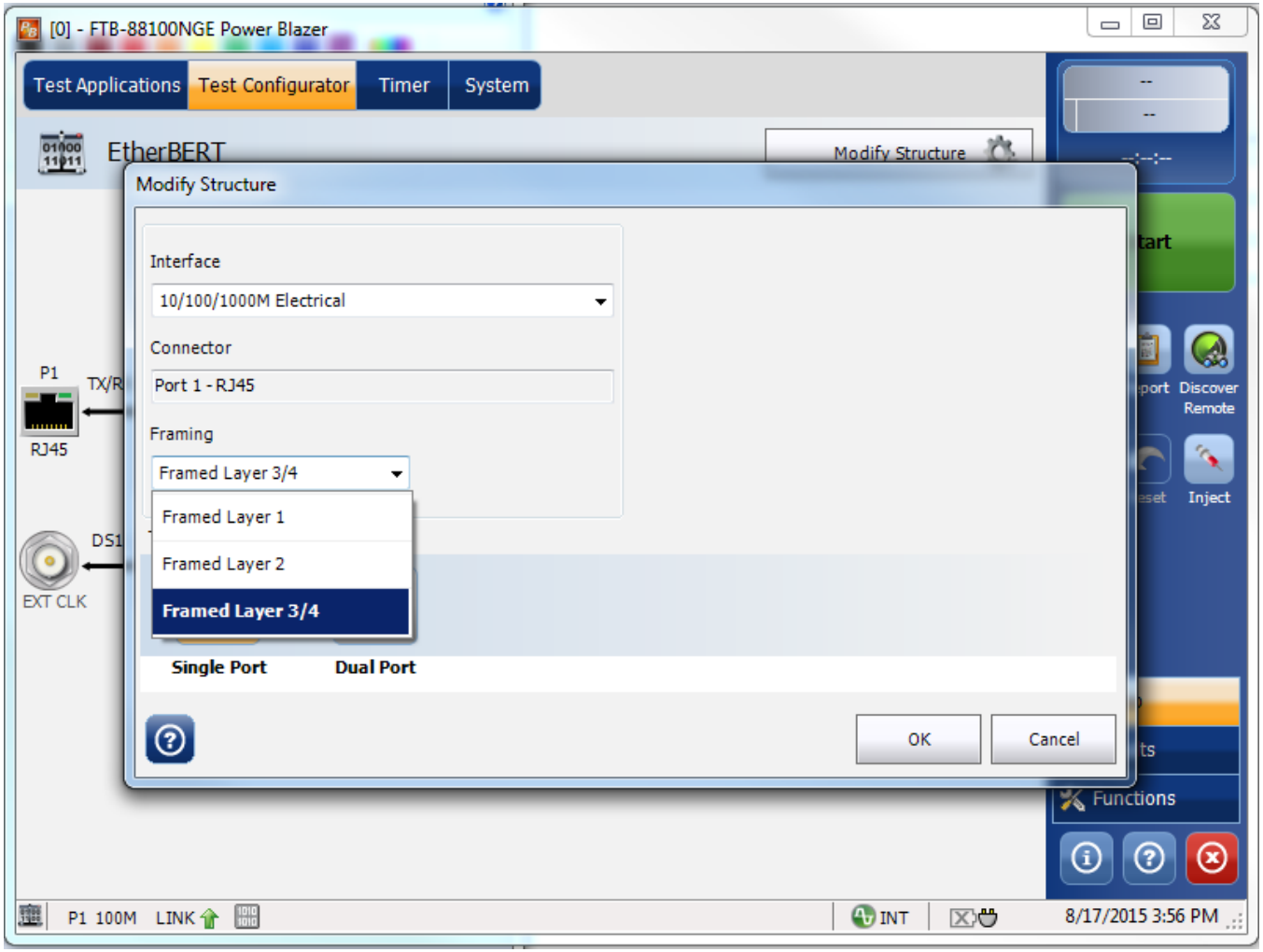
Testing example



- Layer 2-3
- N destinations
- Multi Vlan
- Priorities

DTS: Bidirectional results
Local to remote
Remote to local

Layer 1,2,3


[0] - FTB-88100NGE Power Blazer
Test Applications
Test Configurator
Timer
System
EtherBERT
Modify Structure
Modify Structure
Interface
10/100/1000M Electrical
Connector
Port 1 - RJ45
Framing
Framed Layer 3/4
Framed Layer 1
Framed Layer 2
Framed Layer 3/4
Single Port
Dual Port
OK
Cancel
P1
RJ45
DS1
EXT CLK
Discover Remote
Inject
Functions
P1 100M LINK
INT
8/17/2015 3:56 PM

Interpretation of Test Results

Report Section 5.1.3 Error Analysis

- **Symbol Error:** an invalid code-group in the transmission code is detected – an invalid 8B/10B modulation code sequence
- **Idol Error:** an error detected between the end of a frame and the beginning of the next
- **False Carrier:** a frame that arrives without a valid start of frame indicator
- **FCS:** ***Frame Check Sequence*** **–** extra checksum characters added to a Frame in a communication protocol for error detection and correction.
- **Jabber/Giant:** indicates the presence of a frame larger than 1518/1522 with an invalid FCS.
- **Oversize:** indicates the presence of a frame larger than 1518/1522 with a valid FCS
- **Runt:** The presence of a frame smaller than 64 Bytes with an invalid FCS
- **Undersize:** The presence of a frame smaller than 64 Bytes with an valid FCS
- **Alignment:** The number of bits received does not correlate to an even number of Bytes and the FCS is invalid
- **Collision:** Indicates the number of collisions on the link
- **Late Collision:** Indicates a collision which happens after 64Bytes of the frame has been received
- **Excessive Collision:** Indicates the number of frames that were unsuccessfully sent 16 times because of successive collisions

Report Section 5.2.2 Valid Frame Counts

- **Multicast -** simultaneously delivering a single stream of information to thousands of recipients
- **Braodcast -** transmitting a packet that will be received by every device on the network
- **Unicast –** sending of messages to a single network destination identified by a unique
- **N-unicast -**

Report Section 5.4.1 High Layer Protocol

- **IP Header Checksum –** An error-detection method where each transmitted message results in a value based on the value of total bytes in the message.
- **UDP –** Connectionless oriented - Best effort
- **TCP –** Connection oriented – sequence numbers; flow control; exchange of control messages