

Optimized test regimes and workflows for the certification and troubleshooting of an cabling infrastructure found in today's data centres

***Maximize ...
Optimize ...
Protect ...***

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Agenda

- What makes testing in the data centre **different** from testing cabling in the commercial building ?
- Adapted **fiber** test regimes for the data centre
- Adapter **copper** test regimes for the data centre



Data Centre vs. Commercial Building Cabling Infrastructure Differences Affect Test Regimes

Larger number of links

- Testing time
- Consolidation
- Labeling / ID Mgmt.



800+ Installers VOCs: Top eight problems (hours wasted)

Create
ProjX™



WRONG COPPER LIMIT	4.3	NEGATIVE LOSS	2.8
INCORRECT CABLE IDS	3.2	TROUBLESHOOT COPPER	2.7
CONSOLIDATING RESULTS	3.1		
SETTING UP COPPER TEST	2.9		
EVALUATING OTDR TRACE	2.9		
WRONG FIBER LIMIT	2.8		

Average amongst all respondents in the previous 30 days

Top eight problems:

Wrong Configuration (Limit, IDs, Standard,)

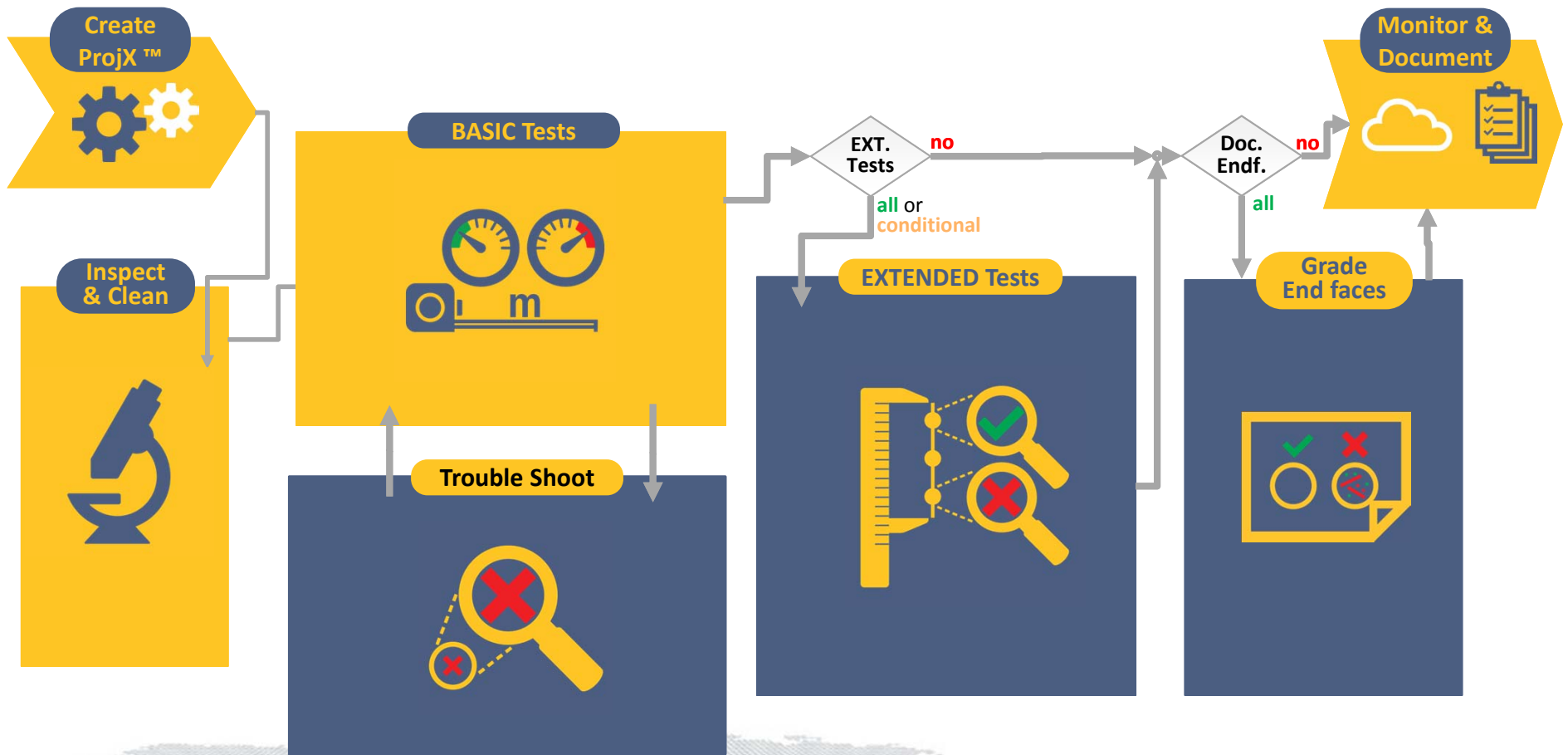
Create
ProjX™



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Average amongst all respondents in the previous 30 days

Step 1: Project Definition



Project Definition

Create
ProjX™

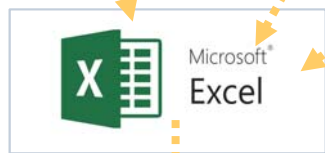


- Limits, Cable Types, Cable ID are best known by the planner/project-manager
- New relaxed ISO limits do not reflect what is possible and/or needed to be future ready → **Custom Limits**



ID Lists ... Sources

Create ProjX™

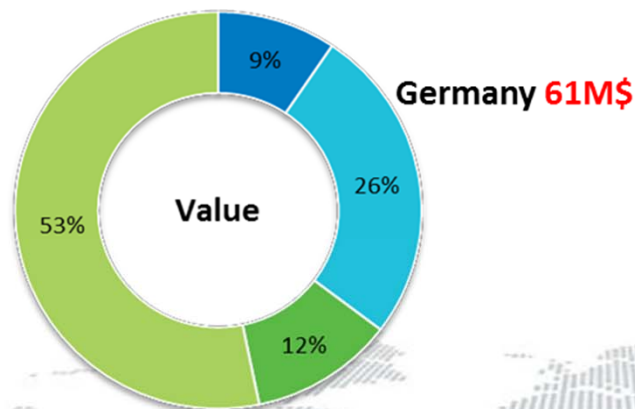


Data Centre vs. Commercial Building Cabling Infrastructure Differences affecting test regimes

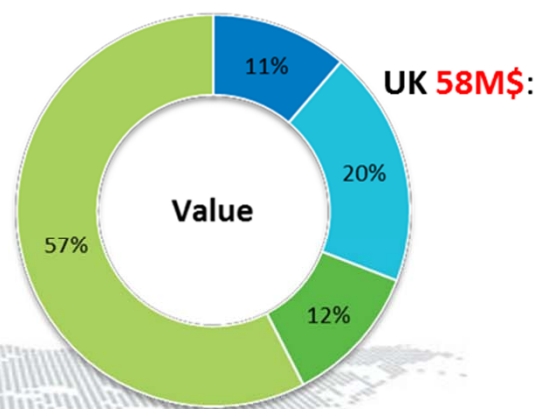
Larger number of links

Larger share of fiber vs. copper

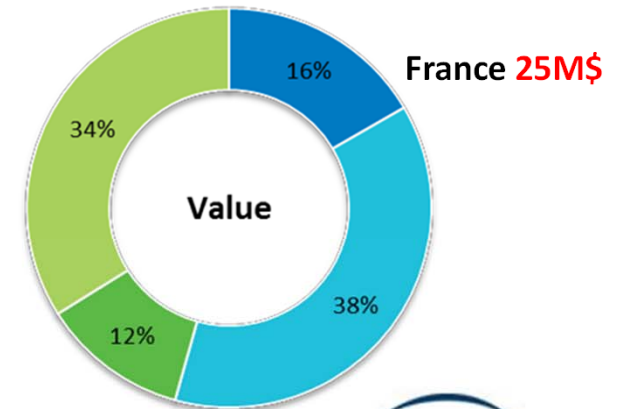
- Testing time
- Consolidation
- Labeling / ID Mgmt.



Source: BSRIA 2015



■ Cu Cable ■ Cu Connectivity
■ Fibre Cable ■ Fibre Connectivity



Data Centre vs. Commercial Building Cabling Infrastructure Differences affecting test regimes

Larger number of links

- Testing time
- Consolidation
- Labeling / ID Mgmt.

Larger share of fiber vs. copper

“Zoned” Data Centers

Low channel loss budgets

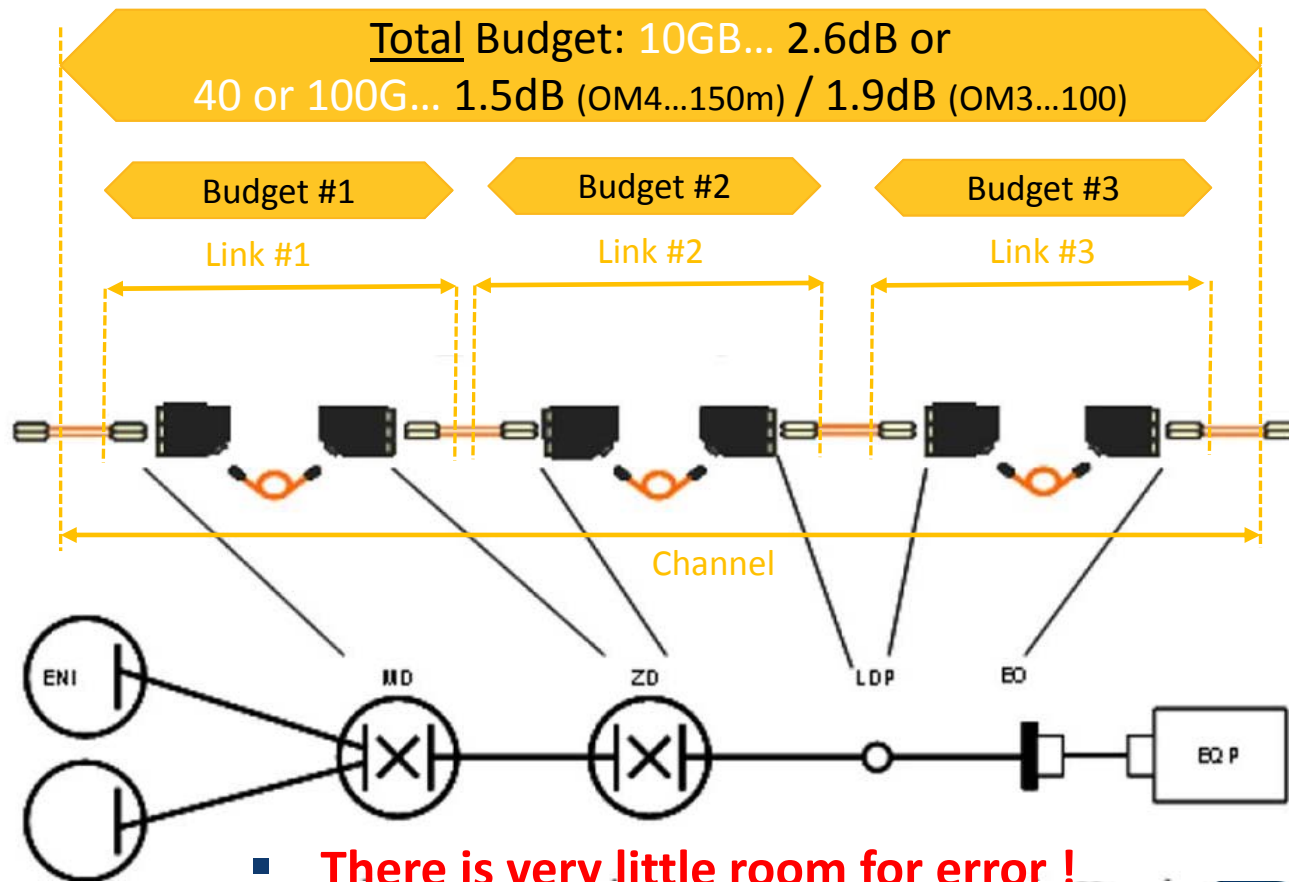
Low loss connectors

- Little room for measurement error



Testing – “Zoned” Data Centers

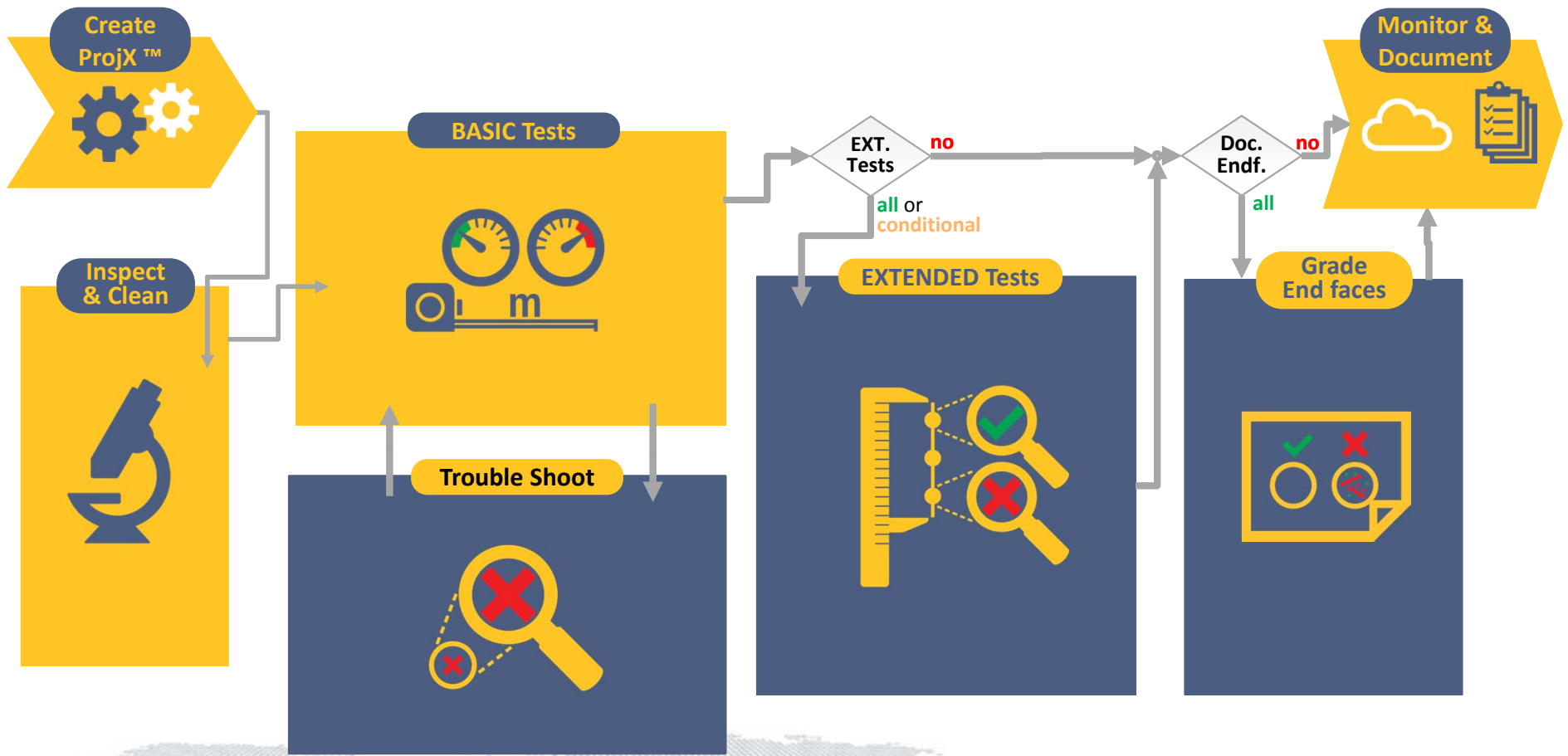
- After the installation only the links can be tested
- The “Patched Channel” is configured by the network user during the operational phase



▪ **There is very little room for error !**

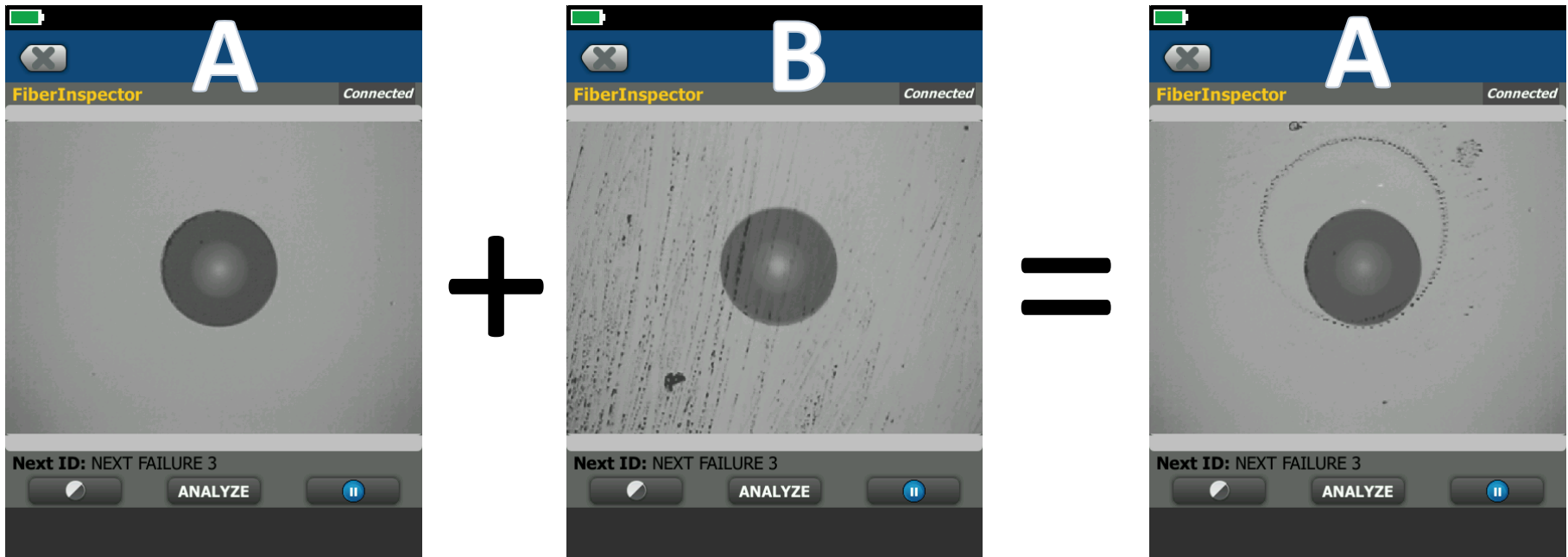


Step 2: Inspect & Clean Fibers



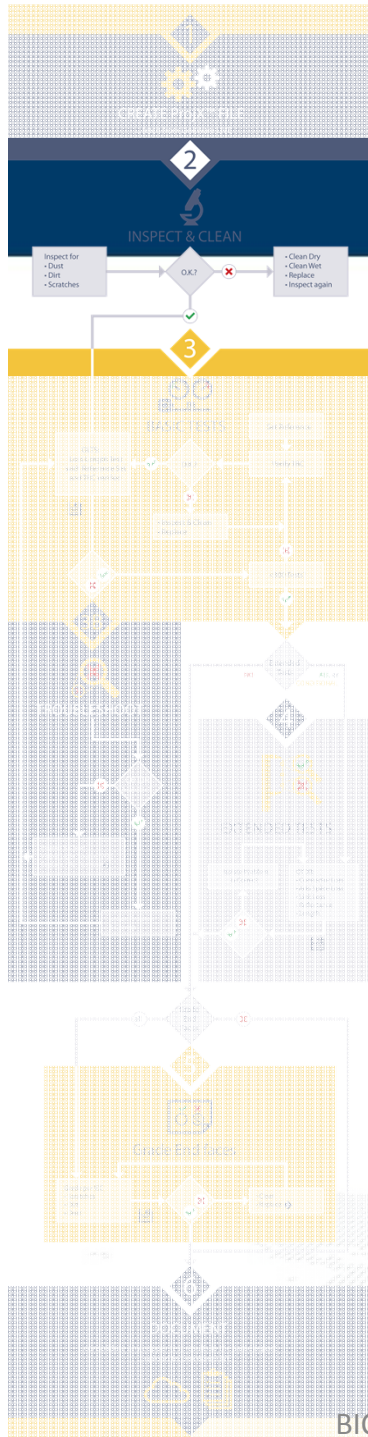
■ ...Optional / Conditional Testing

Dirt will transfer





Conclusion: Clean measurement cord after every mating

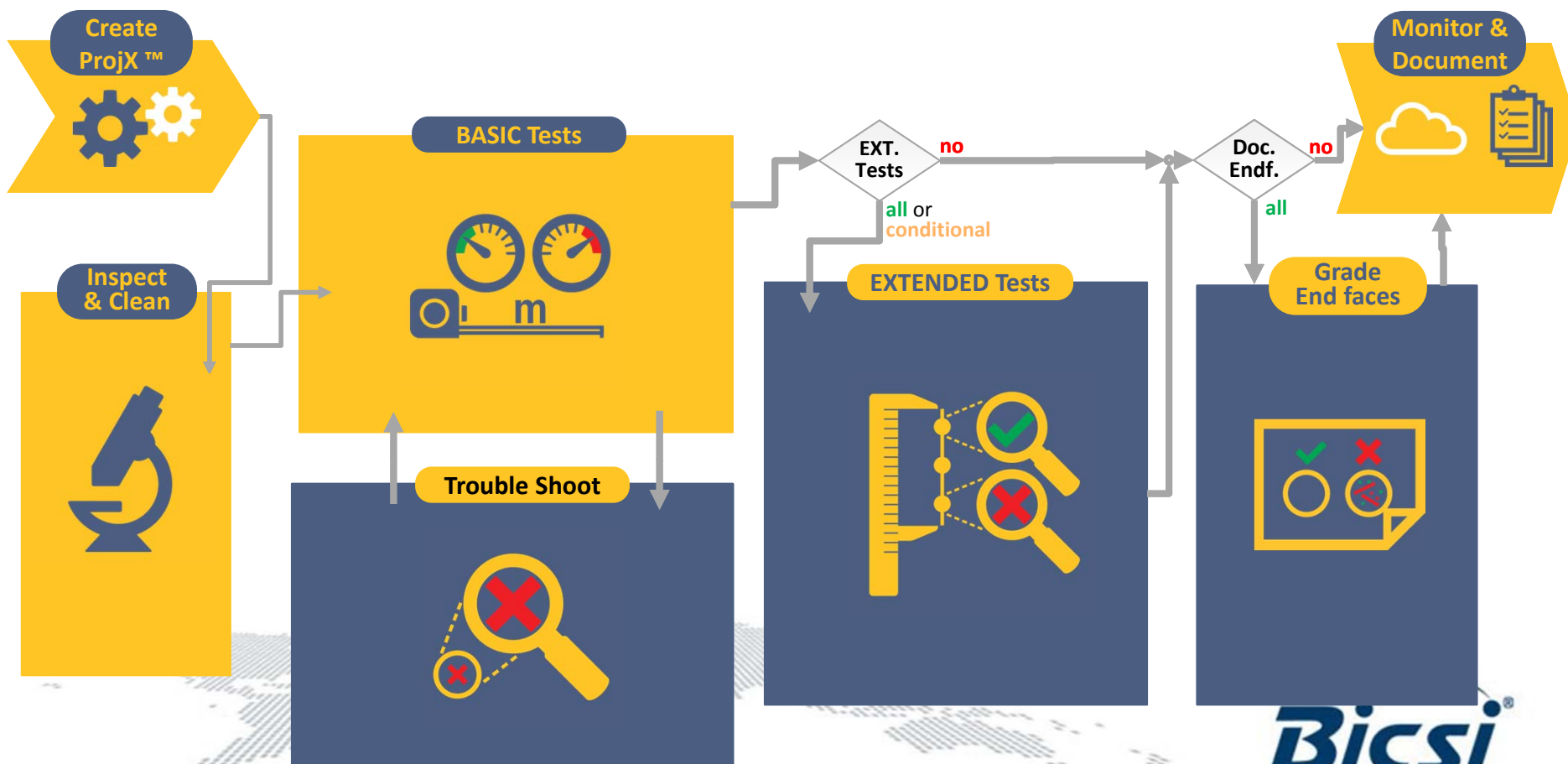
Step 2: Inspect & Clean



- Prevent dirt from causing poor/incorrect Test Results
- Prevent dirt from spreading
- Prevent abrasive dust on test cords damaging ports
- Prevent abrasive dust on ports from damaging valuable test cords

Step 3: BASIC Tests

	Tier 1	Tier 2
	BASIC	EXTENDED



■ ...Optional / Conditional Testing

Being certain of loss uncertainty



Power Meter
Performance

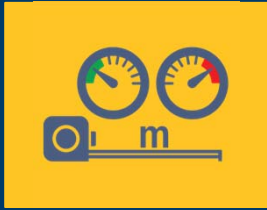
Light Source
Performance

1-Jumper Reference

Encircled Flux
and
Test Reference
Cords

Significance



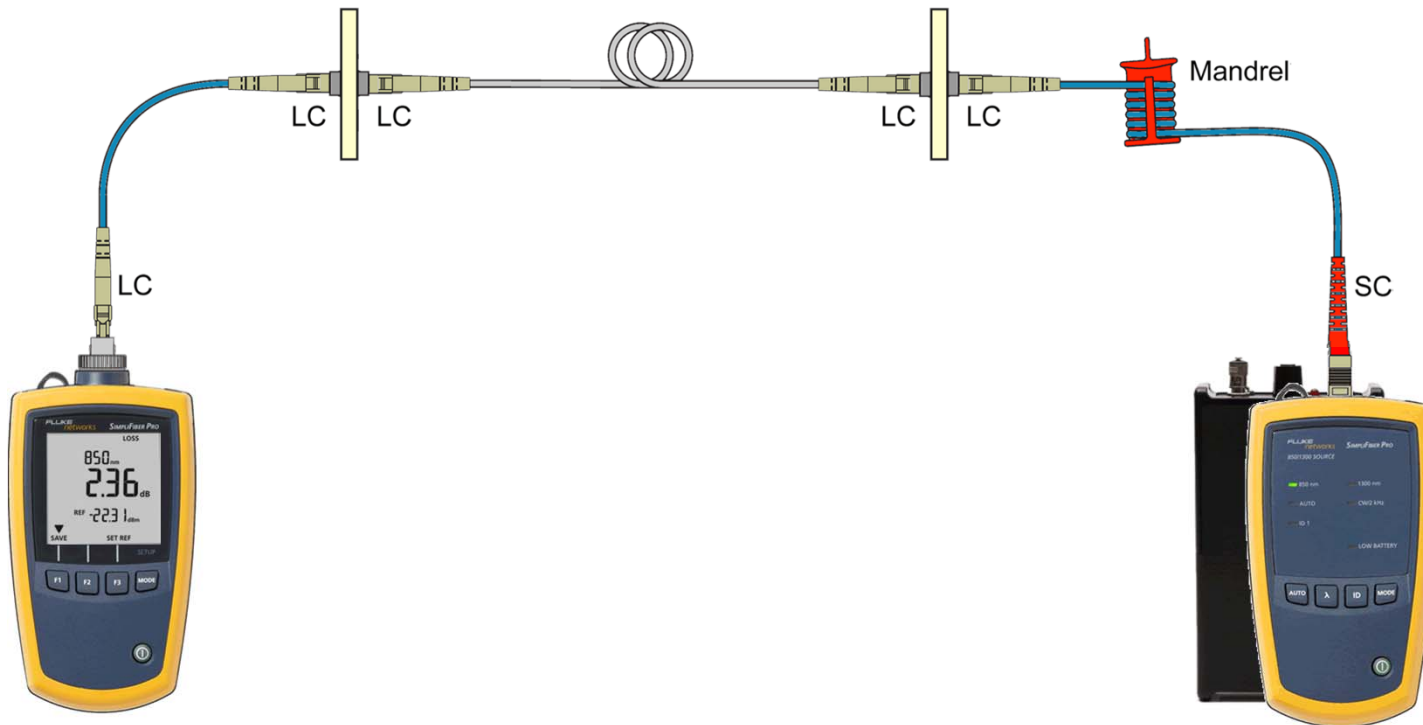


Set Reference & TRC verification

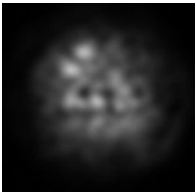
- A wizard guides through the correct process
- TRC verification stored as part of project
- A TRC verification test should be run with regular intervals



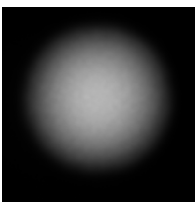
Why was the EF STANDARD NEEDED ?



LED



VCSEL



EF

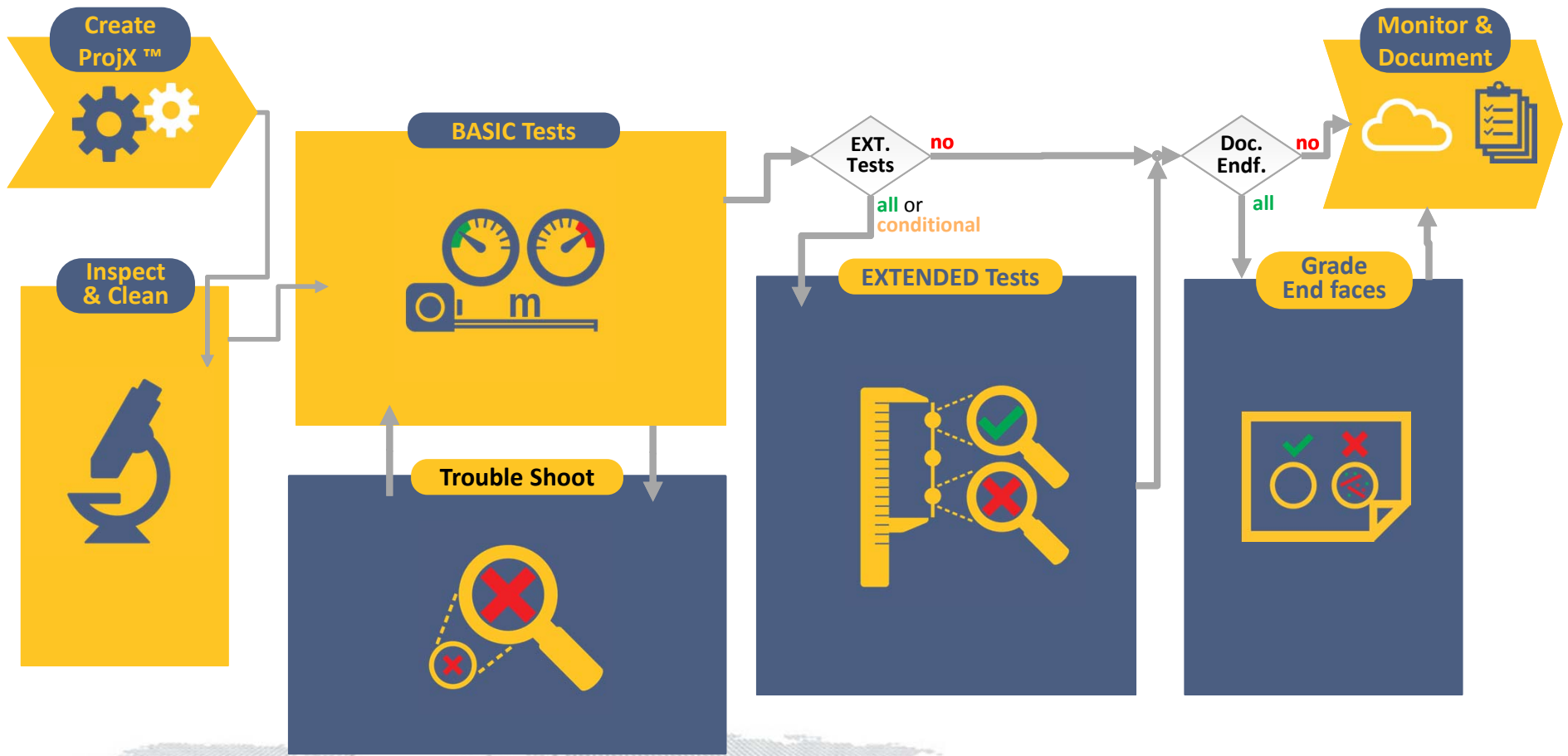
- Different light sources may have different launch conditions
- A EF compliant source reduces the error from 50% to 10%

Encircled Flux



Why ?	How ?
<p>Normative Requirement</p> <ul style="list-style-type: none">• ANSI/TIA-526-14-B• ISO 1180 → ISO/IEC 14763-3 Ed.1 62• EN 50173 → IEC IEC 61280-4-2	

If BASIC Tests **FAIL** ... Step 3B: Trouble Shoot



■ ...Optional / Conditional Testing

800+ Installers VOCs: Top eight problems (hours wasted)

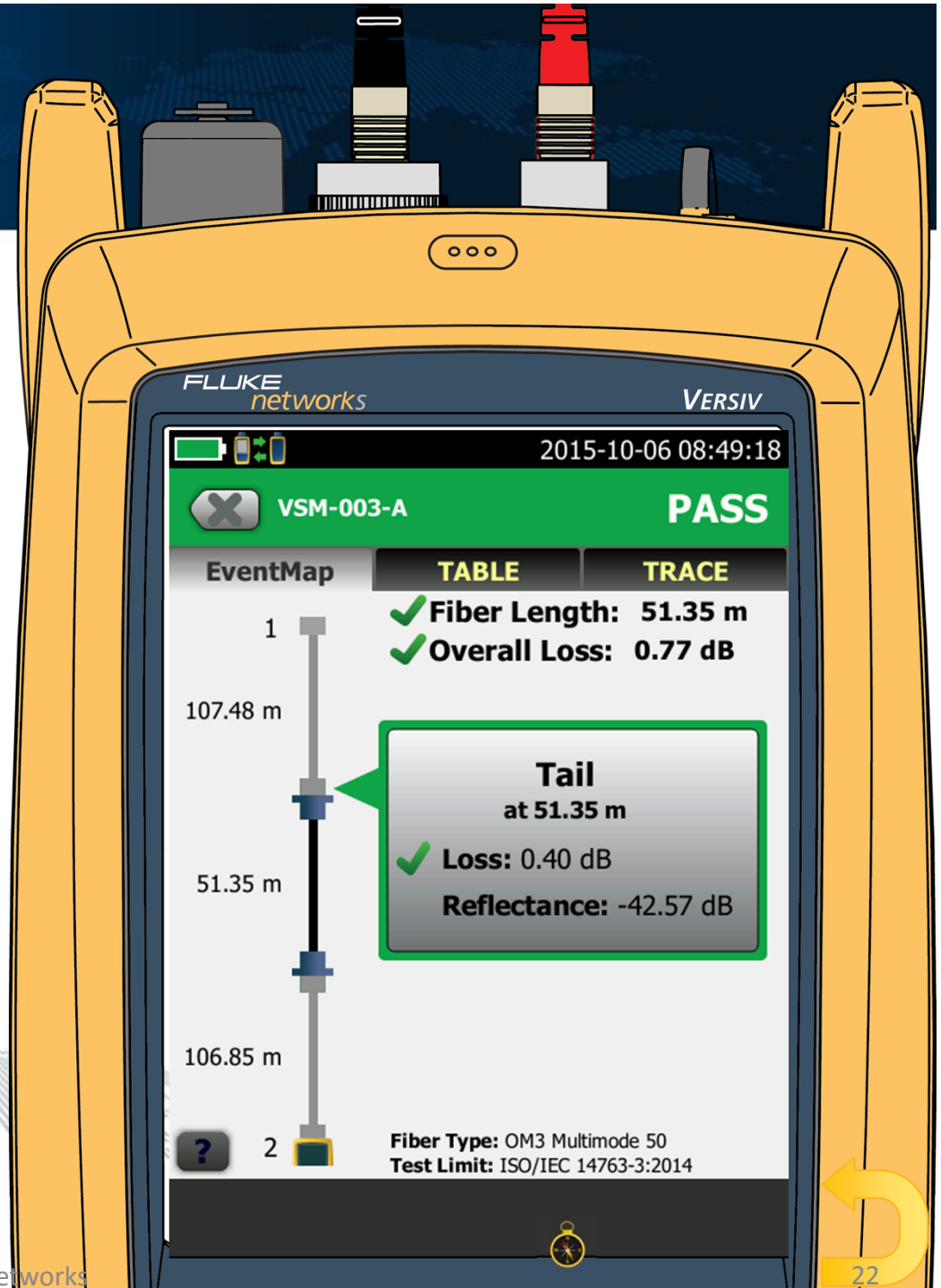


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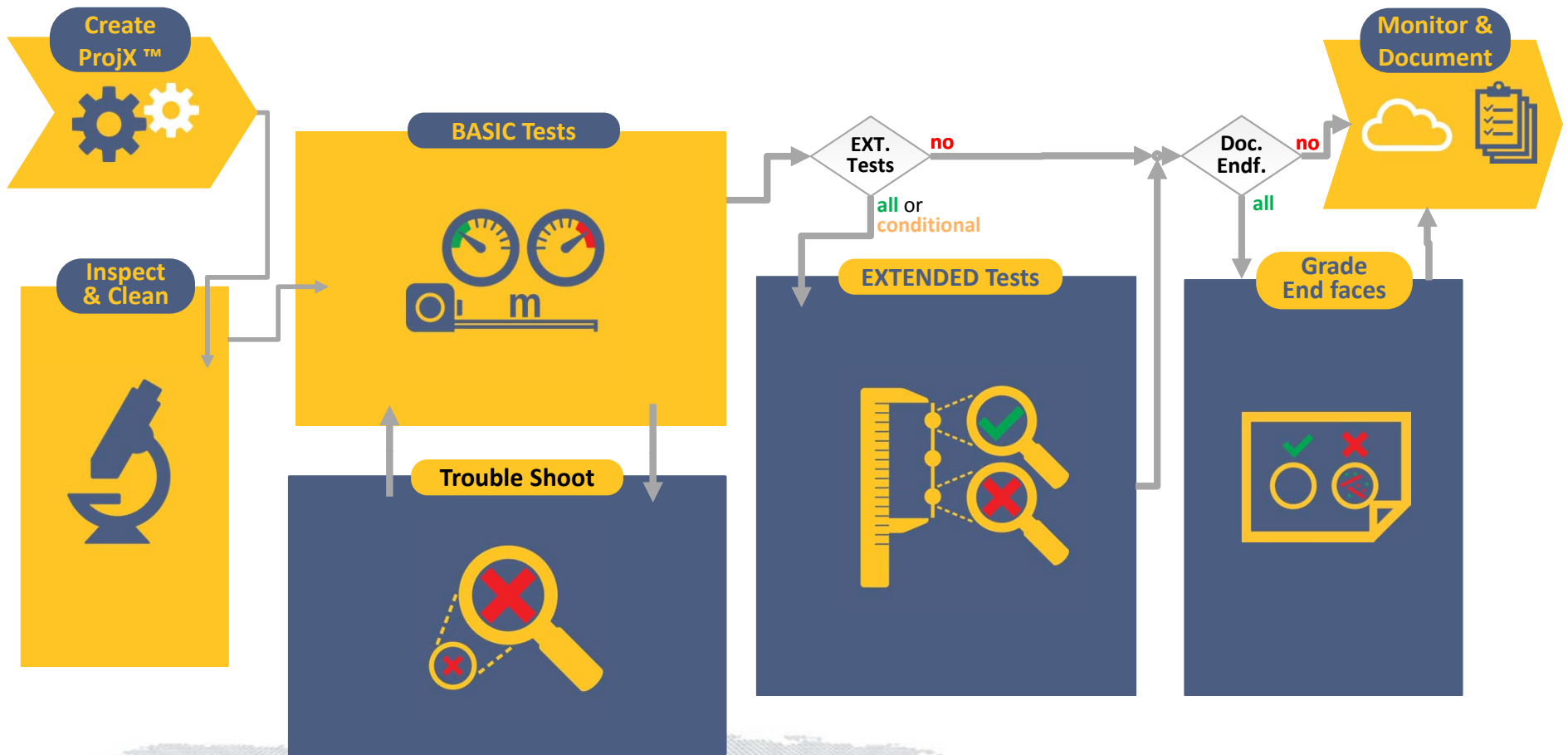


OTDRs are not only for “Gurus”

- Event Maps simplify the presentation
- Overall (Link) limits complement component limits
- Launch & Tail fibers are automatically excluded



Step 4: Extended Test

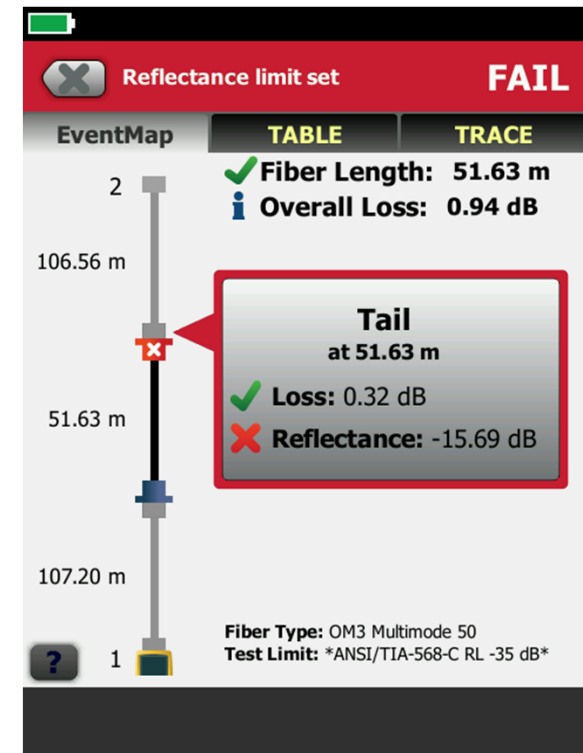


■ ...Optional / Conditional Testing

Why *EXTENDED* Testing ?



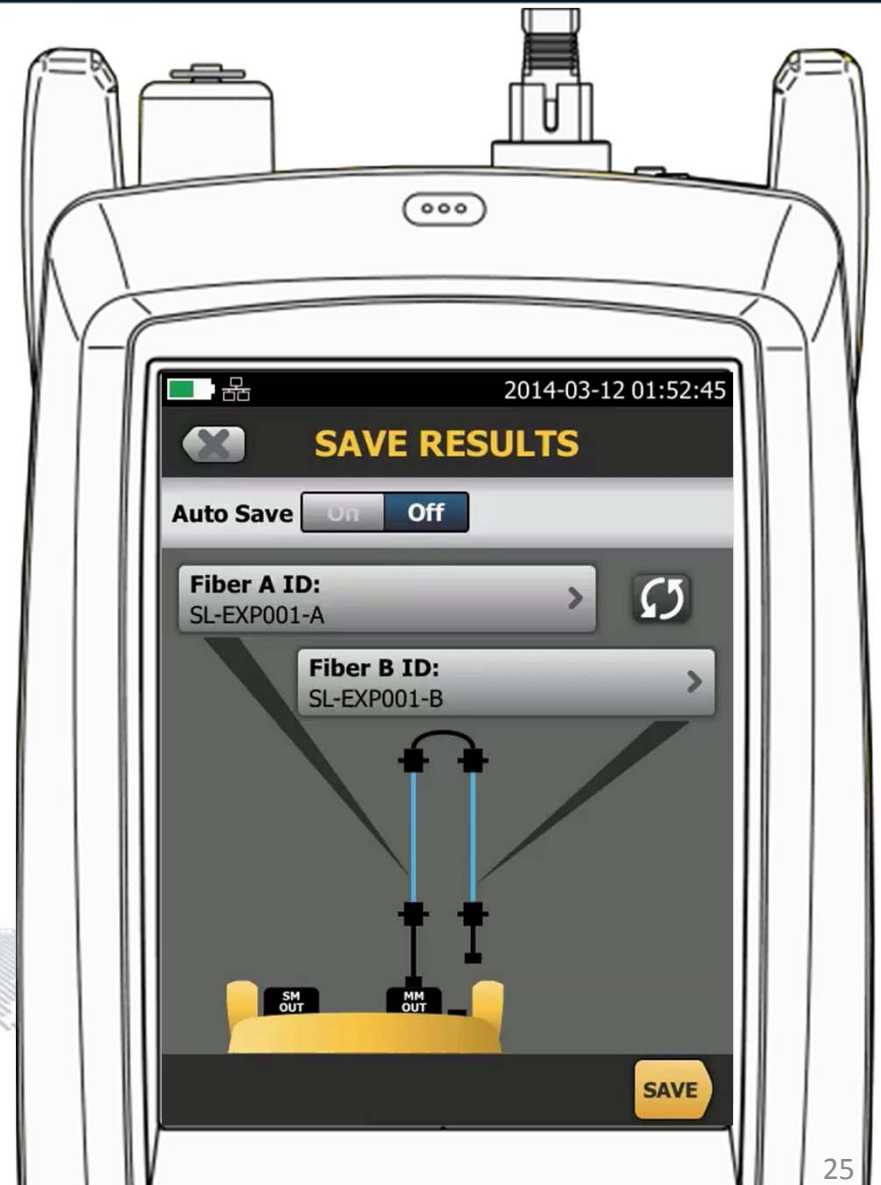
- Identify, locate and eliminate unnecessary bottlenecks in otherwise compliant links
 - Further increase performance margin
- Identify connectors with excessive reflectance
- Document the state of the installation
- Bi-Directional testing and averaging is essential



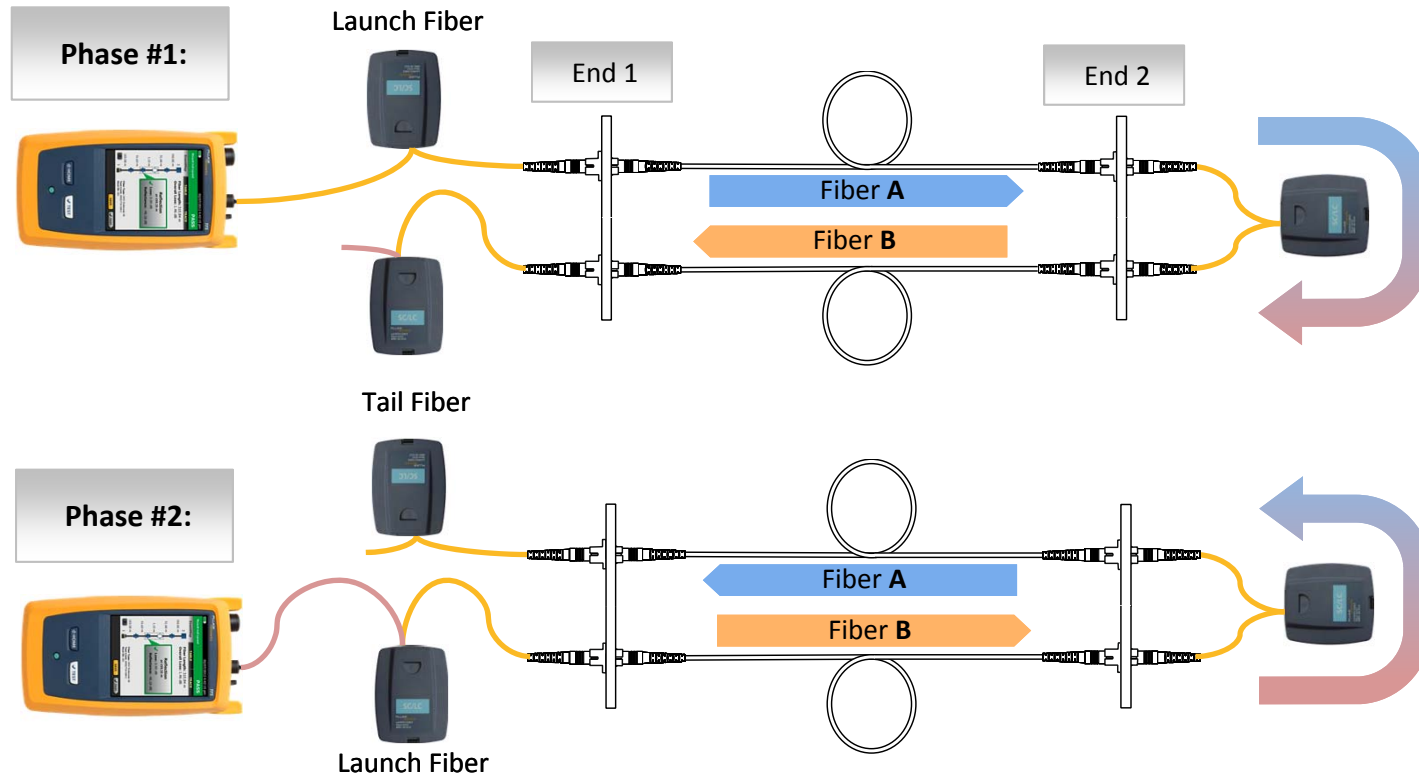
Testing with a *SMART Loop*



- > 9 out of 10 OTDR tests are performed incorrectly. The list of reasons is long
 - No Bi-Directional test and/or averaging
 - No tail fiber
 - Incorrect handling of launch and tail fiber
 - Adaption with hybrid cords
 - etc.
- A SMART Loop concepts forces the user to perform the test correctly
- Multiple remote loops support operation by 1 technician



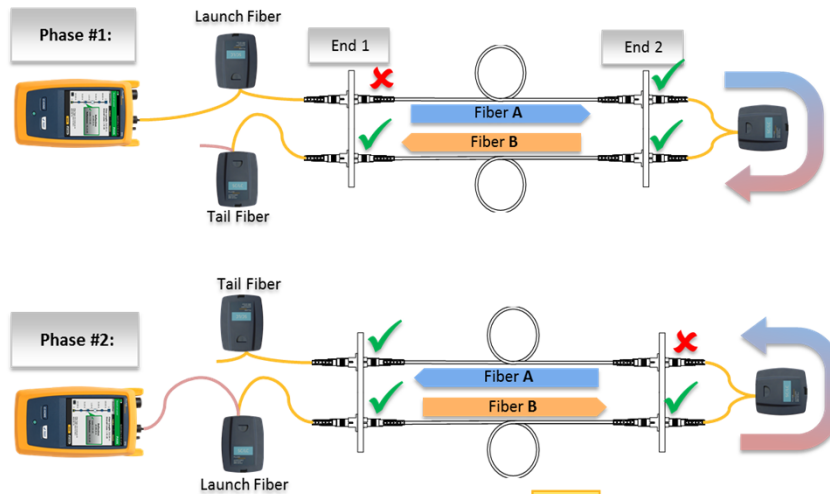
ACCELERATED EXTENDED Testing with a SMART Loop



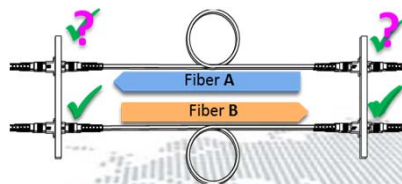
- A built in experts verifies the integrity of the test setup
- The testing time reduced by > 50%



Internal Bi-Directional Averaging



Bi-directional Average

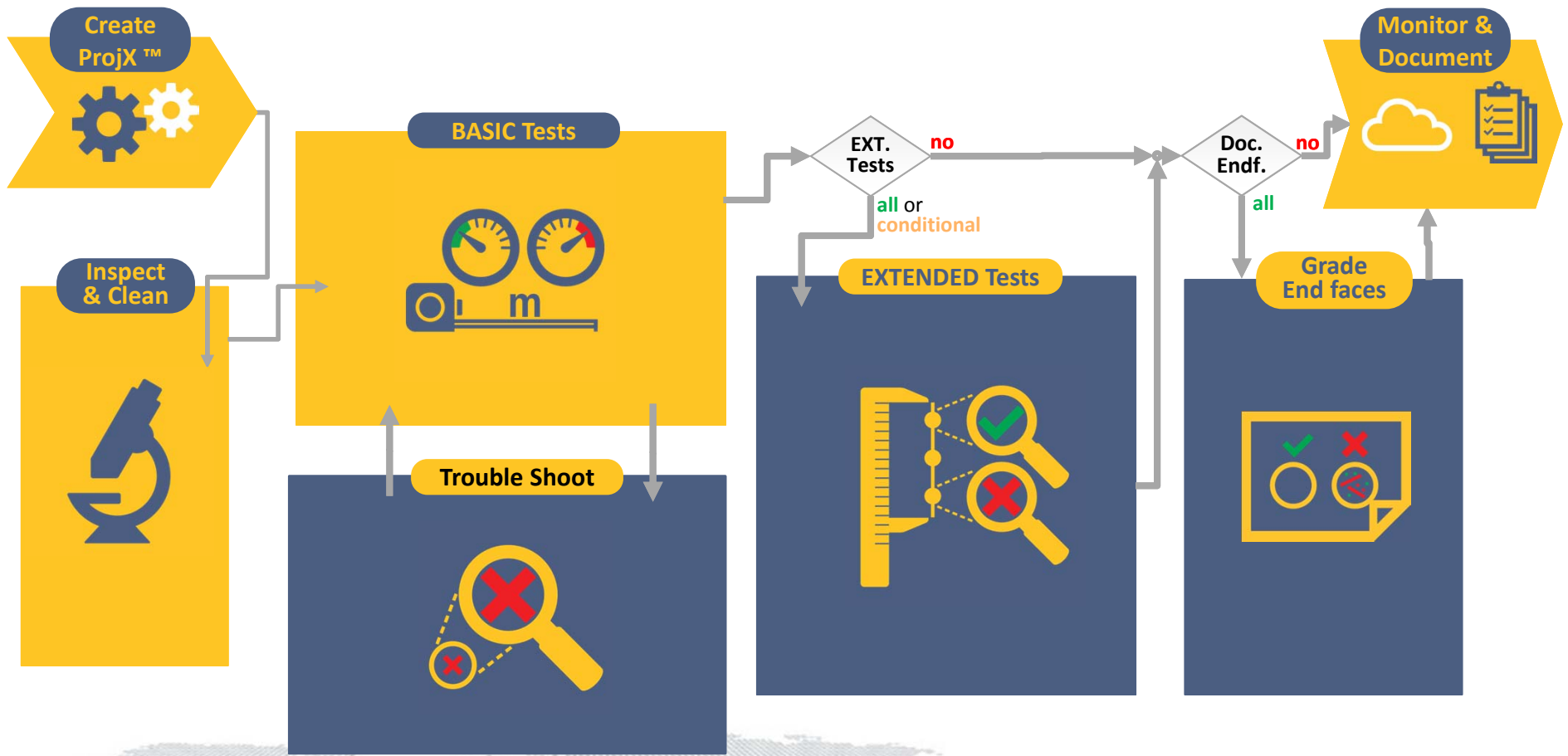


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Slide 301 a **PASS**

EventMap	TABLE	TRACE
1	<ul style="list-style-type: none"> ✓ Fiber Length: 51.18 m i Overall Loss: 0.10 dB 	End 2
104.08 m		
51.18 m		<div style="border: 2px solid green; padding: 5px;"> <p>Tail at 51.18 m</p> <ul style="list-style-type: none"> ✓ Loss: -0.20 dB ✓ Reflectance: -44.34 dB </div>
103.98 m		
2	<p>Fiber Type: OM4 Multimode 50</p> <p>Test Limit: *FNET MM*</p>	

Step 5: Fiber End Face Grading & Documentation



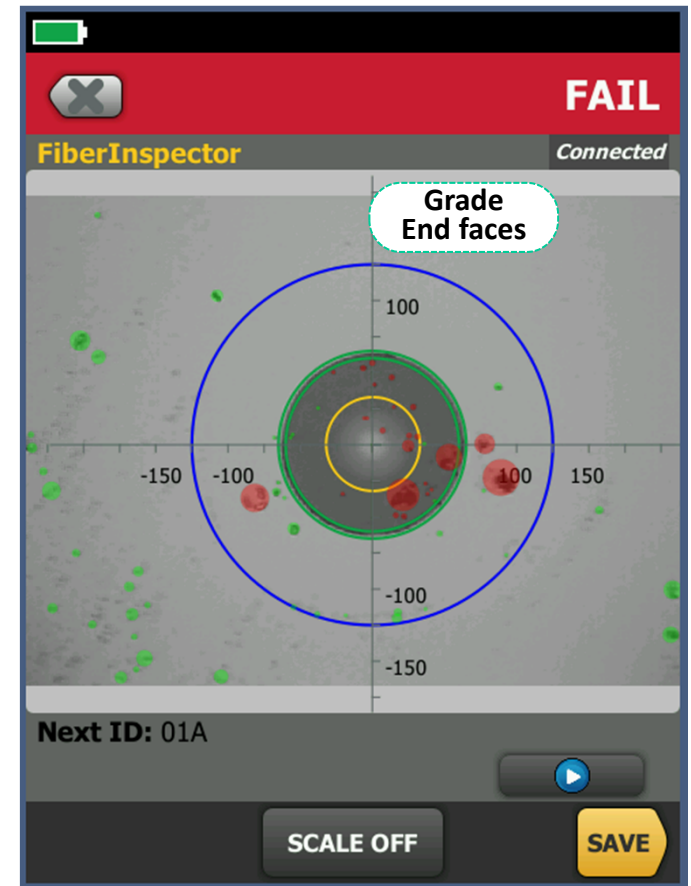
■ ...Optional / Conditional Testing



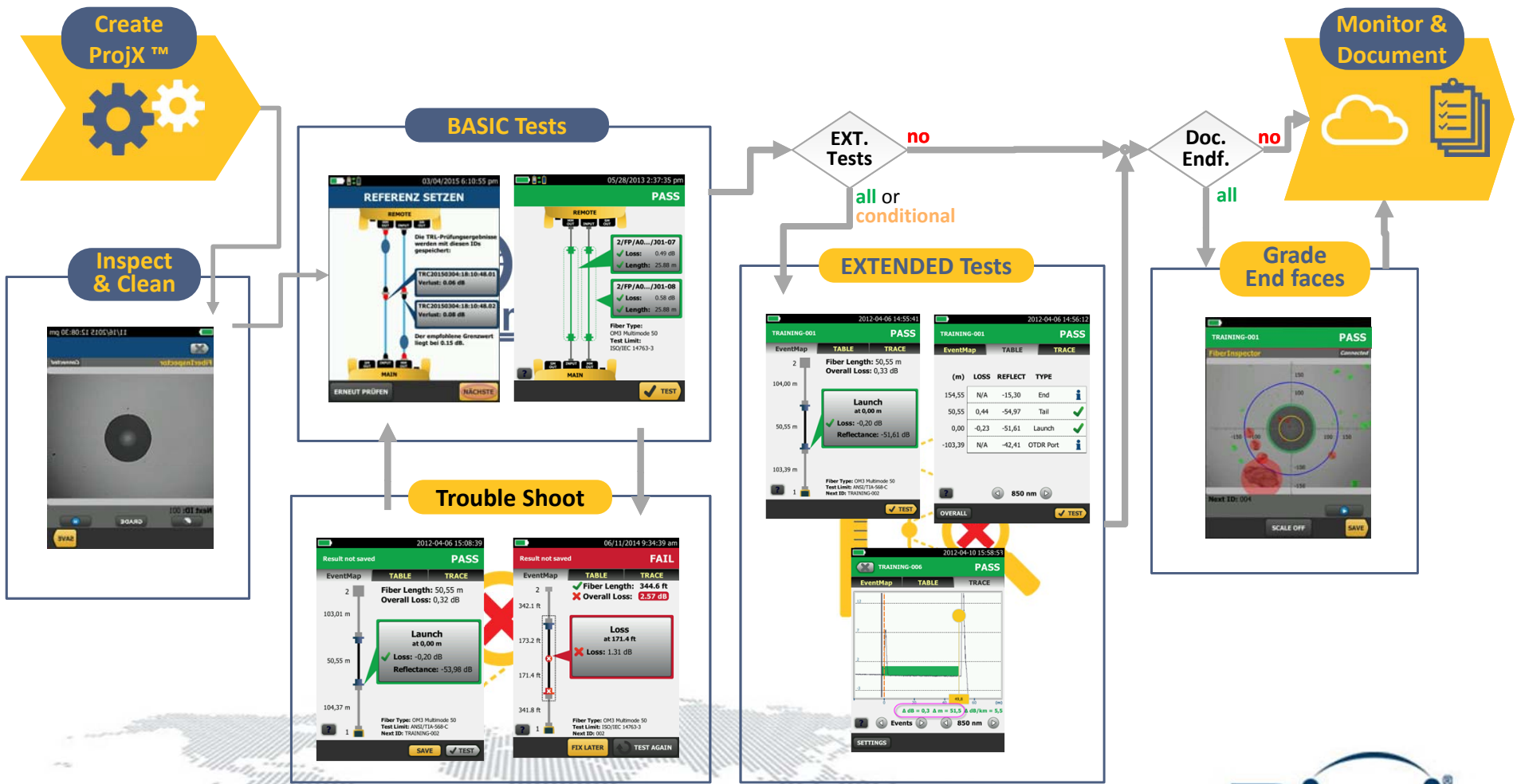
Grade & Document



- Without inspection equipment, you will never know if the connector is clean or not
- Even with inspection equipment, there are arguments as to what is acceptable for a fiber connector
- IEC 61300-3-35 defines levels of acceptable scratches and debris on the end faces of fiber connectors
- Automated field inspection is something to consider
- Images can be stored and made part of the documentation



Fiber Testing Best Practices



...Optional / Conditional Testing



Data Centre vs. Commercial Building Cabling Infrastructure Differences affecting test regimes

Larger number of links

- Testing time
- Consolidation
- Labeling

Larger share of fiber vs. copper

“Zoned” Data Centers

Low channel loss budgets

Low loss connectors

- Little room for measurement error

Copper testing in the Data Centre

10GBASE-T / Cat.6_A dominant

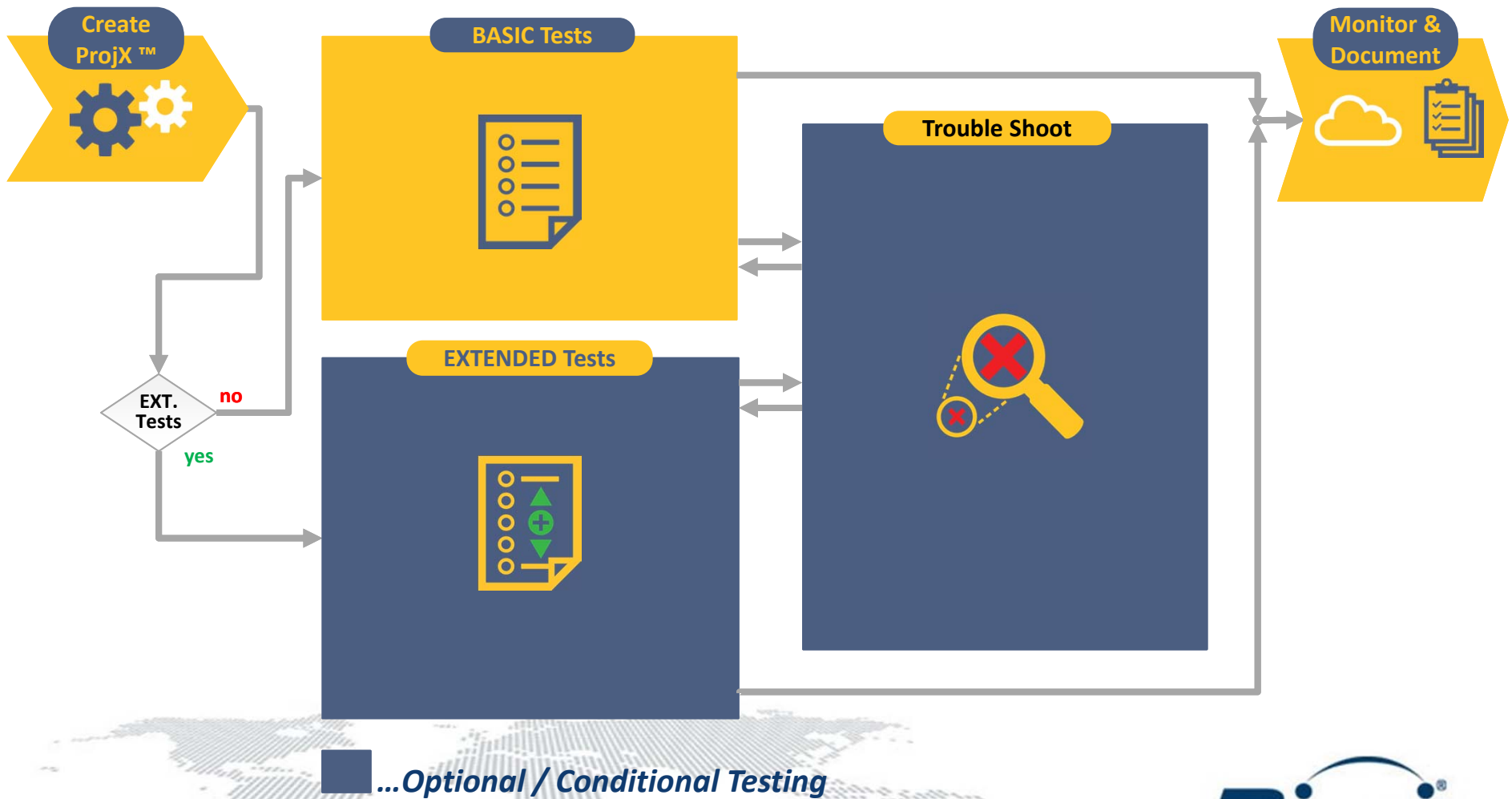
Shielded systems

Future Cat.8 systems

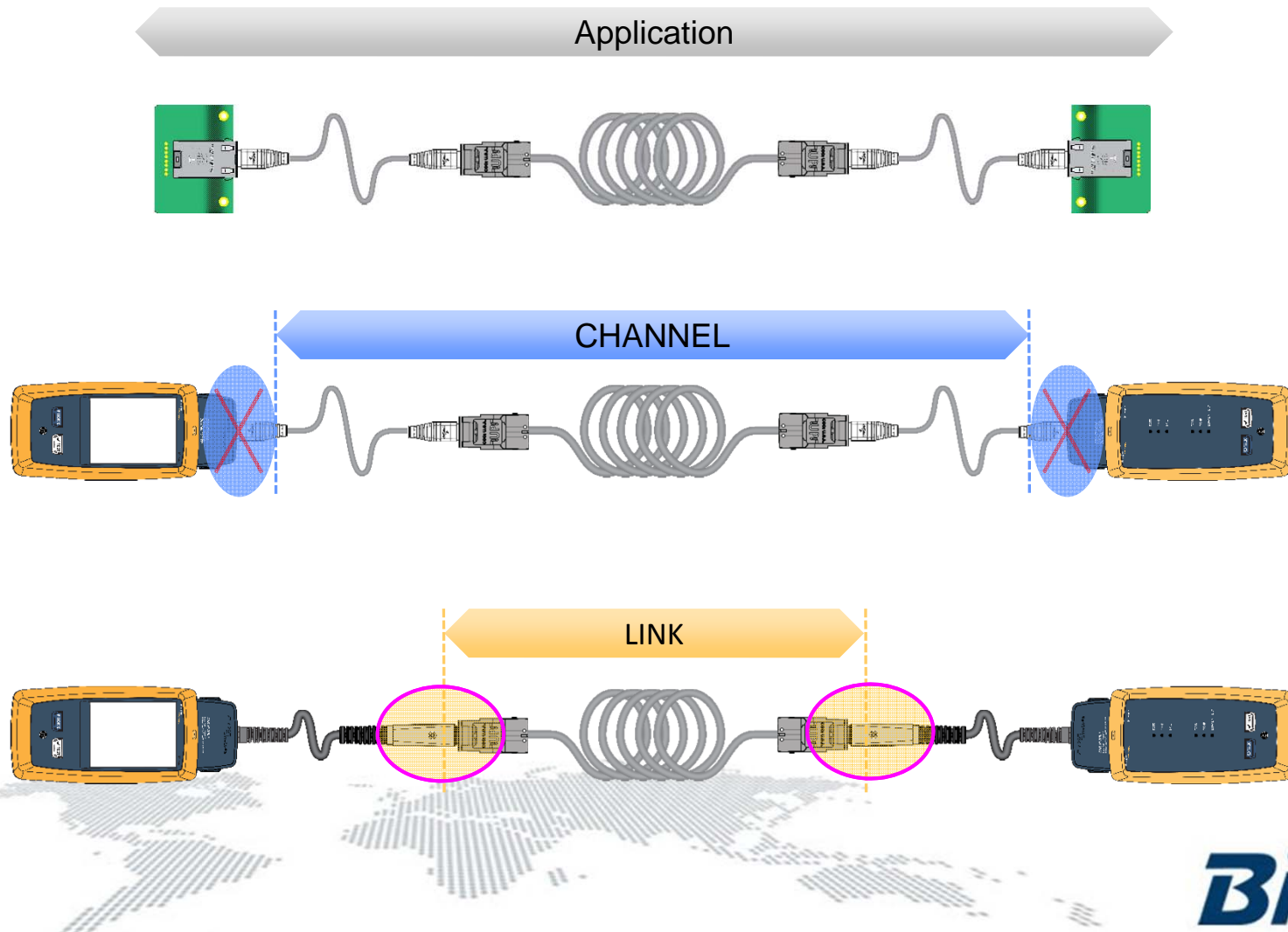
- An Extended Test Regime is beneficial

The Bicsi logo is located in the bottom right corner of the slide. It features the word "Bicsi" in a bold, blue, sans-serif font, with a registered trademark symbol (®) to its upper right.

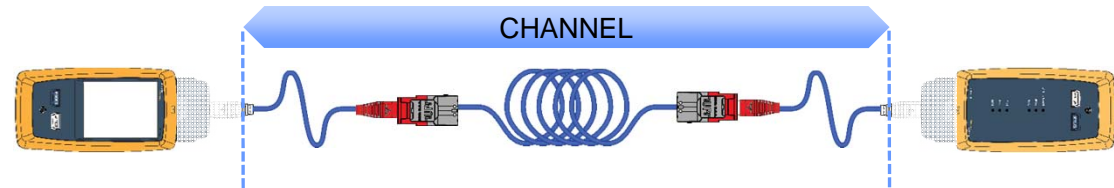
Step 1A: Basic (Minimum) Test Regime



Test Interfaces & Reference Planes

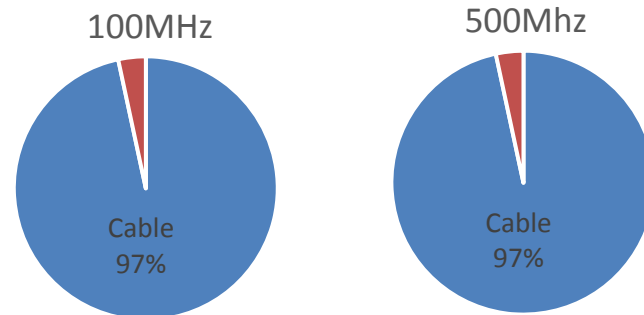


What Limits The Bandwidth more ... Connectors or Cable ?

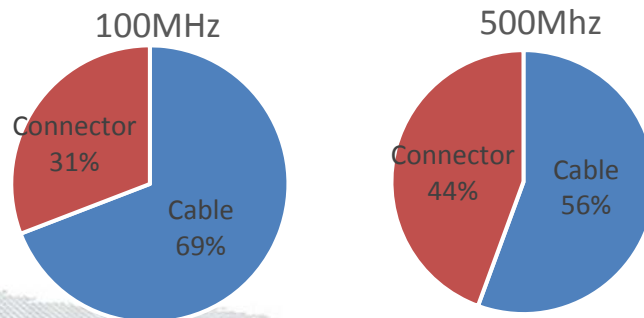


Example: 30m Link

- Insertion Loss (IL)



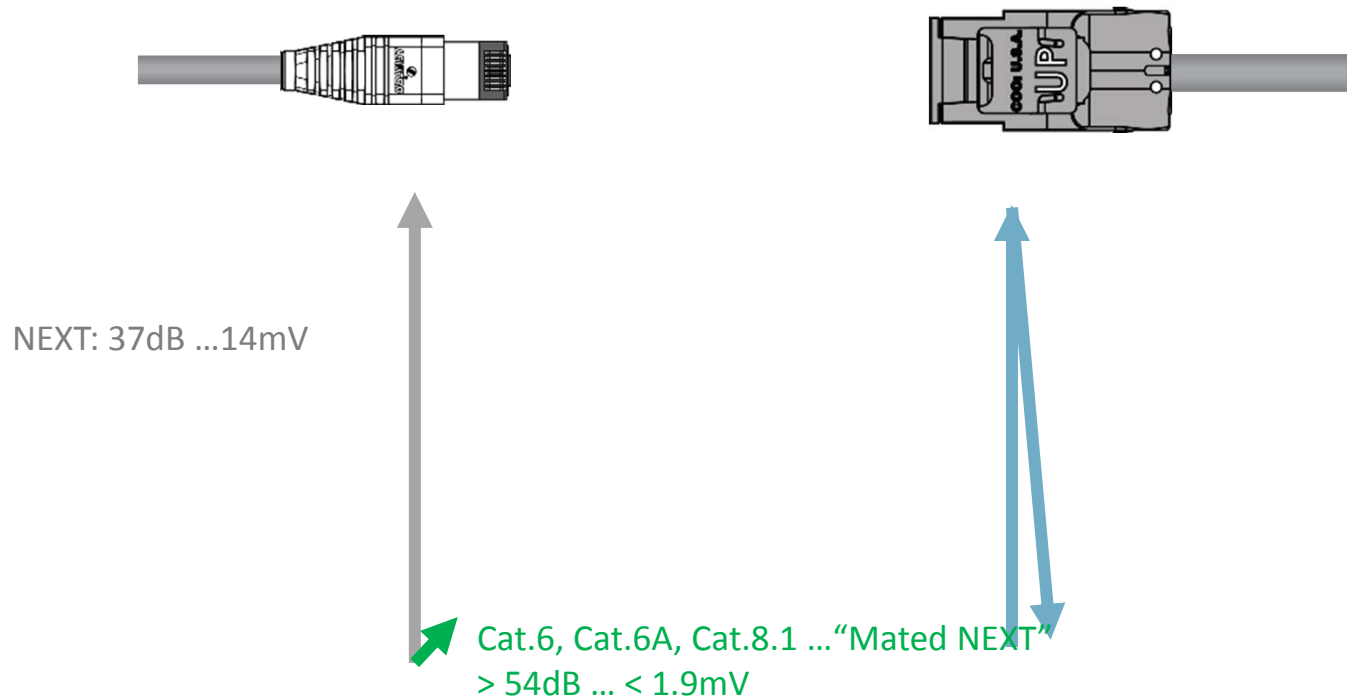
- Near End Cross Talk (NEXT)



...An inch at either end affects results noticeable

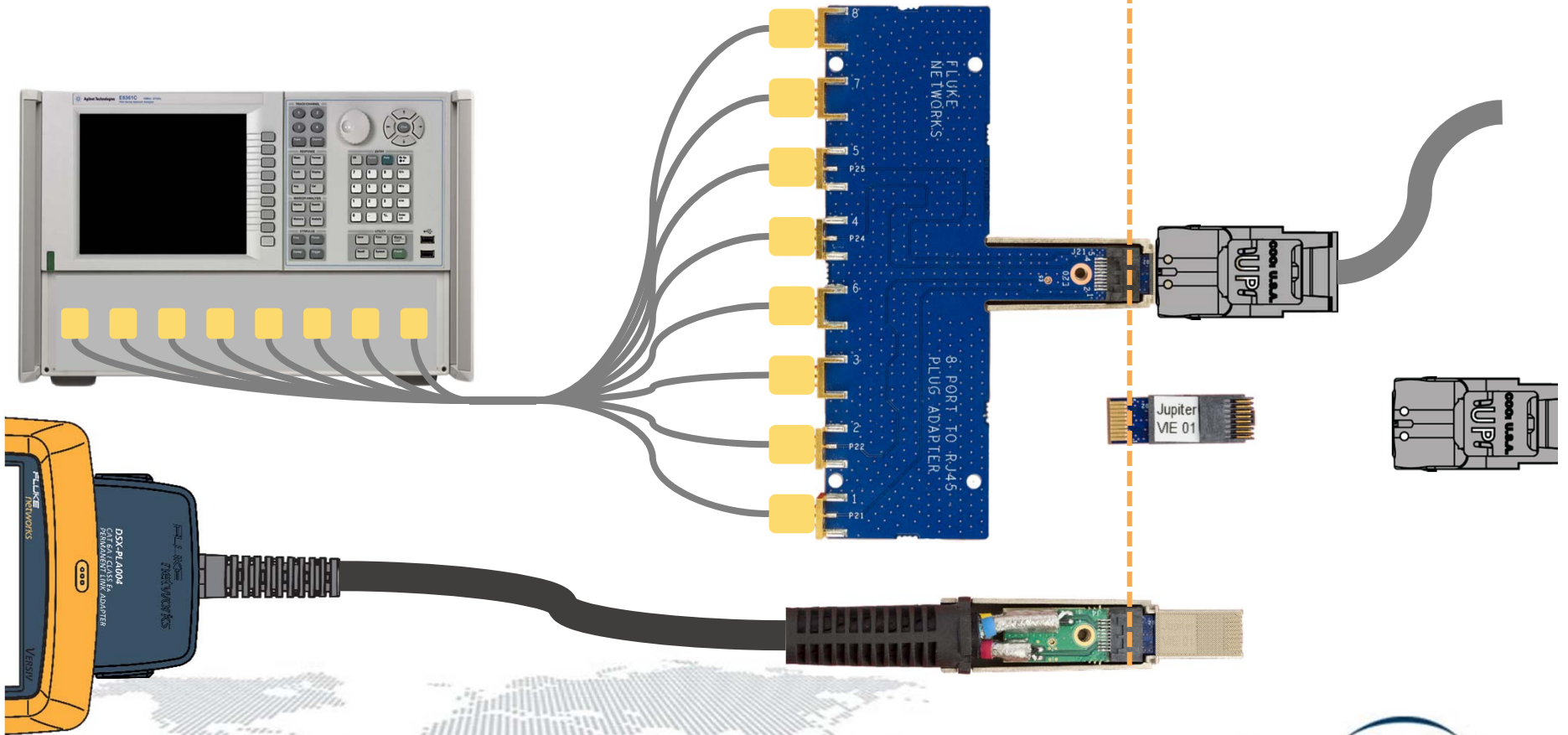
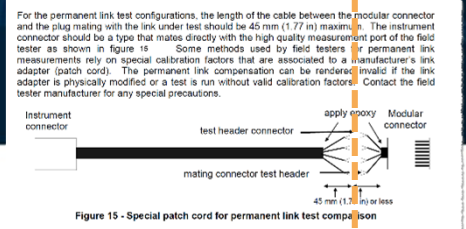


What makes a Cat.5e, -.6, -.6A, .-8.1 Connector work

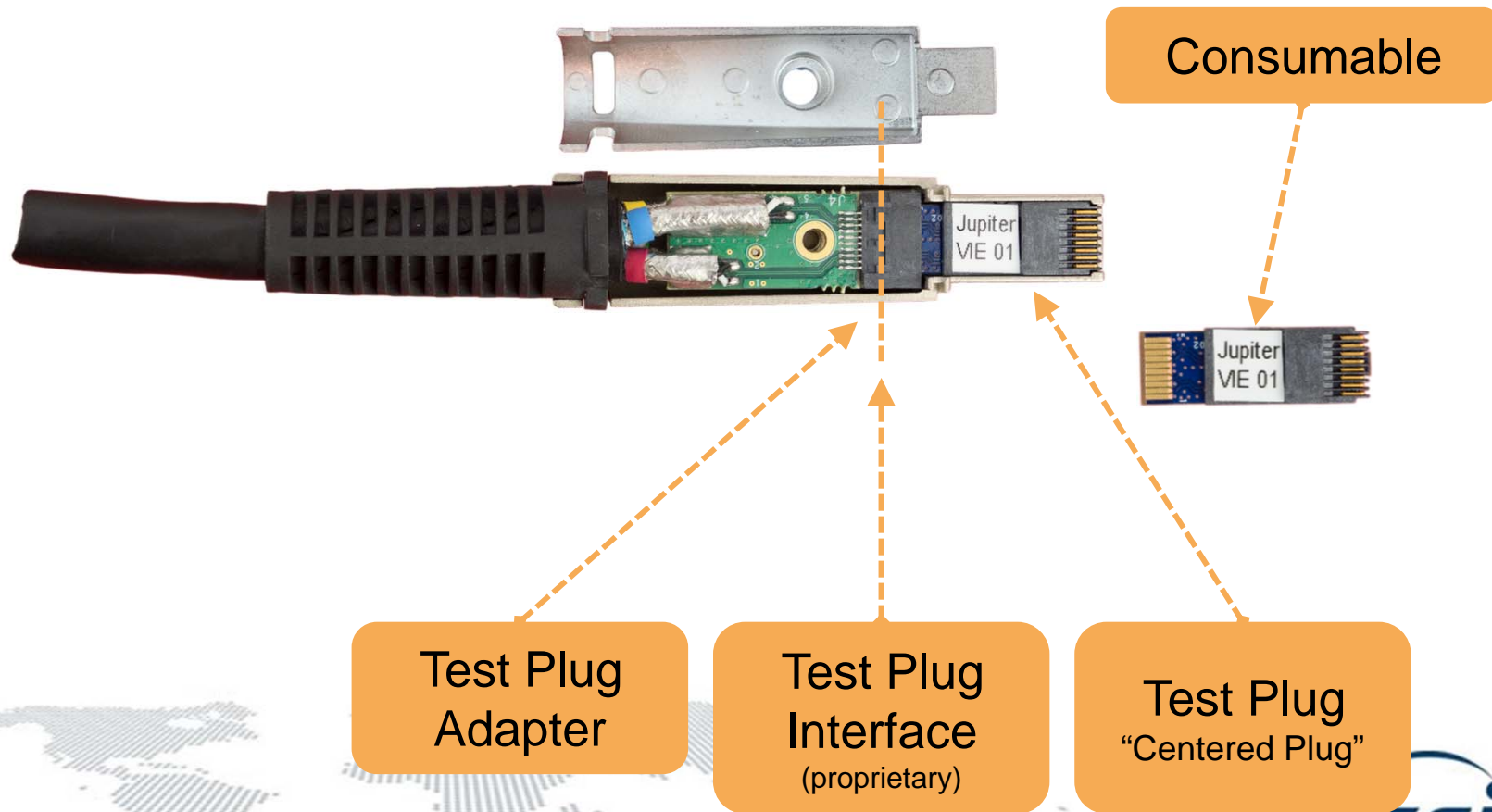


Note: Above is shown for the most critical pair 3,6/4,5 at 100MHz

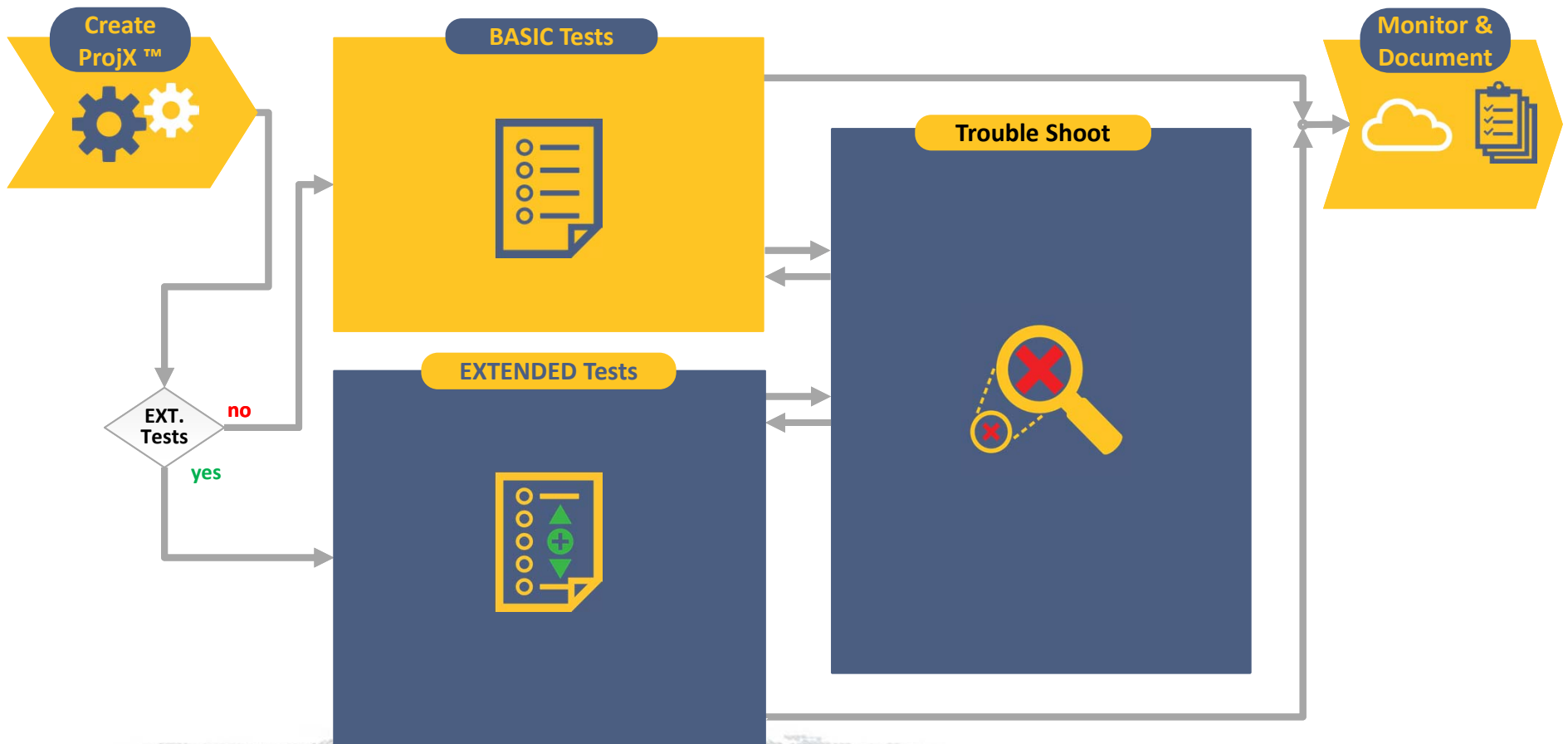
Comparing PERMANENT LINK Results



Permanent Link Adapter with a “**CENTERED**” Test Plug for the „Heavy Duty Field Use“



Step 1B: Extended Test Regime



■ ...Optional / Conditional Testing



Why **EXTENDED** Testing ?



	Copper Certification to ISO/IEC 11801	
	Reference Conformance Testing	Installation Conformance Testing
Wire Map	✓	✓
Length	✓	
Propagation Delay	✓	✓
Delay Skew	✓	✓
DC Loop Resistance	✓	✓
DC Resistance Unbalance	✓	
Insertion Loss	✓	✓
NEXT, PS NEXT	✓	✓
Return Loss	✓	✓
ACR-N, PS ACR-N	✓	✓
ACR-F, PS ACR-F	✓	✓
TCL, ELTCTL	✓	
PS ANEXT, PS AACR-F ¹⁾	✓	✓

1) Class E_A only



Why **EXTENDED** Testing ?



	Copper Certification	
	ANSI/TIA-568-C.2 (Cabling System)	ANSI/TIA-1152 (Minimum Field Test)
Wire Map	✓	✓
Length	✓	✓
Propagation Delay	✓	✓
Delay Skew	✓	✓
DC Loop Resistance	✓	
DC Resistance Unbalance	✓	
Insertion Loss	✓	✓
NEXT, PS NEXT	✓	✓
Return Loss	✓	✓
ACR-F, PS ACR-F	✓	✓
TCL, ELTCTL	✓	
PS ANEXT, PS AACR-F ¹⁾	✓	✓

1) Category 6A only



WHAT IF ...

**TCL / ELTCTL is
not compliant**

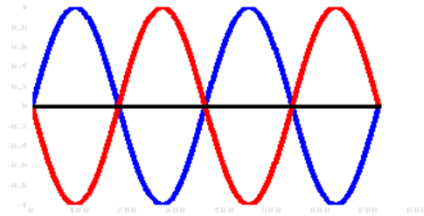


TCL (Transverse Conversion Loss)

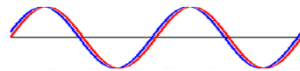


- **Transverse Conversion Loss** is the ratio (in dB) of a common-mode voltage measured on a wire pair relative to a differential-mode voltage applied to the same end of the pair. The TCL value shows you how well the impedances of the pair's conductors are balanced.

Differential
Signal Applied



Common Mode
Voltage Measured



Mode Conversion – Real World Example

GOOD vs. BAD Drum of Cable

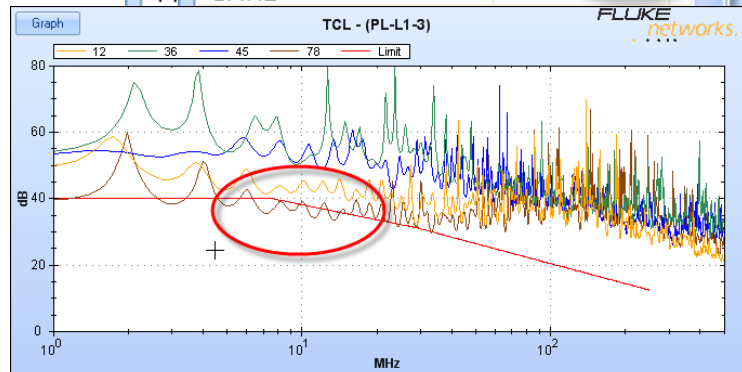


- 18km cable of identical type was installed
- 30% of the links don't carry 1000BASE-T

Drum #1



Tests		
In	Insertion Loss	26.2 dB
NI	NEXT	8.4 dB
PS	PS NEXT	8.2 dB
AC	ACR-N	18.1 dB
PS	PS ACR-N	18.0 dB
AC	ACR-F	20.2 dB
PS	PS ACR-F	20.6 dB
RL	RL	9.7 dB
Le	TCL	-4.7 dB
Pr	CMRL	



Drum #2



Tests		
Ins	Insertion Loss	38.6 dB
NE	NEXT	6.9 dB
PS	PS NEXT	7.5 dB
AC	ACR-N	23.3 dB
PS	PS ACR-N	23.1 dB
AC	ACR-F	17.3 dB
PS	PS ACR-F	19.4 dB
RL	RL	9.1 dB
Le	TCL	5.7 dB
Pro	CMRL	
De	CDNEXT	
Re	ELTCTL	21.9 dB
Wi	Length	22.2 m
	Prop. Delay	102 ns
	Delay Skew	2 ns
	Resistance	3.4 ohms



WHAT IF ...

TCL / ELTCTL is not compliant

Even a legacy application like 1000Base-T may not work on an otherwise compliant Cat.6/6A system !

Resistive Unbalance is not compliant



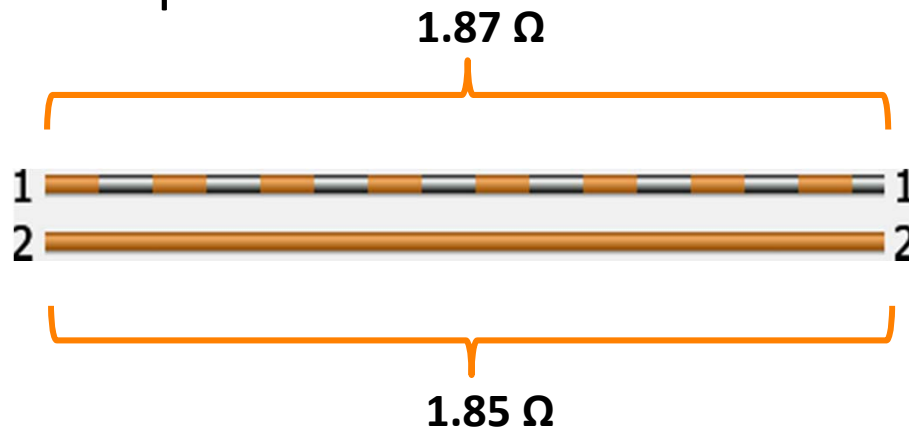
Shield Integrity is not given

Resistance Unbalance



- Difference in Resistance between wires in the pair

- Example:



Resistance = 3.7 Ω

Resistance Unbalance = 0.02 Ω

RESISTANCE		RESISTANCE UNBALANCE	
VALUE	VALUE	VALUE	LIMIT
Ω	Ω	Ω	Ω
1,2	3.7	0.02	0.15
3,6	3.7	0.02	0.15
4,5	3.7	0.01	0.15
7,8	3.6	0.01	0.15
LIMIT	21.0		



WHAT IF ...

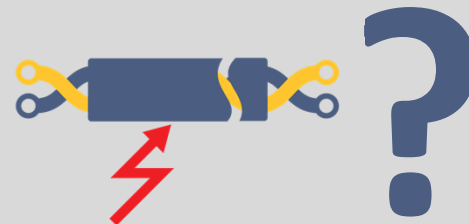
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Even a legacy application like 1000Base-T may not work on an otherwise compliant Cat.6/6A system !

Resistive Unbalance is not compliant

POE operation is at risk during maximum load
Poor contacts may further degrade over time

Shield Integrity is not given





Shield Integrity ... Opinions

Opinion A:

Even when the shield is open at the both ends the requirements for 10GBASE-T are met

Opinion B:

Requirements for 10GBASE-T are not met if the shield is open (floating)

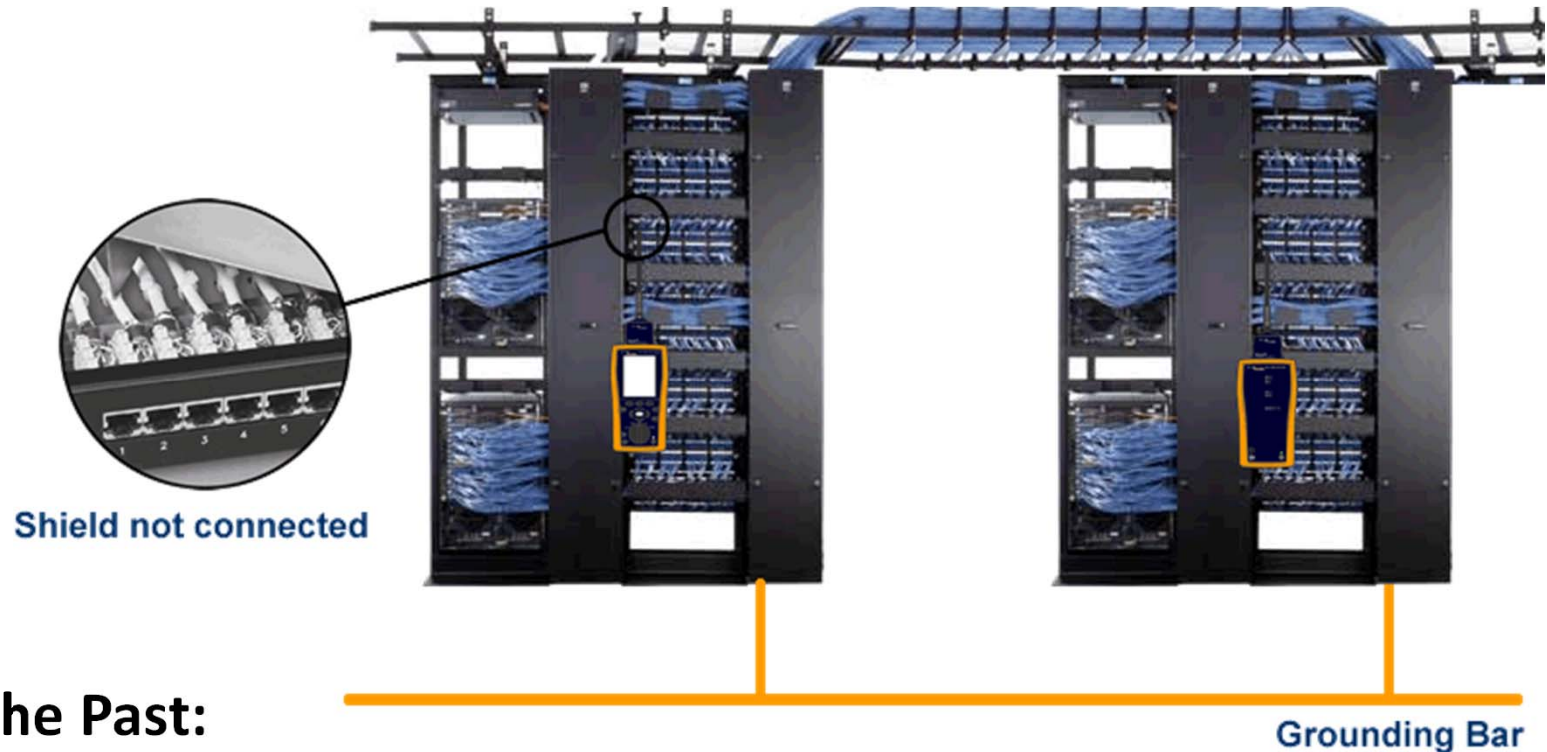
1.) Experiments prove it (both opinions)

2.) The EMI gets significantly worse





Shield Integrity



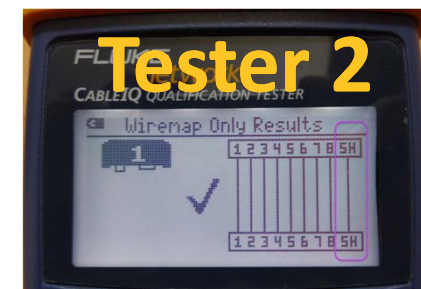
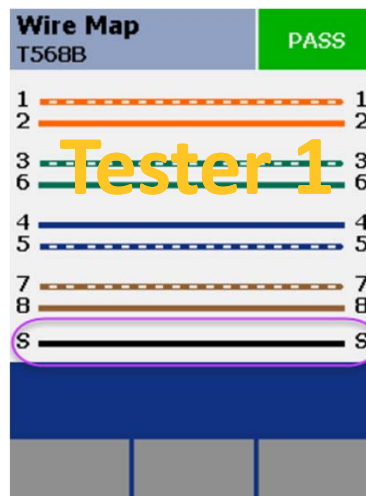
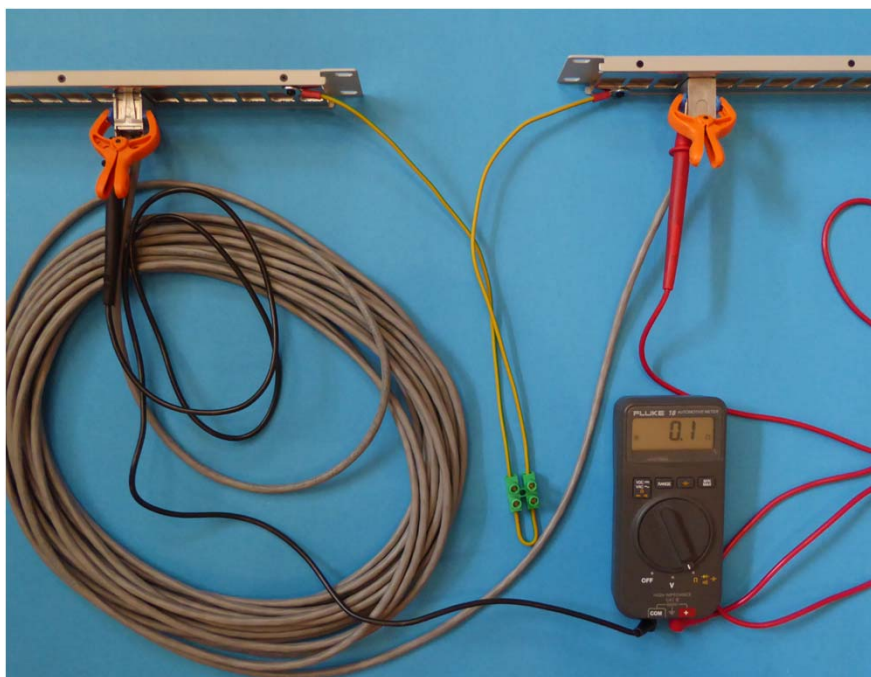
In The Past:

- Field testers could only verify that there is DC Continuity
- DC Continuity is given by grounding and earth
- Any open shields/ends could not be detected

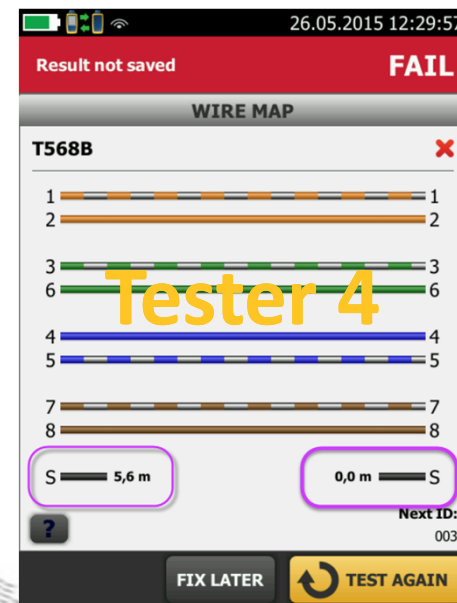
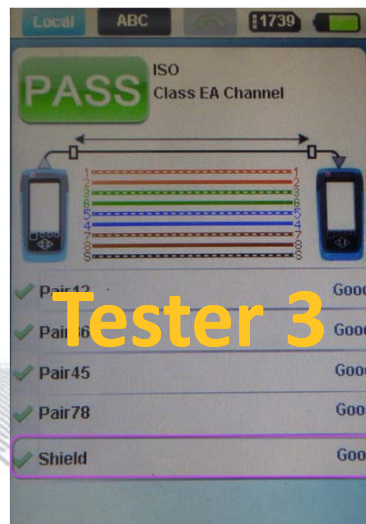




Let's test a UTP cable between shielded patch panels...



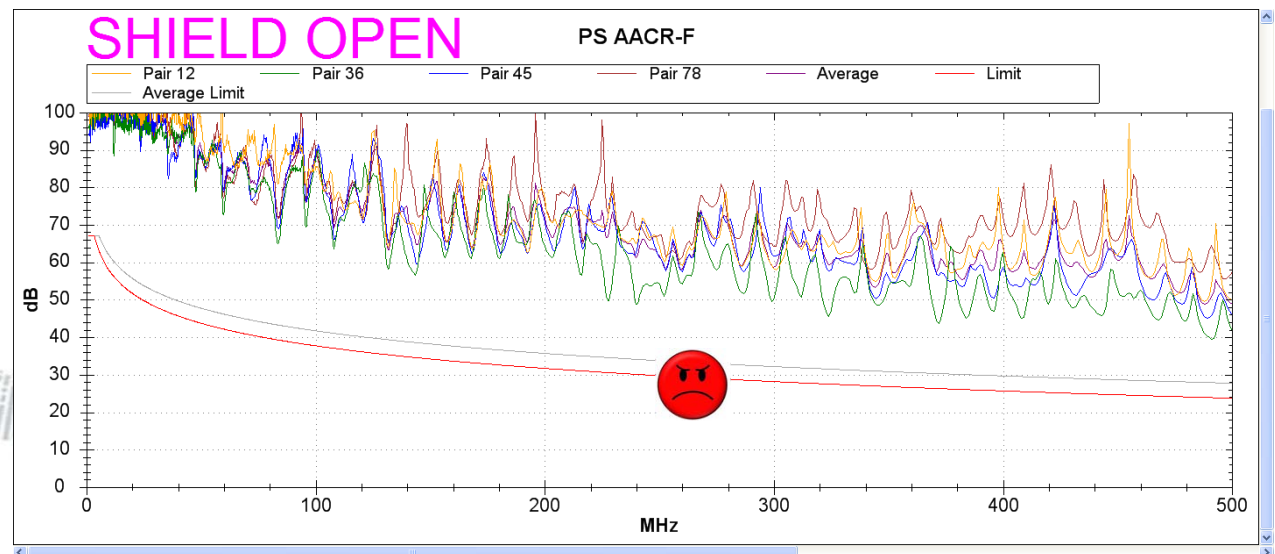
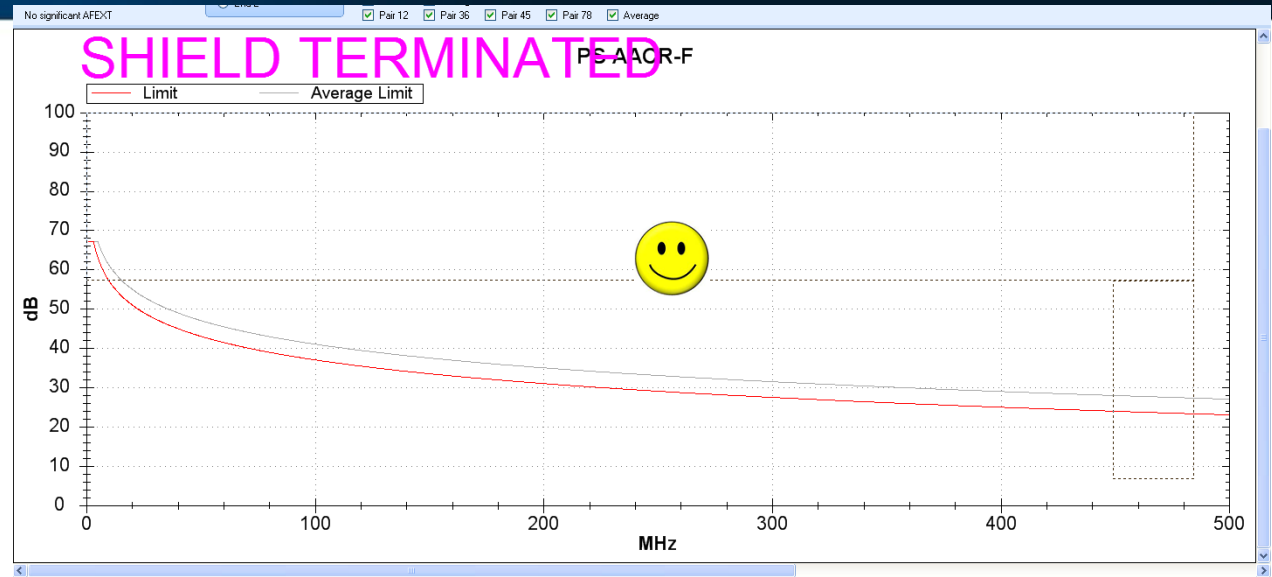
- Only 1 tester will detect the lack of a shield
- NOTE: In special applications it may be essential to verify that the shield is open on a defined end





Example Alien Crosstalk: Shield Open / Connected

- For this high end cable the Alien Crosstalk is below the testers significance level
- The same cable show a $> 20\text{dB}$ worse Alien Crosstalk
- A major portion of the EMI (Electromagnetic Immunity) was lost



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Resistive Unbalance is not compliant

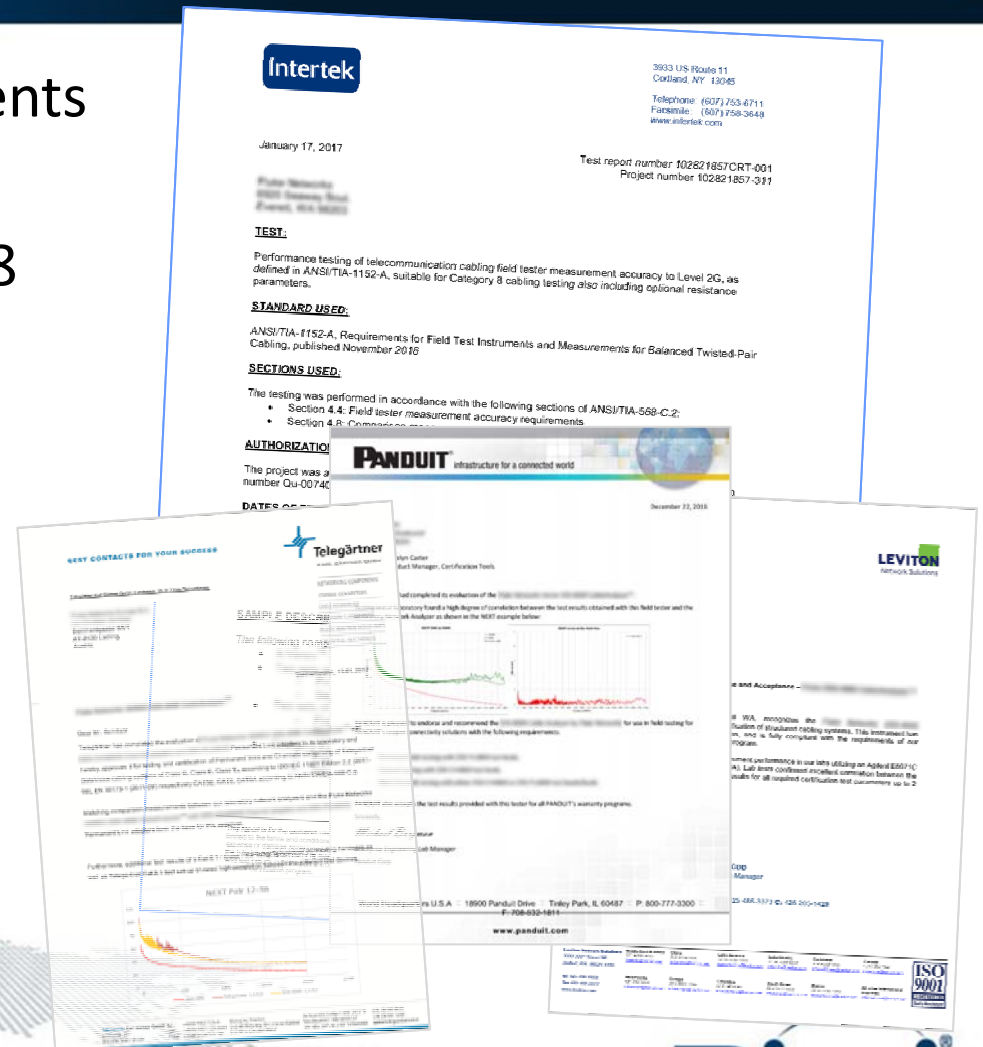
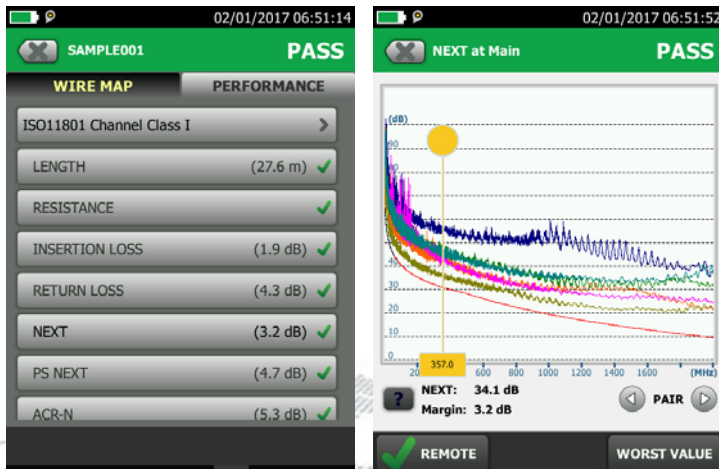
POE operation is at risk during maximum load
Poor contacts may further degrade over time

Shield Integrity is not given

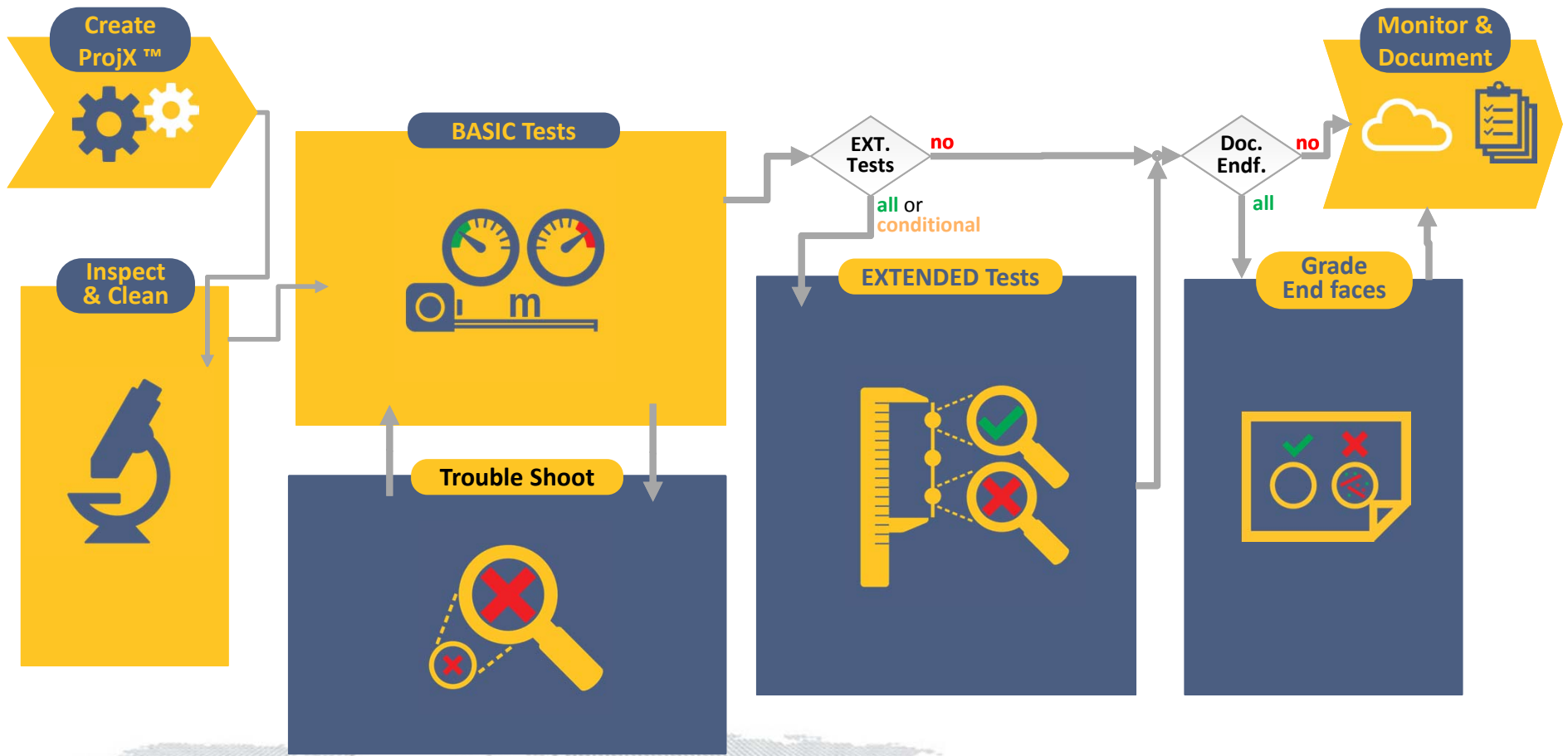
10 or 20 dB of electromagnetic immunity (EMI) is lost.
Alien Crosstalk may become non-compliant

Standards Compliant Cat.8 Field Testing...

- Standards defined requirements for field testers
- Manufacturer endorsed Cat.8 Field Testers
- Testing Cat.8 links is no more complex the Cat.6_A



Step 6: Project Monitoring & Documentation



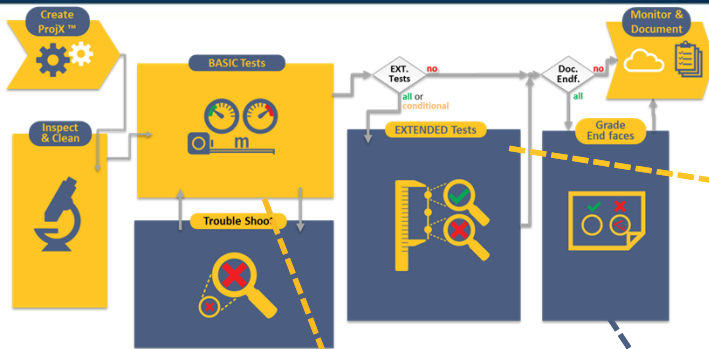
■ ...Optional / Conditional Testing



Monitoring & Documentation



Documentation



LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: R01-C01-001B(M-B)
Date / Time: 10/09/2013 05:16:19 PM n = 1.4670 (1310 nm) Backscatter Coefficient: -79.5dB (1310 nm)
Cable Type: CSI Singlemode n = 1.4680 (1550 nm) Backscatter Coefficient: -82.0dB (1550 nm)

Test Summary: PASS

Endface Image End1
NOT GRADED
Date / Time: 01/01/2013 02:27:01 AM
Operator: JOHN.DOE
Optimize Pres: CS20066 V2.2 Build 0 Beta

Endface Image End2
NOT GRADED
Date / Time: 01/01/2013 02:29:38 AM

Loss (M->R)

Parameter	Value	Unit	Limit	Status
Propagation Delay (ns)	12.1	ns	PASS	
Loss (dB)	0.50	dB	1500 nm	PASS
Margin (dB)	1.30	dB	1500 nm	PASS
Reference (dB)	-3.86	dB		

Number of Splices: 2
Connector Type: LC
Patch Length (m): 2.0
Reference Date: 10/09/2013 11:14:50 AM
1 Jumper

Consistent Network Standards:
100BASE-LN 100BASE-SFM 100BASE-LRM 100BASE-LRM
100BASE-E 100BASE-LRM 100BASE-LRM
100BASE-LAN 100BASE-LRM 100BASE-LRM
Flow Channel 100-SM-LC-L 100-SM-LC-L 100-SM-LC-L 100-SM-LC-L
Flow Channel 200-SM-LC-L 200-SM-LC-L 200-SM-LC-L 200-SM-LC-L
Flow Channel 300-SM-LC-L 300-SM-LC-L 300-SM-LC-L 300-SM-LC-L

Project: FM-GROUP-PREP Page 3 SampleMerged.tif FLUKE networks

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

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Date / Time: 10/09/2013 05:16:19 PM n = 1.4670 (1310 nm) Backscatter Coefficient: -79.5dB (1310 nm)
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EventMap [OTDR Bidir, Avg]

OTDR Bidir, Avg, PASS
Date / Time: 01/01/2013 02:27:01 AM
Operator: JOHN.DOE
Optimize Pres: CS20066 V2.2 Build 0 Beta
Calibration Date: 07/10/2013

OTDR End1 PASS
Date / Time: 01/01/2013 02:27:01 AM
Operator: JOHN.DOE
Optimize Pres: CS20066 V2.2 Build 0 Beta
Module: CP1-QUAD-2007001
Calibration Date: 07/10/2013

Launch + Tail
Launch Length: 102.00 m
Launch Power: 0.00 mW
Launch Wavelength: 1550 nm

Overall Length (m): 102.00
Overall Loss (dB): 48.80
CPL (dB): 48.74

Netting (dBm @ 1550 nm) 1550 nm 1550 nm
Range (m) 200.00 200.00
Range Resolution (m) 20.00 20.00
Pulse Width (ns) 30.00 30.00
Average Time (min) 7.1 7.1
Loss Threshold (dB) 0.10 0.10
End Threshold (dB) 0.10 0.10

Event

Event	1310 nm	1550 nm	Loss (dB)	Reflection (dB)	Length (m)	400 Coeff (dB/km)	Loss
100.00 m End	0.26	0.25	0.00	10.20	54.83	0.00	0.00
102.00 m Launch Event	0.17	0.09	0.10	0.47	0.00	0.46	0.16
100.00 m CS20066 Pres	N/A	N/A	N/A	10.27	74.43	N/A	N/A

Project: FM-GROUP-PREP

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: LETH 03
Date / Time: 09/16/2015 11:46:17 AM Operator: WALTER
Headroom: 8.5 dB (NEXT 12-36) Software Version: V4.3 Build 6
Test Line: TIA Cat 6 Perm. Link (+All) Limits Version: V4.3
Cable Type: Cat 6 U/UTP NVP: 69.0%

Test Summary: PASS
Model: DSK-5000
Main S/N: 2436001
Remote S/N: 24372 90
Main Adaptor: DDX-PLA004
Remote Adaptor: DDX-PLA004

Length (m), Limit 90.0 [Pair 36] 12.2
Prop. Delay (ns), Limit 498 [Pair 45] 61
Delay Skew (ns), Limit 44 [Pair 12] 2
Resistance (ohms), Limit 21.0 [Pair 78] 2.0
Resist. Unbal. (ohms), Limit 0.20 [Pair 36] 0.05
Resist. P2P Unbal. (ohms), Limit 0.20 [Pair 12-36] 0.03

Insertion Loss Margin (dB) [Pair 45] 26.7
Frequency (MHz) [Pair 45] 250.0
Limit (dB) [Pair 45] 31.1

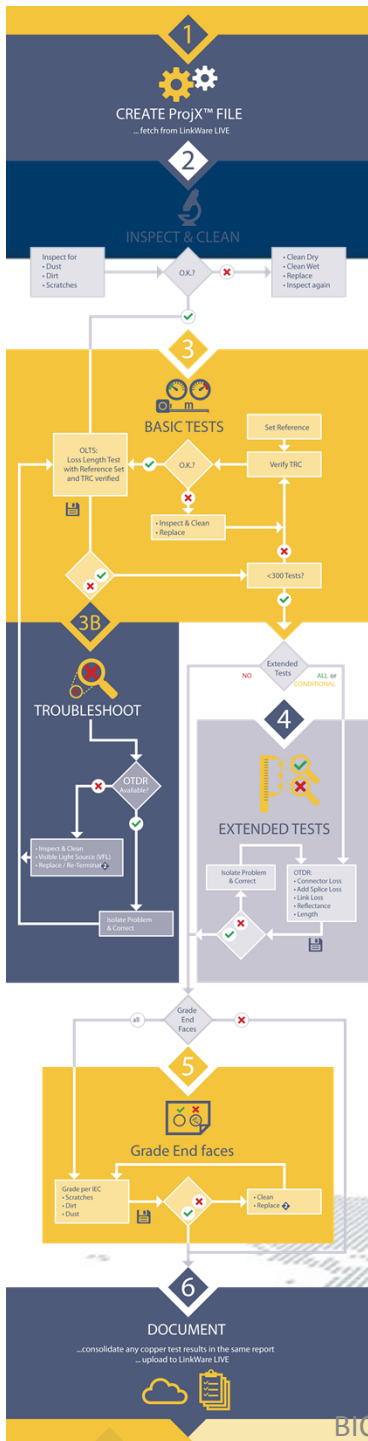
Worst Case Margin Worst Case Value

PASS	MAIN	SR	MAIN	SR
Worst Pair	12-36	12-36	12-36	12-36
NEXT (dB)	18.2	9.3	18.2	9.3
Freq. (MHz)	161.0	239.0	161.5	239.0
Limit (dB)	28.5	36.7	36.4	36.7
Worst Pair	36	36	36	36
P8 NEXT (dB)	12.4	9.0	13.5	9.0
Freq. (MHz)	161.5	239.0	236.5	239.0
Limit (dB)	35.9	33.1	33.1	33.1
Worst Pair	36-78	78-36	36-78	78-36
ACR-F (dB)	18.9	18.9	18.9	18.9
Freq. (MHz)	245.5	245.5	245.5	245.5
Limit (dB)	16.4	16.4	16.4	16.4
Worst Pair	36	36	36	36
P8 ACR-F (dB)	19.4	15.1	21.5	21.5
Freq. (MHz)	1.6	1.3	245.5	245.0
Limit (dB)	57.0	59.3	12.4	12.4
Worst Pair	35-45	35-45	12-36	12-36
ACR-N (dB)	17.7	17.9	39.5	39.5
Freq. (MHz)	6.0	6.4	237.0	239.0
Limit (dB)	53.6	54.0	5.6	5.4
Worst Pair	36	36	36	36
P8 ACR-N (dB)	19.3	19.0	39.6	39.2
Freq. (MHz)	8.6	8.6	236.5	239.0
Limit (dB)	51.4	51.4	3.0	2.8
Worst Pair	45	45	45	45
RL (dB)	6.0	5.9	6.0	5.9
Freq. (MHz)	217.0	217.0	217.0	217.0
Limit (dB)	10.6	10.6	10.6	10.6

Consistent Network Standards:
100BASE-T 100BASE-TX 100BASE-T4
100BASE-G-T ATM-CR ATM-61
ATM-15B 100V-AryLen Tr4
Tr-16 Active Tr-16 Passive

Project: TERACO COPPER TestCo Copper.rpt FLUKE networks

Conclusio



Qualified instruments and personnel paired with an efficient work flow ensures ...

- “Next Generation Readiness” by maximizing performance margins
- ensures a profitable certification of fiber optic or copper cabling systems





***THANK YOU
FOR YOUR ATTENTION !***

Questions?

Christian.Schillab@FlukeNetworks.com

