

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

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



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Agenda

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



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)



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	

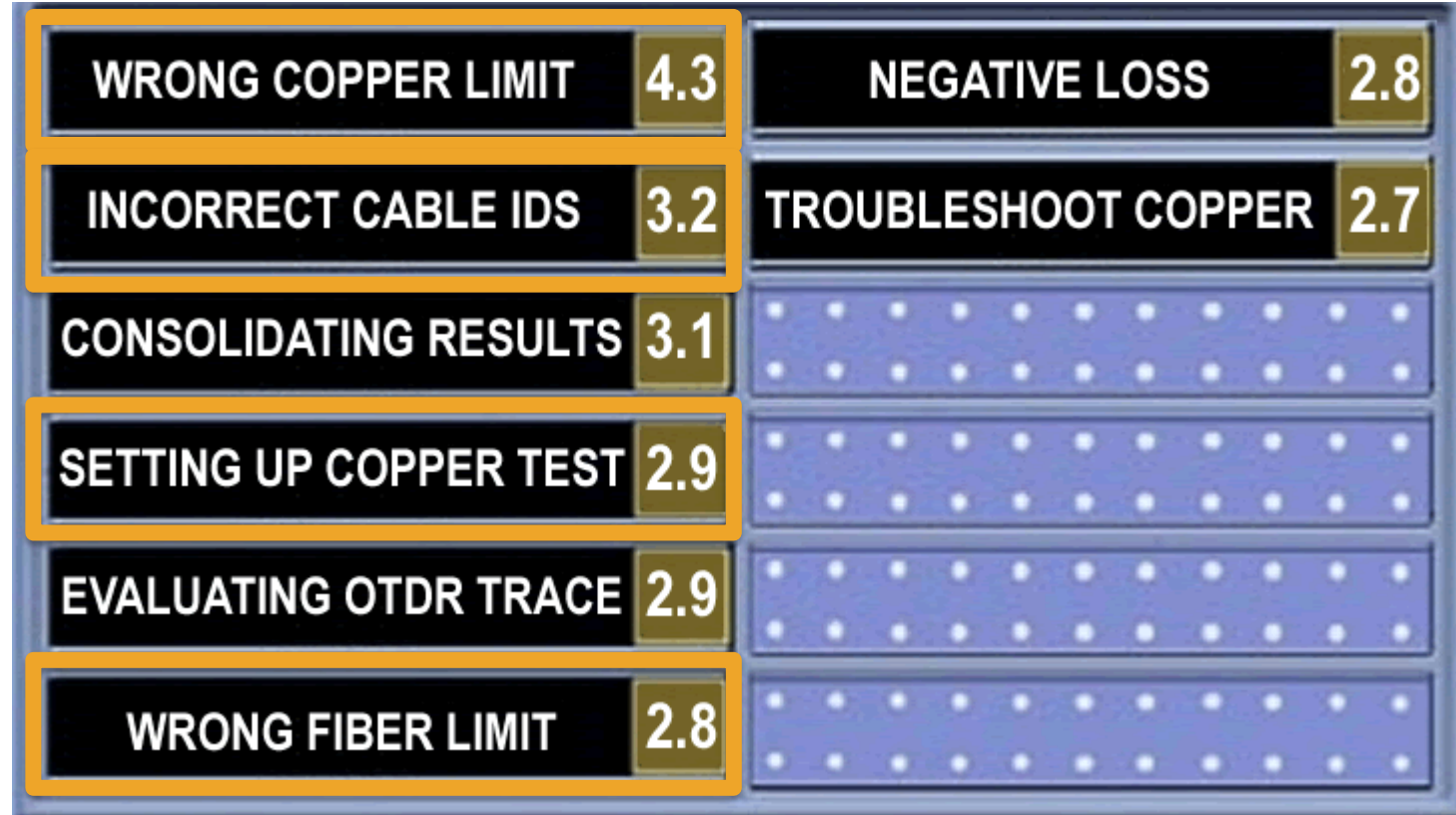
Average amongst all respondents in the previous 30 days





Top eight problems:

Wrong Configuration (Limit, IDs, Standard,)

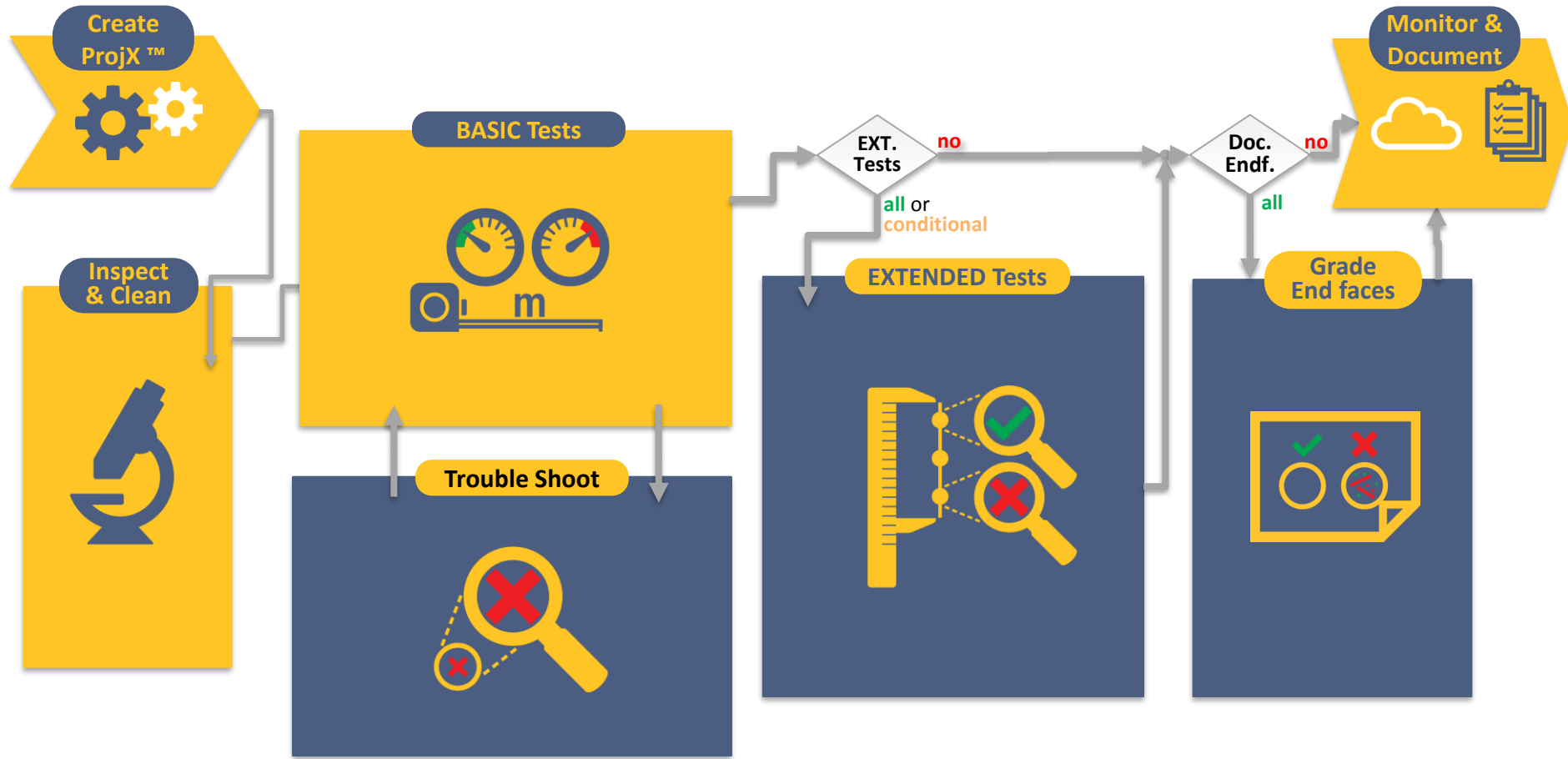


Average amongst all respondents in the previous 30 days





Step 1: Project Definition





Project Definition



- 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





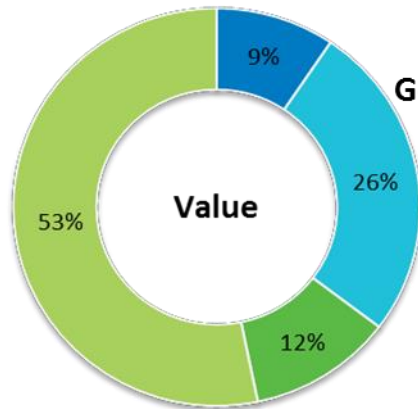
Data Centre vs. Commercial Building Cabling Infrastructure

Differences affecting test regimes

Larger number of links

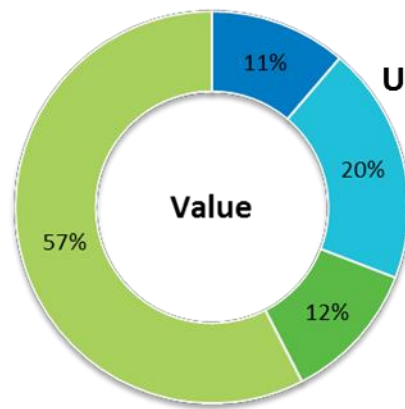
Larger share of fiber vs. copper

- Testing time
- Consolidation
- Labeling / ID Mgmt.

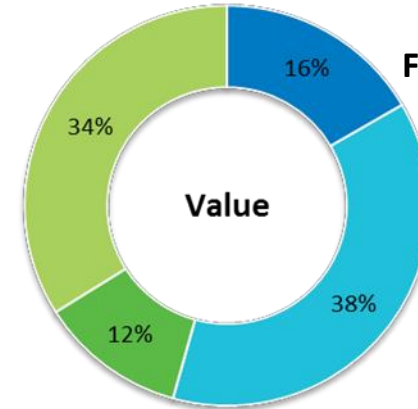


Germany **61M\$**

Source: BSRIA 2015



UK **58M\$**



France **25M\$**

■ 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
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Larger share of fiber vs. copper

“Zoned” Data Centers

Low channel loss budgets

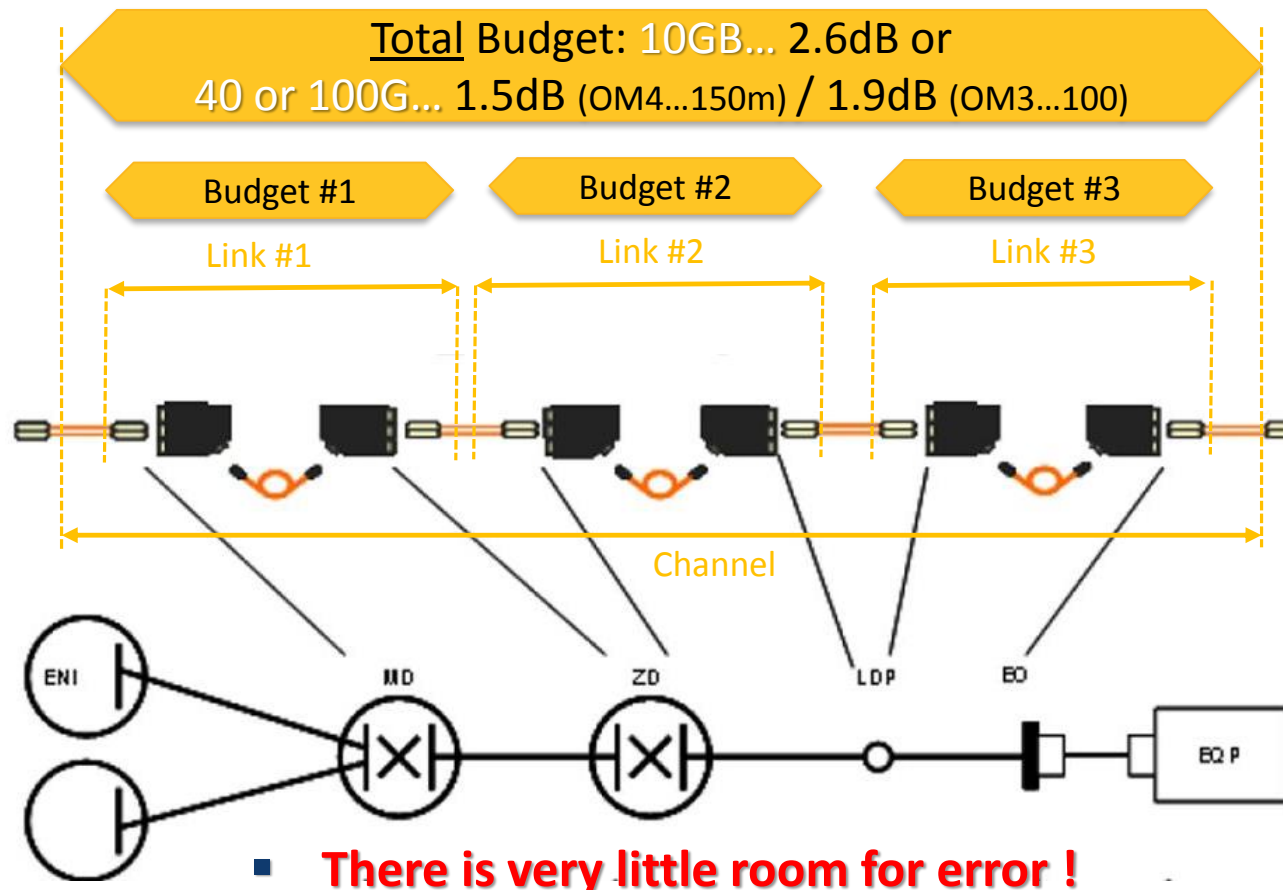
Low loss connectors

- Little room for measurement error



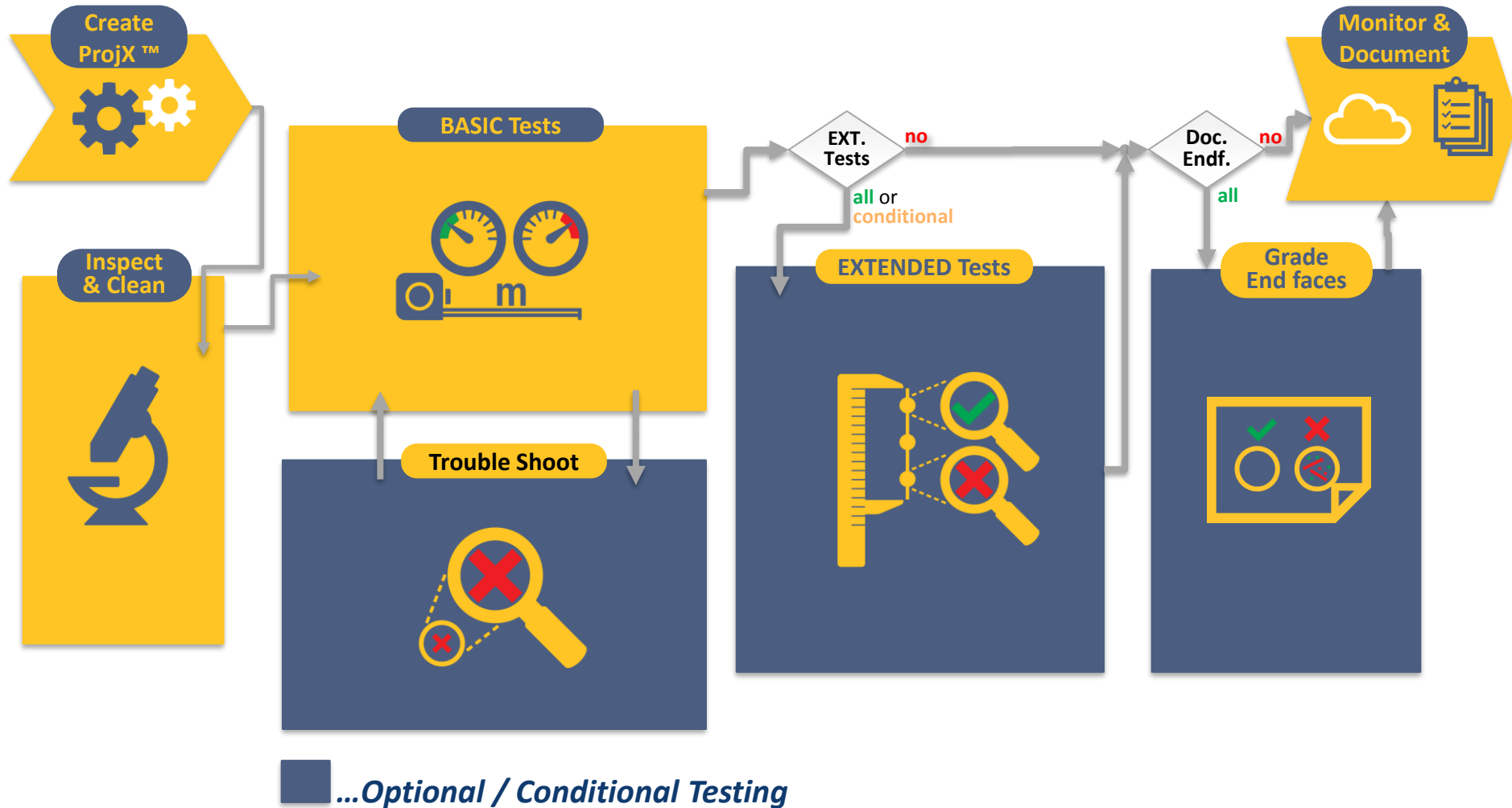
Testing – “Zoned” Data Centers

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



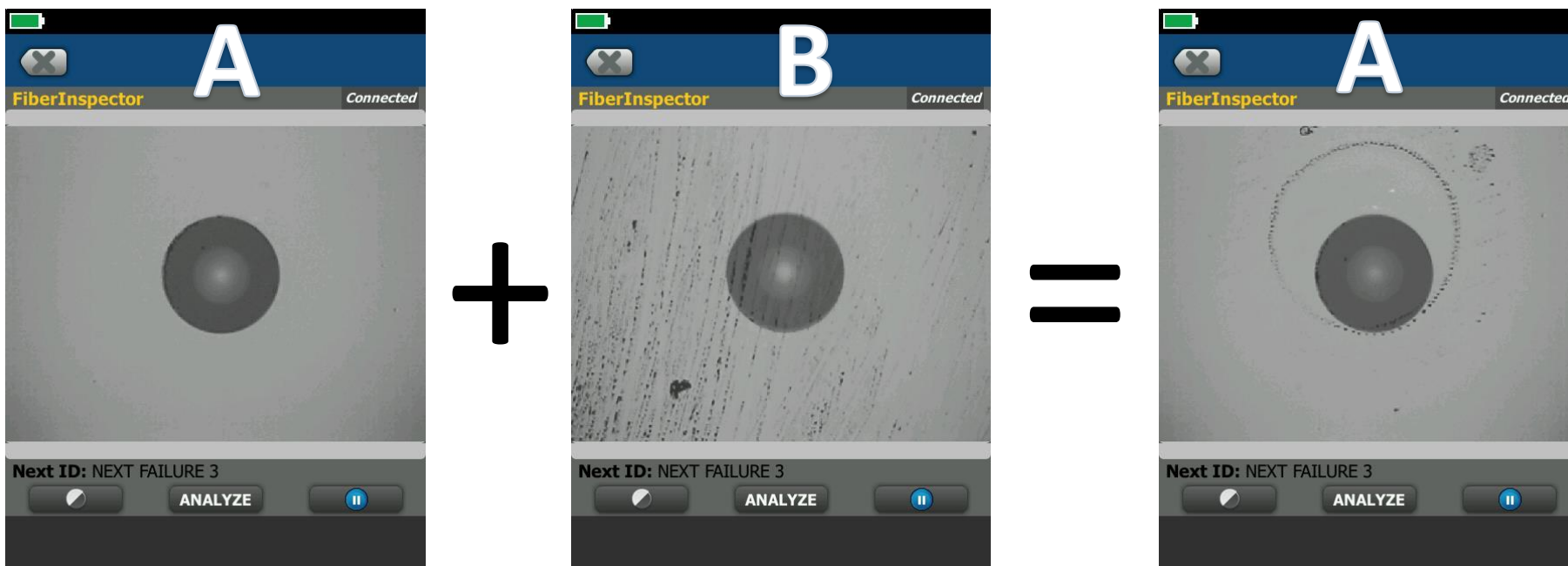


Step 2: Inspect & Clean Fibers







Dirt will transfer

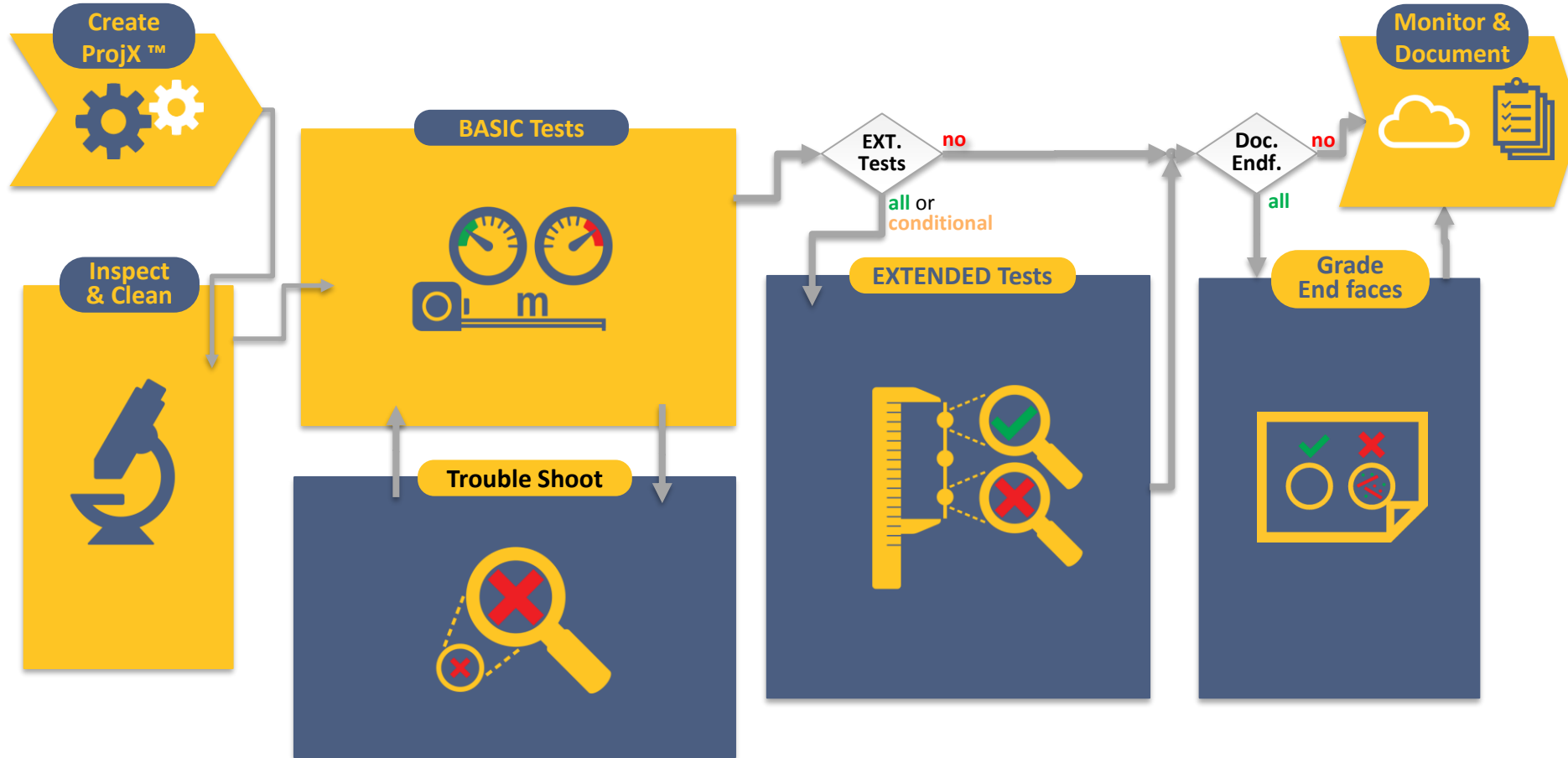


Conclusion: Clean measurement cord after every mating



Step 3: BASIC Tests

	Tier 1	Tier 2
	BASIC	EXTENDED

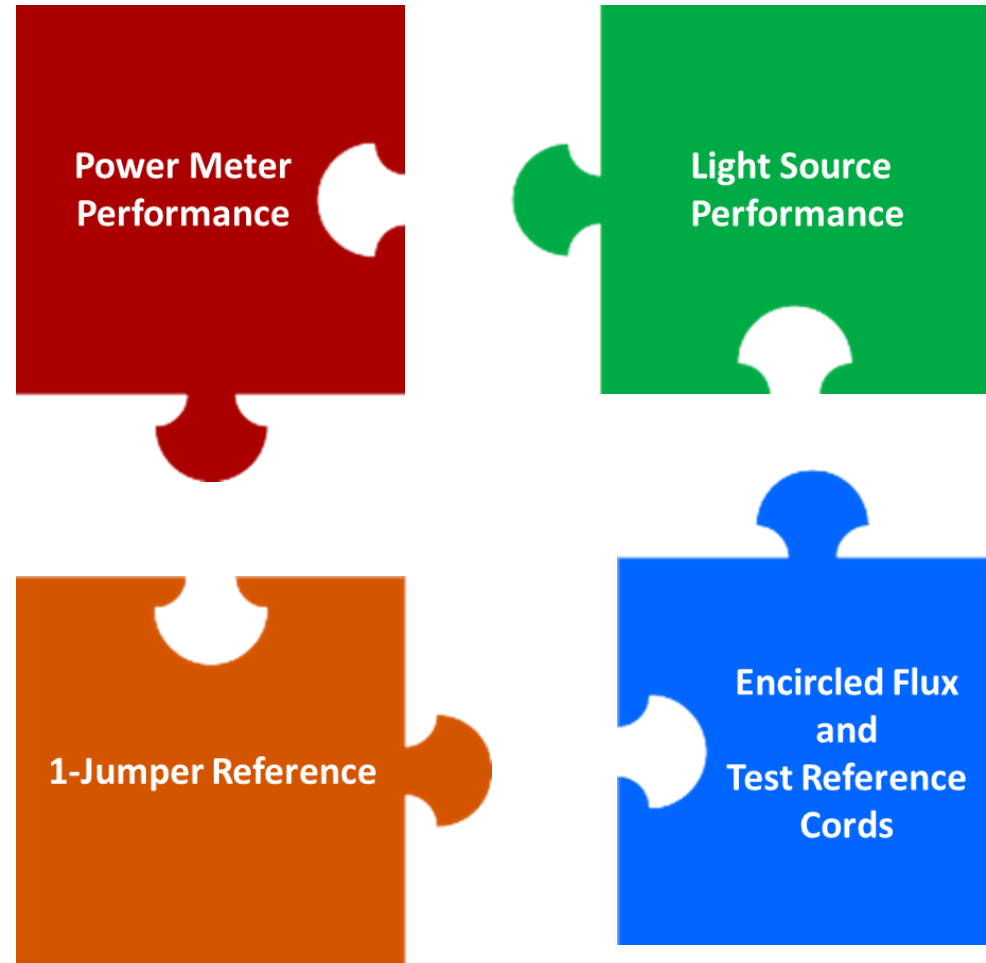


■ ...Optional / Conditional Testing



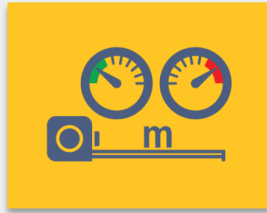


Being certain of loss uncertainty





Set Reference & TRC verification

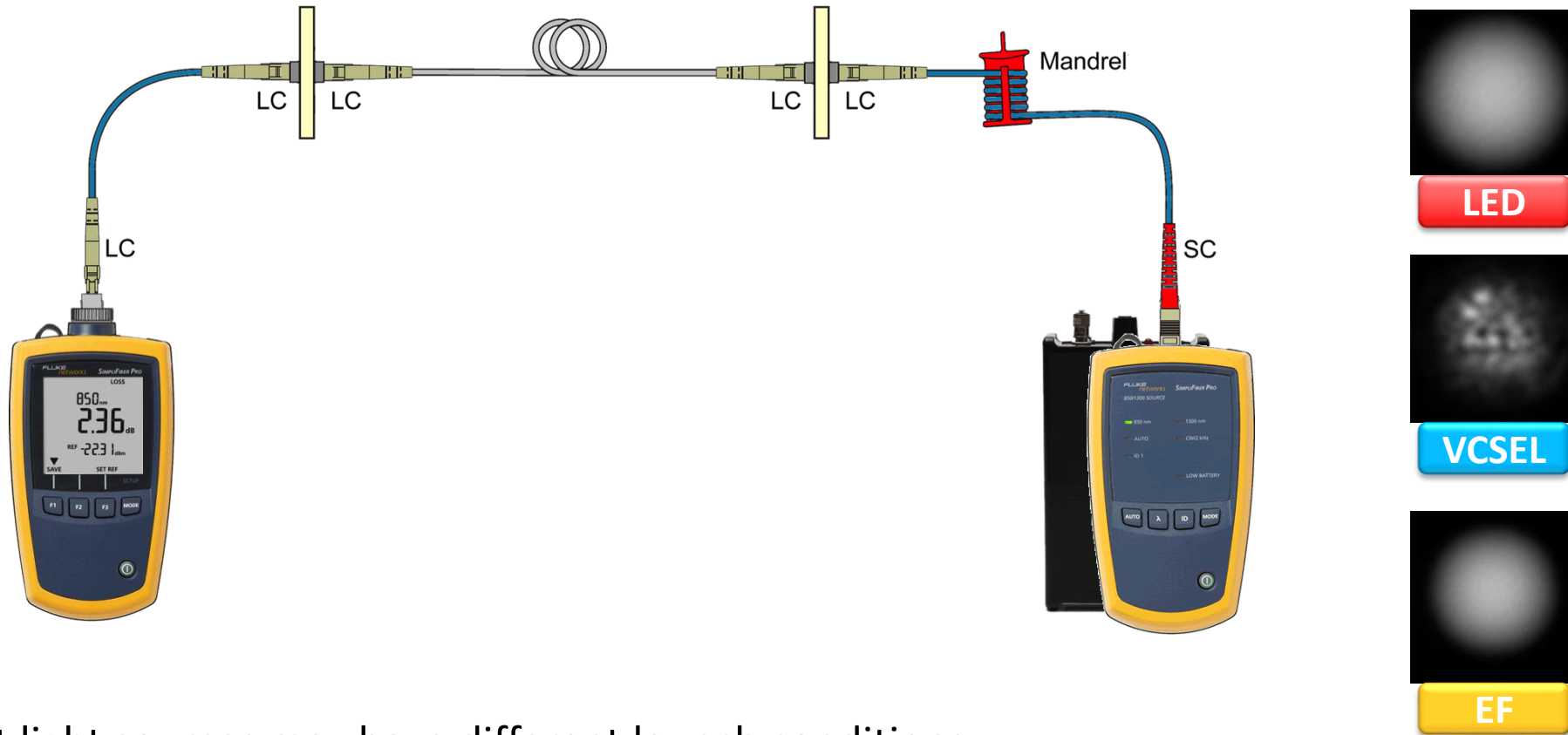


- A wizard guides through the correct process
- TRC verification stored as part of project
- A TRC verification test should be run with regular intervals





Why was the EF STANDARD NEEDED ?



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



Encircled Flux

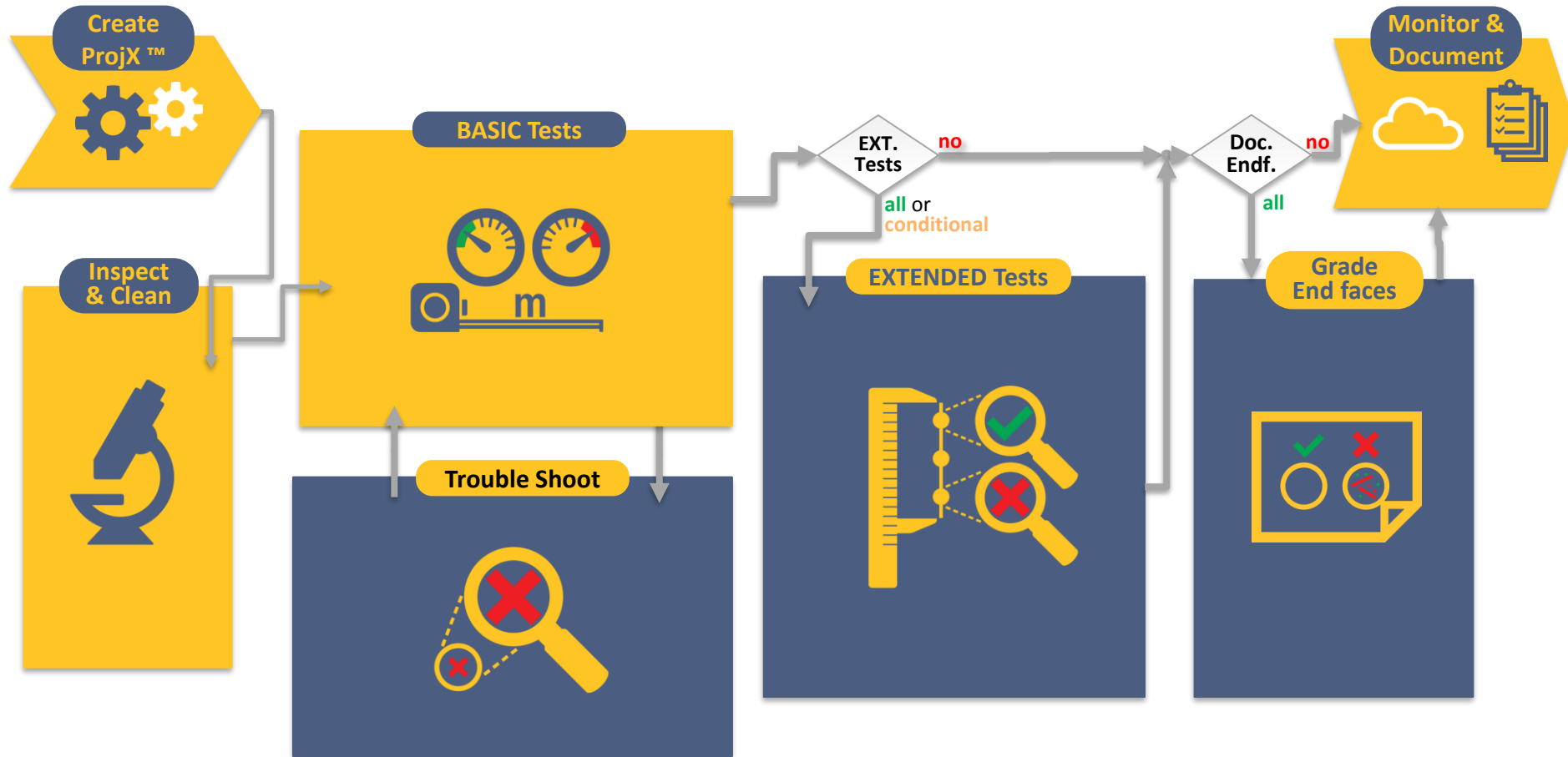


Why ?	How ?
<p>Normative Requirement</p> <ul style="list-style-type: none">• ANSI/TIA-526-14-B• ISO 1180 → ISO/IEC 14763-3 Ed.1 62• EN 50173 → IEC IEC 61280-4-2	



If BASIC Tests **FAIL** ...

Step 3B: Troubleshoot



■ ...Optional / Conditional Testing



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



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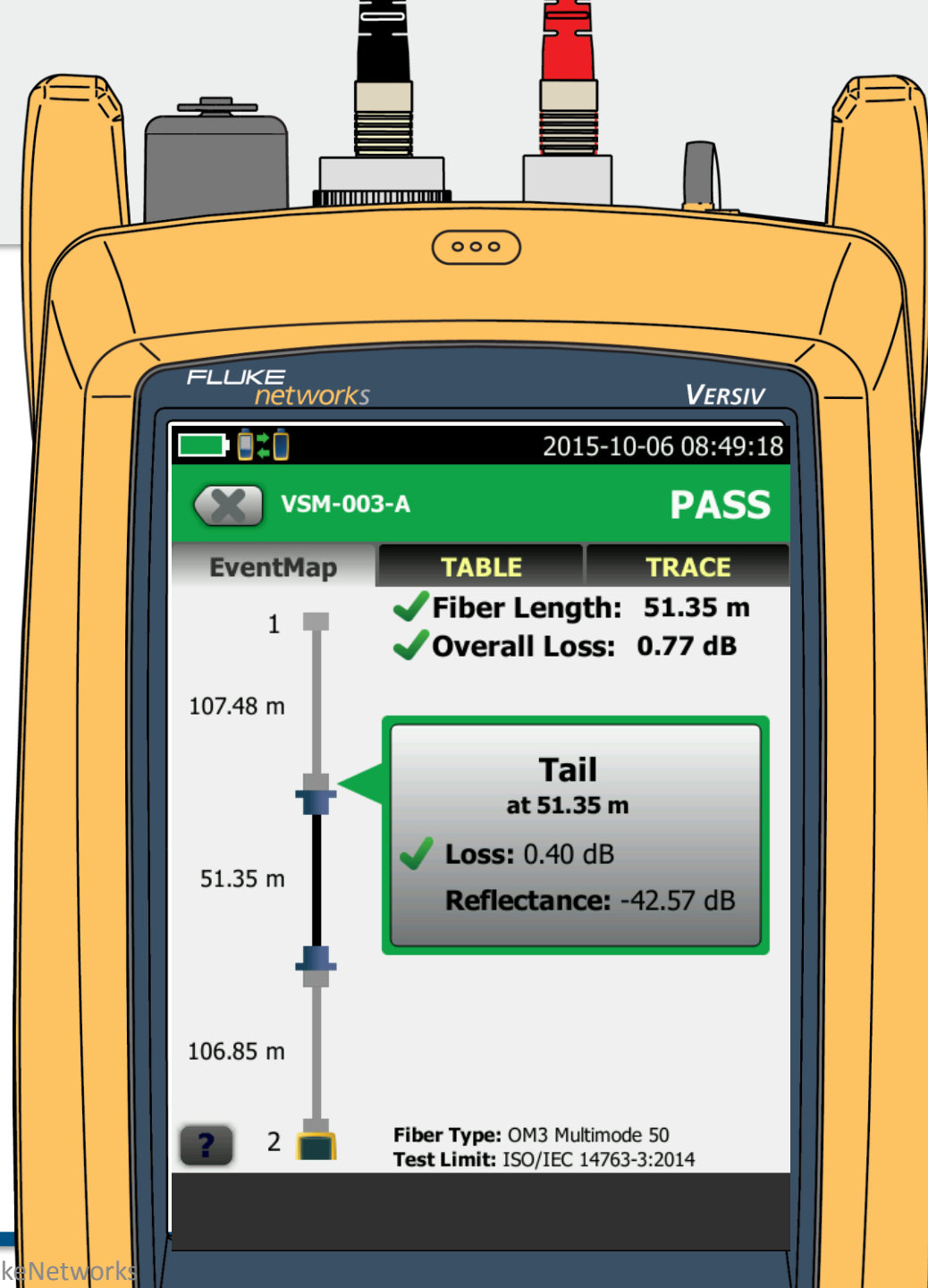




OTDRs are not only for "Gurus"

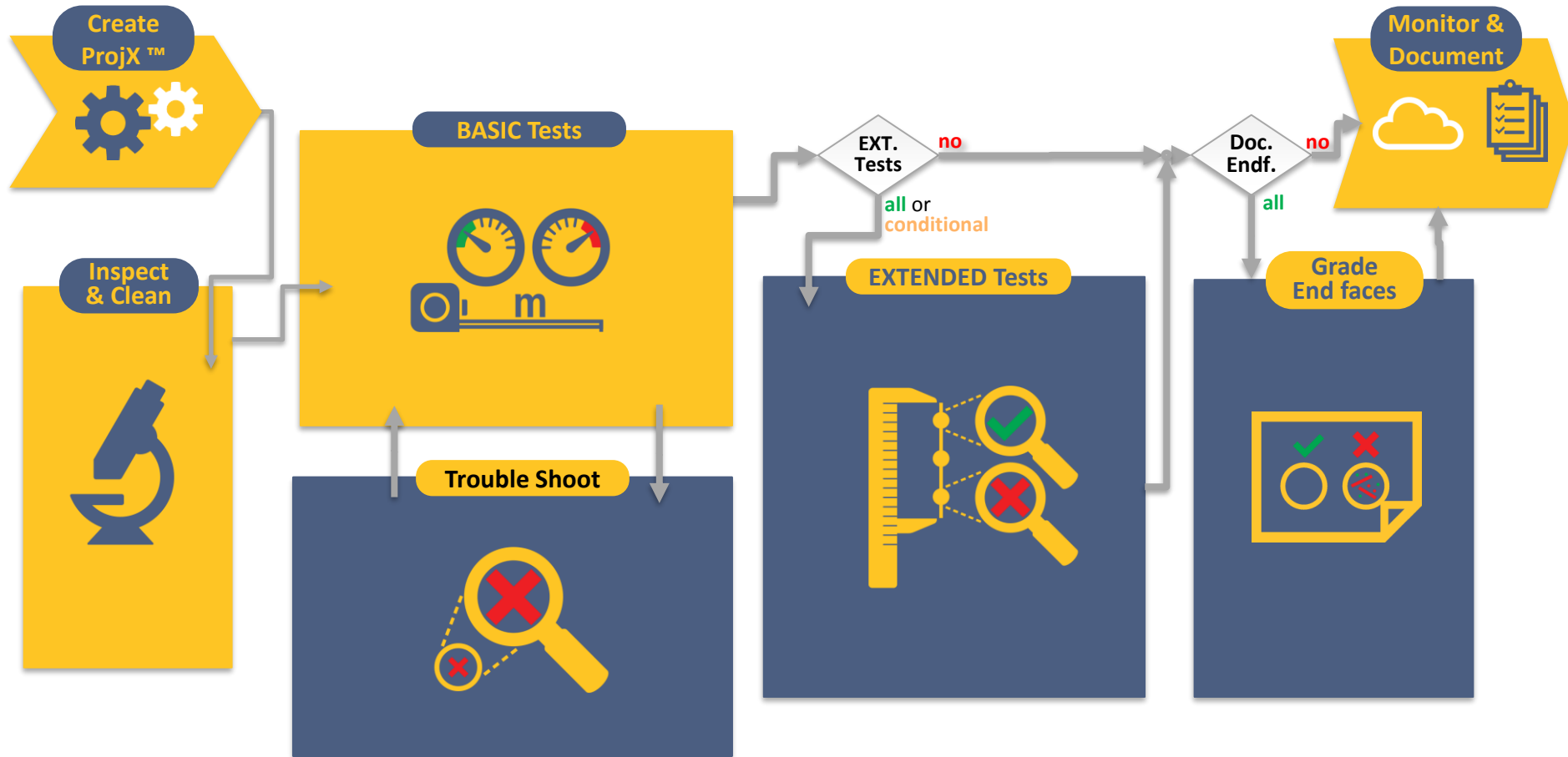


- Event Maps simplify the presentation
- Overall (Link) limits complement component limits
- Launch & Tail fibers are automatically excluded





Step 4: Extended Test



■ ...Optional / Conditional Testing

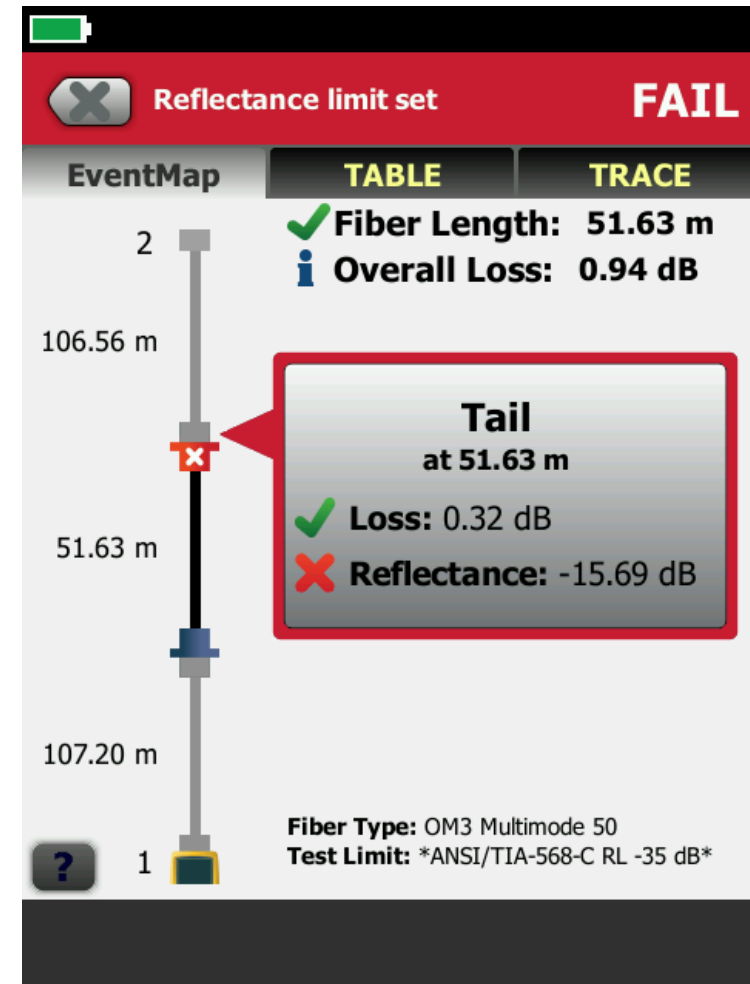


Why *EXTENDED* Testing ?



- 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

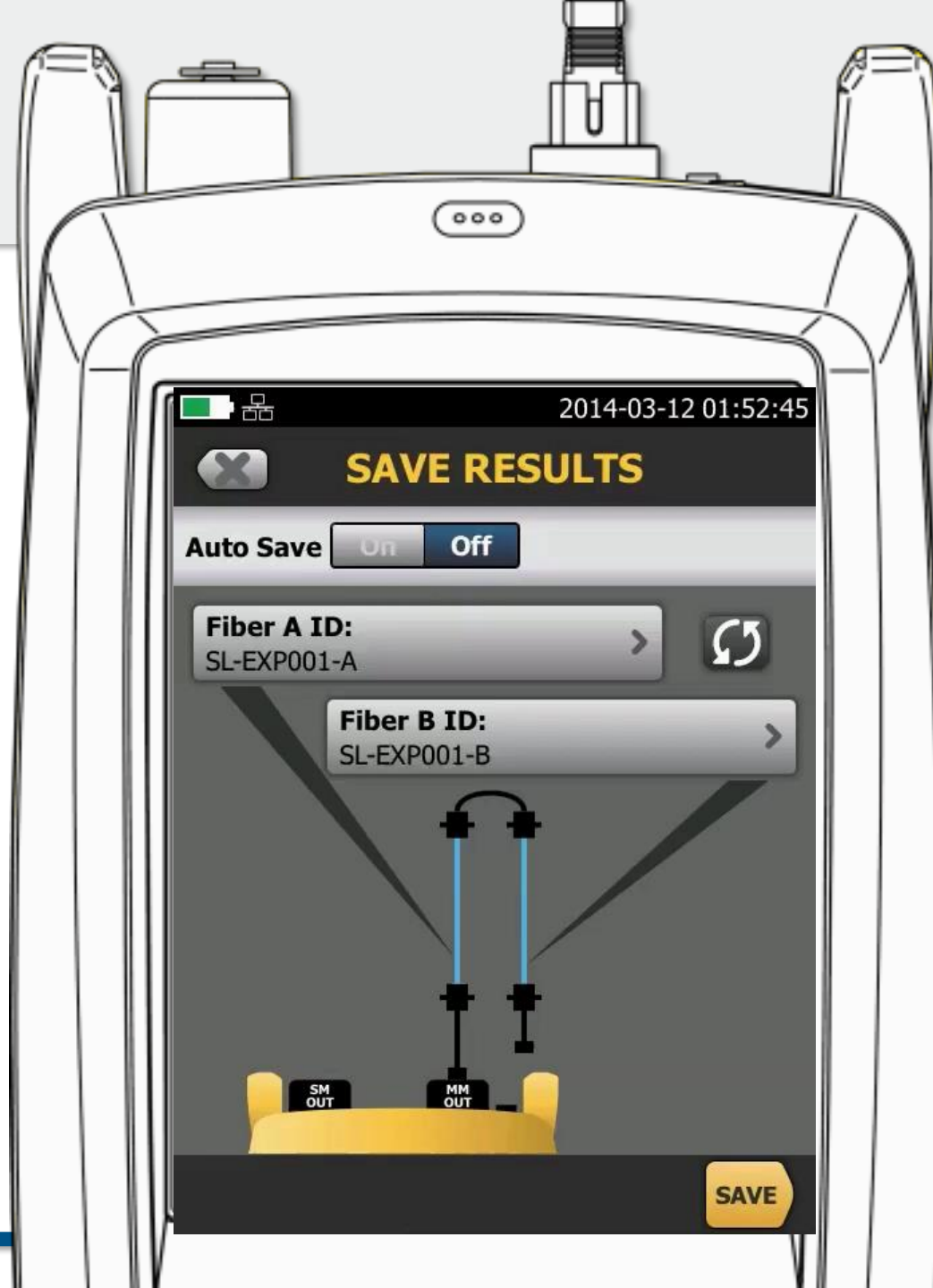
- Bi-Directional testing and averaging is essential





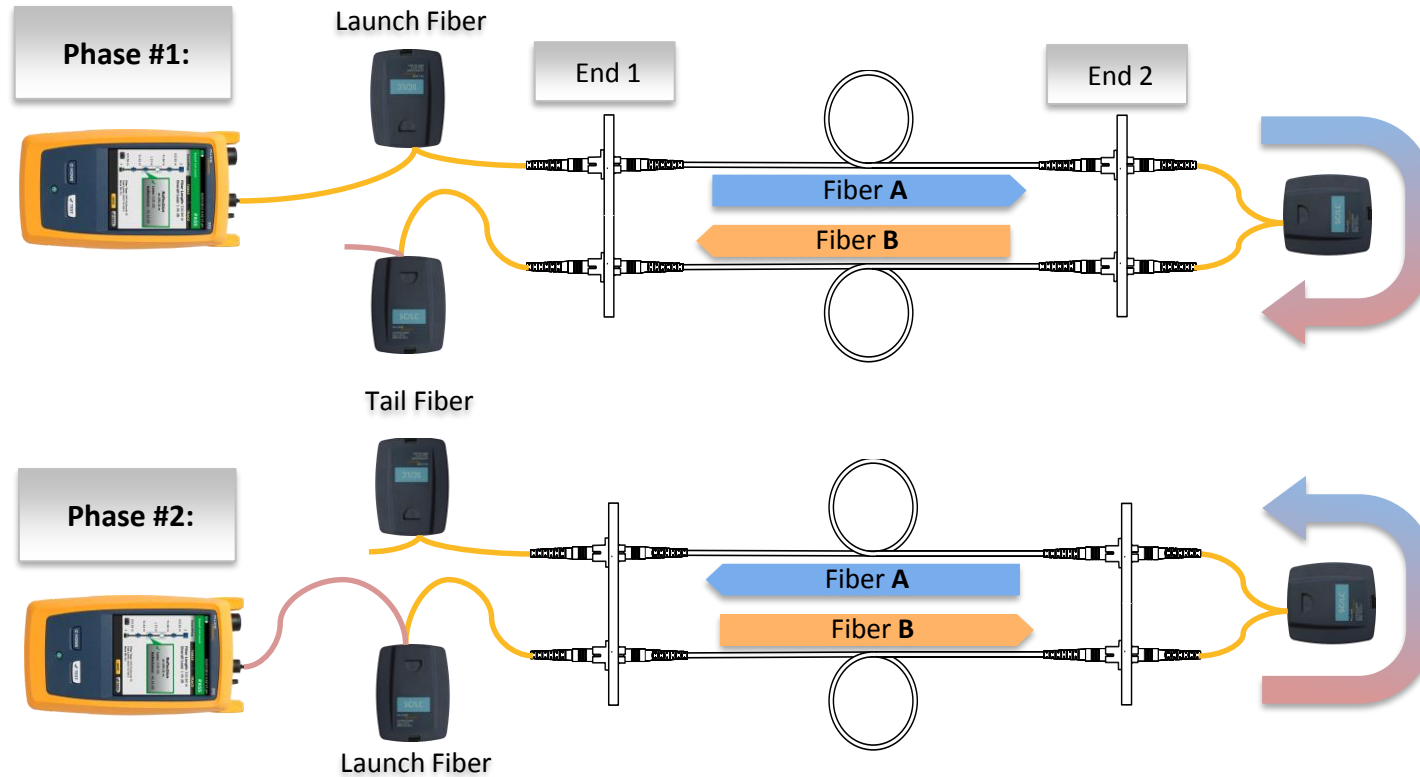
Bi-Directional Testing with a **SMART Loop**

- > 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 concept forces the user to perform the test correctly
- Multiple remote loops support operation by 1 technician





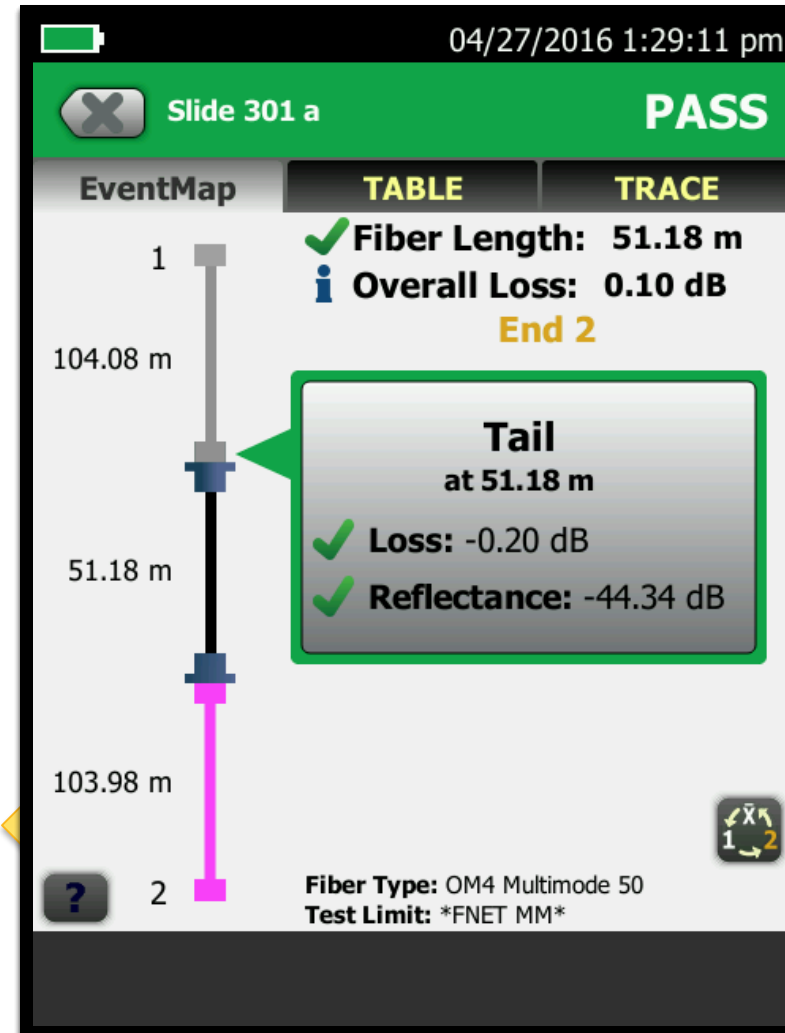
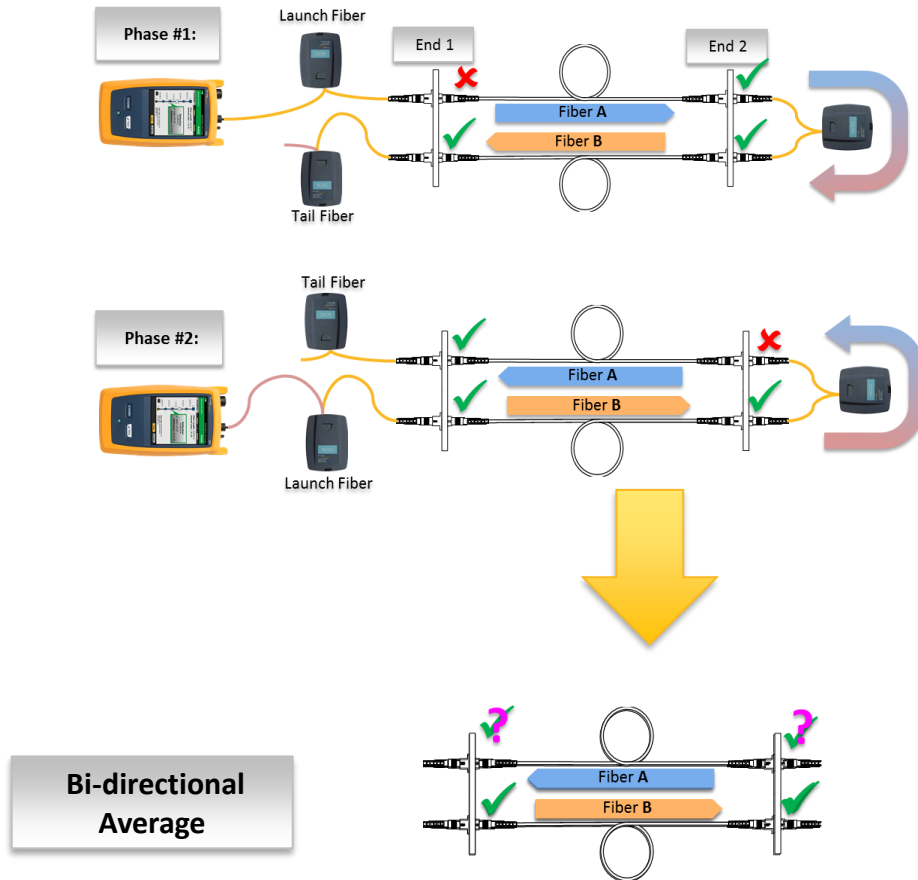
ACCELERATED EXTENDED Testing with a SMART Loop



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

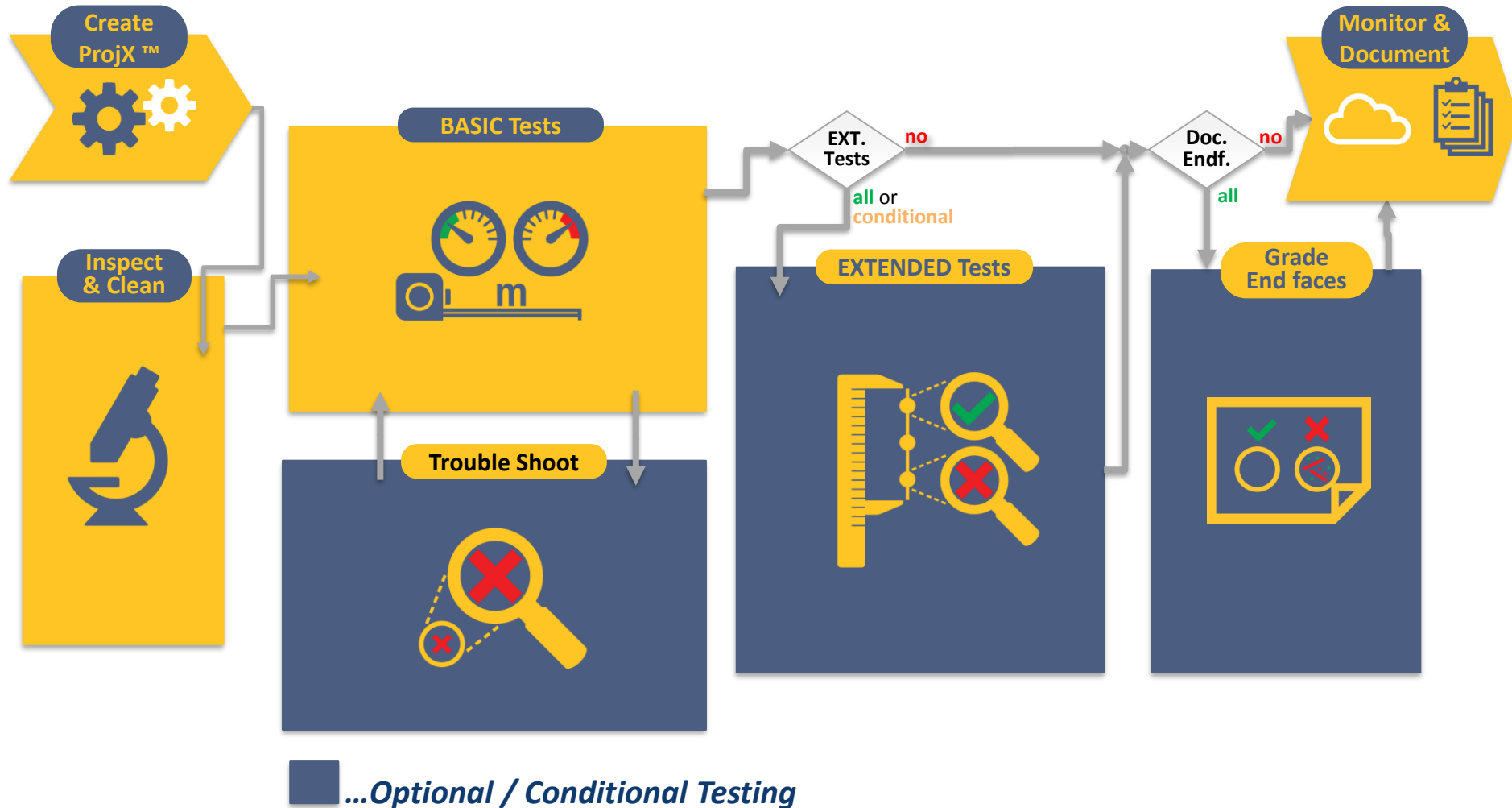


Internal Bi-Directional Averaging



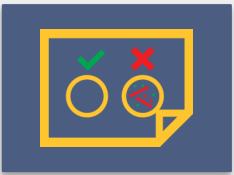


Step 5: Fiber End Face Grading & Documentation

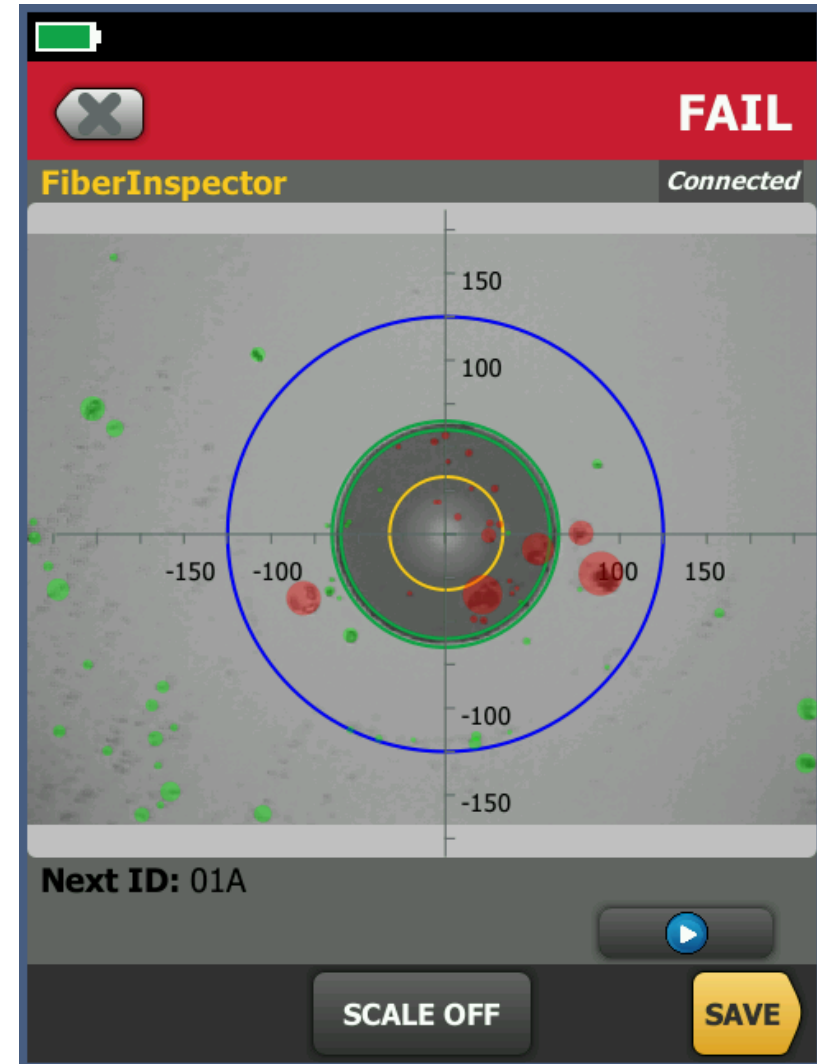




Grade & Document

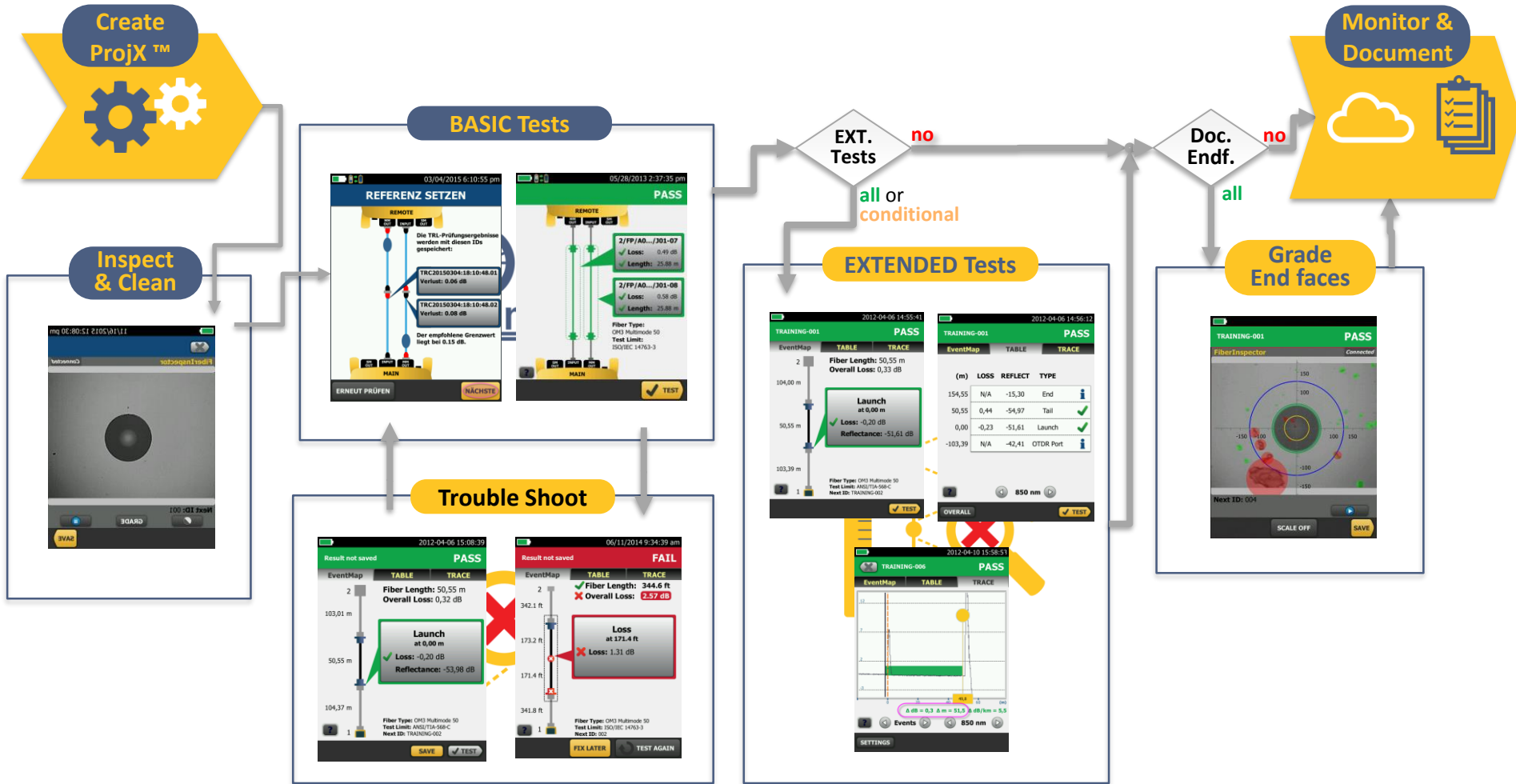


- Without inspection equipment, you will never know if the connector is clean or not
- Even with inspection equipment, there are arguments as to what is acceptable for a fiber connector
- IEC 61300-3-35 defines levels of acceptable scratches and debris on the end faces of fiber connectors
- Automated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

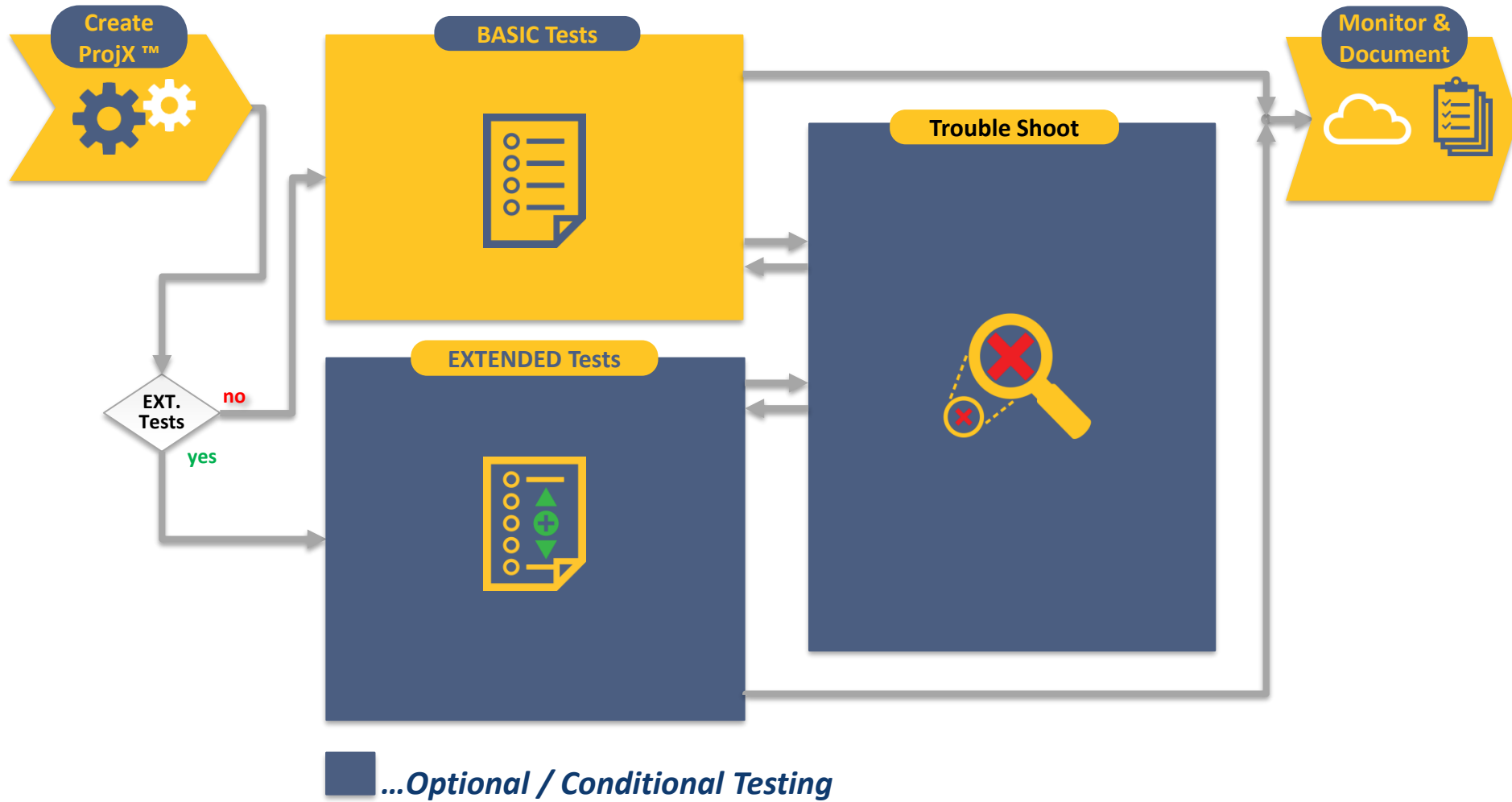
Shielded systems

Future Cat.8 systems

- An Extended Test Regime is beneficial

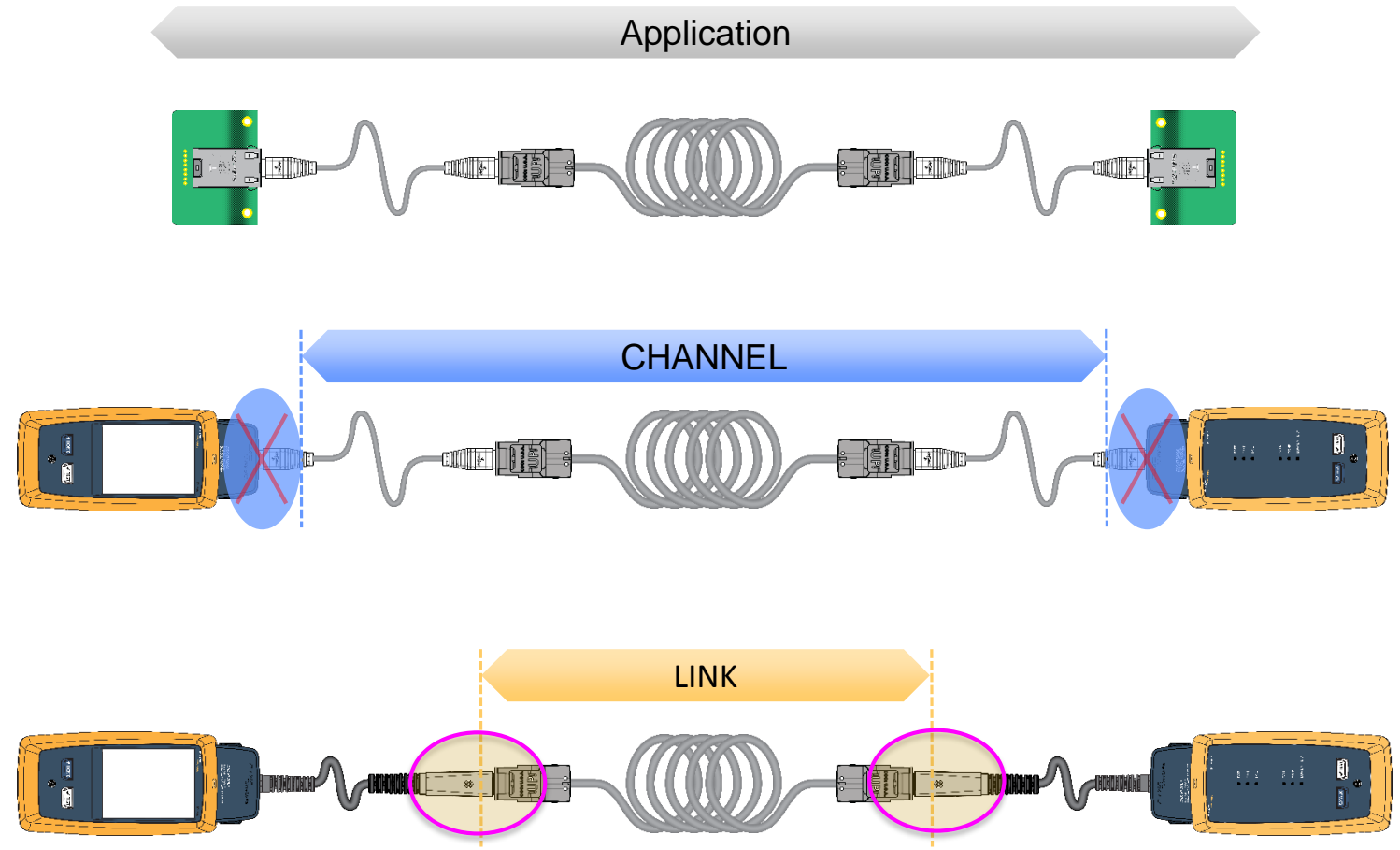


Step 1A: Basic (Minimum) Test Regime



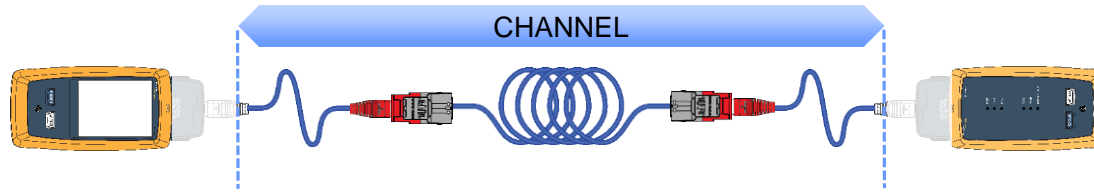


Test Interfaces & Reference Planes



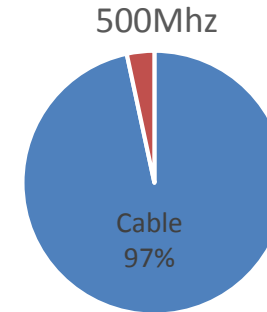
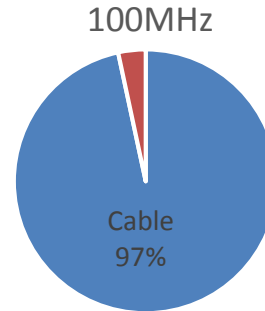


What Limits The Bandwidth more ... Connectors or Cable ?

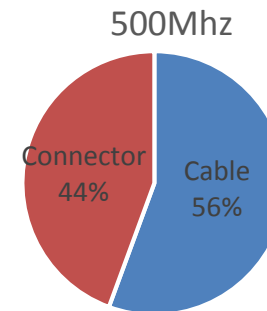
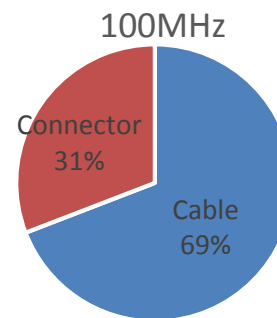


Example: 30m Link

- Insertion Loss (IL)



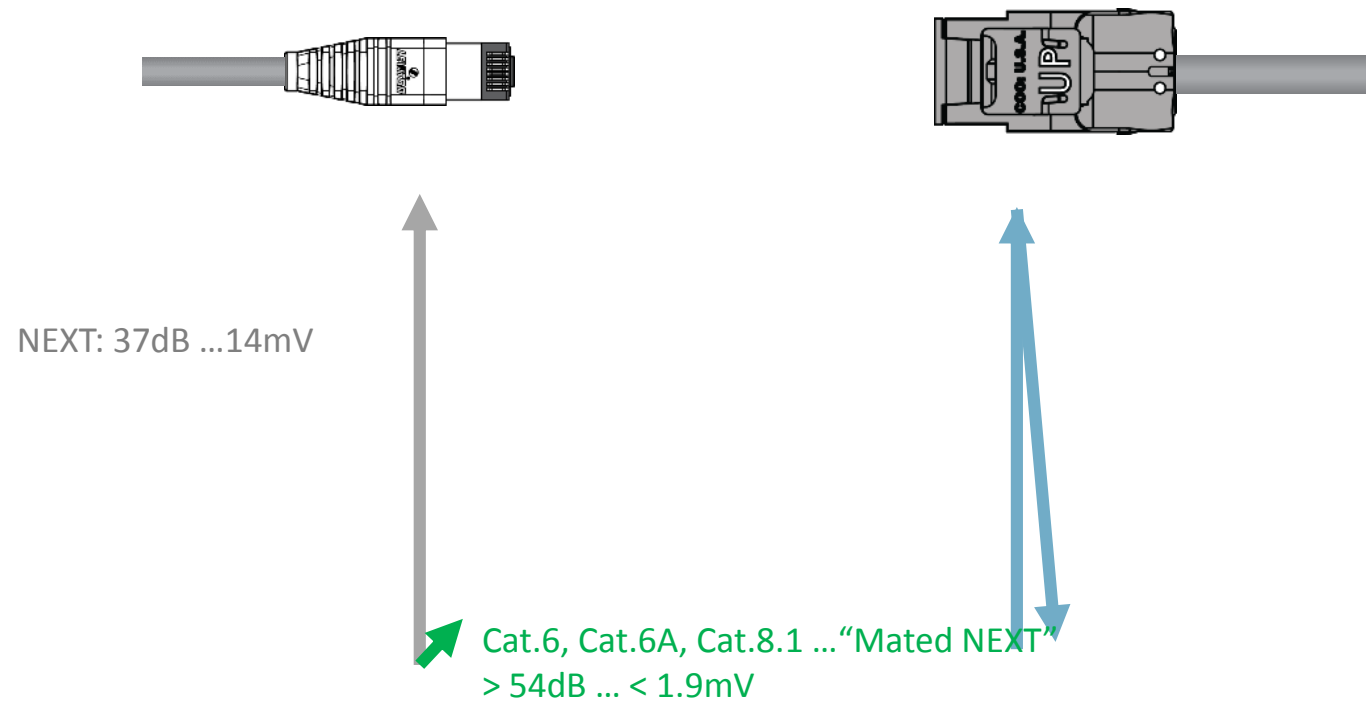
- Near End Cross Talk (NEXT)



...An inch at either end affects results noticeable



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

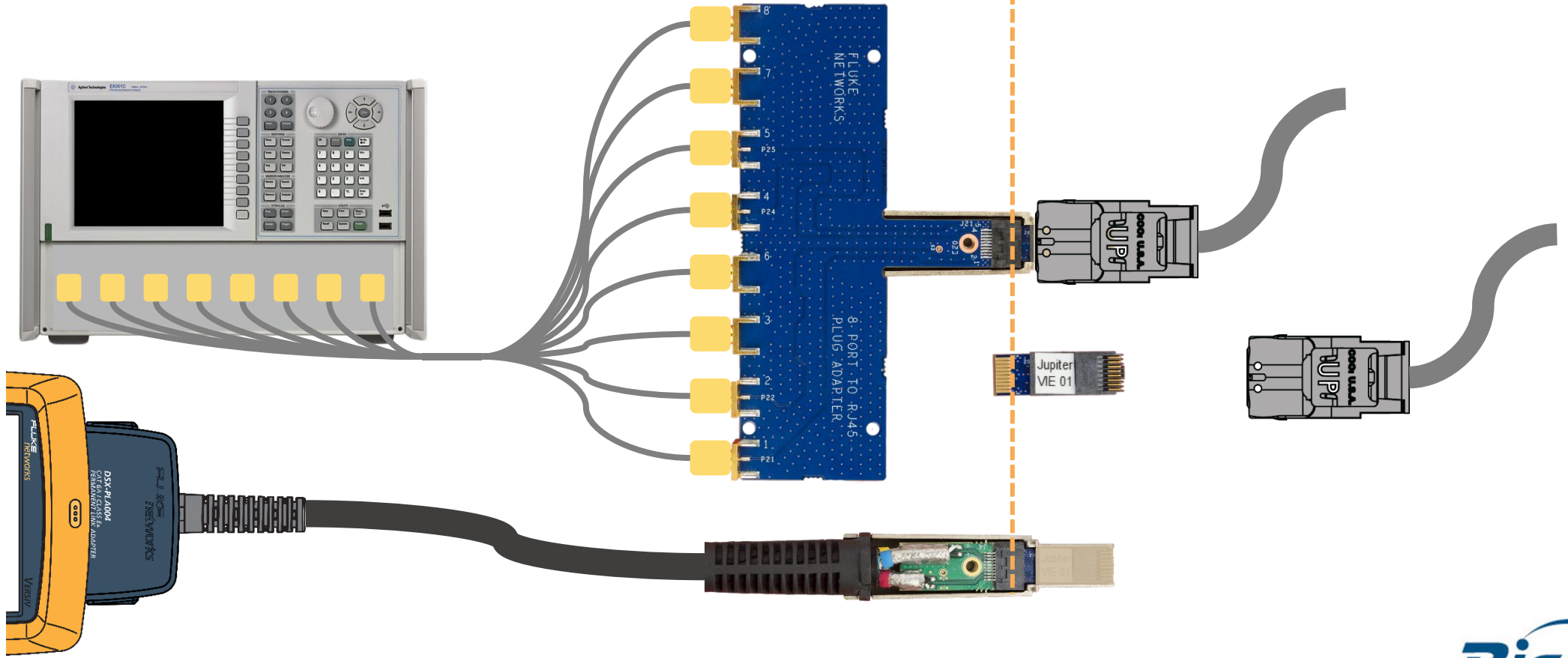
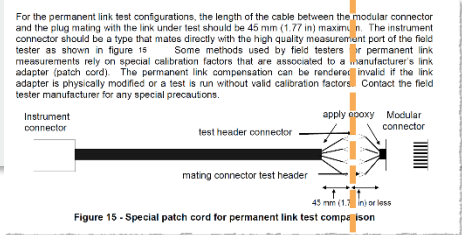


Note: Above is shown for the most critical pair 3,6/4,5 at 100MHz



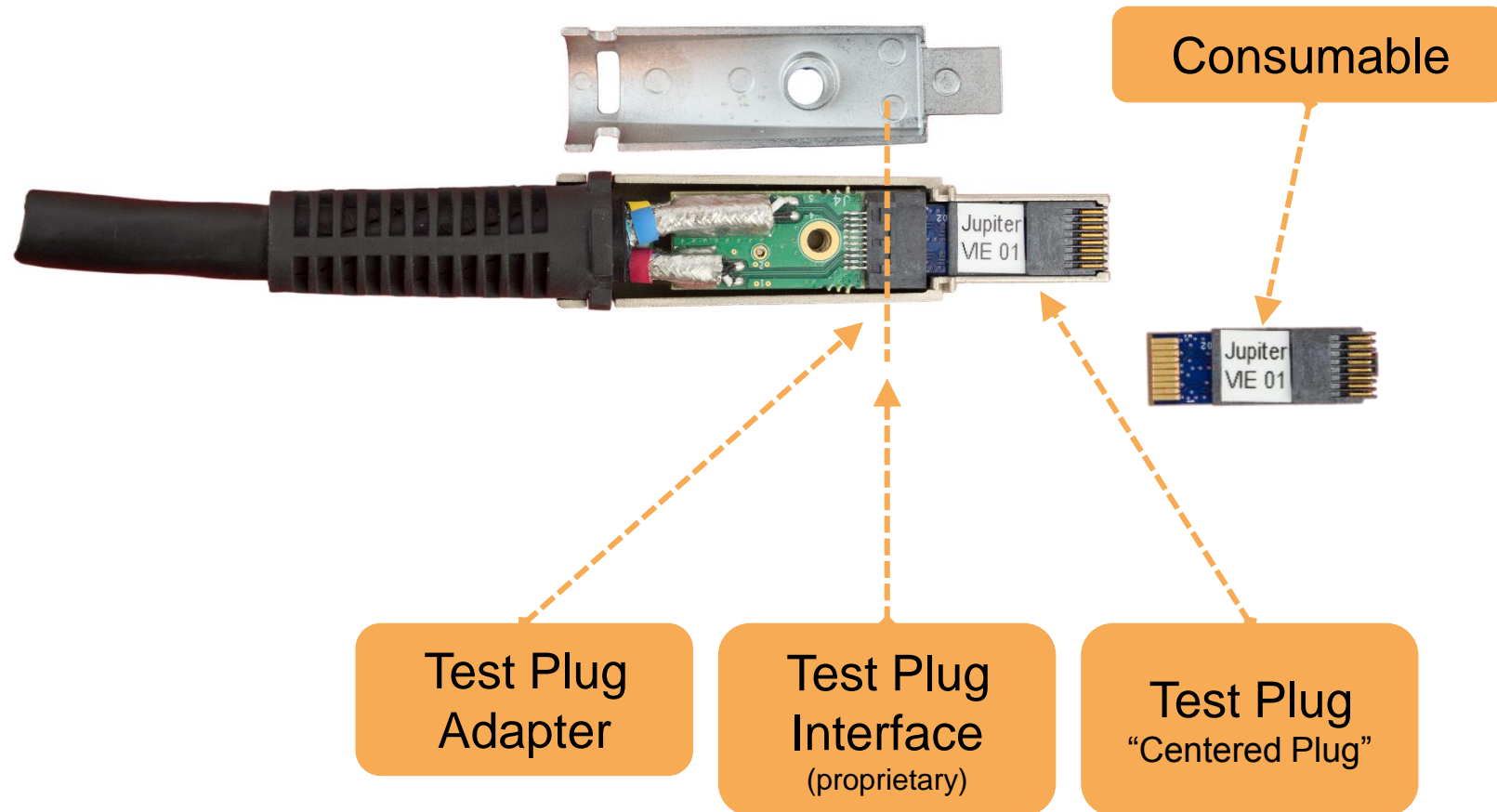


Comparing PERMANENT LINK Results



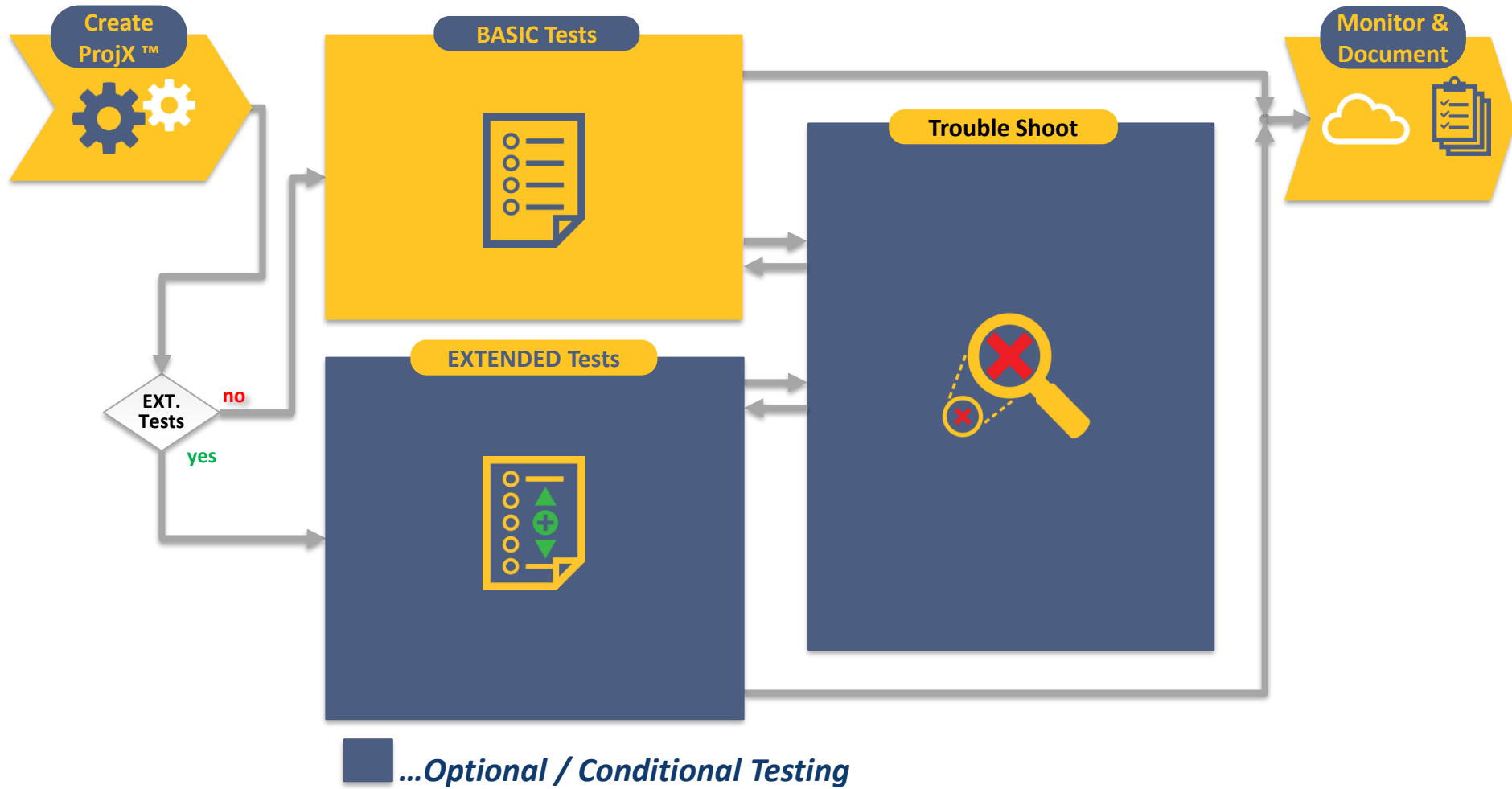


Permanent Link Adapter with a “**CENTERED**” Test Plug for the „Heavy Duty Field Use“





Step 1B: Extended Test Regime





Why **EXTENDED** Testing ?



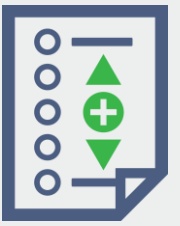
	Copper Certification to ISO/IEC 11801	
	Reference Conformance Testing	Installation Conformance Testing
Wire Map	✓	✓
Length	✓	
Propagation Delay	✓	✓
Delay Skew	✓	✓
DC Loop Resistance	✓	✓
DC Resistance Unbalance	✓	
Insertion Loss	✓	✓
NEXT, PS NEXT	✓	✓
Return Loss	✓	✓
ACR-N, PS ACR-N	✓	✓
ACR-F, PS ACR-F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





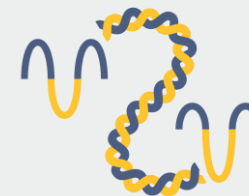
WHAT IF ...

**TCL / ELTCTL is
not compliant**



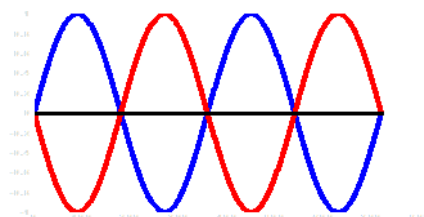


TCL (Transverse Conversion Loss)

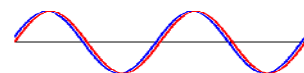


- **Transverse Conversion Loss** is the ratio (in dB) of a common-mode voltage measured on a wire pair relative to a differential-mode voltage applied to the same end of the pair. The TCL value shows you how well the impedances of the pair's conductors are balanced.

Differential
Signal Applied



Common Mode
Voltage Measured





Mode Conversion – Real World Example

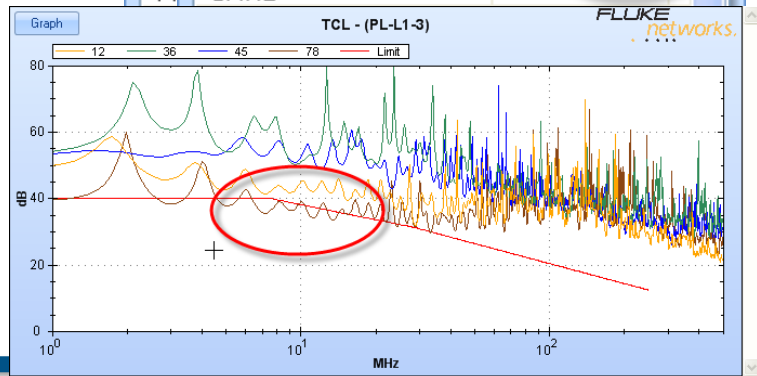
GOOD vs. BAD Drum of Cable



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



Tests		
In	Insertion Loss	26.2 dB
NE	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	



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
Pr	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

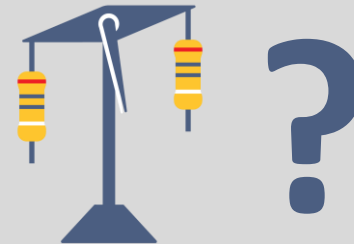


WHAT IF ...

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

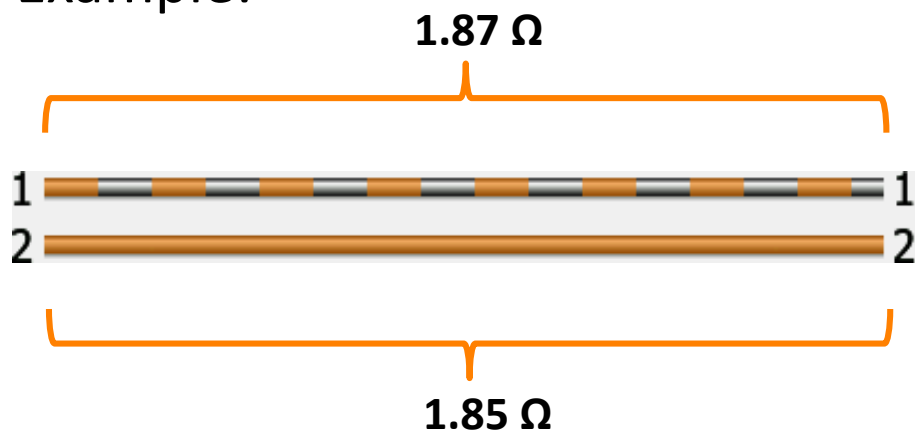


Resistance Unbalance



- Difference in Resistance between wires in the pair

- Example:



Resistance = 3.7 Ω

Resistance Unbalance = 0.02 Ω

Result not saved				PASS
	RESISTANCE	RESISTANCE UNBALANCE		
	VALUE	VALUE	LIMIT	
	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 ...

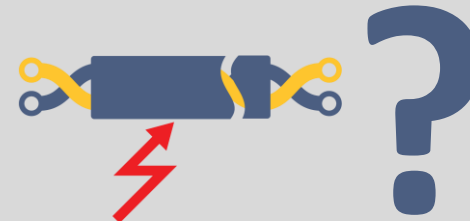
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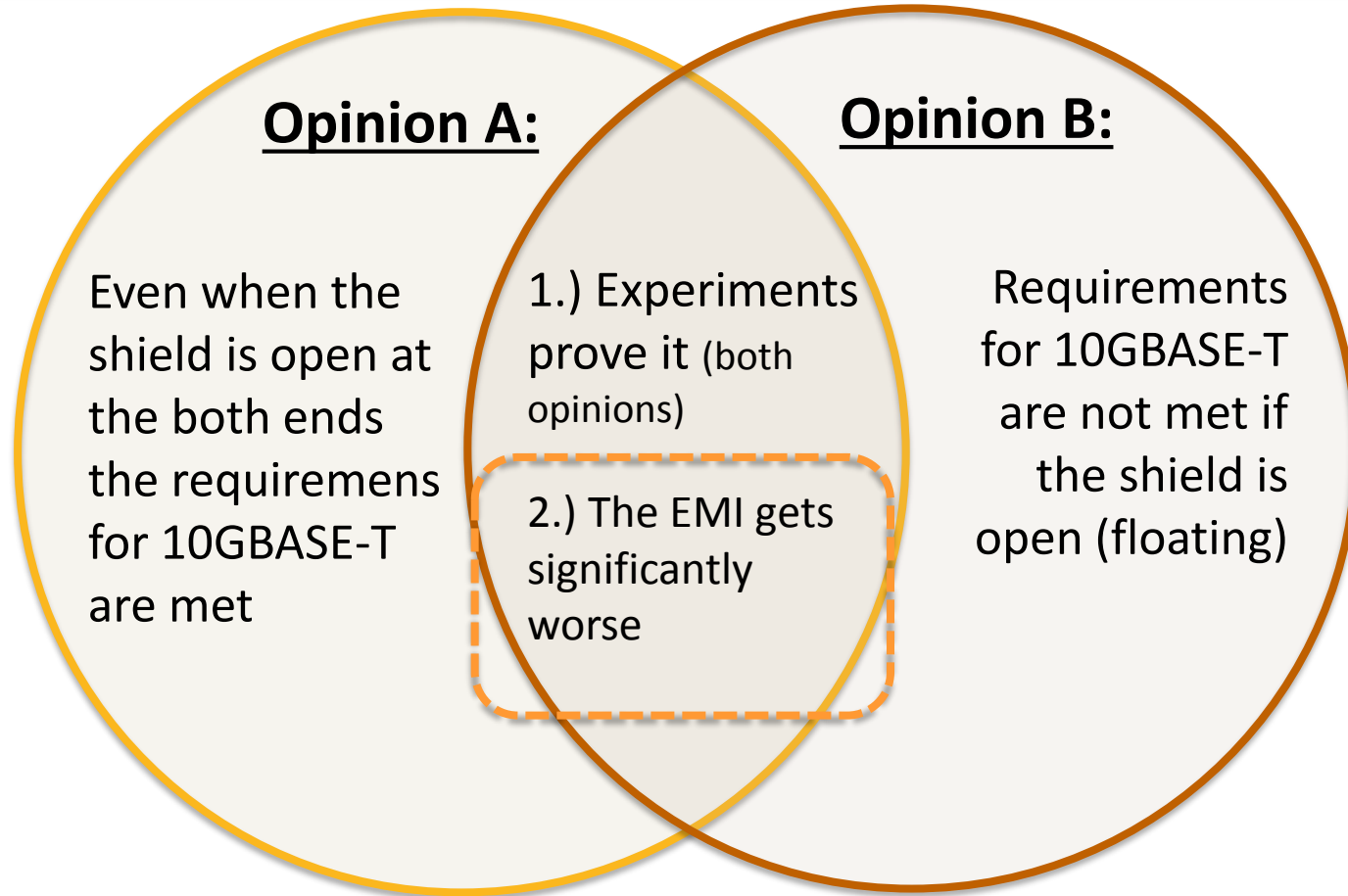
POE operation is at risk during maximum load
Poor contacts may further degrade over time

Shield Integrity is not given





Shield Integrity ... Opinions





Shield Integrity

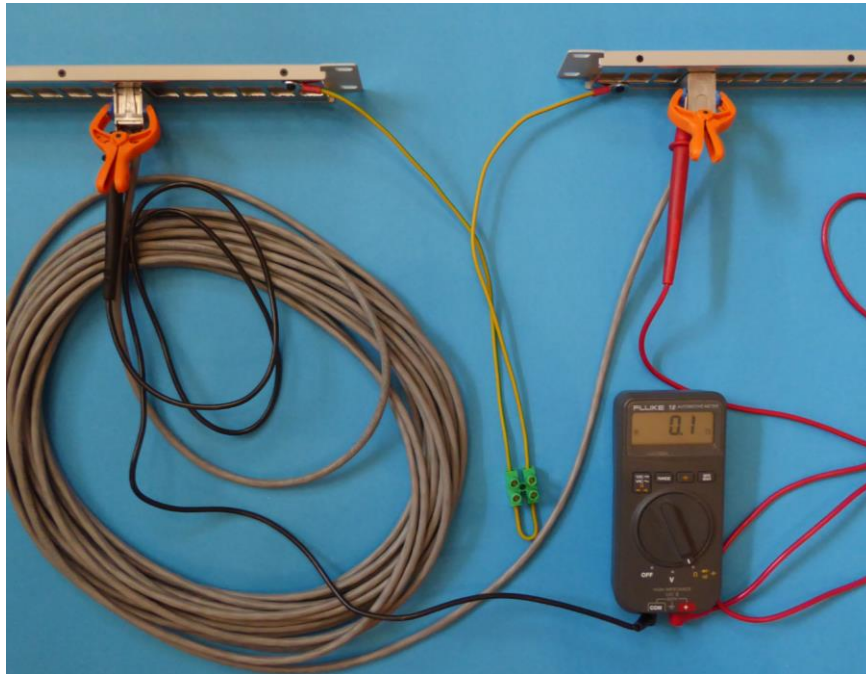


In The Past:

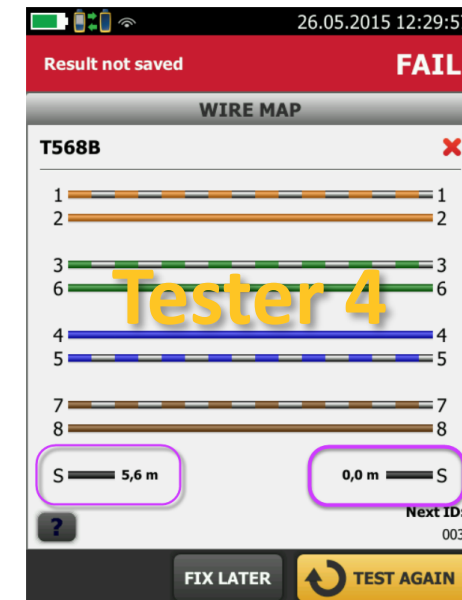
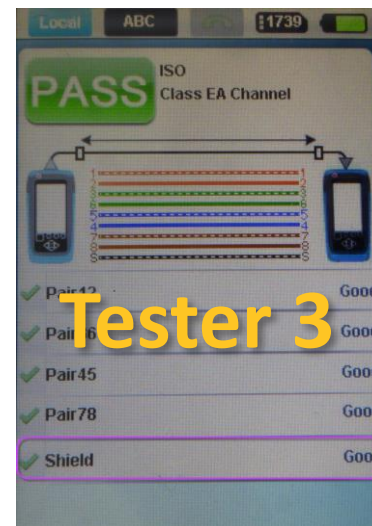
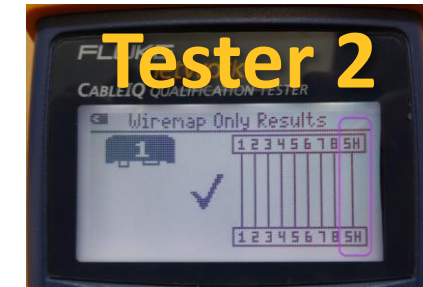
- Field testers could only verify that there is DC Continuity
- DC Continuity is given by grounding and earth
- Any open shields/ends could not be detected



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

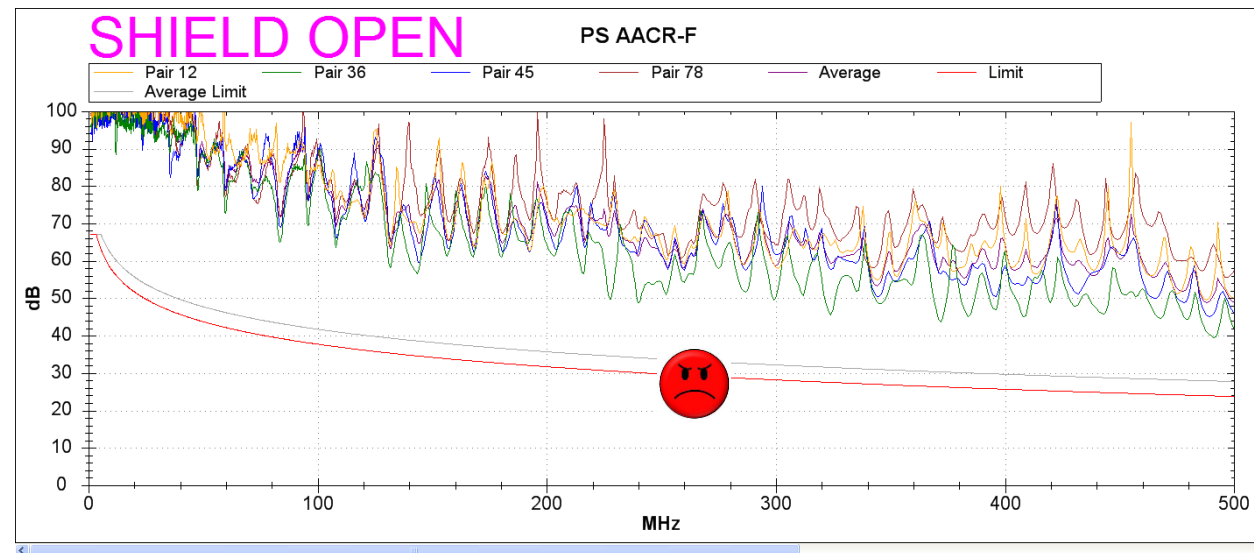
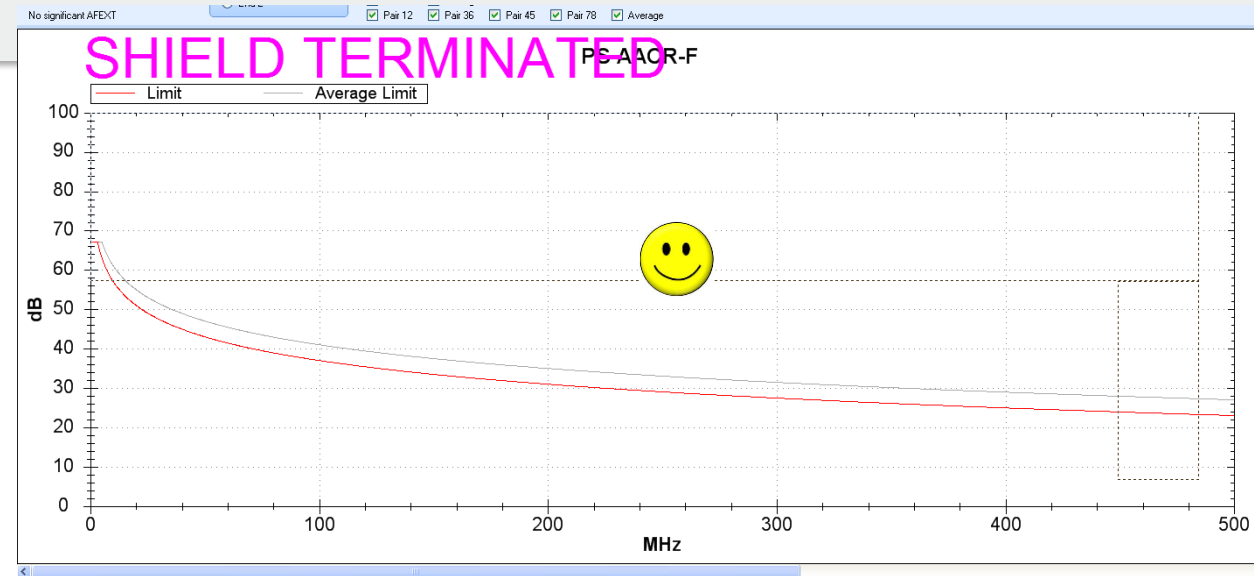




Example Alien Crosstalk: Shield Open / Connected



- 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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Poor contacts may further degrade over time

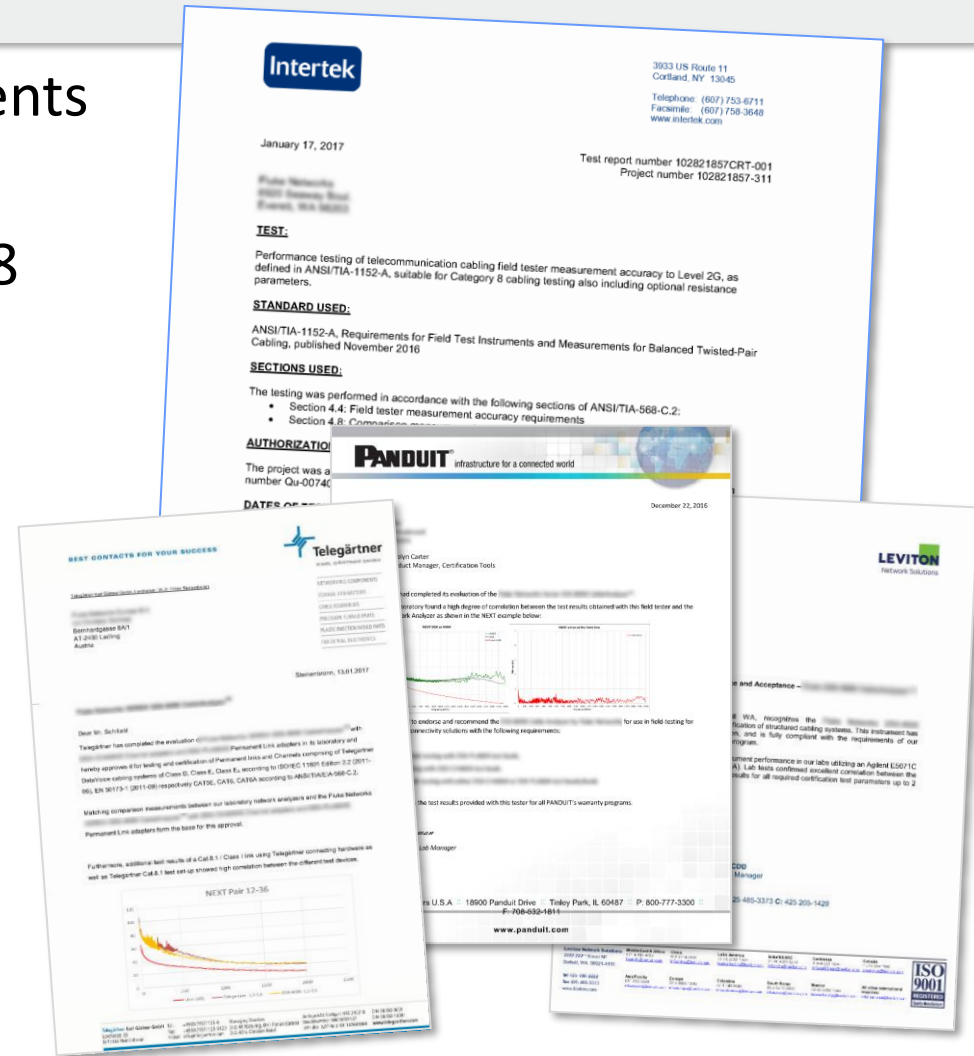
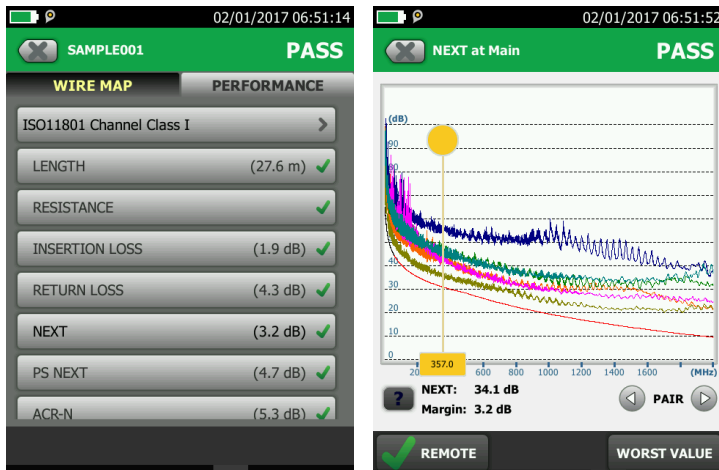
Shield Integrity is not given

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



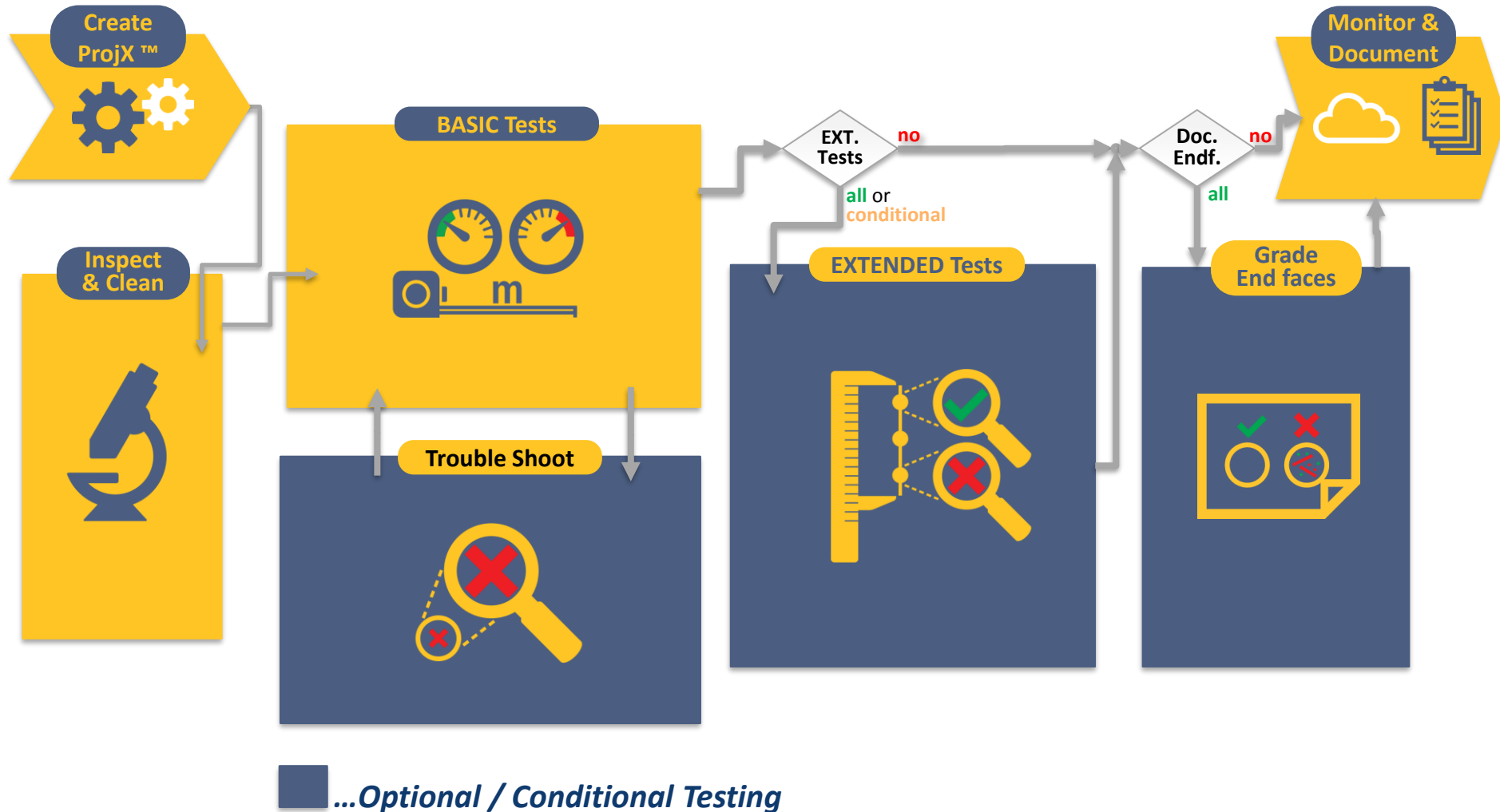
Standards Compliant Cat.8 Field Testing...

- 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





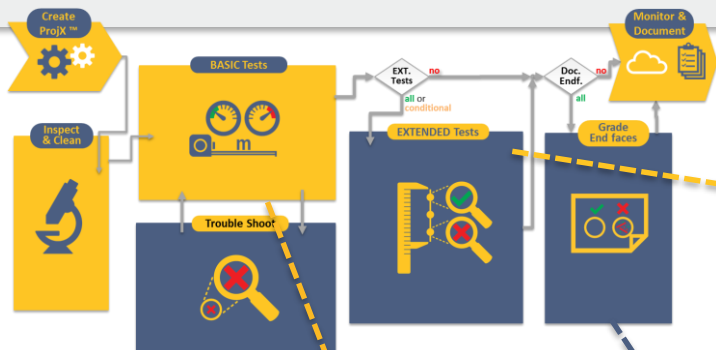
Monitoring & Documentation

Try it... www.linkwarelive.com
user: c.puller@mailinator.com
Password: Versisv4u





Documentation



LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Test Summary: PASS
Cable ID: R01-C01-001(B-M-B) n = 1.4670 (1310 nm) Backscatter Coefficient: -79.5dB (1310 nm)
Date / Time: 10/09/2013 05:16:19 PM n = 1.4690 (1550 nm) Backscatter Coefficient: -92.0dB (1550 nm)
Cable Type: OS1 Singlemode

Endface Image End1 NOT GRADED
Date / Time: 01/10/1970 02:27:01 AM
Operator: JOHN DOE
Certificate No: 020006 V2.2 Build 6 Beta

Endface Image End2 NOT GRADED
Date / Time: 01/10/1970 02:29:38 AM

Loss (M-R)
Date / Time: 10/09/2013 11:28:57 AM
Test Line: 12.00m
Operator: JOHN DOE
Certificate No: 0112004 V2.1 Build 5
Module: CPP-2LAC(205001)
Calibration Date: 04/01/2013
Optifiber pro remote (229021 v2.1 build 5)
Module: CPP-2LAC(205002)
Calibration Date: 04/01/2013

Parameter	1310 nm	1550 nm
Length (m)	12.1	PASS
Propagation Delay (ns)	88	PASS
Number of Splices	2	2
Connector Type	LC	LC
Patch Length (m)	2.0	2.0
Reference Date	10/09/2013	11/14/50 AM
1 Jumper		

Parameter	Result	Limit
Loss (dB)	0.52	0.41
Loss (dB)	1.32	1.50
Margin (dB)	0.78	0.69
Reference (dBm)	-3.84	-3.70

Compliant Network Standards:
 100BASE-LN 100BASE-ENM 100BASE-LN4 100BASE-LN4
 100BASE-E 100BASE-E 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN
 100BASE-LM 100BASE-LM 100BASE-LN 100BASE-LN

Project: PM-GROUP-PREP Page 3 Sample Merged.flw FLUKE networks

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Test Summary: PASS
Cable ID: R01-C01-001(B-M-B) n = 1.4670 (1310 nm) Backscatter Coefficient: -79.5dB (1310 nm)
Date / Time: 10/09/2013 05:16:19 PM n = 1.4690 (1550 nm) Backscatter Coefficient: -92.0dB (1550 nm)
Cable Type: OS1 Singlemode

EventMap [OTDR Bidir. Avg]
Fiber Length: 10.03 m
Overall Loss: 0.53 dB

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Test Summary: PASS
Cable ID: R01-C01-001(B-M-B) n = 1.4670 (1310 nm) Backscatter Coefficient: -79.5dB (1310 nm)
Date / Time: 10/09/2013 05:16:19 PM n = 1.4690 (1550 nm) Backscatter Coefficient: -92.0dB (1550 nm)
Cable Type: OS1 Singlemode

OTDR Endf. PASS
Date / Time: 01/10/1970 12:02:21 AM
Operator: JOHN DOE
Certificate No: 020006 V2.2 Build 6 Beta
Module: CPP-2LAC(205001)
Calibration Date: 07/01/2013

Launch + Tail
Launch Length: 1.00 m
Tail Length: 0.50 m
Cal Length: 1.50 m
Date / Time: 01/10/1970 12:30:38 AM

Parameter	1310 nm (dB)	1550 nm
Overall Length (m)	10.03	10.03
Overall Loss (dB)	0.53	0.53
ORL (dB)	48.80	49.74

Settings (Auto OTDR):
 Range (dB): 233 m 333 m
 Pulse Width (nsec): 40 nsec 50 nsec
 Averaging Time (sec): 7.5 15.0
 Loss Threshold (Auto): 0.10 dB 0.10 dB
 End Threshold (Auto): 0.00 dB 0.00 dB

Event	1310 nm	1550 nm	Loss (dB)	Reflectance (dB)	Att. Coef (dB/km)	Limit
10.03 m End	100%	100%	0.53	-79.5	-	0.50
0.00 m Launch Event	0.28	0.25	0.50	-30.20	64.63	35.0
0.00 m Launch Event	0.24	0.17	0.50	-61.47	30.50	0.20
0.00 m OTDR Port	100%	100%	0.00	-53.27	-54.45	100%

Project: PM-GROUP-PREP

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Test Summary: PASS
Cable ID: LE1H 03 Operator: WALTER
Date / Time: 09/16/2015 11:46:17 AM Software Version: V4.3 Build 6 Model: DQX-5000
Test Line: TIA Cat 6 Perm. Link (+All) Remote S/N: 24372 90 Main S/N: 2436001
Cable Type: Cat 6 U/UTP NVP: 69.0% Remote Adapter: DQX-PLA004 Remote Adapter: DQX-PLA004
Calibration Date: 09/14/2015

Length (m), Limit 90.0 [Pair 36] 12.2
Prop. Delay (ns), Limit 498 [Pair 45] 61
Capacitance (pF/m), Limit 4.4 [Pair 12] 2
Resistance (ohms), Limit 21.0 [Pair 36] 2.0
Resist. Unbal. (ohms), Limit 0.20 [Pair 36] 0.05
Resist. P2P Unbal. (ohms), Limit 0.05 [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

Pair	MAIN	SR	MAIN	SR
Worst Pair	12-36	12-36	12-36	12-36
NEXT (dB)	10.2	9.3	10.3	9.3
Frequency (MHz)	161.0	239.0	161.5	239.0
Limit (dB)	38.5	35.7	38.4	35.7
Worst Pair	36	36	36	36
P3 NEXT (dB)	12.4	9.0	13.5	9.0
Frequency (MHz)	1.5	239.0	236.5	239.0
Limit (dB)	35.9	33.1	33.1	33.1

Worst Case Margin Worst Case Value

Pair	MAIN	SR	MAIN	SR
Worst Pair	36-78	78-36	36-78	78-36
ACR-F (dB)	18.9	18.8	18.9	18.8
Frequency (MHz)	246.5	246.5	246.5	246.5
Limit (dB)	16.4	16.4	16.4	16.4
Worst Pair	36	36	78	36
P3 ACR-F (dB)	19.4	15.1	21.5	21.5
Frequency (MHz)	1.5	246.5	246.5	246.5
Limit (dB)	17.0	15.4	17.4	17.4

Worst Case Margin Worst Case Value

Pair	MAIN	SR	MAIN	SR
Worst Pair	36-45	39-45	12-36	12-36
ACR-N (dB)	17.7	17.9	39.5	36.5
Frequency (MHz)	8.9	8.4	237.0	239.0
Limit (dB)	53.8	54.0	5.6	5.4
Worst Pair	36	36	36	36
P3 ACR-N (dB)	19.3	15.0	39.5	35.2
Frequency (MHz)	8.6	8.6	236.5	238.0
Limit (dB)	51.4	51.4	3.0	2.8

Worst Case Margin Worst Case Value

Pair	MAIN	SR	MAIN	SR
Worst Pair	45	45	45	45
RL (dB)	6.0	5.9	6.0	5.9
Frequency (MHz)	217.0	217.0	217.0	217.0
Limit (dB)	10.6	10.6	10.6	10.6

Compliant Network Standards:
 100BASE-T 100BASE-TX 100BASE-T4
 100BASE-G-T ATM-64 ATM-64
 ATM-155 100VG-AryLen TR-4
 TR-16 Active TR-16 Passive

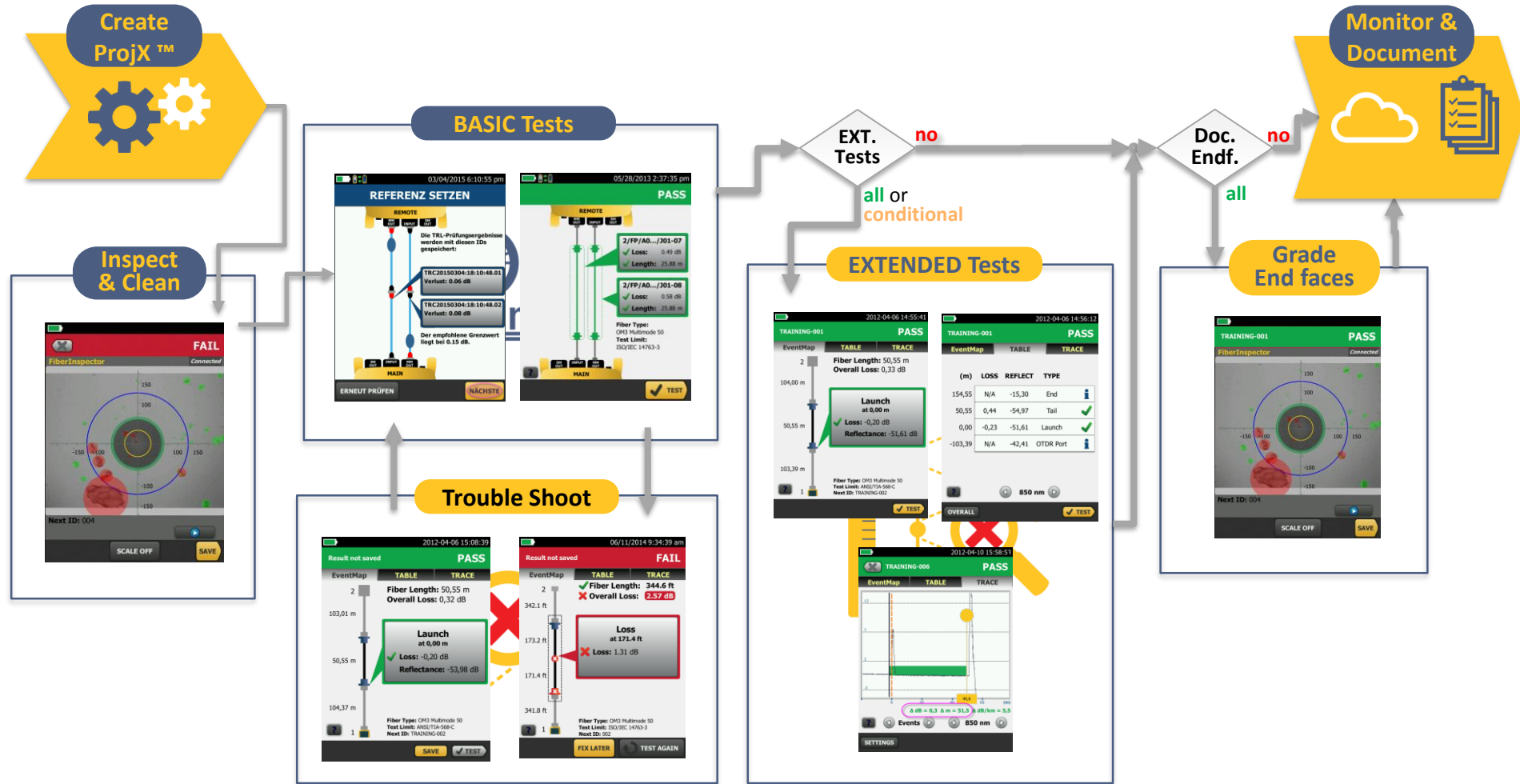
Project: TERACO COPPER Teraco Copper.flw FLUKE networks





Fiber Testing Best Practices

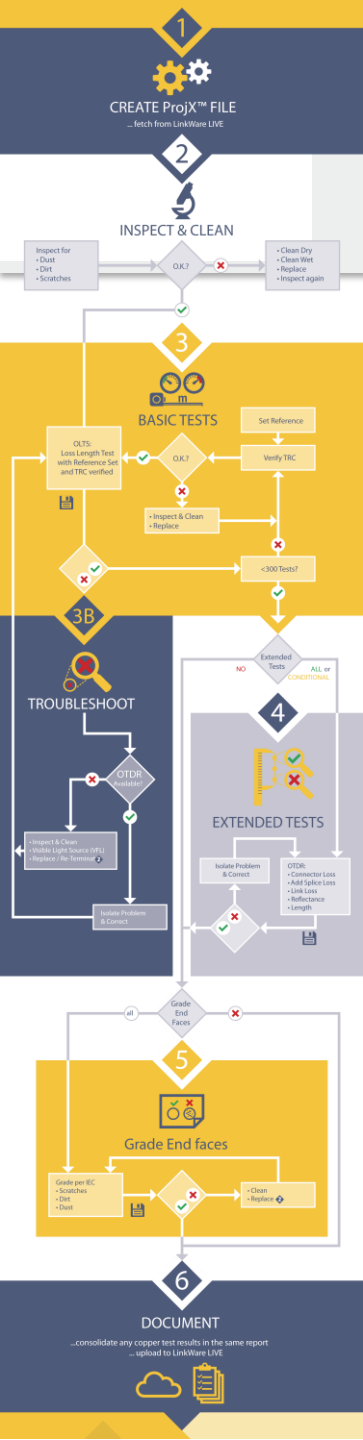
The VERSIV Family cover it....



...Optional / Conditional Testing



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?

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