10GBASE-LRM
Interoperability & Technical Feasibility Report

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Interoperability / Technical Feasibility Goals

- To independently confirm, experimentally, initial feasibility of a 300m 1310nm serial PMD using multiple vendor's devices

- Demonstration of compliance / credible path to compliance to 10GBASE-LRM D1.1 clause 68 specifications
  - Parameter measurements and testing based on IEEE P802.3aq D1.1 specification (unless otherwise noted)

- An Interoperability test using 10GBASE-LRM XENPAK transponders with $2^{31}-1$ PRBS data

- Stimulate discussion for upcoming work to complete the multi-vendor interoperability testing prior to Sponsor Ballot

Interoperability Test Description

- Two 10GBASE-LRM PMA/PMD modules

- Vendor A & B modules connected over a broad range of 50um and 62.5um fiber types operating at the 10GBASE-R rate

- Module electrical interfaces defined by the XAUI specification

Fiber Type	Fiber Identifier	Link Distance
OM1	1Green, 2Blue, 2Orange	300m
OM2	4Blue, 4Green, 5Orange	300m
OM3	Blue-Slate, Orange-Red	300m

- OM1 & OM2 fibers from FO2-2 12/96 BW Modal Launch Test Cable
- OM3 fibers from TIA FO4.2.1 10GbE Demo Cables
  - OM3 Fibers provided courtesy of Corning, Inc.

Test Set-up Diagram

Multimode Patch-cord

MMF

Tx

Rx

MCP / SMF
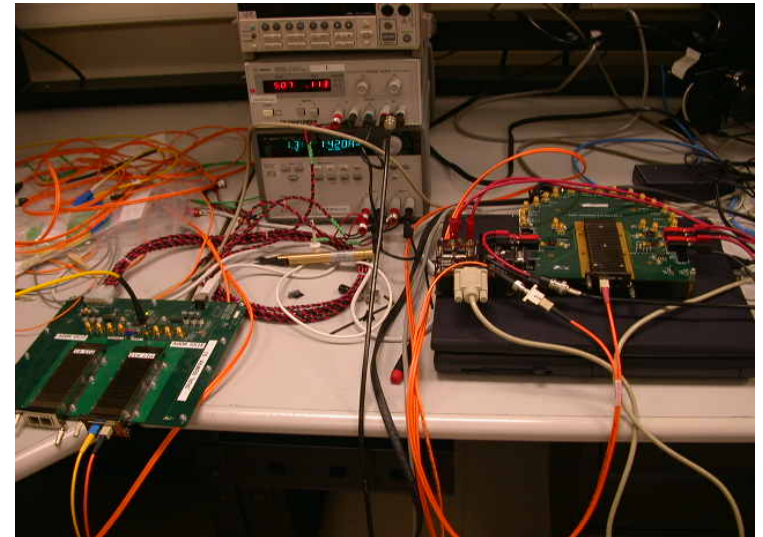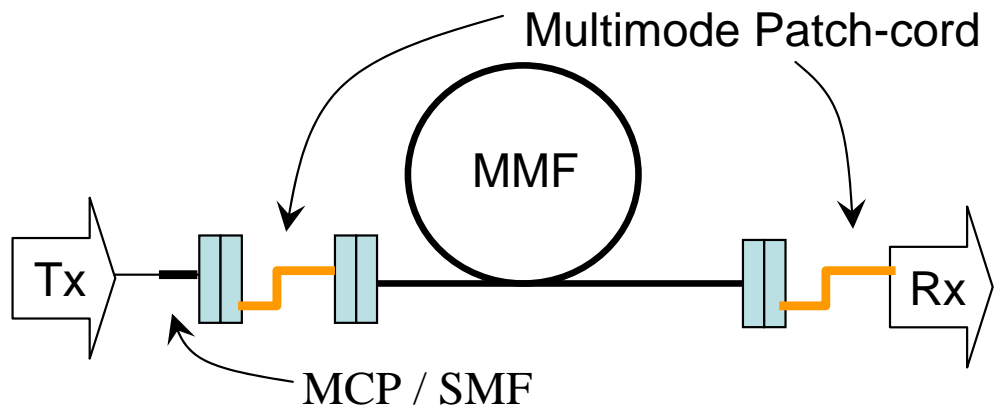
- Test Pattern: PRBS 2^{31}-1
  (Rx under test looped back to Transmitter to verify PRBS)
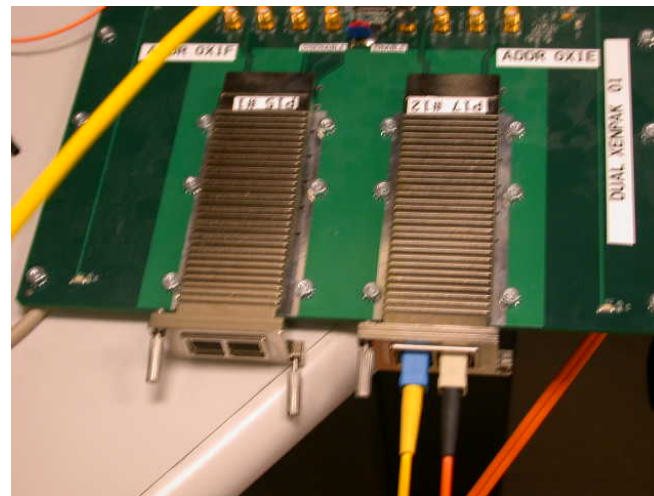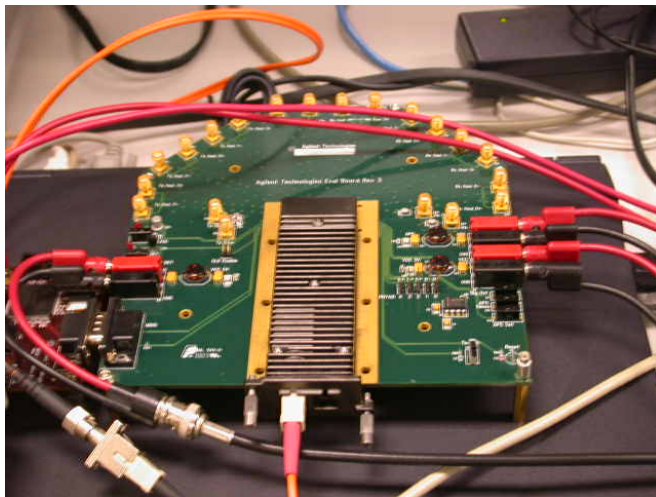
OM1, OM2 & OM3 – Eye Diagrams

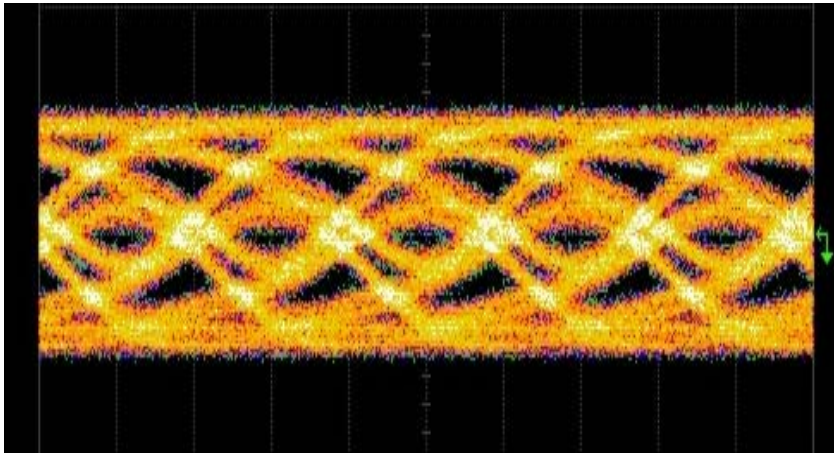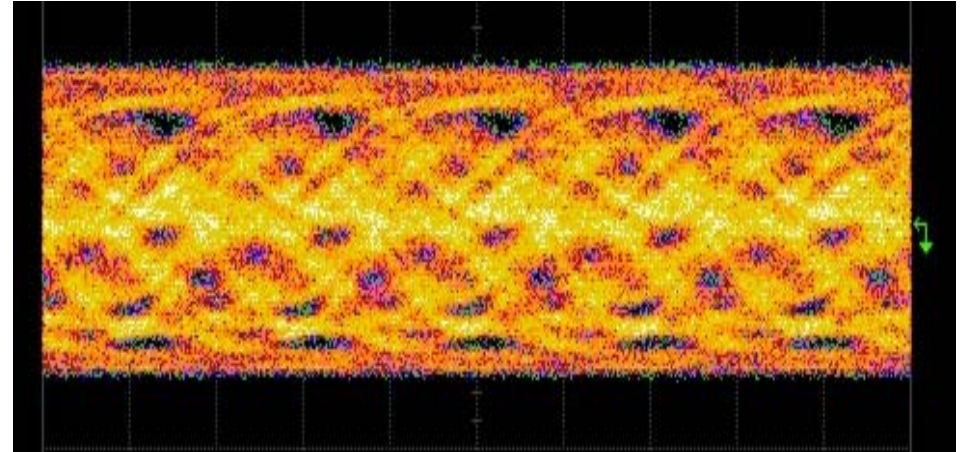1-Green: MCP   PIE-D: 3.41dB

2-Blue: CL   PIE-D: 4.34dB

4-Green: MCP   PIE-D: 3.63dB
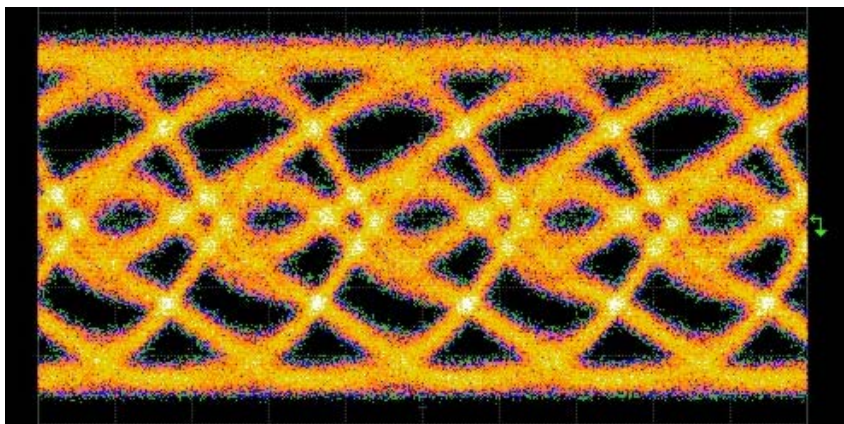
Orange-Red: CL   PIE-D: 1.23dB
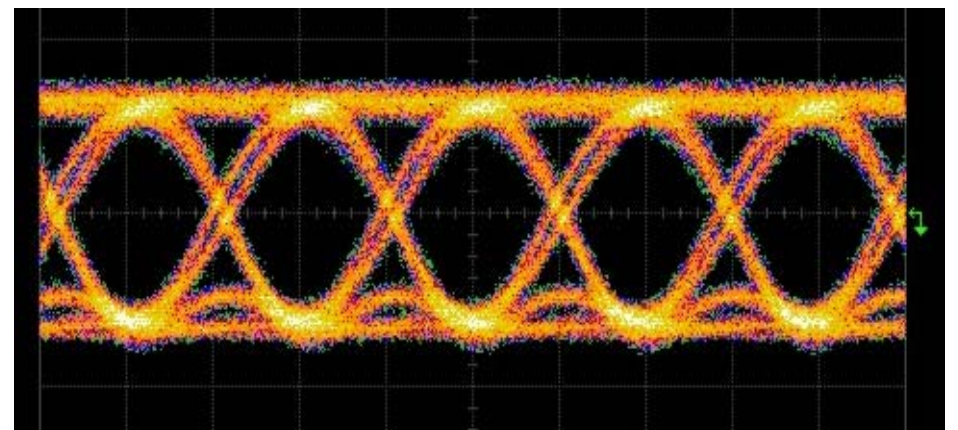
Comparison of TIA 12/96 & Gen67YY
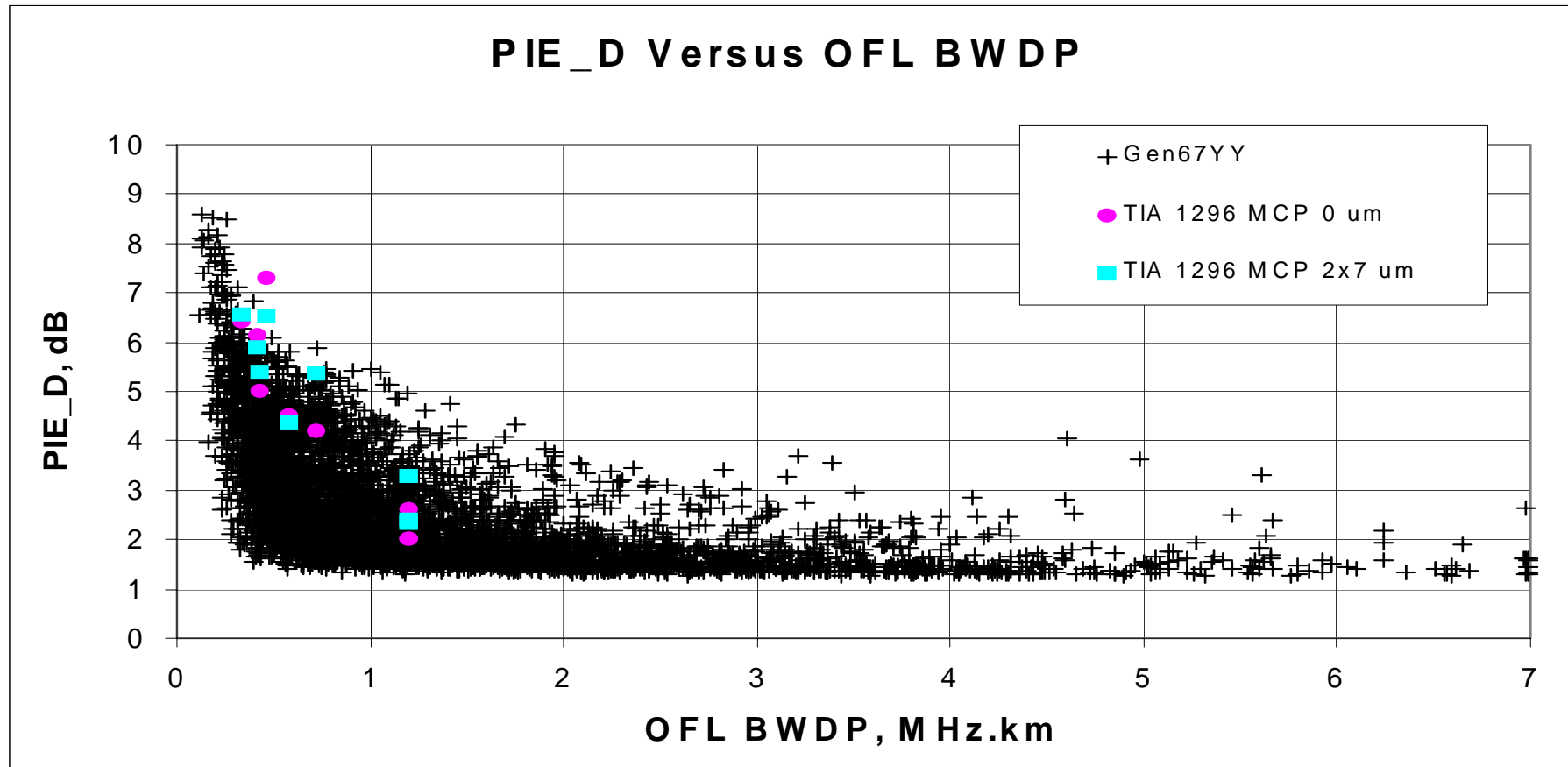
- TIA FO2-2 12/96 fibers are generally at the high PIE-D range of the Gen67YY Monte-Carlo fiber model

Vendor A & B Interoperability

Fiber Type	Fiber Name	OFL BW MHz·km	D1.1 Interoperation Result
62MMF	2 Orange	433	Pass CL (Fiber not compliant)
FDDI/OM1	1 Green	585	Pass CL & MCP
FDDI/OM1	2 Blue	723	Pass CL
OM2	4 Green	788	Pass CL & MCP
OM2	4 Blue	>1200	Pass CL & MCP
OM2	5 Orange	>1200	Pass MCP
OM3	Orange - Red	574	Pass CL (MCP not tested)
OM3	Blue - Slate	801	Pass CL (MCP not tested)

Note: Each fiber/launch was tested for 5 minutes and any error was recorded as a fail

Vendor Compliance Data
802.3aq Draft 1.1

Vendor A: Table 68-3 10GBASE-LRM Transmit Characteristics (1)

Description	Type	Value	Unit	Compliance
Signaling speed	nom	10.3125	GBd	**Yes**
Signaling speed variation from nominal	max	± 100	ppm	**Yes**
Center wavelength	range	1260 to 1355	nm	**Yes**
RMS spectral width at 1260 nm	max	2.4	nm	**Yes**
RMS spectral width at 1300 nm	max	4	nm	**Yes**
RMS spectral width at 1355 nm	max	4	nm	**Yes**
		See Figure 68-3 for illustration		**Yes**
Launch power in OMA	max	1.5	dBm	**Yes**
Launch power in OMA	min	-4.5	dBm	**Yes**
Extinction ratio	min	3.5	dB	**Yes**
Average launch power	max	0.5	dBm	**Yes**
Average launch power	min	-6.5	dBm	**Yes**
Average launch power of OFF transmitter	max	-30	dBm	**Yes**
RIN12OMA	max	-128	dB/Hz	**Yes**

Vendor A: Table 68-3 10GBASE-LRM Transmit Characteristics (2)

Eye mask parameters {X1, X2, X3, Y1, Y2, Y3}		{0.25, 0.40, 0.45, 0.25, 0.28, 0.80}		**Yes**
Transmitter waveform and dispersion penalty (TWDP)	max	5	dB	**Yes**
Uncorrelated jitter (rms)	max	0.033	UI	**Not tested**
Optical launch specification for 62.5 mm fiber: Default Encircled flux for alternative launch	-	Mode conditioning patch cord as specified in 38.11.4		**Yes**
	min	30 % in 5 mm radius	%	
	min	86 % in 11 mm radius	%	**Not Tested**
Optical launch specification for OM2, 50 mm fiber: Default	-	Mode conditioning patch cord as specified in 38.11.4		**Yes**
Encircled flux for alternative launch	min	30 % in 5 mm radius	%	
	min	86 % in 11 mm radius	%	**Not Tested**
Optical launch specification for OM3, 50 mm fiber: Default - Encircled flux for default launch	min	30 % in 5 mm radius	%	
	min	86 % in 11 mm radius	%	**Not Tested**
Alternative launch		Mode conditioning patch cord as specified in 38.11.4		**Yes**
Optical return loss tolerance	min	12	dB	**Yes**
Transmitter reflectance	max	-12	dB	**Yes**

Vendor A: Table 68-3 10GBASE-LRM Receive Characteristics

Description	Type	Value	Unit	Compliance
Signaling speed	nom	10.3125	GBd	**Yes**
Signaling speed variation from nominal	max	±100	ppm	**Yes**
Center wavelength	range	1260 to 1355	nm	**Yes**
Received power in OMA (overload)	max	1.5	dBm	**Not tested**
Received power in OMA	min	-6.5	dBm	**Yes**
Average receive power	max	0.5	dBm	**Yes**
Average received power (informative)	min	-8.5	dBm	**Yes**
Receiver reflectance	max	-12	dB	**Yes**

	Compliance
Simple SRS test	**Not tested**
Comprehensive test	**Not tested**

Vendor B: Table 68-3 10GBASE-LRM Transmit Characteristics (1)

Description	Type	Value	Unit	Compliance
Signaling speed	nom	10.3125	GBd	**Yes**
Signaling speed variation from nominal	max	± 100	ppm	**Yes**
Center wavelength	range	1260 to 1355	nm	**Yes**
RMS spectral width at 1260 nm	max	2.4	nm	**Yes**
RMS spectral width at 1300 nm	max	4	nm	**Yes**
RMS spectral width at 1355 nm	max	4	nm	**Yes**
		See Figure 68-3 for illustration		**Yes**
Launch power in OMA	max	1.5	dBm	**Yes**
Launch power in OMA	min	-4.5	dBm	**Yes**
Extinction ratio	min	3.5	dB	**Yes**
Average launch power	max	0.5	dBm	**Yes**
Average launch power	min	-6.5	dBm	**Yes**
Average launch power of OFF transmitter	max	-30	dBm	**Yes**
RIN12OMA	max	-128	dB/Hz	**Yes**

Vendor B: Table 68-3 10GBASE-LRM Transmit Characteristics (2)

Eye mask parameters {X1, X2, X3, Y1, Y2, Y3}		{0.25, 0.40, 0.45, 0.25, 0.28, 0.80}		**Yes**
Transmitter waveform and dispersion penalty (TWDP)	max	5	dB	**Not tested**
Uncorrelated jitter (rms)	max	0.033	UI	**Not tested**
Optical launch specification for 62.5 mm fiber: Default Encircled flux for alternative launch	-	Mode conditioning patch cord as specified in 38.11.4		**Yes**
	min	30 % in 5 mm radius	%	
	min	86 % in 11 mm radius	%	**Not tested**
Optical launch specification for OM2, 50 mm fiber: Default	-	Mode conditioning patch cord as specified in 38.11.4		**Yes**
Encircled flux for alternative launch	min	30 % in 5 mm radius	%	
	min	86 % in 11 mm radius	%	**Not tested**
Optical launch specification for OM3, 50 mm fiber: Default - Encircled flux for default launch	min	30 % in 5 mm radius	%	**Not Tested**
	min	86 % in 11 mm radius	%	
Alternative launch		Mode conditioning patch cord as specified in 38.11.4		**Yes**
Optical return loss tolerance	min	12	dB	**Yes**
Transmitter reflectance	max	-12	dB	**Yes**

Vendor B: Table 68-3 10GBASE-LRM Receive Characteristics

Description	Type	Value	Unit	Compliance
Signaling speed	nom	10.3125	GBd	Yes
Signaling speed variation from nominal	max	±100	ppm	Yes
Center wavelength	range	1260 to 1355	nm	Yes
Received power in OMA (overload)	max	1.5	dBm	Not tested
Comprehnsive stressed receiver sensitivity in OMA	min	-6.5	dBm	Yes
Conditions of comprehensive stressed receiver tests:				
Noise Bandwidth	min	10	GHz	Not tested
OMA:(2 x rms noise) ratio		11.5		Not tested
Pre-cursor ISI parameters {A1,A2,A3,A4}		{0.65,0.50,0.91,0.26}		Yes
Symmetrical ISI parameters {A1,A2,A3,A4}		{0.88,0.58,0.89,0.10}		Yes
Post-cursor ISI parameters {A1,A2,A3,A4}		{0.51,0.89,0.29,0.81}		Yes
Simple stressed reveiver sensitivity in OMA (informative)	max	-7.5	dBm	Yes
Conditions of simple stressed receiver tests:				
Signal rise & fall times (20%-80%)		129	ps	Not tested
Average receive power	max	0.5	dBm	Yes
Average received power (informative)	min	-8.5	dBm	Yes
Receiver reflectance	max	-12	dB	Yes

Summary & Next Steps

- Successfully interoperated between two vendor 10GBASE-LRM modules across a range of fiber types at the specification maximum fiber distance (300m)

- Vendors demonstrated compliance on all of the measured parameters (some parameters not yet tested)

- Multiple vendors creating products for 10GBASE-LRM PMD with different EDC sub-components

- Next Step Discussion – upcoming testing for Sponsor Ballot:
  - Vendors test compliance to draft clause 68 specifications
  - Pass / Fail results on a range of fibers at the maximum link distance
  - ….