FIBER OPTIC TESTING ENHANCEMENT FOR COST REDUCTION FOLLOW-ON (2)

Improvement to FO Testing for significant manpower and schedule reduction benefits

Project Final Update
8/14/2025

Presented by:
Dan Morris (KITCO Fiber Optics)

FIBER OPTIC TESTING ENHANCEMENT FOR COST REDUCTION FOLLOW-ON

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Project Summary

- A project team made up of KITCO Fiber Optics, EXFO, HII-NNS, Penn State – ARL, NSWCDD Fiber Optic Section has executed this follow-on project to investigate the potential for Fiber Optic Testing Enhancement for Cost Reduction by evaluating the commercial practice of using on an Optical Time Domain Reflectometer (OTDR) to replace the Optical Loss Test Set (OLTS) and Optical Return Loss Meter (ORLM) in performance of Mil-Std-2042-6C required testing for shipboard installations.

- This effort was a follow-on project to NSRP ASE Subcontract Agreement No. 2016-416 and was intended to validate the laboratory findings from the previous FO test enhancement projects completed May 15, 2017 and May 31, 2022.

- Project execution and testing outlined in the remainder of this report focused on Multimode and Singlemode (SM) fiber testing conducted at the NSWCDD lab in Dalgren, VA.

Project Scope

The commercial industry has adopted a source light launch condition for Multimode fiber called Encircled Flux which provides more precise and repeatable loss measurements and have begun adopting OTDR testing results for full fiber optic network verification and acceptance for both Multimode and Single Mode systems. Specifically for MM fibers, historical launch conditions are shifting from CPR to the Encircled Flux (EF) method as specified in IEC-61280-4-1.

This follow-on project was intended to investigate the use of an OTDR with a slightly overfilled variation of the commercial EF launch condition for Multimode and validate the SM test results identified during the previous Fiber Optic Test Enhancement project, onboard a new construction submarine.

Goals / Objectives

1. Measure optical test equipment output parameters against Navy source launch conditions requirements.
2. Manufacture and investigate if MQJs manufactured with tight fiber optic lot specification requirements (M49291/6) produce more consistent loss measurement values than MQJs produced with non-controlled fiber lots.
3. Conduct investigative optical experimentation to determine if MQJ length impacts reference value measurements that would account for observed inconsistencies in measurement value result between OLTS and OTDR units.
4. Evaluate cost savings potential for high density fiber configurations.
5. Identify test unit specifications for future shipyard and fleet procurement.
6. Identify roadmap for TWH approval and implementation process.

The primary investigation was focused on verifying if the OTDR test unit can be used in place of the OLTS and ORLM test units to perform multiple required tests (e.g. total attenuation/loss and ORL of links and additional troubleshooting capacity of local loss and reflectance) at the same time. Tests that are currently performed separately were conducted alongside combined tests and the results compared. The results and observations are identified in this report

Procured Material

- MIL-PRF-85045/16-01 FIBER (Specification Controlled)
  - KITCO was able to procure a batch of M85045/16-01 cable containing (M49291/6-01) fiber with known specifications for Core Diameter (CD) and Numerical Aperture (NA). Prysmian Batch W8J97H was identified with a CD of 62.1 (µm) and NA of 0.273. This fiber was used to manufacture project MQJs and DUT cable assemblies.

	Nominal µ ±0.5 s
Core Size [µm]	62.1-62.9
NA	0.271-0.273

- MEASUREMENT QUALITY JUMPERS

MQJ: M85045/16-01 (MM)						
part #	Serial	Fiber Batch ID	Description	Core Size	NA	QTY
KFO 15253-M01	1.1-1	W8J97H - FC9700022	ST/ST MM, 1-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M01	1.2-1	W8J97H - FC9700022	ST/ST MM, 1-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M01	1.3-1	W8J97H - FC9700022	ST/ST MM, 1-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253	1.1-3	K6W0014381	ST/ST MM, 3-METER, 6877804-5 (62.7 UM)	62.7	0.272	1
KFO 15253-M03	1.2-3	W8J97H - FC9700022	ST/ST MM, 3-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M03	1.3-3	W8J97H - FC9700022	ST/ST MM, 3-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M03	1.3-4	W8J97H - FC9700022	ST/ST MM, 3-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M03	1.3-5	W8J97H - FC9700022	ST/ST MM, 3-METER, 6877804-5 (62.7 UM)	62.1	0.273	1
KFO 15253-M50	1.1-50	W8J97H - FC9700022	ST/ST MM, 50-METER, (62.7 UM)	62.1	0.273	1
KFO 15253-M50	1.2-50	W8J97H - FC9700022	ST/ST MM, 50-METER, (62.7 UM)	62.1	0.273	1
KFO 15253-M50	1.3-50	W8J97H - FC9700022	ST/ST MM, 50-METER, (62.7 UM)	62.1	0.273	1
KFO 15253-M50	1.4-50	W8J97H - FC9700022	ST/ST MM, 50-METER, (62.7 UM)	62.1	0.273	1
KFO 15253-M100	1.1-100	W8J97H - FC9700022	ST/ST MM, 100-METER, (62.7 UM)	62.1	0.273	1
KFO 15253-M100	1.2-100	W8J97H - FC9700022	ST/ST MM, 100-METER, (62.7 UM)	62.1	0.273	1
KFO 15254	2.2-1	K6Z0002044	ST/ST MM, 1-METER, 6877804-5 (64.2 UM)	64.3	64.2	1
					Total	15

MQJ: M85045/16-02 (SME)						
part #			Description	Core Size	NA	QTY
KFO 15256-M01	4.1-1	N/A	ST/ST SME, 1-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M01	4.2-1	N/A	ST/ST SME, 1-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M01	4.3-1	N/A	ST/ST SME, 1-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M03	4.1-3	N/A	ST/ST SME, 3-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M03	4.2-3	N/A	ST/ST SME, 3-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M03	4.3-3	N/A	ST/ST SME, 3-METER, 6877804-5SME	N/A	N/A	1
KFO 15256-M50	4.1-50	N/A	ST/ST SME, 50-METER, 6877804-1SME	N/A	N/A	1
KFO 15256-M50	4.2-50	N/A	ST/ST SME, 50-METER, 6877804-1SME	N/A	N/A	1
KFO 15256-M50	4.3-50	N/A	ST/ST SME, 50-METER, 6877804-1SME	N/A	N/A	1
KFO 15256	4.1-100		ST/ST SME, 100 Meter	N/A	N/A	1
KFO 15256	4.2-100		ST/ST SME, 100 Meter	N/A	N/A	1
						11

Procured Material

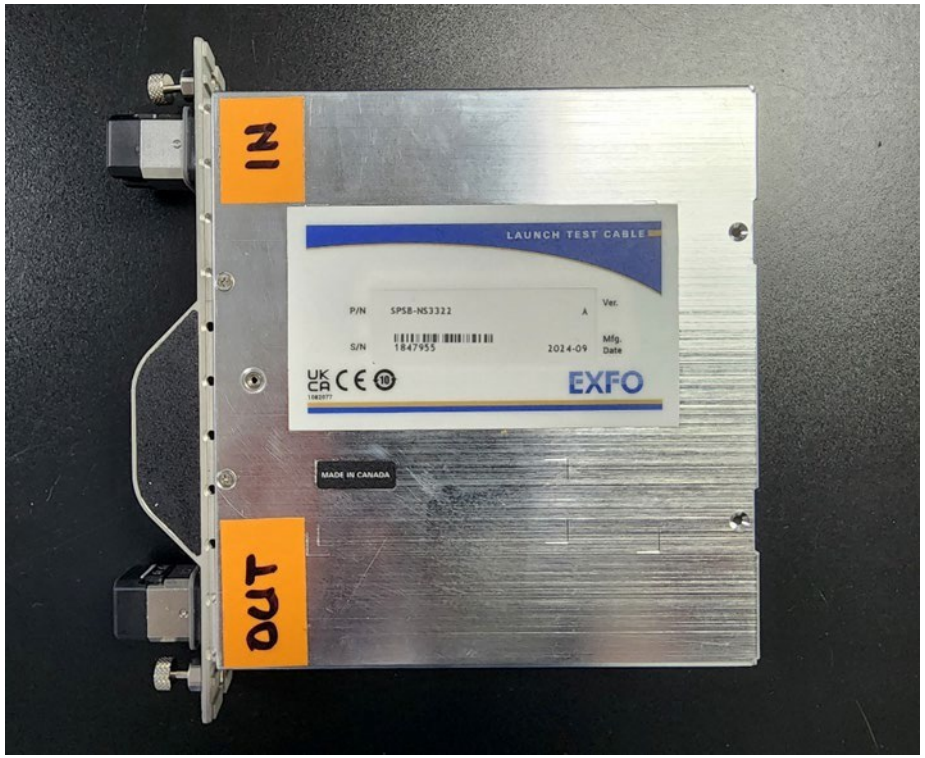
- DEVICE UNDER TEST (DUT) CABLES
  - KITCO manufactured new DUT cables and reused some from the previous project.

MOCK FOCP (MM DUT Cables)						
part #		Fiber Batch ID	Description	Core Size	NA	QTY
KFO 15257-F10	5.1-10	W8J97H - FC9700022	ST/ST, MM 10 FT. (62.7 UM)	62.1	0.273	1
KFO 15257-F10	5.2-10	W8J97H - FC9700022	ST/ST, MM 10 FT. (62.7 UM)	62.1	0.273	1
KFO 15257	5.1-40	K6W0014381	ST/ST, MM 40 FT. (62.7 UM)	62.7	0.272	1
KFO 15257	5.2-40	K6W0014381	ST/ST, MM 40 FT. (62.7 UM)	62.7	0.272	1
KFO 15257	5.1-130	K6W0014381	ST/ST, MM 130 FT. (62.7 UM)	62.7	0.272	1
KFO 15257-F130	5.2-130	W8J97H - FC9700022	ST/ST, MM 130 FT. (62.7 UM)	62.1	0.273	1
KFO 15257-F500	5.1-500	W8J97H - FC9700022	ST/ST, MM 500 FT. (62.7 UM)	62.1	0.273	1
KFO 15257-BF60	5.1-B60	W8J97H - FC9700022	Bare Fiber (62.7 UM)	62.1	0.273	1
KFO 15257-BF60	5.2-B60	W8J97H - FC9700022	Bare Fiber (62.7 UM)	62.1	0.273	1
KFO 15257-BF60	5.3-B60	W8J97H - FC9700022	Bare Fiber (62.7 UM)	62.1	0.273	1
KFO 15258	6.1-10	K6Z0002044	ST/ST, MM 10 FT. (64.3 UM)	64.3	64.2	1
KFO 15258	6.1-40	K6Z0002045	ST/ST, MM 40 FT. (64.3 UM)	64.3	64.2	1
KFO 15258	6.2-130	K6Z0002046	ST/ST, MM 130 FT. (64.3 UM)	64.3	64.2	1
KFO 15259	7.1-10	K6Z0000728	ST/ST, MM 10 FT. (63.3 UM)	63.3	63.3	1
KFO 15259	7.2-10	K6Z0000728	ST/ST, MM 10 FT. (63.3 UM)	63.3	63.3	1
KFO 15259	7.2-40	K6Z0000728	ST/ST, MM 40 FT. (63.3 UM)	63.3	63.3	1
KFO 15259	7.1-500	K6Z0000728	ST/ST, MM 500 FT. (63.3 UM)	63.3	63.3	1
						17

MOCK FOCP (SM DUT Cables)						
part #		Fiber Batch ID	Description	Core Size	NA	QTY
KFO 15260-F10	8.1-10	N/A	ST/ST, SME, 10 FT.	N/A	N/A	1
KFO 15260-F10	8.2-10	N/A	ST/ST, SME, 10 FT.	N/A	N/A	1
KFO 15260-F20	8.1-20	N/A	ST/ST, SME, 20 FT.	N/A	N/A	1
KFO 15260-F20	8.2-20	N/A	ST/ST, SME, 20 FT.	N/A	N/A	1
KFO 15260-F40	8.1-40	N/A	ST/ST, SME, 40 FT.	N/A	N/A	1
KFO 15260-F40	8.2-40	N/A	ST/ST, SME, 40 FT.	N/A	N/A	1
KFO 15260-F130	8.1-130	N/A	ST/ST, SME, 130 FT.	N/A	N/A	1
KFO 15260-F130	8.2-130	N/A	ST/ST, SME, 130 FT.	N/A	N/A	1
KFO 15260-F500	8.1-500	N/A	ST/ST, SME, 500 FT.	N/A	N/A	1
KFO 15260-BF60	8.1-B60	N/A	Bare 60 FT	N/A	N/A	1
KFO 15260-BF60	8.2-B60	N/A	Bare 60 FT	N/A	N/A	1
KFO 15260-BF60	8.3-B60	N/A	Bare 60 FT	N/A	N/A	1
						12

Procured Material

- EXTERNAL MODE CONDITIONER
  - To optimize the OTDR launch condition for consistency with the OLTS, KITCO worked with EXFO Optical Engineers to build an external mode conditioner with the intention of meeting the Navy defined launch condition for OLTS performance with a primary focus on High Order Mode Power (HOMP). EXFO produced the Mode Conditioner for the project which was used for MM testing with the OTDR.



Navy Launch Condition Requirements (SCAT 4960)

3.3. Launch conditions:

3.3.1.1. Coupled Power Ratio (CPR):

a. CPR 1300 nm source: Optical light source shall have a CPR value of 20.5dB to 22.5dB (into 62.5 µm fiber).

b. CPR 850 nm source: Optical light source shall have a CPR value of 24dB to 29.5dB (into 62.5 µm fiber).

3.3.1.2. High Order Mode Power (HOMP):

a. HOMP 1300 nm source: Optical Power loss in a nominal 62.5 µm fiber caused by five wraps around a 20 mm mandrel shall be in the range of **0.30 dB to 0.80 dB**.

b. HOMP 850 nm source: Optical power loss in a nominal 62.5 µm fiber caused by five wraps around a 20 mm mandrel shall be in the range of **0.30 dB to 0.80 dB**.

3.3.1.3. Fiber optic cables for CPR and HOMP verifications:

a. Single mode cable with 5.2 µm MFD at 850 nm wavelength.

b. Single mode cable with 9.2 µm MFD at 1310 nm wavelength.

c. Multimode cable with 62.5 µm core diameter at both 850 nm and 1300 nm wavelengths.

d.Government furnished equipment for MIL-STD-2042 compliance. Cables in “a” through “c” terminated with ST connectors will be provided to manufacturers for CPR and HOMP measurements.

e.Government furnished equipment for Fleet use: Cables in “a” through “c” terminated with diamond connectors will be provided to manufacturers for CPR and HOMP measurements.

2. Output power: > -21 dBm (into 62.5/125 µm).

1. Time stability: ≤ ± 0.1 dB / 4 hours and ≤ 0.05 dB peak/15 minutes; each stability level test performed at a constant temperature of 25 ± 1°C.

Test Equipment

- Test Equipment used for project testing

Manufacturer	Type	Test Method Applied	Test Description
NAVY Approved			
EXFO MAX-945-NAV-M2042	Light Source/Power Meter (MM/SM)	MIL-STD-2042: Method 6C1	Cable Assembly Link Loss
		MIL-STD-2042: Method 6E1	Cable Assembly End to End Loss
		MIL-STD-2042: Method 6K1	Cable Assembly Optical Return Loss (ORL)
		MIL-STD-2042: Method 6L1	Cable Assembly End to End Optical Return Loss (ORL)
Commercially Identified			
EXFO MAX-720CiOLM	OTDR (MM) with EF Launch	MIL-STD-2042: Method 6C1	Cable Assembly Link Loss
		MIL-STD-2042: Method 6E1	Cable Assembly End to End Loss
EXFOMAX-720DiOLM	OTDR (SM) with EF Launch	MIL-STD-2042: Method 6C1	Cable Assembly Link Loss
		MIL-STD-2042: Method 6E1	Cable Assembly End to End Loss

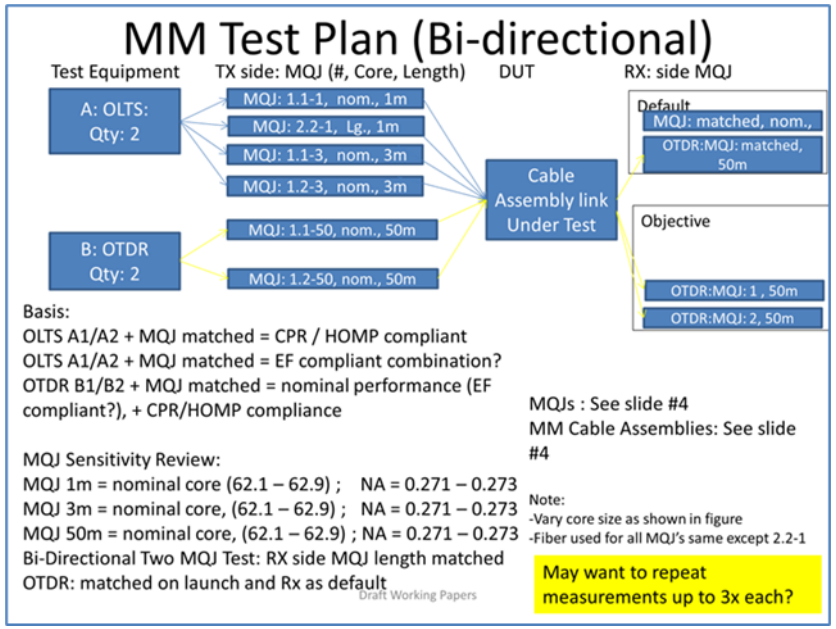
MAX-945-NAV-M2042 - OLTS UNITS

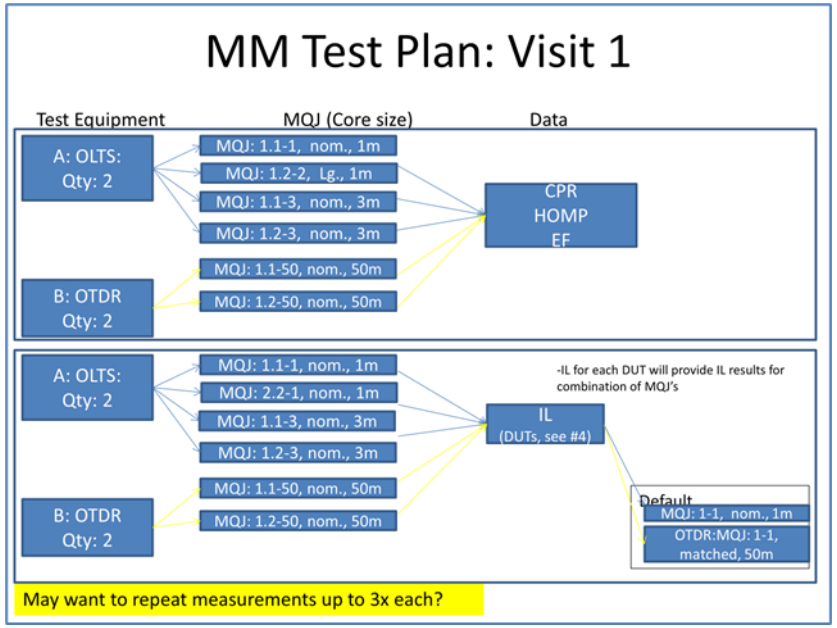
MAX-720C/720D – OTDR UNITS

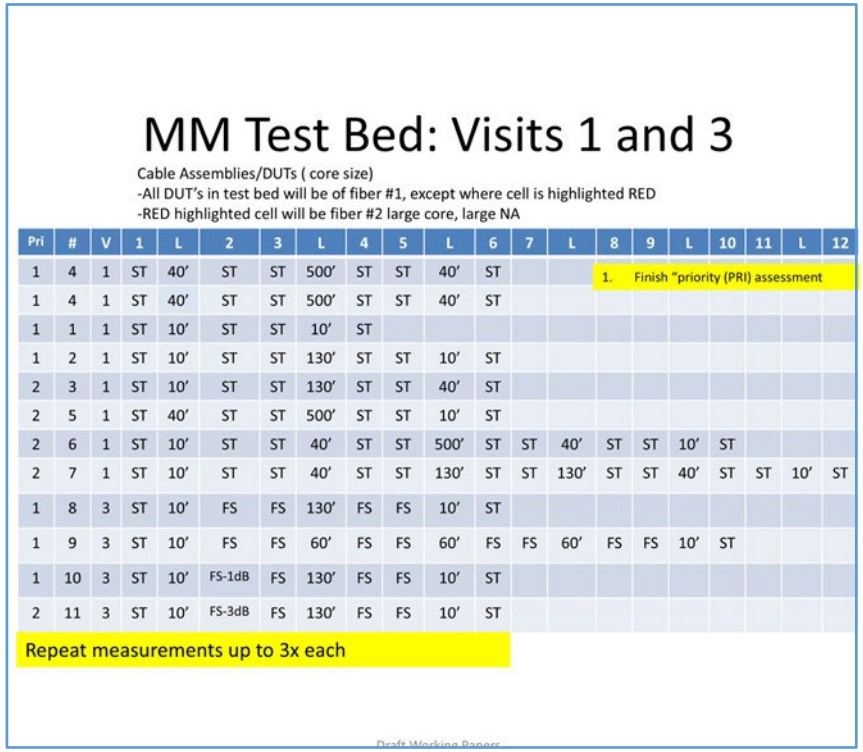
Test Plans

➢MM Test Plan

Overview





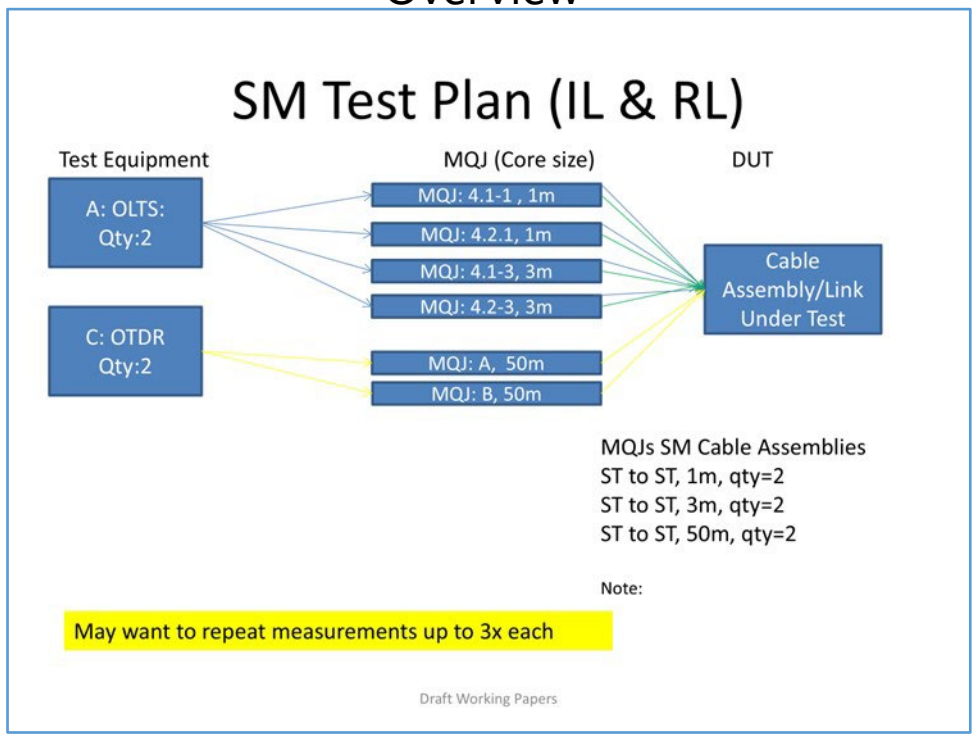


Pri	#	V	1	L	2	3	L	4	5	L	6	7	L	8	9	L	10	11	L	12
1	4	1	ST	40′	ST	ST	500′	ST	ST	40′	ST									
1	4	1	ST	40′	ST	ST	500′	ST	ST	40′	ST									
1	1	1	ST	10′	ST	ST	10′	ST												
1	2	1	ST	10′	ST	ST	130′	ST	ST	10′	ST									
2	3	1	ST	10′	ST	ST	130′	ST	ST	40′	ST									
2	5	1	ST	40′	ST	ST	500′	ST	ST	10′	ST									
2	6	1	ST	10′	ST	ST	40′	ST	ST	500′	ST	ST	40′	ST	ST	10′	ST			
2	7	1	ST	10′	ST	ST	40′	ST	ST	130′	ST	ST	130′	ST	ST	40′	ST	ST	10′	ST
1	8	3	ST	10′	FS	FS	130′	FS	FS	10′	ST									
1	9	3	ST	10′	FS	FS	60′	FS	FS	60′	FS	FS	60′	FS	FS	10′	ST			
1	10	3	ST	10′	FS-1dB	FS	130′	FS	FS	10′	ST									
2	11	3	ST	10′	FS-3dB	FS	130′	FS	FS	10′	ST									

Test Plans

- SM Test Plan

Overview



SM Test Bed: Visits 2-3

#	V	1	L	2	3	L	4	5	L	6	7	L	8	9	L	10	11	L	12
1	2	ST	10′	ST	ST	10′	ST												
2	2	ST	10′	ST	ST	130′	ST	ST	10′	ST									
3	2	ST	10′	ST	ST	130′	ST	ST	40′	ST									
4	2	ST	40′	ST	ST	500′	ST	ST	40′	ST									
5	2	ST	40′	ST	ST	500′	ST	ST	10′	ST									
6	3	ST	10′	ST	ST	40′	ST	ST	500′	ST	ST	40′	ST	ST	10′	ST			
7	3	ST	10′	ST	ST	40′	ST	ST	130′	ST	ST	130′	ST	ST	40′	ST	ST	10′	ST
8	4	ST	10′	FS	FS	130′	FS	FS	10′	ST									
9	4	ST	10′	FS	FS	60′	FS	FS	60′	FS	FS	60′	FS	FS	10′	ST			
10	4	ST	10′	FS-1dB	FS	130′	FS	FS	10′	ST									
11	4	ST	10′	FS-3dB	FS	130′	FS	FS	10′	ST									

1. Finish “priority (PRI) assessment

Project Testing

- Three Test Visits to NSWCDD

Test Visit Schedule	
Test Visit 1 -	1/13/2025 - 1/17/2025
Test Visit 2 -	2/3/2025 - 2/7/2025
Test Visit 3 -	5/5/2025 - 5/9/2025

- LAUNCH CONDITION TECHNICAL BACKGROUND

Encircled Flux (EF) is a measurement of the intensity profile at the output of a MM fiber. A desired profile can be achieved by means of conditioning at the output of a light source using various techniques which allow for MM fibers with different characteristics (mainly core size and NA) to end up with a very similar desired launch profile.

Coupled Power Ratio (CPR) measures the ratio of light referenced thru a MM fiber, that will propagate thru a SM fiber when the two fibers are coupled together. This will effectively identify how “underfilled” a light source may transmit relative to a MM fiber.

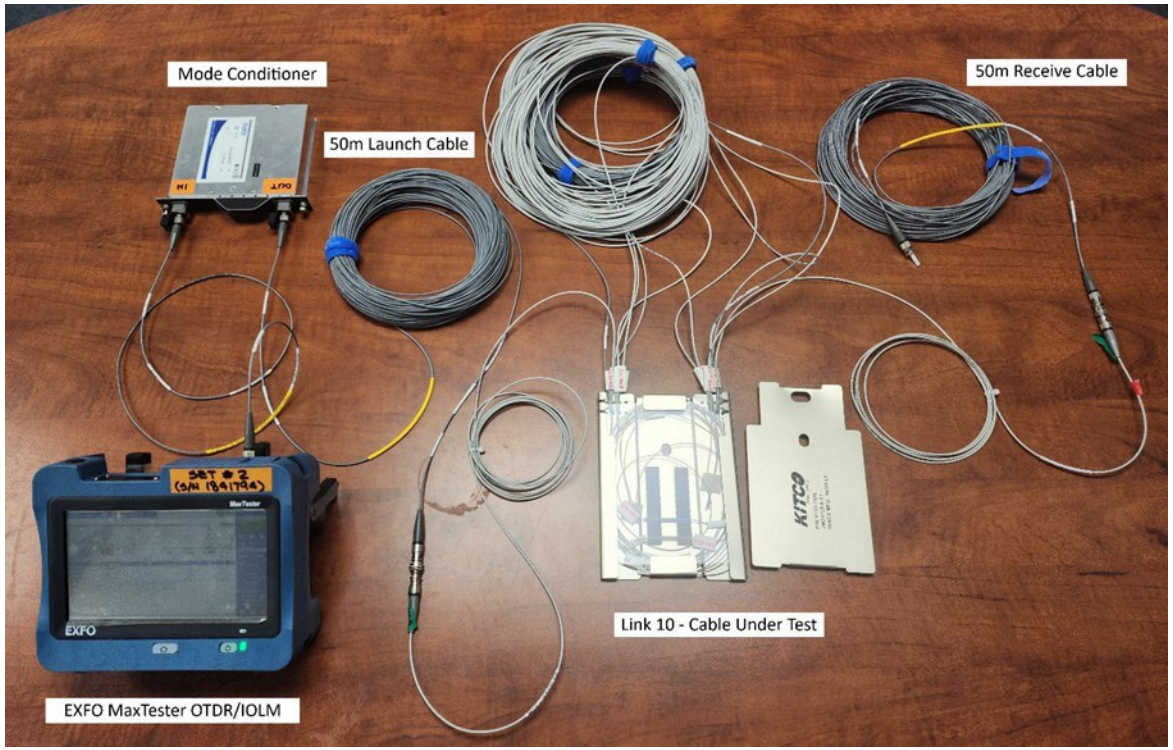
High Order Mode Power (HOMP) measures the relative amount of power travelling at the core cladding boundary (High Order Modes) that can be filtered out thru a mandrel wrap. The more loss the more Overfilled the source.

CPR and HOMP when combined together can help characterize the balance between underfilled and overfilled light sources.

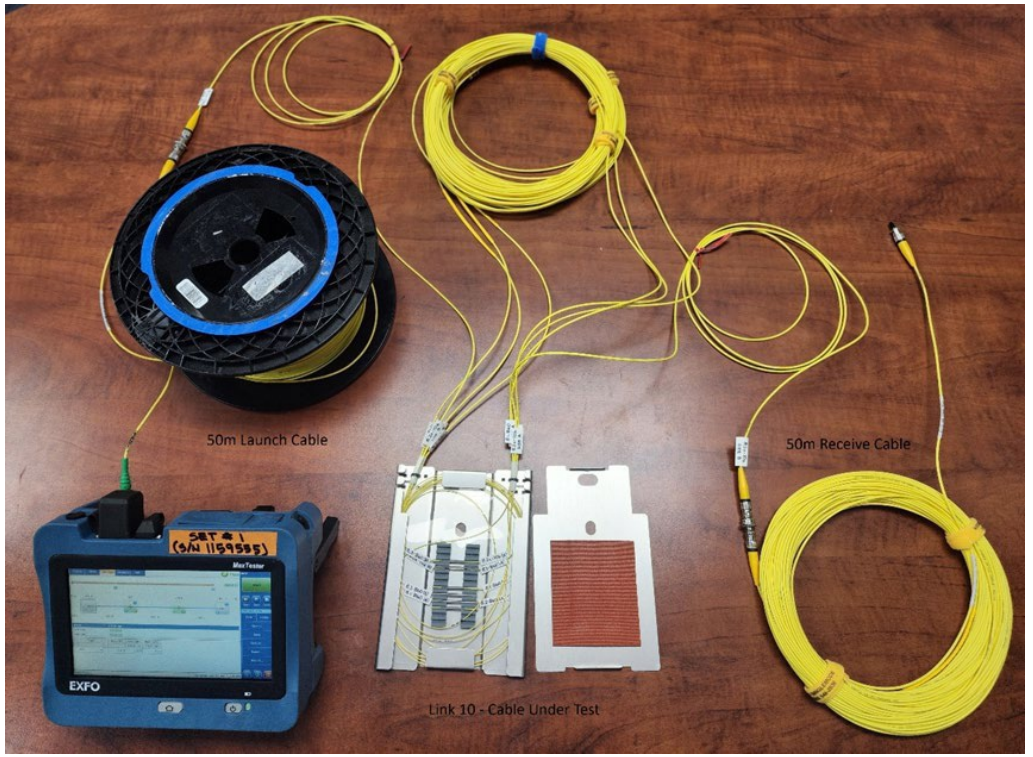
Project Testing

- Test configurations

Typical MM Test Configuration (showing with splice DUT)



Typical SM Test Configuration (showing with splice DUT)



Project Testing

- MM LAUNCH CONDITION TESTING RESULTS – MAX-945 OLTS Units

				Test Equipment characterization at NSWCDD during Test Visit																
OLTS	S/N	OTHER	TX-MQJ	Date	EF: 10	EF: 15	EF: 20	EF: 26	EF: 28	Comply: EF10	Comply: EF15	Comply: EF20	Comply: EF26	Comply: EF28	EF COMPLY RESULT	CPR Ref (dBm)	4.2-1 (SM 4	CPR Comply Range = (-20.5 to -22.5)	HOMP	HOMP Comply Range = (0.3 to 0.8)
MAX:945: Set 1	1540293		1.1-1	1/14/2025	0.2415	0.4818	0.7204	0.9341	0.9758	Pass	Pass	Pass	Pass	Pass	Pass	-18.06	-38.83	**-20.77**	-18.76	**0.70**
MAX:945: Set 1	1540293		1.2-1	1/14/2025	0.2419	0.4836	0.7230	0.9360	0.9761	Pass	Pass	Pass	Pass	Pass	Pass	-18.06	-38.95	**-20.89**	-18.73	**0.67**
MAX:945: Set 1	1540293		1.3-1	1/14/2025	0.2403	0.4793	0.7178	0.9303	0.9733	Pass	Pass	Pass	Pass	Pass	Pass	-18.28	-39.16	**-20.88**	-19.00	**0.72**
MAX:945: Set 1	1540293		1.1-3	1/14/2025	0.2274	0.4599	0.7017	0.9235	0.9687	Pass	Pass	Pass	Fail	Fail	Fail	-18.38	-39.08	**-20.70**	-18.95	**0.57**
MAX:945: Set 1	1540293		1.2-3	1/14/2025	0.2114	0.4297	0.6597	0.8864	0.9405	Pass	Pass	Pass	Fail	Fail	Fail	-18.12	-38.96	**-20.84**	-18.75	**0.63**
MAX:945: Set 1	1540293		1.3-3	1/14/2025	0.2065	0.4208	0.6477	0.8752	0.9311	Pass	Pass	Pass	Fail	Fail	Fail	-18.33	-38.99	**-20.66**	-18.90	**0.57**
MAX:945: Set 2	1540572		1.1-1	1/14/2025	0.2297	0.4639	0.7041	0.9258	0.9701	Pass	Pass	Pass	Pass	Fail	Fail	-20.39	-41.26	**-20.87**	-21.06	**0.67**
MAX:945: Set 2	1540572		1.2-1	1/14/2025	0.2391	0.4799	0.7216	0.9375	0.9774	Pass	Pass	Pass	Pass	Pass	Pass	-20.40	-41.21	**-20.81**	-21.04	**0.64**
MAX:945: Set 2	1540572		1.3-1	1/14/2025	0.2373	0.4768	0.7177	0.9335	0.9753	Pass	Pass	Pass	Pass	Pass	Pass	-20.34	-41.20	**-20.86**	-21.02	**0.68**
MAX:945: Set 2	1540572		1.1-3	1/14/2025	0.2243	0.4559	0.6990	0.9223	0.9685	Pass	Pass	Pass	Fail	Fail	Fail	-20.19	-41.16	**-20.97**	-20.75	**0.56**
MAX:945: Set 2	1540572		1.2-3	1/14/2025	0.2393	0.4805	0.7237	0.9409	0.9796	Pass	Pass	Pass	Pass	Pass	Pass	-20.48	-41.17	**-20.69**	-21.04	0.56
MAX:945: Set 2	1540572		1.3-3	1/14/2025	0.2390	0.4799	0.7218	0.9376	0.9770	Pass	Pass	Pass	Pass	Pass	Pass	-20.41	-41.76	**-21.35**	-21.02	0.61
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.1-50	1/14/2025	0.2497	0.4916	0.7360	0.9444	0.9799	Pass	Pass	Pass	Pass	Pass	Pass	-4.45	-24.40	**-19.95**	-4.90	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.2-50	1/14/2025	0.2447	0.4882	0.7348	0.9452	0.9801	Pass	Pass	Pass	Pass	Pass	Pass	-4.41	-24.98	**-20.57**	-4.86	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.3-50	1/14/2025	0.2314	0.4721	0.7210	0.9350	0.9713	Pass	Pass	Pass	Pass	Pass	Pass	-4.39	-25.85	**-21.46**	-4.84	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.4-50	1/14/2025	0.2346	0.4714	0.7170	0.9313	0.9706	Pass	Pass	Pass	Pass	Fail	Fail	-4.40	-25.24	**-20.84**	-4.83	0.43
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.1-50	1/14/2025	0.2512	0.5024	0.7455	0.9456	0.9798	Pass	Pass	Pass	Pass	Pass	Pass	-2.82	-23.79	**-20.97**	-3.22	0.40
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.2-50	1/14/2025	0.2631	0.5100	0.7498	0.9488	0.9810	Fail	Pass	Pass	Fail	Pass	Fail	-2.85	-23.02	**-20.17**	-3.21	0.36
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.3-50	1/14/2025	0.2339	0.4709	0.7121	0.9260	0.9646	Pass	Pass	Pass	Pass	Fail	Fail	-2.77	-23.89	**-21.12**	-3.16	0.39
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.4-50	1/14/2025	0.2352	0.4782	0.7250	0.9344	0.9717	Pass	Pass	Pass	Pass	Pass	Pass	-2.74	-23.09	**-20.35**	-3.11	0.37

- Both MAX-945-NAV-M2042 units were found to be complaint for the Navy required parameters for CPR and HOMP.
- MAX-945 Set 1 was fully EF compliant for all 1 meter MQJ assemblies
- MAX-945 Set 1 not complaint for EF at the 26µm and 28µm radius test locations when tested with the 3 meter MQJ's
- Those test results show that the 3 meter MQJ's resulted in a more underfilled core than the 1 meter MQJ's
- MAX-945 Set 2 had a failing EF value at the 28µm radius location with 1 meter MQJ 1.1-1 and failures at both the 26µm and 28µm radius locations with 3 meter MQJ 1.1-3.
- **Implications for the variation between the 1 meter and 3 meter MQJ's for core underfill will need to be analyzed and considered relative to the remainder of the project test results.**

Project Testing

- MM LAUNCH CONDITION TESTING RESULTS – MAX-720C/720D Units

				Test Equipment characterization at NSWCDD during Test Visit																
OLTS	S/N	OTHER	TX-MQJ	Date	EF: 10	EF: 15	EF: 20	EF: 26	EF: 28	Comply: EF10	Comply: EF15	Comply: EF20	Comply: EF26	Comply: EF28	EF COMPLY RESULT	CPR Ref (dBm)	4.2-1 (SM 4	CPR Comply Range = (-20.5 to -22.5)	HOMP	HOMP Comply Range = (0.3 to 0.8)
MAX:945: Set 1	1540293		1.1-1	1/14/2025	0.2415	0.4818	0.7204	0.9341	0.9758	Pass	Pass	Pass	Pass	Pass	Pass	-18.06	-38.83	**-20.77**	-18.76	**0.70**
MAX:945: Set 1	1540293		1.2-1	1/14/2025	0.2419	0.4836	0.7230	0.9360	0.9761	Pass	Pass	Pass	Pass	Pass	Pass	-18.06	-38.95	**-20.89**	-18.73	**0.67**
MAX:945: Set 1	1540293		1.3-1	1/14/2025	0.2403	0.4793	0.7178	0.9303	0.9733	Pass	Pass	Pass	Pass	Pass	Pass	-18.28	-39.16	**-20.88**	-19.00	**0.72**
MAX:945: Set 1	1540293		1.1-3	1/14/2025	0.2274	0.4599	0.7017	0.9235	0.9687	Pass	Pass	Pass	Fail	Fail	Fail	-18.38	-39.08	**-20.70**	-18.95	**0.57**
MAX:945: Set 1	1540293		1.2-3	1/14/2025	0.2114	0.4297	0.6597	0.8864	0.9405	Pass	Pass	Pass	Fail	Fail	Fail	-18.12	-38.96	**-20.84**	-18.75	**0.63**
MAX:945: Set 1	1540293		1.3-3	1/14/2025	0.2065	0.4208	0.6477	0.8752	0.9311	Pass	Pass	Pass	Fail	Fail	Fail	-18.33	-38.99	**-20.66**	-18.90	**0.57**
MAX:945: Set 2	1540572		1.1-1	1/14/2025	0.2297	0.4639	0.7041	0.9258	0.9701	Pass	Pass	Pass	Pass	Fail	Fail	-20.39	-41.26	**-20.87**	-21.06	**0.67**
MAX:945: Set 2	1540572		1.2-1	1/14/2025	0.2391	0.4799	0.7216	0.9375	0.9774	Pass	Pass	Pass	Pass	Pass	Pass	-20.40	-41.21	**-20.81**	-21.04	**0.64**
MAX:945: Set 2	1540572		1.3-1	1/14/2025	0.2373	0.4768	0.7177	0.9335	0.9753	Pass	Pass	Pass	Pass	Pass	Pass	-20.34	-41.20	**-20.86**	-21.02	**0.68**
MAX:945: Set 2	1540572		1.1-3	1/14/2025	0.2243	0.4559	0.6990	0.9223	0.9685	Pass	Pass	Pass	Fail	Fail	Fail	-20.19	-41.16	**-20.97**	-20.75	**0.56**
MAX:945: Set 2	1540572		1.2-3	1/14/2025	0.2393	0.4805	0.7237	0.9409	0.9796	Pass	Pass	Pass	Pass	Pass	Pass	-20.48	-41.17	**-20.69**	-21.04	0.56
MAX:945: Set 2	1540572		1.3-3	1/14/2025	0.2390	0.4799	0.7218	0.9376	0.9770	Pass	Pass	Pass	Pass	Pass	Pass	-20.41	-41.76	**-21.35**	-21.02	0.61
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.1-50	1/14/2025	0.2497	0.4916	0.7360	0.9444	0.9799	Pass	Pass	Pass	Pass	Pass	Pass	-4.45	-24.40	**-19.95**	-4.90	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.2-50	1/14/2025	0.2447	0.4882	0.7348	0.9452	0.9801	Pass	Pass	Pass	Pass	Pass	Pass	-4.41	-24.98	**-20.57**	-4.86	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.3-50	1/14/2025	0.2314	0.4721	0.7210	0.9350	0.9713	Pass	Pass	Pass	Pass	Pass	Pass	-4.39	-25.85	**-21.46**	-4.84	0.45
OTDR: Set 1 MAX-720D	1159555	w/ Mode Conditioner	1.4-50	1/14/2025	0.2346	0.4714	0.7170	0.9313	0.9706	Pass	Pass	Pass	Pass	Fail	Fail	-4.40	-25.24	**-20.84**	-4.83	0.43
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.1-50	1/14/2025	0.2512	0.5024	0.7455	0.9456	0.9798	Pass	Pass	Pass	Pass	Pass	Pass	-2.82	-23.79	**-20.97**	-3.22	0.40
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.2-50	1/14/2025	0.2631	0.5100	0.7498	0.9488	0.9810	Fail	Pass	Pass	Fail	Pass	Fail	-2.85	-23.02	**-20.17**	-3.21	0.36
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.3-50	1/14/2025	0.2339	0.4709	0.7121	0.9260	0.9646	Pass	Pass	Pass	Pass	Fail	Fail	-2.77	-23.89	**-21.12**	-3.16	0.39
OTDR: Set 2 MAX-720C	1841794	w/ Mode Conditioner	1.4-50	1/14/2025	0.2352	0.4782	0.7250	0.9344	0.9717	Pass	Pass	Pass	Pass	Pass	Pass	-2.74	-23.09	**-20.35**	-3.11	0.37

- Neither the MAX-720C or MAX-720D was fully compliant for EF or CPR with all MQJ configurations.
- Both complaint with the bottom end of the HOMP requirement (0.3db) but were each at the low end of the window.
- This indicates that the core is more underfilled than what the project team had desired.
- The MAX-720C set showed an HOMP average of 0.38dB across the four 50 meter MQJs that were used.
- The MAX-720D set had a slightly higher HOMP average of 0.45dB.
- **These values were below the desired HOMP target value of 0.6dB that the project team had targeted.**
- **Starting with approximately a 0.15 to 0.22dB loss bias with the OTDR's. (Loss results likely to be lower than desired.)**

Project Testing

- VISIT 1 MM INDIVIDUAL LINK TESTING RESULTS - OLTS

	OLTS	Exfo MAX-945-NAV-M2042 Set 1: (1540293; S:xxxxx/D:xxxxx)							
	MQJ TX:	1.1-1							
	MQJ RX:	1.2-1							
	Operator:	William Land				START	END		
	Date	14-Jan-25			TIME				
	MQJ Verification (<=0.35dB)	Ref:	8.01dB	0.11dB			Comply		
		A-B				B-A			
Sequence	CABLE	M1	M2	M3	Avg IL	M1	M2	M3	Avg IL
1	5.1-10	0.32	0.31	0.87	0.50	0.31	0.31	0.31	0.31
2	5.2-10	0.37	0.37	0.37	0.37	0.43	0.43	0.43	0.43
6	5.1-40	0.22	0.21	0.21	0.21	0.14	0.15	0.15	0.15
3	5.2-40	0.26	0.26	0.25	0.26	0.28	0.28	0.28	0.28
4	5.1-130	0.29	0.29	0.29	0.29	0.31	0.33	0.47	0.37
5	5.2-130	0.45	0.44	0.45	0.45	0.39	0.38	0.37	0.38
7	5.1-500	0.49	0.49	0.48	0.49	0.15	0.14	0.15	0.15
8	6.1-10	0.19	0.19	0.19	0.19	0.27	0.28	0.27	0.27
10	6.1-40	0.24	0.23	0.24	0.24	0.23	0.23	0.23	0.23
9	6.2-130	0.28	0.27	0.28	0.28	0.26	0.26	0.26	0.26
11	7.1-10	0.32	0.32	0.32	0.32	0.27	0.27	0.27	0.27
12	7.2-10	0.37	0.37	0.36	0.37	0.29	0.28	0.29	0.29
13	7.2-40	0.29	0.3	0.3	0.30	0.35	0.35	0.35	0.35
14	7.1-500	0.4	0.39	0.39	0.39	0.47	0.47	0.47	0.47

	OLTS	EXFO MAX-945-NAV-M2042 Set 2: (1540572							
	MQJ TX:	1.1-1							
	MQJ RX:	1.2-1							
	Operator:	Martineau				START	END		
	Date	1/14/2025			TIME				
	MQJ Verification (<=0.35dB)	Ref:	-20.2	0.17			Comply		
		A-B				B-A			
Sequence	CABLE	M1	M2	M3	Avg IL	M1	M2	M3	Avg IL
14	5.1-10	0.4	0.39	0.34	0.38	0.15	0.16	0.15	0.15
13	5.2-10	0.4	0.56	0.55	0.50	0.48	0.48	0.48	0.48
9	5.1-40	0.3	0.29	0.29	0.29	0.3	0.3	0.3	0.30
12	5.2-40	0.25	0.26	0.26	0.26	0.28	0.28	0.28	0.28
11	5.1-130	0.34	0.34	0.34	0.34	0.36	0.35	0.35	0.35
10	5.2-130	0.47	0.47	0.48	0.47	0.46	0.46	0.45	0.46
8	5.1-500	0.59	0.59	0.59	0.59	0.6	0.55	0.57	0.57
7	6.1-10	0.31	0.28	0.28	0.29	0.33	0.34	0.34	0.34
5	6.1-40	0.33	0.33	0.33	0.33	0.3	0.33	0.33	0.32
6	6.2-130	0.25	0.26	0.25	0.25	0.26	0.27	0.26	0.26
4	7.1-10	0.29	0.29	0.29	0.29	0.28	0.28	0.3	0.29
3	7.2-10	0.4	0.41	0.41	0.41	0.4	0.4	0.4	0.40
21	7.2-40	0.35	0.35	0.35	0.35	0.4	0.4	0.39	0.40
1	7.1-500	0.47	0.48	0.49	0.48	0.54	0.54	0.54	0.54

Project Testing

- VISIT 1 MM INDIVIDUAL LINK TESTING RESULTS - OTDR

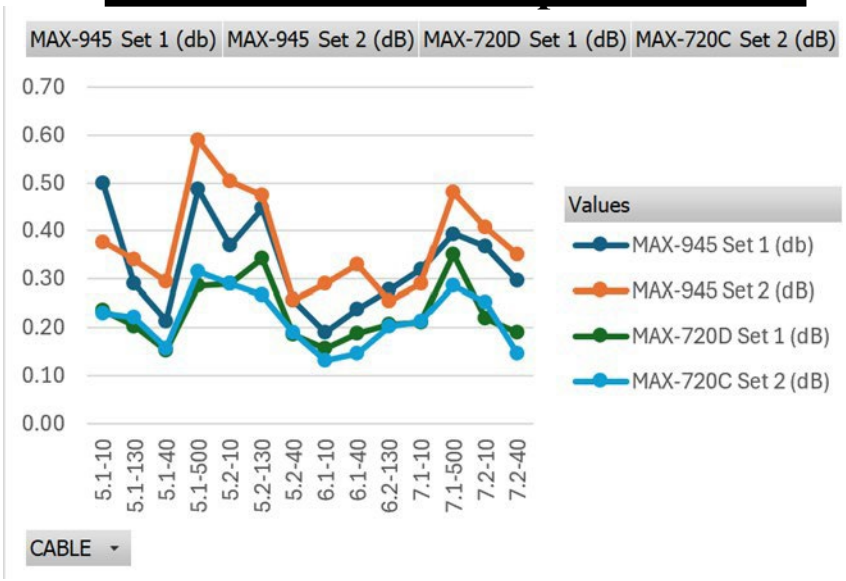
OTDR	EXFO SET 1 s/n:1159555										
MQJ TX:	1.1-50 Length:										
MQJ RX:	1.2-50 Length:										
Operator:	Dan Martineau										
Date	1/15/2025										
MQJ Verification (<=0.35dB)	IL	RL	IOLM Method								Comply
	TX: 0.31 / RX: 0.25										
	A-B				B-A						
CABLE	Link Loss	Event 1 IL	Event 1 RL	Event 2 IL	Event 1 IL	Event 1 RL	Event 2 RL	Event 2 IL	Event 2 RL	Link Loss	Bi-Direction LL
5.1-10	0.24	0.13	-53.00	0.33	0.09	-50.80	-25.35	0.25	-53.90	0.19	0.21
5.2-10	0.29	0.25	-52.20	0.25	0.24	-51.90	-25.83	-	-	0.28	0.29
5.1-40	0.15	0.01	-39.90	0.10	0.04	-56.30	-28.13	0.06	-52.90	0.14	0.15
5.2-40	0.19	0.04	-54.50	0.10	0.04	-53.80	-26.88	0.15	-55.00	0.24	0.21
5.1-130	0.20	0.07	-47.10	0.07	0.03	-48.50	-24.24	0.13	-52.00	0.23	0.21
5.2-130	0.34	0.15	-50.90	0.10	0.07	-52.40	-26.17	0.06	-54.50	0.23	0.29
5.1-500	0.29	0.13	-57.90	0.02	0.13	-51.00	-25.44	0.04	-55.70	0.33	0.31
6.1-10	0.16	0.11	-50.30	0.11	0.19	-49.40	-24.60	-	-	0.23	0.19
6.1-40	0.19	0.07	-36.70	0.08	0.13	-52.50	-26.18	0.09	-54.40	0.27	0.23
6.2-130	0.21	0.07	-57.10	0.07	0.14	-48.70	-24.28	0.02	-56.20	0.22	0.21
7.1-10	0.21	0.17	-50.80	0.17	0.07	-27.80	-13.86	-	-	0.11	0.16
7.2-10	0.22	0.18	-33.80	0.18	0.10	-31.60	-15.75	-	-	0.14	0.18
7.2-40	0.19	0.04	-54.60	0.09	0.11	-57.70	-28.79	0.08	-54.90	0.24	0.21
7.1-500	0.35	0.13	-26.00	0.05	0.14	-54.10	-26.98	0.05	-50.70	0.34	0.35

	OTDR	EXFO SET 2 s/n:1841794										
	MQJ TX:	1.1-50 Length:										
	MQJ RX:	1.2-50 Length:										
	Operator:	William Land										
	Date											
	MQJ Verification (<=0.35dB)	IL	RL	IOLM Method TX: 0.31 ; RX: 0.25								Comply
		A-B				B-A						
File: Sequence	CABLE	Link Loss	Event 1 IL	Event 1 RL	Event 2 IL	Event 1 IL	Event 1 RL	Event 2 RL	Event 2 IL	Event 2 RL	Link Loss	Bi-Direction LL
1	5.1-10	0.229	0.048	-58.2	0.122	0.098	-57.6	-28.75	0.043	-52.3	0.197	0.21
2	5.2-10	0.289	0.042	-54.2	0.194	0.209	-56.6	-28.20	0.067	-57.3	0.309	0.30
3	5.1-40	0.157	0.052	-52.4	0.052	0.047	-55.9	-27.93	0.034	-52	0.148	0.15
4	5.2-40	0.19	0.067	-54.7	0.079	0.101	-52.1	-26.00	0.067	-55.3	0.231	0.21
5	5.1-130	0.22	0.076	-47.5	0.057	0.071	-49.4	-24.66	0.081	-32.9	0.222	0.22
6	5.2-130	0.266	0.1	-55.6	0.098	0.076	-55.6	-27.76	0.072	-55.3	0.227	0.25
7	5.1-500	0.316	0.123	-56.5	0.054	0.128	-51.8	-25.84	0.038	-56.6	0.314	0.32
8	6.1-10	0.13	0.087	-54.5	0.005	0.083	-49.2	-24.56	0.056	-53.6	0.2	0.17
9	6.1-40	0.146	0.083	-54.8	0.019	0.09	-54.7	-27.31	0.059	-30.7	0.193	0.17
10	6.2-130	0.201	0.084	-56.1	0.062	0.101	-57.7	-28.80	0.03	-41.7	0.191	0.20
11	7.1-10	0.213	0.047	-55.8	0.109	0.036	-30.5	-15.23	0.148	-54.3	0.226	0.22
12	7.2-10	0.253	0.129	-58.7	0.086	0.157	-33.2	-16.52	-	-	0.195	0.22
13	7.2-40	0.146	0.083	-54.9	0.034	0.098	-55.4	-27.65	0.084	-50.8	0.226	0.19
14	7.1-500	0.285	0.123	-51.6	0.014	0.092	-54.4	-27.15	0.059	-51.2	0.312	0.30

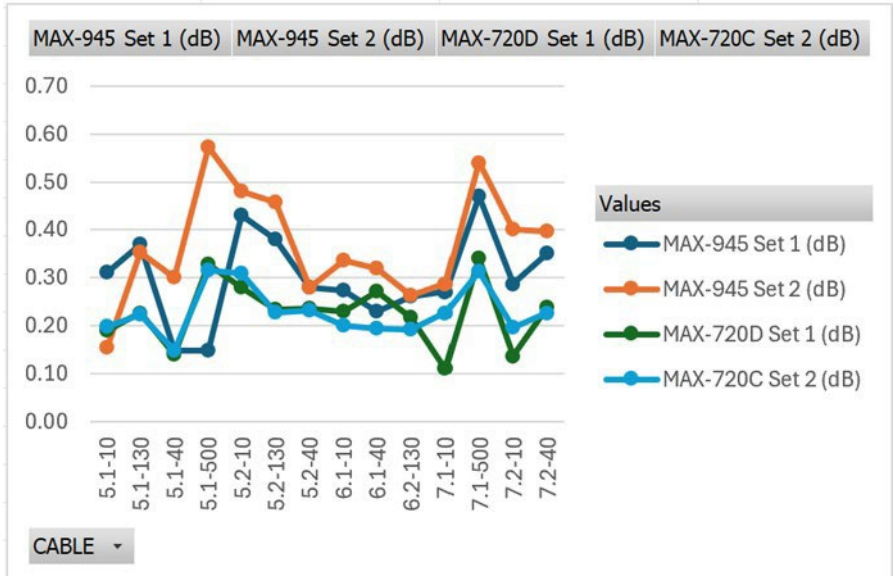
Project Testing

- VISIT 1 MM INDIVIDUAL LINK TESTING RESULTS - OTDR

Individual Link Comparison A – B



Individual Link Comparison B - A



- A to B direction, between OLTS and OTDR there is an average difference of -0.13dB in the loss measurements.
  - Measurement spread range is from -0.21dB to -0.06dB or a 0.15dB measurement spread.
- B to A direction, between OLTS and OTDR the average difference is -0.04dB in the loss measurements.
  - Measurement spread range is from -0.08 to +0.09db or 0.17dB measurement spread.
- Individual link measurements differences are very encouraging, but the loss measurements **still do not show enough agreement to recommend direct adoption of the OTDR as an OLTS replacement for MM** applications.

Project Testing

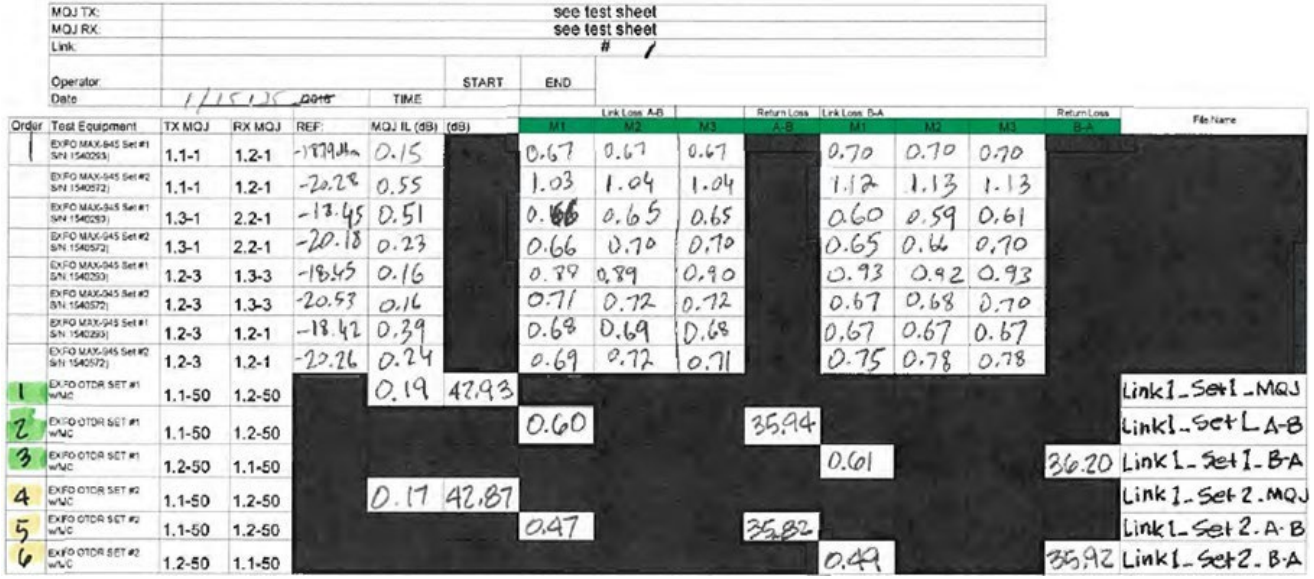
- VISIT 1 MM DUT MOCK FOCP Configurations (Concatenated) Testing

  - The project teams conducted testing per the Test Plan and recorded the results on a test sheet for each link. The test sheet data was then entered into a master spreadsheet. The current version of the master spreadsheet is provided with this report: “NSRP FOTE Project Test Data Final Results Ver 7-14-25” and has been submitted with the initial “final report”.

Link	CA #1	CA #2	CA #3	CA #4	CA #5	CA #6
1	5.1-40	5.1-500	5.2-40			
2	6.1-40	7.1-500	7.2-40			
3	5.1-10	5.2-10				
4	7.1-10	5.1-130	6.1.10			
5	6.1-10	5.1-130	5.1-40			
6	6.1-40	5.1-500	7.1-10			
7	5.1-10	7.2-40	7.1-500	5.2-40	5.2-10	
8	5.1-10	5.1-40	5.1-130	5.2-130	5.2-40	5.2-10
9	5.x-10 : FUSION SPLICE	5.x-130: Fusion splice	5.x-10			
10	5.3x-10a : FUSION SPLICE	5.1-B60: Fusion splice	5.2-B60: Fusion splice	5.3-B60: Fusion splice	5.3x-10b : FUSION SPLICE	
11	5.3x-10a: 1dB Attenuated Splice	5.x-B60: Fusion splice	5.3x-10b : FUSION SPLICE			
12	5.3x-10a: 3dB Attenuated Splice	5.x-B60: Fusion splice	5.3x-10b : FUSION SPLICE			
13	5.3x-10a : FUSION SPLICE	5.1-B60: Fusion splice	5.3x-10b : FUSION SPLICE			

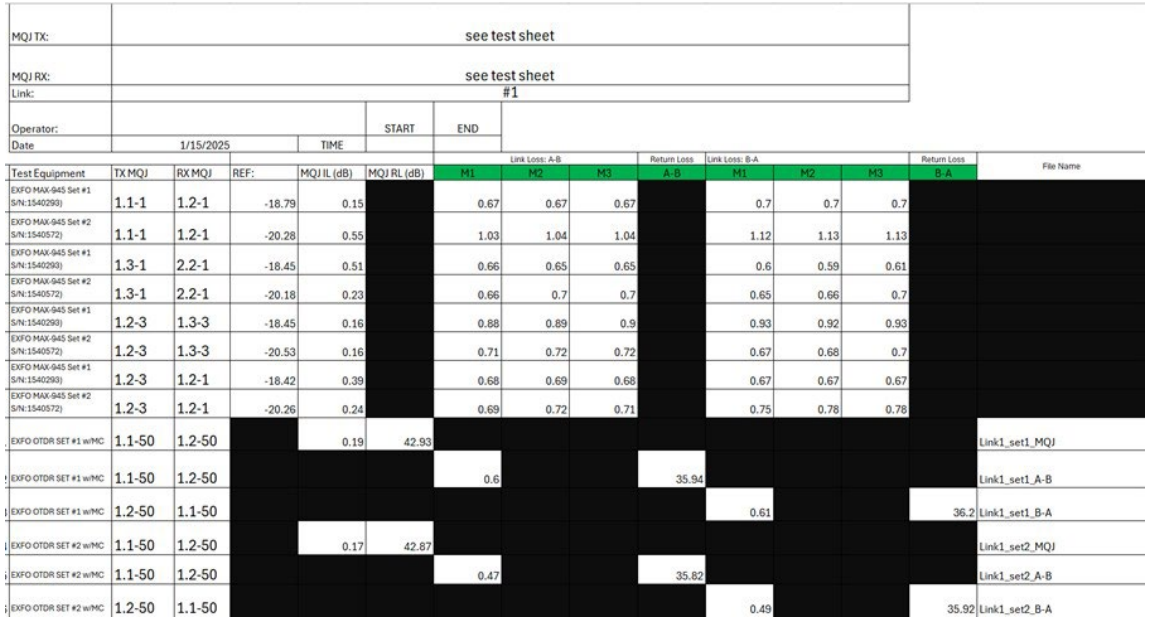
Project Testing

- VISIT 1 MM DUT MOCK FOCP Configurations (Concatenated) Testing



MQJ TX:	see test sheet
MQJ RX:	see test sheet
Link:	# 1
Operator:	
Date	1/15/25 2025

Order	Test Equipment	TX MQJ	RX MQJ	REF:	MQJ IL (dB)	(dB)	START	END	Link Loss A-B M1	Link Loss A-B M2	Link Loss A-B M3	Return Loss A-B	Link Loss B-A M1	Link Loss B-A M2	Link Loss B-A M3	Return Loss B-A	File Name
1	EXFO MAX-945 Set #1 S/N 1540293	1.1-1	1.2-1	-18.79dBm	0.15				0.67	0.67	0.67		0.70	0.70	0.70		
	EXFO MAX-945 Set #2 S/N 1540572	1.1-1	1.2-1	-20.28	0.55				1.03	1.04	1.04		1.12	1.13	1.13		
	EXFO MAX-945 Set #1 S/N 1540293	1.3-1	2.2-1	-18.45	0.51				0.66	0.65	0.65		0.60	0.59	0.61		
	EXFO MAX-945 Set #2 S/N 1540572	1.3-1	2.2-1	-20.18	0.23				0.66	0.70	0.70		0.65	0.66	0.70		
	EXFO MAX-945 Set #1 S/N 1540293	1.2-3	1.3-3	-18.45	0.16				0.89	0.89	0.90		0.93	0.92	0.93		
	EXFO MAX-945 Set #2 S/N 1540572	1.2-3	1.3-3	-20.53	0.16				0.71	0.72	0.72		0.67	0.68	0.70		
	EXFO MAX-945 Set #1 S/N 1540293	1.2-3	1.2-1	-18.42	0.39				0.68	0.69	0.68		0.67	0.67	0.67		
	EXFO MAX-945 Set #2 S/N 1540572	1.2-3	1.2-1	-20.26	0.24				0.69	0.72	0.71		0.75	0.78	0.78		
1	EXFO OTDR SET #1 w/MC	1.1-50	1.2-50		0.19	42.93											Link1_Set1_MQJ
2	EXFO OTDR SET #1 w/MC	1.1-50	1.2-50						0.60			35.94					Link1_Set1_A-B
3	EXFO OTDR SET #1 w/MC	1.2-50	1.1-50										0.61			36.20	Link1_Set1_B-A
4	EXFO OTDR SET #2 w/MC	1.1-50	1.2-50		0.17	42.87											Link1_Set2_MQJ
5	EXFO OTDR SET #2 w/MC	1.1-50	1.2-50						0.47			35.82					Link1_Set2_A-B
6	EXFO OTDR SET #2 w/MC	1.2-50	1.1-50										0.49			35.92	Link1_Set2_B-A



MQJ TX:	see test sheet
MQJ RX:	see test sheet
Link:	#1
Operator:	
Date	1/15/2025

Test Equipment	TX MQJ	RX MQJ	REF:	MQJ IL (dB)	MQJ RL (dB)	Link Loss: A-B M1	Link Loss: A-B M2	Link Loss: A-B M3	Return Loss A-B	Link Loss: B-A M1	Link Loss: B-A M2	Link Loss: B-A M3	Return Loss B-A	File Name
EXFO MAX-945 Set #1 S/N:1540293	1.1-1	1.2-1	-18.79	0.15		0.67	0.67	0.67		0.7	0.7	0.7		
EXFO MAX-945 Set #2 S/N:1540572	1.1-1	1.2-1	-20.28	0.55		1.03	1.04	1.04		1.12	1.13	1.13		
EXFO MAX-945 Set #1 S/N:1540293	1.3-1	2.2-1	-18.45	0.51		0.66	0.65	0.65		0.6	0.59	0.61		
EXFO MAX-945 Set #2 S/N:1540572	1.3-1	2.2-1	-20.18	0.23		0.66	0.7	0.7		0.65	0.66	0.7		
EXFO MAX-945 Set #1 S/N:1540293	1.2-3	1.3-3	-18.45	0.16		0.88	0.89	0.9		0.93	0.92	0.93		
EXFO MAX-945 Set #2 S/N:1540572	1.2-3	1.3-3	-20.53	0.16		0.71	0.72	0.72		0.67	0.68	0.7		
EXFO MAX-945 Set #1 S/N:1540293	1.2-3	1.2-1	-18.42	0.39		0.68	0.69	0.68		0.67	0.67	0.67		
EXFO MAX-945 Set #2 S/N:1540572	1.2-3	1.2-1	-20.26	0.24		0.69	0.72	0.71		0.75	0.78	0.78		
EXFO OTDR SET #1 w/MC	1.1-50	1.2-50		0.19	42.93									Link1_set1_MQJ
EXFO OTDR SET #1 w/MC	1.1-50	1.2-50				0.6			35.94					Link1_set1_A-B
EXFO OTDR SET #1 w/MC	1.2-50	1.1-50								0.61			36.2	Link1_set1_B-A
EXFO OTDR SET #2 w/MC	1.1-50	1.2-50		0.17	42.87									Link1_set2_MQJ
EXFO OTDR SET #2 w/MC	1.1-50	1.2-50				0.47			35.82					Link1_set2_A-B
EXFO OTDR SET #2 w/MC	1.2-50	1.1-50								0.49			35.92	Link1_set2_B-A

- CURRENT PROJECT STATUS
  - The project test teams worked diligently and made over 5000 unique optical measurements during the 3 test visits to NSWCDD.
  - The final project test visit was conducted from May 5 to May 9, 2025.
  - Due to the vast nature of the measurement data taken and the need to carefully and critically analyze the data, those efforts are ongoing and will continue.

Project Testing

- SM Testing

SINGLE-MODE LINK #11

MQJ TX:	see test sheet
MQJ RX:	see test sheet
Link:	8.3x-10a (1dB SPLICE)/8.x-B60/8.3x-10b # 11
Operator:	
Date	5/7/2025 TIME START 11:00 END 12:00

Order	Test Equipment	TX MQJ	RX MQJ	REF:	MQJ IL (dB)	MQ. RL (dB)	Link Loss: A-B M1	M2	M3	Return Loss A-B	Link Loss: B-A M1	M2	M3	O.R.L B-A
29	EXFO MAX-945 Set #1 S/N:1540293	4.1-1	4.2-1	5.36	0.20		1.72	1.73	1.73		1.96	2.04	2.02	
33	EXFO MAX-945 Set #2 S/N:1540572	4.1-1	4.2-1	4.20	0.10		1.82	1.76	1.75		1.96	1.91	1.88	
30	EXFO MAX-945 Set #1 S/N:1540293	4.2-1	4.1-1	5.43	0.20		1.44	1.78	1.46		1.67	1.76	1.69	
34	EXFO MAX-945 Set #2 S/N:1540572	4.2-1	4.1-1	4.24	0.10		1.47	1.49	1.48		1.94	1.98	2.03	
31	EXFO MAX-945 Set #1 S/N:1540293	4.1-3	4.2-3	5.37	0.13		1.91	1.94	1.93		1.64	1.59	1.60	
35	EXFO MAX-945 Set #2 S/N:1540572	4.1-3	4.2-3	4.39	0.06		1.65	1.57	1.59		1.52	1.53	1.61	
32	EXFO MAX-945 Set #1 S/N:1540293	4.2-3	4.1-3	5.37	0.35		1.91	1.73	1.68		1.97	1.90	1.90	
36	EXFO MAX-945 Set #2 S/N:1540572	4.2-3	4.1-3	4.32	0.29		1.81	1.92	1.88		1.76	1.73	1.80	
40	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50		0.39	39.87								
41	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50				1.68			36.70				
42	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50								1.68			35.71
37	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~		0.26	50.89								
38	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~				1.80			40.51				
39	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~								1.92			40.09

LINK #11

← 8.3x-10a / 1dB ATTEN. SPLICE/8.x-B60/FUSION SPLICE/8.3x-10b →

SINGLE-MODE LINK #12

MQJ TX:	see test sheet
MQJ RX:	see test sheet
Link:	8.3x-10a/3dB ATTN. SPLICE/8.x-B60/8.3x-10b # 12
Operator:	
Date	5/7/2025 TIME START 13:30 END 14:20

Order	Test Equipment	TX MQJ	RX MQJ	REF:	MQJ IL (dB)	MQ. RL (dB)	Link Loss: A-B M1	M2	M3	Return Loss A-B	Link Loss: B-A M1	M2	M3	O.R.L. B-A
43	EXFO MAX-945 Set #1 S/N:1540293	4.1-1	4.2-1	5.43	0.26		3.72	3.72	3.72		3.91	3.89	3.99	
47	EXFO MAX-945 Set #2 S/N:1540572	4.1-1	4.2-1	4.09	0.27		3.84	3.84	3.88		4.87	4.82	4.81	
44	EXFO MAX-945 Set #1 S/N:1540293	4.2-1	4.1-1	4.99	0.07		4.20	4.30	4.13		3.44	3.49	3.46	
48	EXFO MAX-945 Set #2 S/N:1540572	4.2-1	4.1-1	3.92	0.16		4.33	4.31	4.35		3.57	3.61	3.63	
45	EXFO MAX-945 Set #1 S/N:1540293	4.1-3	4.2-3	5.42	0.29		4.04	4.02	4.04		4.14	4.19	4.21	
49	EXFO MAX-945 Set #2 S/N:1540572	4.1-3	4.2-3	4.59	0.08		4.07	4.05	4.08		3.90	3.80	3.78	
46	EXFO MAX-945 Set #1 S/N:1540293	4.2-3	4.1-3	5.17	0.11		3.69	3.71	3.67		3.85	3.87	3.89	
50	EXFO MAX-945 Set #2 S/N:1540572	4.2-3	4.1-3	4.59	0.31		4.43	4.36	4.37		4.14	4.13	4.09	
51	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50		0.93	39.78								
52	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50				3.97			31.50				
53	EXFO OTDR SET #1 w/NC	APC ~~4-15B~~	4.2-50								3.29			35.89
54	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~		0.21	50.21								
55	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~				4.85			43.74				
56	EXFO OTDR SET #2 w/NC	50 4.1-~~100~~	50 4.2-~~100~~								3.57			41.13

LINK #12

← 8.3x-10a/3dB ATTEN SPLICE/8.x-B60/FUSION SPLICE/8.3x-10b →

- SM OTDR test results with UPC connection showed very close alignment to OLTS results.

Project Modeling

- MULTIMODE FIBER OPTICAL MODEL OF OTDR LINK LOSS – Not covered in this presentation

  - As an enhancement to this project, KITCO engaged the Applied Research Laboratory of The Pennsylvania State University (Penn State /ARL) to investigate the forward and reverse propagation of light pulses on optical fibers, including both multi-mode and single-mode optical fibers. The specific intent was to determine if an OTDR (Optical Time Domain Reflectometer) can be used to measure connector losses between mated optical patch cords. The study was intended to provide an estimate for the loss measured by an OTDR and that measured by standard point-point link testing.

  - This predictive modelling was intended to determine if the loss values measured in this project could be predicted by OTDR and light propagation theory.

  - The Penn State/ARL final report: “983382 Multimode Fiber Optical Model of OTDR Link Loss” authored by: Michael Reilly, Stephen Chapman, John Mazurowski: Penn State University, Applied Research Labs will be provided along with this project final report.

  - Provided with Final Report

Current Project Conclusions

- Although the launch condition of the Multimode OTDR was modified to align more closely with the Navy preferred launch condition, the testing results were similar to the original project results and do not currently provide the desired test result alignment required to recommend acceptance for using the OTDR in place of the OLTS for MM testing.

- SM OTDR measurements showed strong alignment or were more conservative than OLTS. Additional analysis required.

- At this time it cannot be recommended to accept the OTDR for equivalence to the OLTS for testing acceptance.

- Additional analysis to be conducted.

Questions???