2019-482-002 (Joint ETP and SWSI) Fusion Splice Enclosure at Equipment

NSRP All Panel Meeting
March 2021

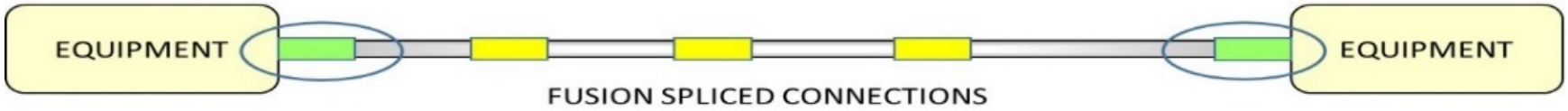
Eliminating Fiber Optic Connectors

NSRP Panel Project 2015-442 Alternatives to Fiber Optic Connectors provided a business case for the use of fusion splicing.

One more increment remains: ***connections direct to consoles and racks using fusion splices in lieu of connectors.***

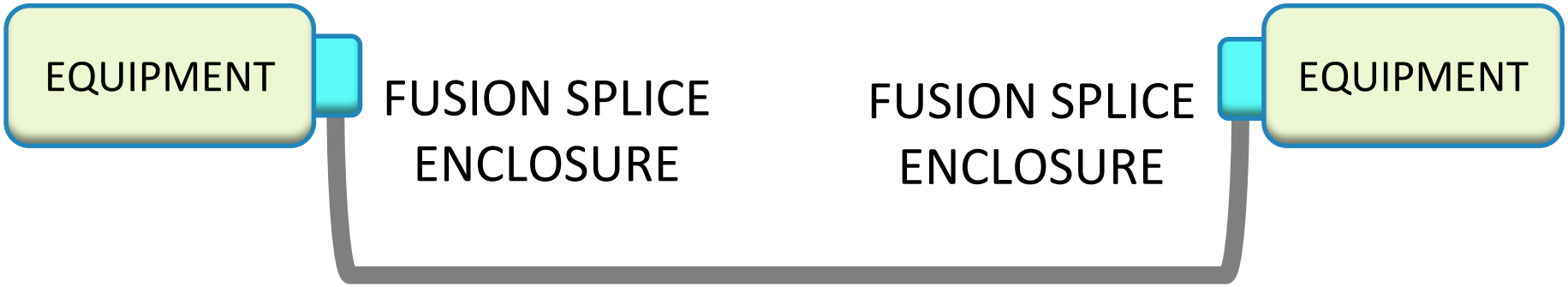



FROM / TO



CONNECTOR CONNECTOR

- FROM -



- TO -

BENEFITS

ACQUISITION- 75% less cost
Connector- the connector and termini provide submicron alignment for the fibers.
Fusion splice- the fusion splicer provides the alignment.

TESTING- saves unscheduled rework
Connector- the two connector halves cannot be tested until they are mated.
Fusion splice- the fusion splicer estimates splice loss during the fusion splicing process.

MAINTENANCE- zero maintenance
Connector- connectors need periodic inspection for wear and contamination.
Fusion splice – a fusion splice is a permanent weld between fibers.

OPTICAL IMPAIRMENTS- decrease
Connector- fiber interfaces are subject to transients and multipath.
Fusion splice - continuous interface between fibers.

ROI

The panel project cost has finished concept development to TRL-3.

This fusion splice enclosure concept is ready for design optimization against mil requirements, and qualification.

A team member may develop the enclosure as part of their product line.

PROJECT TASKS

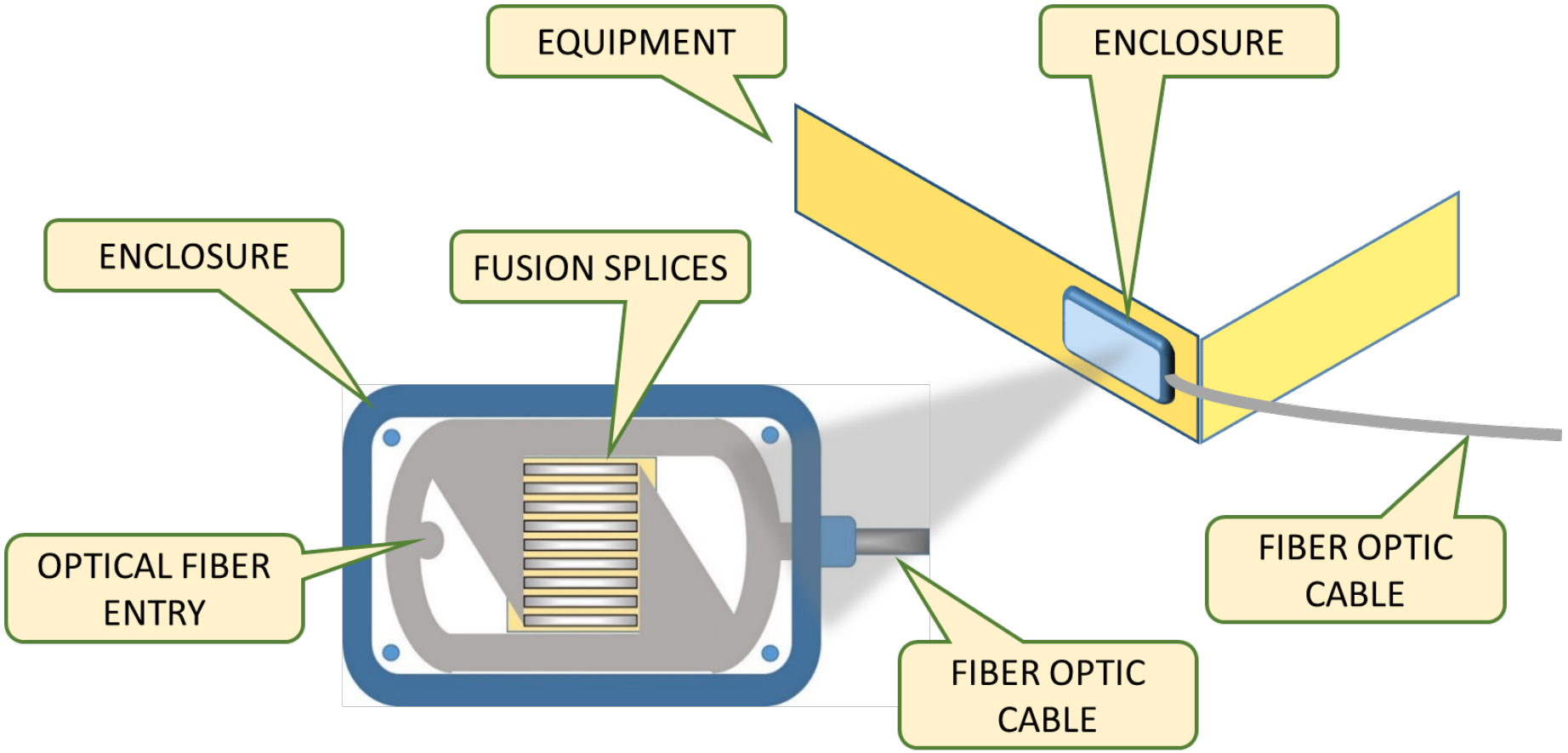
TASK	ARL-EOC	NSWC-DD	KITCO
1) Project and Subcontract Management	L	R	R
2) Project team to identify applications, use cases, and environments for alternate enclosure approach.	L	C	C
3) Requirements will be developed for proposed approach within applications and environments.	C	C	L
4) Industry research to identify commercial solutions.	L	C	C
5) Design hardware concepts for proposed approach as necessary.	C	L	C
6) Evaluate hardware for performance against requirements.	L	C	C
7) Develop documentation package to facilitate transition with Navy stakeholders.	P	C	L

L = Lead C = Technical Contributor P = Participant R = Reviewer

PROJECT PROGRESS- COMPLETE!

TASK
1) Project and Subcontract Management
2) Project team identified applications, use cases, and environments for alternate enclosure approach.
3) Requirements developed for proposed approach within applications and environments.
4) Industry research to identify commercial solutions.
5) Design hardware concepts for proposed approach as necessary.
6) Evaluate hardware for performance against requirements.
7) Develop documentation package to facilitate transition with Navy stakeholders (KITCO, NSWC-DD).

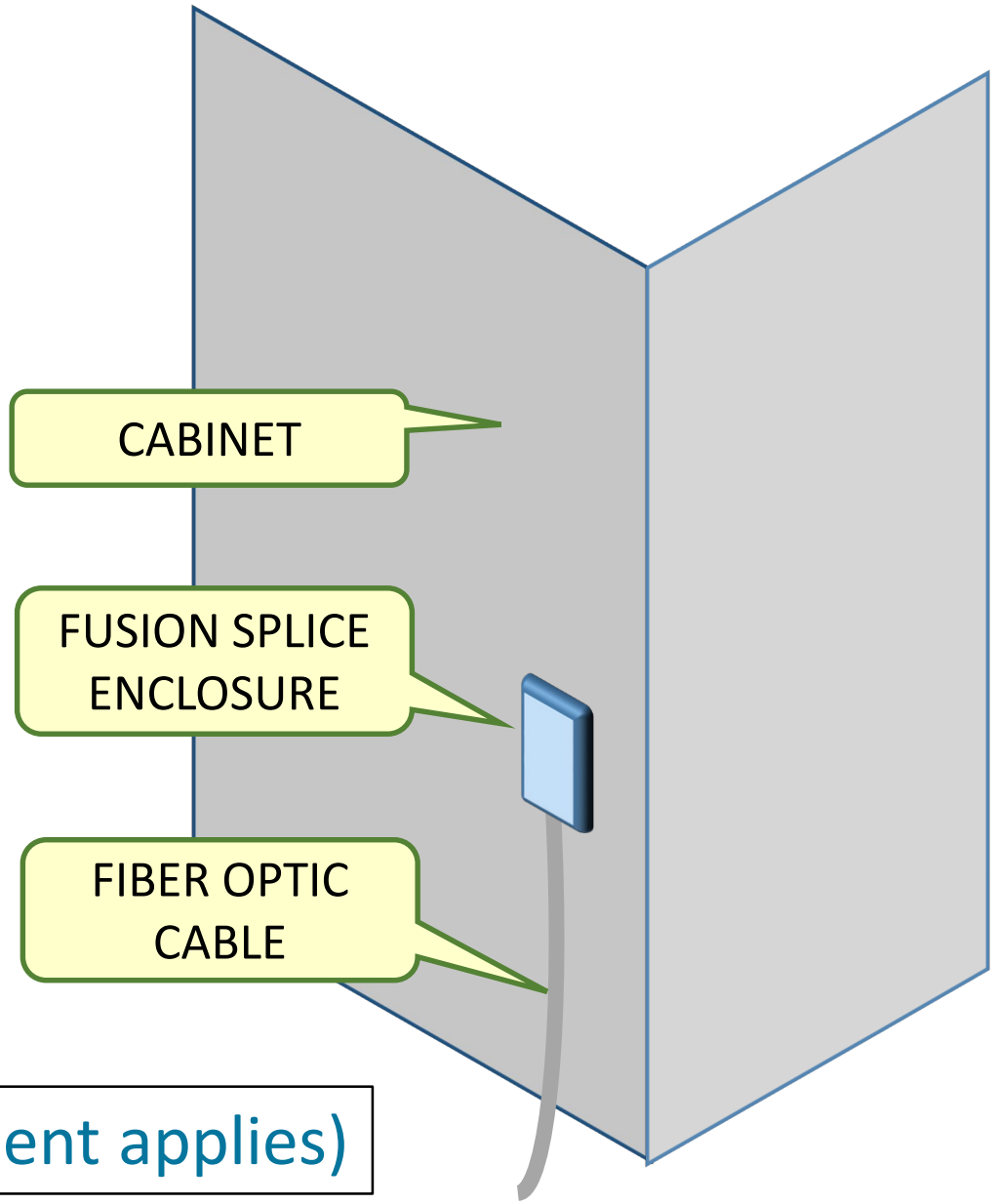
EQUIPMENT VIEW



(internal environment applies)

CABINET VIEW

The project vision is to accommodate connections to consoles and straight back / razor back cabinets.



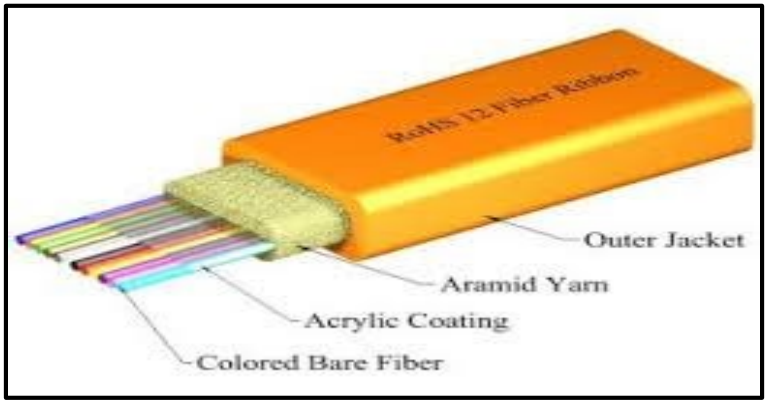
(external environment applies)

CABLE COMPATIBILITY

MIL-85045
4 & 8 Fibers

MIL-85045
Blown Opt. Fiber
(BOF)

MIL-85045
Compatible
Ribbon Cable



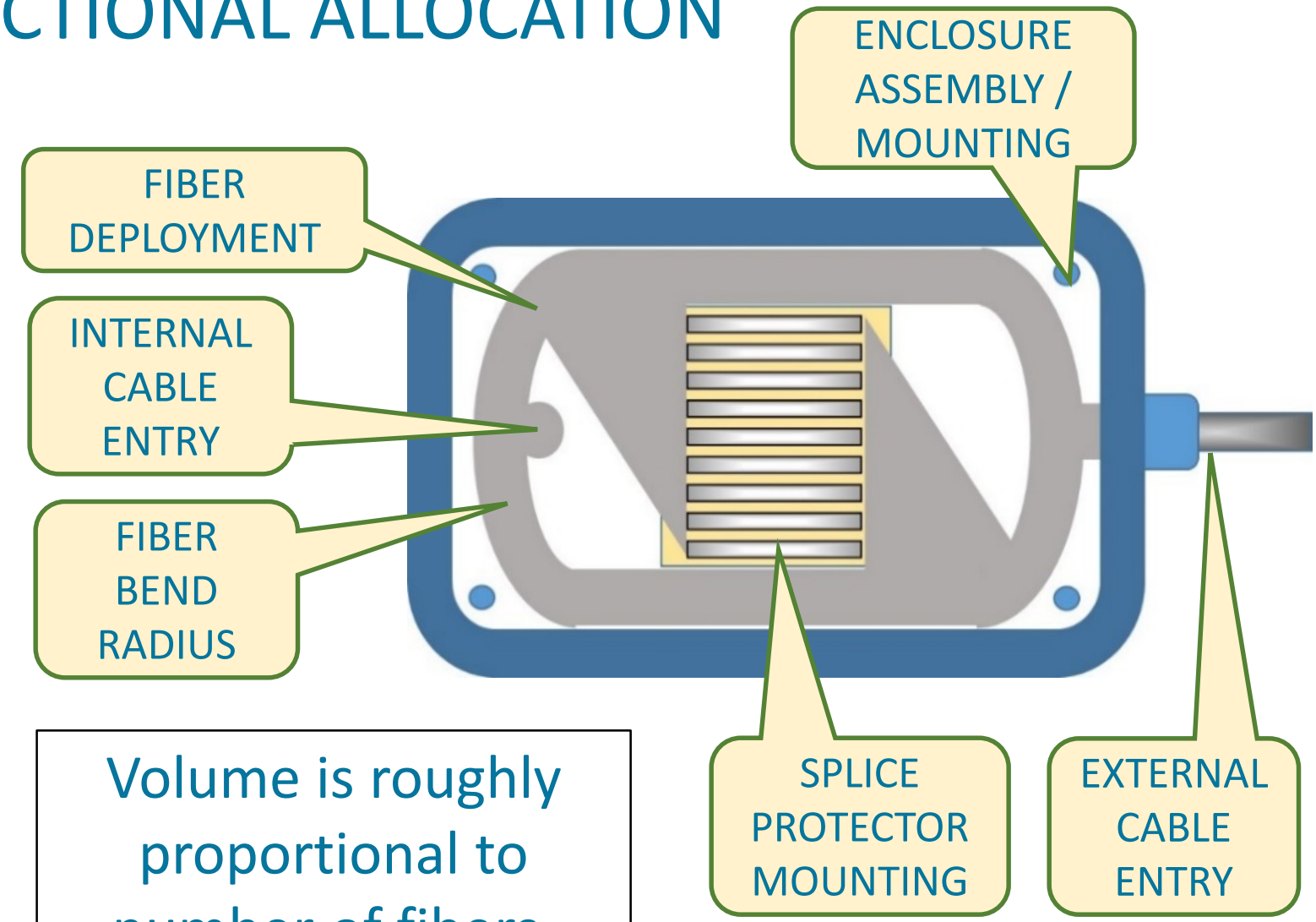
Cable type compatibility requires:

a) Specific strain relief / gland.

b) Internal fiber management.

c) Splice protector mount.

FUNCTIONAL ALLOCATION



Volume is roughly proportional to number of fibers.

VOLUME ANALYSIS

MS Excel-based analytical tool calculates volume required for functional features.

VOLUME- FUSION SPLICE ENCLOSURE- calculation of enclosure volume for purposes of fit.			
Enter data in yellow spaces. Green spaces are calculated. Use consistent dimensions.			
TOTAL VOLUME =	15.10	Dimensions in:	inch
TOTAL with PF =	16.87		inch
CABLE ENTRY EXTERNAL- includes external cable gland / strain relief. Not necessarily a part of internal volume.			
RADIUS =	0.5		
LENGTH =	2		
TOTAL =	6.28		
CABLE STRAIN RELIEF EXTERNAL- strain relief for external cable. Strain relief to meet cable oull test requirement.			
WIDTH A=	0.5		
WIDTH B=	0.5		
LENGTH=	1		
TOTAL=	0.25		
CABLE ENTRY INTERNAL- includes internal cable gland / strain relief. Not necessarily a part of internal volume.			
RADIUS =	0.5		
LENGTH =	1		
TOTAL =	3.14		
CABLE STRAIN RELIEF INTERNAL- strain relief for internal cable. Strain relief to meet cable oull test requirement.			
WIDTH A=	0.5		
WIDTH B=	0.5		
LENGTH=	1		
TOTAL=	0.25		
FIBER DEPLOYMENT- this deployment is for excess fiber required reach the fusion splicer and fiber guide features.			
FIBER DIA=	0.04		
BEND RADIUS=	1		
DIST TO SPLICER=	20		
PACKING FACTOR=	1.8		
PROT LENGTH=	2.4		
NO FIBERS=	8		
TOTAL=	1.92680448		
SPLICE PROTECTOR VOLUME- this volume includes splice protectors and their mounting.			
PROT DIAMETER=	0.1		
PROT LENGTH=	2.4		
NO FIBERS=	8		
PACKING FACTOR=	1.5		
TOTAL=	0.45216		
ENCLOSURE MOUNT VOLUME- this is incremental volume required for enclosure mounting to cabinet or console surface.			
WIDTH=	2		
HEIGHT=	1		
LENGTH=	4		
OCCUPIED VOL=	6		
TOTAL=	2		
ENCLOSURE COVER VOLUME- incremental volume for splice enclosure cover and locking mechanism.			
WIDTH=	2		
HEIGHT=	0.1		
LENGTH=	4		
TOTAL=	0.8		

COMMERCIAL PRODUCTS

28-30 parts analyzed for 11 metrics.

Desirable features were noted.

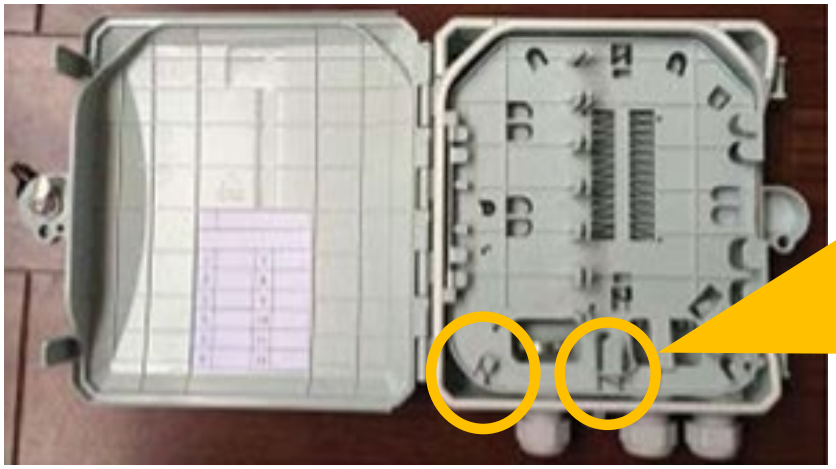
Have purchased several example parts.

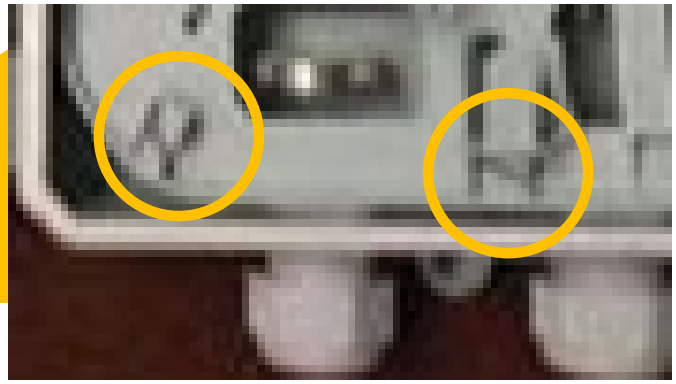
Manufacturer	Model / Description	Part Number
AFL	OptiNID Duo	See Spec
Bud Industries	FOTB / FOSC	FBR-11608
Bud Industries	FOTB / FOSC	FBR-11607
Bud Industries	FOTB / FOSC	FBR-11609
Coyote	Runt Enclosure FOSC	8006671
Coyote	Axcess Solutions, FOTB / FOSC	WDC2A
Coyote	Service Temination Point (FOSC)	STP-EE-1-N-0-N
Coyote	STP-JR Service Term Point	STPJR-DD-1-N-0-N
Coyote	PLP COYOTE Drop Termination	COYDTC001
Fiber Instrument Sales	FOTB / FOSC	Z1602FTTX
Fiber Instrument Sales	FOTB / FOSC	Z176SFTTX
Fiber Instrument Sales	FOSC	F1-4868FLL
Fiber Tronics	FOTB / FOSC	FOTB-C01
Fiber Tronics	FOTB / FOSC	FT-SPB1
Fiber Tronics	FOTB / FOSC	FT-WTB-5B-24
Mooseline	Wall Mount Fiber Optic NID	F1-62DW-3
Mooseline	FOSC	F1-OSPDBC24
Multilink	FOTB / FOSC	F1-OTE
NCM Solutions	FOTB / FOSC	NCM-FOSC-ILIC-XX-C
Norland	Inline tube	20960M
Norland	FOSC	21300
Norland	FOSC	21310
Tyco Electronics Raychem	FOSC Slim In-Line Enclosure	FOSC-500AA
Tykoflex	Joint Closure OPGW 3H	11 160 631
Tykoflex	Joint Closure T SLIM	11 161 431
Glenair	Joint Closure TSG	140-060-XMS-01
Glenair		
US Pioneer	M24728/4	1166-101

COMMERCIAL FEATURES

FIBERS CONFINED FROM OUTSIDE

RUGGED CONSTRUCTION





“SLANT SLOT” FOR FIBER CONFINEMENT

TECHNICAL DISCUSSION

USE CASES- equipment, consoles, and racks.

CABLE TYPES- 4&8 fiber, Blown Optical Fiber, Ribbon Cable.

MATERIALS- will require external evaluation.

DESIGN- use M24728 as a baseline (rugged).

DESIGN- use best features of commercial products.

NUMBER OF FIBERS- affects enclosure volume.

MOUNTING- can we use size 23 bulkhead cutout?

NUMBER OF ENCLOSURES- multiple per cabinet?

ACQUISITION- evaluated commercial product data.

ADDITIVE MANUFACTURING- quick iterations.

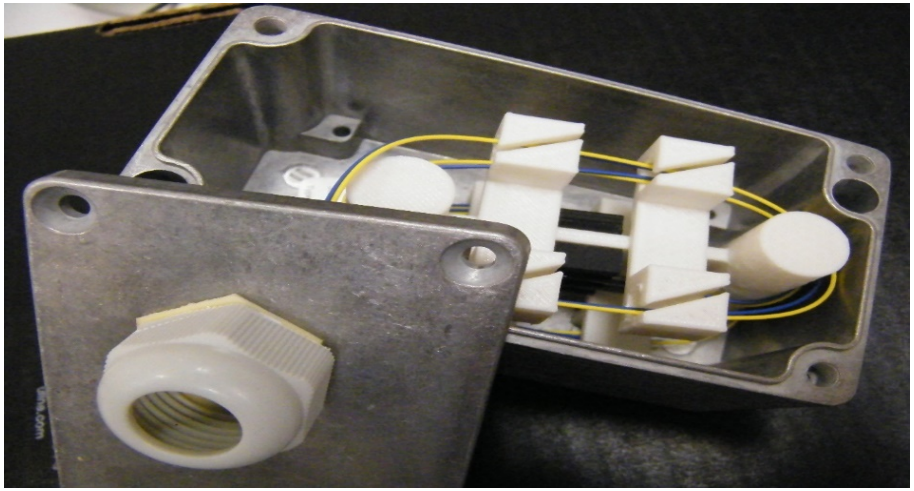
THE ITERATION PROCESS

The panel project team learned to provide quick successive iterations using 3D printing.

Design files were made for procured parts and for designed parts, and shared via email.

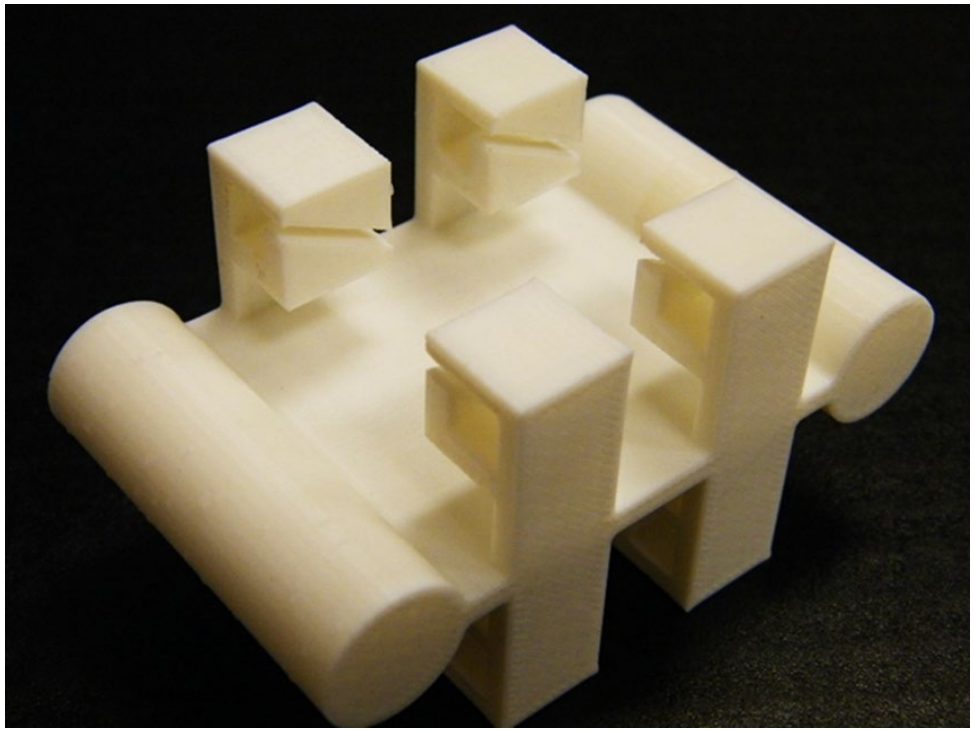
Five iterations in total were prepared. Each iteration took two weeks to make and evaluate.

ITERATION 1



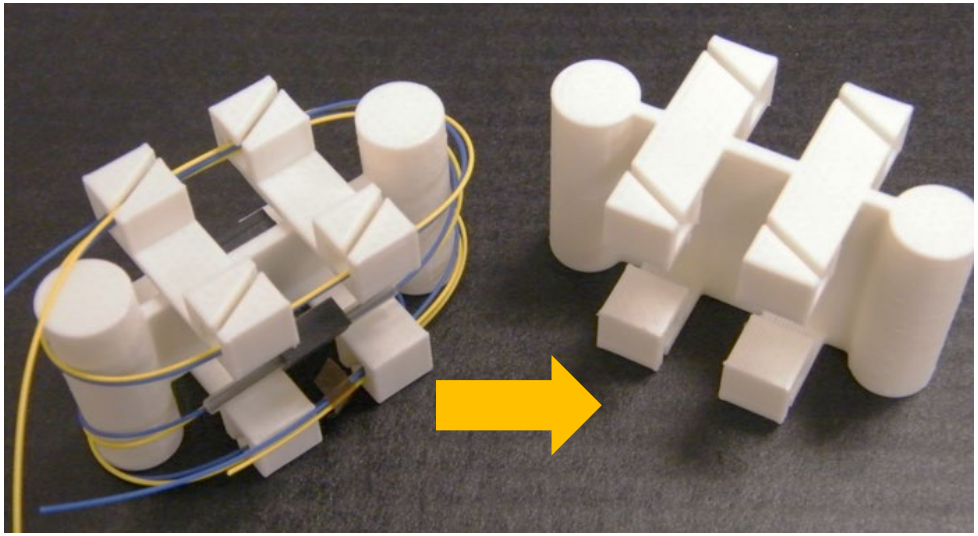
PROS	CONS
Via our calculation tool, the enclosure volume will accommodate the volume of the components. The present volume seems acceptable for the allowed space.	We need a transition from the jacketed individual fibers to the 900 micron beffered fibers, so that the jacketed fibers do not apply significant strain to the 900 micron fibers.
The fiber holders work very well in a) being easy to load and b) capturing the fiber well.	The die cast box is rugged and the mounting via the connector mounting pattern is rigid. It is not completely certain whether it will withstand a sailor using the enclosure as a ladder step.
The fiber bend radius is maintained within the enclosure.	The splice protector mounting grooves should be included in the mandrel / bobbin.
The fiber holders may even have the capacity to hold individual jacketed fibers if the splice protectors are compatible with the jacketed fibers.	Ease of installation with the full capacity of fibers is not necessarily known. We will need to identify the relevant strain relief parts.

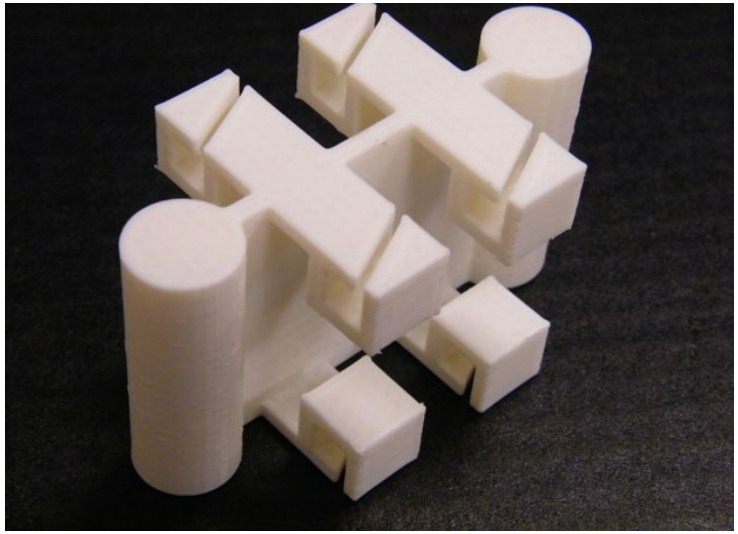
ITERATION 2



PROS	CONS
Some volume was saved by re-positioning the fiber holders adjacent to the outside surface.	The fiber holders did not work very well; fibers were not easy to load.

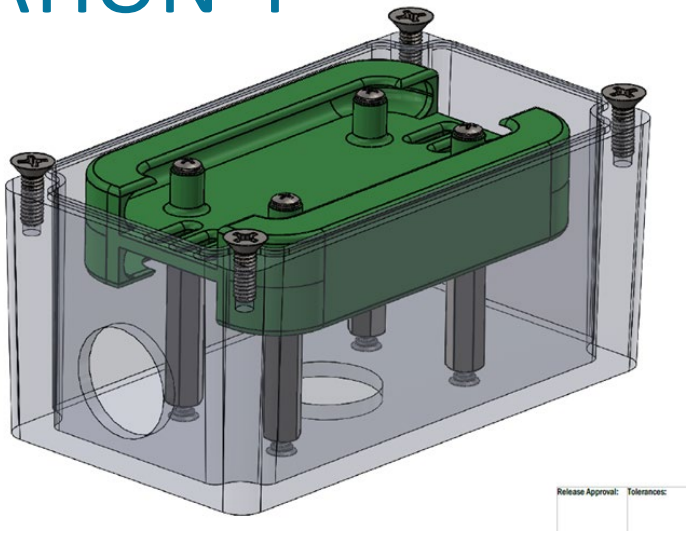
ITERATION 3





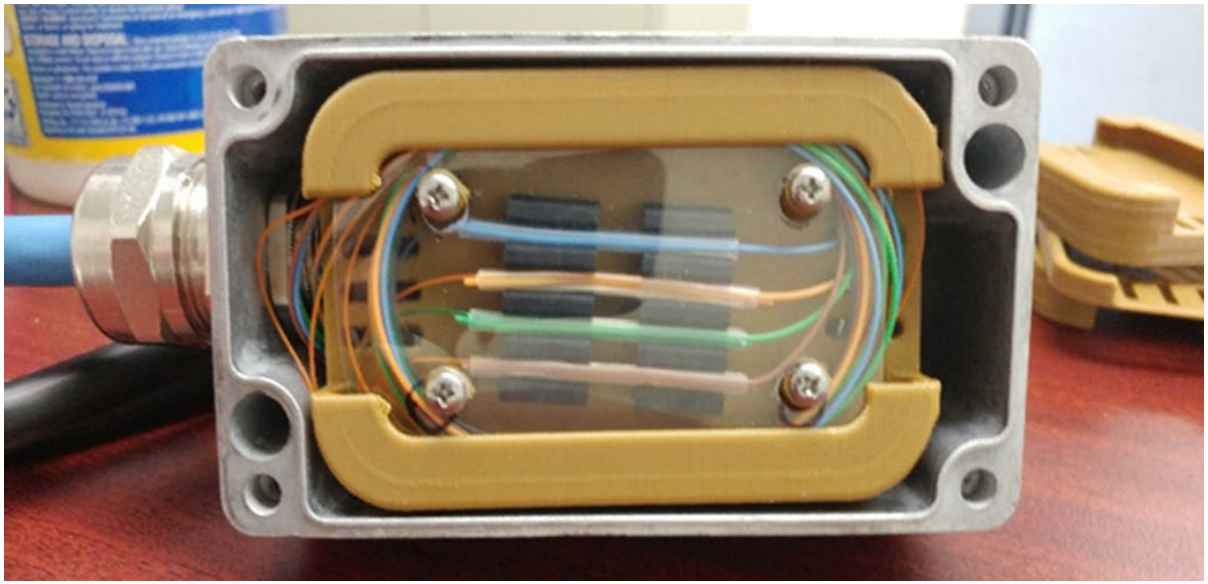
PROS	CONS
Volume was saved by re-positioning the fiber holders adjacent to the outside surface.	The need remains to provide stability for jacketed individual fibers so they do not stress the buffered 900 micron fibers wound inside the package.
Relocating the slots to the exterior surface made it easier to load the fiber.	
More splice protectors fit in the middle wall of the boobin / mandrel.	

ITERATION 4



PROS	CONS
Penetrations have cable glands that grip the aramid yarn of the fiber cable, so that the enclosure secures the cable .	Splice holder method for the tray has yet to be implemented
Splice tray is more compact which provides more space for the incoming / outgoing fiber to maximize the bend radius.	Fiber bend radius accomodates 900 micron fiber, but routing rules will will need to be applied when using larger fiber.
Splice tray has troughs on both sides to allow for looping excess fiber. Also, the tray has stanchions on both sides and slots on both ends to further secure the fiber.	
Splice tray is mounted directly to the enclosure.	
Enclosure can be directly mounted to the equipment cabinet via a size 23 connector hole pattern.	

ITERATION 5



PROS	CONS
The deployment of fiber from the strain relief to the fusion splice protector is satisfactory.	The fiber bend radius is satisfactory for 900 micron fiber but deployment rules may be necessary for larger fibers.
The enclosure reasonably passed assemnly tests performed at KITCO Fiber Optics and at Penn State ARL.	
The transparent sheets help retain the fiber in the tray.	

NEXT STEPS

Transition meeting held on March 1, 2021.

a) Identify platform / equipment need.
b) Push from Navy and/or pull from shipyard.
c) Optical performance vs shock is valuable.
d) Refine design as needed to meet requirements.
e) Rigorous qualification.

QUESTIONS?

TEAM MEMBERS:

NSRP Mark Smitherman- ATI
PTR Jason Farmer- Ingalls Shipbuilding
LEAD John Mazurowski- Penn State ARL-EOC
GOVT Chris Good- NSWC-DD
SUBCONTRACTOR Dan Morris- KITCO Fiber Optics
SUBCONTRACTOR Shane Baker- KITCO Fiber Optics
SHIPYARD Greg Stevens- Bath Iron Works
ENGINEER Lucas Cashdollar- Penn State ARL-EOC