

SHDAS TRUNK CABLE SPECIFICATION AND PERFORMANCE WORK
STATEMENT

DRAFT

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1 SCOPE

- 1.1 This document defines the requirements and terms of supply for the backbone cable for the Seismo-Hydroacoustic Data Acquisition System.
- 1.2 The cables required for this application are commercially available submarine telecommunication cables with a proven service history.

2 DEFINITIONS

- 2.1 GOVERNMENT: US Government and its designated agents
- 2.2 CONTRACTOR: The manufacturer or supplier of the cables, including Sub-contractor(s) sub contracted or appointed by the CONTRACTOR to carry out part or all of the work.

3 APPLICABLE DOCUMENTS

The CONTRACTOR shall be responsible for obtaining the documents listed in Table 1.

DOCUMENT	TITLE
IEC 60811	Measurements of Thickness and Overall Dimensions Test for Determining Mechanical Properties
IEC 794	Optical Fiber Cables, Part 1, Generic Specification
BS 5099	Specification for Spark Testing of Electrical Cables
ISO 9001	Model for Quality Assurance in Design/Development, Production, Installation and Servicing
ISO 14000/14001	Environmental management
ITU-T G.652	Characteristics for single-mode optical fiber cable, 2009
EIA TIA/EIA-455-B	Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
ASTM B193	Standard Test Method for Resistivity of Electrical Conductor Materials

4 ORDER OF PRECEDENCE

In the event of a conflict between this document and the references cited herein, this document will take precedence. Nothing in this document, however, shall be interpreted as superseding application laws or regulations unless the CONTRACTOR obtains a specific exemption.

In the event that there are conflicts with items or information contained within these documents, the following order of precedence shall be used when interpreting the information of GOVERNMENT provided documentation and references:

- Performance specification
- Standards and reference documents

5 BID SUBMISSION

- 5.1 The cable design offered shall have a record of successful use and the CONTRACTOR shall provide a project history of the designs with their proposal.
- 5.2 The cable designs shall comply with this specification.
- 5.3 The bid submission shall include all information as stated in the Submittal List.

6 GENERAL REQUIREMENTS FOR CABLES

- 6.1 The cables shall be a central strength member design, with the Lightweight cable providing the core for the protected and armored cables as shown in Figure 1

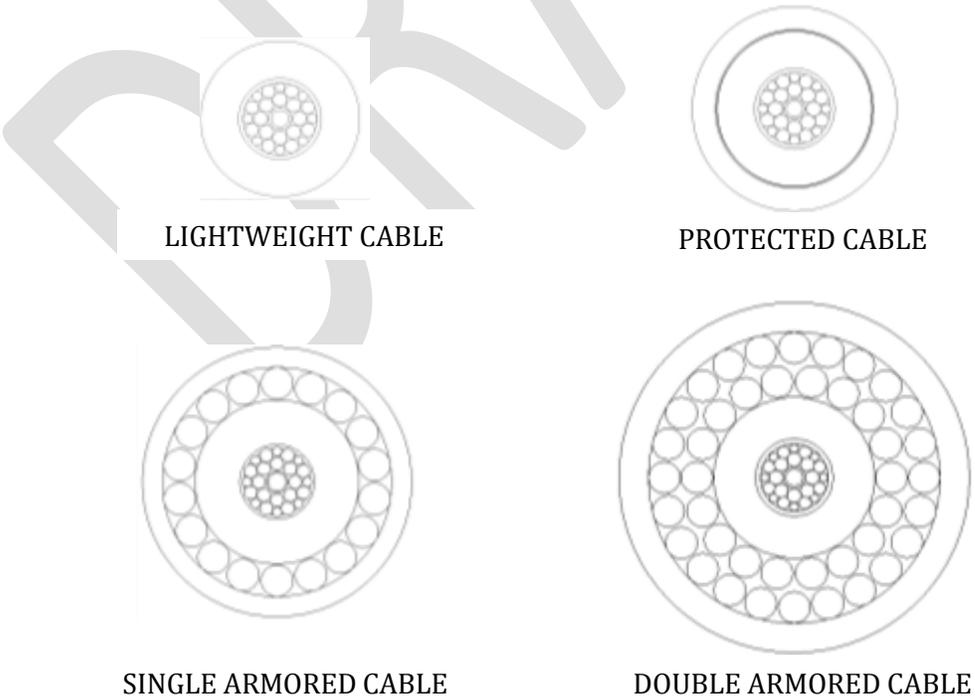


Figure 1. Center Strength Member Cable Types

- 6.2 Materials used in the manufacturing of the cables shall be new and free from defects, imperfections, or contamination which would adversely affect the cable performance or service life.
- 6.3 The cables shall be qualified by the Universal Jointing Consortium for use with the Universal Joint.
- 6.4 The cables shall be installable and recoverable from the ocean surface to the seafloor at the depths listed in Table 2 using standard telecommunication cable installation equipment (i.e. linear cable engine, cable drum, etc.)
- 6.5 Transitions between armored and LW or Protected cables shall be made during the armoring process, with the length of the transition being sufficient to avoid cable twist issues during deployment or recovery.
- 6.6 The armored cables shall be capable of being buried in the seabed using a conventional cable plow, jetting tools, or other trenching machines, and shall also be capable of being extracted from the seabed in a useable condition in the event of cable recovery
- 6.7 Fiber tube joints, fiber splices, insulation repairs, jacket repairs, steel tape repairs, armor wire welds, or factory joints are only permitted in the delivered cable length(s) if they are fully qualified.
- 6.8 The qualification documentation for all splices, repairs, and joints to be used for manufacture of the cables shall be provided to the GOVERNMENT for review.
- 6.9 The cables shall allow the use of industry standard stoppers such as pre-formed stoppers (e.g. PMI Stoppers), Chinese fingers (e.g. Kellems Grip), and Kevlar stoppers (e.g. Yale Grip) without damaging the cable. The recommended cable grips will be or have been tested and proven to not negatively impact the performance of the cable by the CONTRACTOR, and the qualification reports shall be provided to the GOVERNMENT.
- 6.10 The cables shall have a minimum bend diameter of no more than 3m when under tension.
- 6.11 The armored cables shall be capable of being pulled into an HDD bore for the shore landings

7 ELECTRICAL REQUIREMENTS

The electrical performance specified shall be met under all mechanical and environmental conditions detailed within this specification.

- 7.1 The maximum continuous operating voltage of the cable shall be + or – 10 kV
- 7.2 The cable shall be rated for a maximum continuous line current of 1.6 Amps dc
- 7.3 The power conductor resistance shall be ≤ 1 ohm/km when corrected to 20°C
- 7.4 The insulation resistance shall be > 10 G Ω -km at 1 kV
- 7.5 The cable shall withstand a surge voltage of 25 kV
- 7.6 The cables shall be capable of transmitting a low frequency AC toning signal to aid fault location during service.

8 OPTICAL REQUIREMENTS

The optical performance specified shall be met under all mechanical and environmental conditions detailed within this specification

- 8.1 The fiber tube shall be capable of containing up to 24 fibers.
- 8.2 The optical fibers shall conform to ITU-T G.652 D (i.e. Zero water peak – full spectrum fiber)
- 8.3 Each fiber shall be uniquely color coded in accordance with EIA/TIA-598. For high fiber counts ring marking in conjunction with the standard colors shall be implemented. The fiber colors and markings shall be approved by the Government prior to fiber procurement or manufacturing.
- 8.4 The optical attenuation shall not exceed 0.22 dB/km at 1550 nm.
- 8.5 The fibers shall be proof tested at 200 kpsi.
- 8.6 Any fiber splices within the cable shall be proof tested to 200 ksi.
- 8.7 The chromatic dispersion zero dispersion wavelength shall be between 1300 and 1324 nm
- 8.8 The chromatic dispersion zero dispersion slope shall be < 0.09 ps/nm²·km
- 8.9 The polarization mode dispersion (PMD) shall be < 0.2 ps/ $\sqrt{\text{km}}$

9 ENVIRONMENTAL REQUIREMENTS

- 9.1 The cable shall be designed to operate for 20-year life while constantly submerged in seawater.
- 9.2 The operating, storage, deployment and recovery temperature range for the cables shall be -20°C to 60°C
- 9.3 In the event of cable being severed in service, the water ingress rate shall be less than 250m / 2 weeks for depths < 1000 m depth and < 1 km / 2 weeks for depths > 1 km.
- 9.4 The optical attenuation increment from hydrogen induced aging shall be < 0.003 dB/km at 1550 nm over the system life.
- 9.5 The cable shall be designed to meet all of the performance requirements of this specification under an external hydrostatic pressure equivalent to the maximum water depths as listed in Table 2

Cable	Maximum Operational Depth (m)
LW	8000
Protected	6500
SA	1500
DA	800

10 CABLE CONSTRUCTION

10.1 Lightweight Cable

10.1.1 Fiber Tube

10.1.1.1 The fiber tube shall be capable of housing up to 24 fibers.

10.1.1.2 The fibers shall be housed within a polymer or metallic fiber tube

10.1.1.3 The free space within the tube shall be filled with a filling or buffer gel to act as a water blocking compound

10.1.2 Power Conductor

10.1.2.1 The fiber tube shall be contained within a stranded bridged wire nest structure to provide stability and hydrostatic pressure resistance.

10.1.2.2 The strand wire material shall be improved plow steel

- 10.1.2.3 The wires in the nest shall have a left hand lay.
- 10.1.2.4 A copper jacket shall be applied over the steel wires to maintain mechanical stability, provide the required electrical resistance, and provide a barrier to hydrogen ingress to the fibers.
- 10.1.2.5 The axial weld in the copper tube shall be subject to 'weld integrity checking' throughout the power conductor manufacturing process.
- 10.1.2.6 The interstices between the steel wires shall be water blocked to minimize water ingress should the cable be severed in service.
- 10.1.2.7 The interlayer adhesion between the copper jacket and steel wires shall prevent cable damage when transferring load from the cable during marine operations (e.g. cable stoppering).

10.1.3 Insulation

- 10.1.3.1 The power conductor shall be insulated with natural polyethylene.
- 10.1.3.2 The insulation shall be bonded to the copper jacket to ensure a high shear transfer rate across the interface between the copper and insulation to prevent cable damage when transferring load from the cable during marine operations (e.g. cable stoppering).
- 10.1.3.3 The insulation shall be subject to spark testing during the insulation extrusion process.
- 10.1.3.4 The insulation to power conductor concentricity shall be $> 90\%$
- 10.1.3.5 There shall be no voids within the insulation, or at the interface to the copper jacket of the power conductor.
- 10.1.3.6 The insulation diameter tolerance shall be $< 1\%$ of the nominal diameter of the insulation.

10.2 Protected Cable

- 10.2.1 The lightweight cable shall form the core of the Protected Cable.
- 10.2.2 A laminate steel tape (e.g. Zetabon tape) shall be formed around the lightweight core.
- 10.2.3 A black high density polyethylene shall be extruded over the laminate steel tape.
- 10.2.4 The jacket shall be subject to spark testing during the jacket extrusion process.

10.3 Armored Cables

- 10.3.1 The Lightweight cable shall form the core of the armored cables
- 10.3.2 The armor layers shall have a left hand lay
- 10.3.3 The armor layers shall be flooded with a slushing compound such as bitumen or natural asphalt to minimize corrosion of the wires during service.
- 10.3.4 The armor wire material shall be galvanized improved plow steel.
- 10.3.5 The outside of the armored cables shall be finished with two contra-laid servings impregnated with slushing compound.
- 10.3.6 At least 10 ends of the outer serving layer will be yellow to provide a visual stripe on the cable to aid ROV inspection/location.

10.4 Subsequent to final testing (defined in Section 13), the ends of the cables shall be sealed and fitted with a “rigid pull in head” to allow fitting of a swivel and shackle to facilitate pulling the cable during transfers and hauling the cable ashore. The maximum pulling force of the pull in head shall be at least equal to the designed maximum pulling force of the cable. The ends shall be prepared such that the fibers and conductor are connectorized using FC/UPC connectors and lug connectors compatible with a 3/8” bolt respectively. These shall be housed within the rigid pull head.

11 DESIGN DATA

11.1 CONTRACTOR shall provide with their Proposal, for GOVERNMENT review, the following physical parameters for the cables:

- 11.1.1 Cable diameter
- 11.1.2 Hydrodynamic constant
- 11.1.3 Weights in air and water
- 11.1.4 International standards applied for each cable element and raw materials
- 11.1.5 Dimensioned cross section drawings, including lay lengths or lay angles
- 11.1.6 Technical description of ‘Rigid Pull-in Heads’

11.2 CONTRACTOR shall furnish with their Proposal, for GOVERNMENT review, the following mechanical performance parameters for the CABLE:

- 11.2.1 Tensile strength
- 11.2.2 Maximum allowable cable tension during installation with justification for limit
- 11.2.3 Maximum residual tension for service life with justification for limit
- 11.2.4 Cyclic load / fatigue performance
- 11.2.5 Minimum bend radius under load and at zero tension
- 11.2.6 Maximum side wall pressure during installation
- 11.2.7 Maximum allowable crush loading with justification for limit
- 11.2.8 Maximum allowable impact
- 11.2.9 Maximum and minimum ambient temperatures for storage and operation
- 11.2.10 Torque vs. load and twist vs. load characteristics
- 11.2.11 Tensile and flexural stiffness's

12 QUALITY ASSURANCE

12.1 General Requirements

- 12.1.1 The CONTRACTOR shall maintain a Quality Assurance program in accordance with ISO 9001 and ISO 14000/14001
- 12.1.2 The CONTRACTOR shall be capable of testing the cable as required by this specification.
- 12.1.3 All testing and inspection equipment shall have valid calibration certificates, which are traceable to national standards, and will be made available for review and comment by the GOVERNMENT.

12.2 Responsibility for Inspection

- 12.2.1 The CONTRACTOR is responsible for the performing all inspection tests required to demonstrate that the cables meet the intent of this specification (as defined in section 13).
- 12.2.2 The GOVERNMENT, or their designated representative, shall have access rights to witness or audit the relevant manufacturing, inspection, and testing activities at the CONTRACTOR and Sub-contractor facilities.

- 12.2.3 The CONTRACTOR shall not begin assembly and testing activities prior to receiving authorization from the GOVERNMENT, or their designated representative.
- 12.2.4 The GOVERNMENT, or their designated representative, shall have access to and receive copies of all QC documentation.
- 12.2.5 The GOVERNMENT, or their designated representative, shall have access rights to perform final inspection of the cable, and any other contract deliverables.
- 12.2.6 The CONTRACTOR shall not ship cable without receiving authorization from the GOVERNMENT, or their designated representative.

12.3 Inspection & Test Plan

- 12.3.1 The CONTRACTOR shall propose a comprehensive inspection and test plan (ITP), and a test matrix document for all cables.
- 12.3.2 The GOVERNMENT shall review the preliminary inspection matrix and provide comment to specify which activities shall be designated as review, monitor, witness, hold, etc.

13 ACCEPTANCE TESTING

13.1 General

- 13.1.1 All test procedures shall be submitted to the GOVERNMENT for review and approval with the proposal submission.
- 13.1.2 The GOVERNMENT or their representative shall be given at least 4 weeks' notice prior to the final acceptance testing being conducted.
- 13.1.3 The CONTRACTOR shall submit certified reports for all acceptance tests for GOVERNMENT review and approval.
- 13.1.4 The overall responsibility for the cable inspection rests solely with the CONTRACTOR. However, the GOVERNMENT, or their representative, reserves the right to inspect the deliverables at any time during manufacture, transportation, or installation, to ensure that materials and workmanship are in accordance with the requirements of this specification, the Project Data Sheet, Project Drawings, the applicable codes and other associated standards. GOVERNMENT shall have the right to observe and review the operation of the inspection system at any time during the contract.

- 13.1.5 GOVERNMENT shall have access to all inspection/test data and material purchasing documents generated by the CONTRACTOR regarding this cable.
- 13.1.6 Acceptance of factory tests shall not constitute a waiver of meeting a requirement, nor shall inspection relieve the CONTRACTOR of his responsibilities in any way whatsoever.
- 13.1.7 The CONTRACTOR shall furnish at their expense all spares and consumables for the testing of the cables. Rectifying any defects revealed by such tests shall be at the CONTRACTOR'S expense.
- 13.1.8 The CONTRACTOR shall perform the verifications (as defined in Section 13.2) prior to GOVERNMENT Acceptance.
- 13.1.9 All production verifications shall be performed at room temperature of $22^{\circ}\pm 5^{\circ}\text{C}$.

13.2 Final Verification Tests

- 13.2.1 As a minimum, the following tests for the cables shall be included in the test program:
 - 13.2.1.1 Bi-directional OTDR testing at 1550 and 1310 nm. Traces shall be saved in electronic form for later viewing or analysis
 - 13.2.1.2 Location and the magnitude of optical splice attenuation, and a record of the optical length for each fiber. Other than fiber splices, there shall be no point losses > 0.1 dB at any point along any fiber.
 - 13.2.1.3 Polarization mode dispersion (certified data provided by fiber manufacturer can be used).
 - 13.2.1.4 Chromatic dispersion (certified data provided by fiber manufacturer can be used).
 - 13.2.1.5 Inspection of end samples for diameter conformance and correct location of strand wires.
 - 13.2.1.6 Copper to steel adhesion measurement on end samples taken from completed the cables.
 - 13.2.1.7 The outer diameter of the armored cables shall be measured at four locations spaced not less than 1 meter apart at both cable ends.

- 13.2.1.8 The dc conductor resistance per unit length of each cable length shall be measured, recorded, and corrected to 20°C. Before measurement, the cable shall have been thermally stabilized with the surrounding environment for a minimum of 4-hours.
- 13.2.1.9 Each cable length shall be subjected to a 50 kV high voltage test applied between the center conductor and an external wet ground for a period of 5 minutes.
- 13.2.1.10 The CONTRACTOR shall submit a Production Verification Report.

14 DOCUMENTATION

14.1 General

- 14.1.1 CONTRACTOR shall provide documentation to validate the cable design, qualification, QA/QC, project management, manufacturing, operations and maintenance, and production testing.
- 14.1.2 Documentation shall be provided by CONTRACTOR at the beginning and end of each stage of contract/project execution as detailed in the following sections
- 14.1.3 Where documentation is proprietary to CONTRACTOR, they shall make documentation available for GOVERNMENT review and comment. If necessary, at CONTRACTOR'S office most convenient to GOVERNMENT or GOVERNMENT'S designated representative. Any such documentation shall be identified in the proposal.

14.2 Documentation after Contract Issuance

- 14.2.1 Documentation for a project, contract, or order shall be initiated at beginning of project and developed iteratively through the course of project, including progress reports on a periodic basis.

14.3 Quality Assurance and Quality Control Documentation

- 14.3.1 CONTRACTOR shall provide Manufacturing Quality Plan: Identifies each part of every assembly, reference documents defining manufacturing processes, inspection procedures and acceptance criteria, and GOVERNMENT representatives who will monitor and verify that work conforms to GOVERNMENT technical requirements.

14.3.2 CONTRACTOR shall provide Inspection and Test Plan (ITP) details and quality requirements applicable to cables assemblies or subassemblies, while identifying activities that require GOVERNMENT QA participation for review, hold, monitor, or witness points.

14.4 Project Management Documentation

14.4.1 CONTRACTOR shall provide the following project management documentation on a monthly basis, to report progress against planned schedule through the engineering, manufacturing, and shipment phases of project, in compliance with GOVERNMENT supplied documents

14.4.1.1 Master Document Register (MDR): List of all documents with document format, planned date for completion, and restrictions on reviewing. Register shall be updated on a periodic basis, to be defined after contract award, with status, new listings, and actual completion dates.

14.4.1.2 Master Project Schedule: Progress report covering (as necessary) engineering and development, design review schedule, qualification testing, material procurement, manufacturing, assembly and testing.

14.5 Manufacturing Documentation

14.5.1 CONTRACTOR shall make the following manufacturing documents available for GOVERNMENT review and comment, either by providing documents for review or by making documents available for review at CONTRACTOR'S office as agreed in master document register:

14.5.1.1 Manufacturing procedure specifications, including material specifications

14.5.1.2 Material test reports

14.5.1.3 Dimensional inspection logs and nondestructive test reports

14.5.1.4 Equipment and process qualification test reports

14.5.1.5 Release certificates for cables prior to integration

14.5.1.6 Non-Conformance Report (NCR) log

14.5.1.7 Root cause analysis reports in response to GOVERNMENT initiated Corrective Action Request (CAR), as applicable

15 FINAL DOCUMENTATION

15.1 General

Final documentation shall be provided, as specified in the following sections, for preliminary review prior to shipment of the cables.

15.2 Engineering Documentation

15.2.1 Engineering data book shall be provided, which shall include but not be limited to the following:

15.2.1.1 Summary reports for product verification work, including design, analysis, and qualification testing activities.

15.2.1.2 Summary reports for material qualification testing.

15.2.1.3 Summary reports for reliability engineering activities as applicable.

15.2.1.4 Recommended integrity management criteria including but not limited to inspection points, inspection frequency, condition monitoring requirements, and analytical requirements.

15.3 Operation and Maintenance Manuals

15.3.1 Operation and Maintenance (O&M) manuals shall be provided that cover installation, commissioning, operation, maintenance, and retrieval activities.

15.3.2 Final O&M manuals shall be provided to GOVERNMENT for review and comment prior to shipment of any cable.

15.3.3 O&M manuals shall be in hard copy and electronic format, including three hard copies in a loose-leaf three-ring binder and three electronic copies on compact disc/digital video disc (CD/DVD) unless otherwise specified.

15.3.4 The following documentation shall be included in the O&M manuals:

15.3.4.1 Procedures for handling, shipment, preservation, and storage (short and long term)

15.3.4.2 Procedures for shore-based and offshore testing, and on-deck testing prior to installation

15.3.4.3 Installation, jointing, repair, subsea testing, and retrieval procedures

15.4 Manufacturing Data Book

15.4.1 Prior to shipment, CONTRACTOR shall compile and submit in electronic format manufacturing data book for GOVERNMENT review and comment.

15.4.2 Manufacturing data book shall include the following:

15.4.2.1 Inspection and test plans

15.4.2.2 Material test reports

15.4.2.3 Nondestructive examination/nondestructive testing reports

15.4.2.4 Dimensional inspection and critical dimension logs

15.4.2.5 Release certificates for assembly and test.

15.4.2.6 Relevant NCRs with dispositions and applicable waivers

15.4.2.7 Root cause analysis reports in response to GOVERNMENT-initiated CARs.

15.4.2.8 FAT reports with original test charts as applicable

15.4.2.9 A copy of the certificates of conformance

15.5 Document Retention

15.5.1 CONTRACTOR shall retain product verification documentation (engineering and testing) and final documentation within CONTRACTOR'S document control system (electronic storage) for a minimum period of 20 years, unless specified otherwise.

15.5.2 CONTRACTOR shall provide paper copies or electronic copies of final documentation at GOVERNMENT request.

15.5.3 CONTRACTOR shall make product verification documentation and other detailed engineering and manufacturing records available for review at CONTRACTOR'S office at GOVERNMENT request.

16 SUPPLY REQUIREMENTS

- 16.1 The straight line diagram of the cable system with the associated cable types and nominal lengths are shown in Appendix A. NOTE: The marine survey will be completed by May 2015, at which time the GOVERNMENT may revise the cable lengths and armor schedule up to a maximum of +/- 10%. Any changes to the cable length or armor schedule within +/-10% by 30 June 2015, shall be at the agreed upon per kilometer price.
- 16.2 The completed cable sections shall be capable of loading onto a cable ship. The CONTRACTOR shall provide a loading cost with their proposal.
- 16.3 The length of the cable sections shall have a length tolerance of -0/+2 %.
- 16.4 Adhesive marker bands shall be applied to the cable at 2 km intervals and shall bear the running kilometer mark from the start of the cable section.
- 16.5 Joint and repeater housings shall be signaled on each side of the housing by applying adhesive warning marker bands to the cable with the following schedule:

- 4 markers at 10 m from housing
- 3 markers at 50 m from housing
- 2 markers at 100 m form housing
- 1 marker at 500 m from housing

17 COST PROPOSAL

The CONTRACTOR shall provide a cost estimate for the following cables, Universal Joints (or equivalent), and services, in Tables 3 and 4, according to the Specifications in Sections 1.0 through 16.0, and the SLD provided in Appendix A. The costs shall be inclusive of all planned joints (factory or UJ), cable transitions, and testing, but exclusive of all UJs required for the system installation and for spares, as described in Table 4.

18 CONTRACTING OPTION 1 – SPARE UJ SPLICE KITS

The Government may be required to purchase additional universal joint splice kits in order repair the SHDAS trunk cable once deployed on the ocean bottom. Table 4 specifies the potential spare UJ kits required in rows 1, 2, 3, and 4.

Table 3 – Cost Proposal								
ID	Item Description	SA	DA	SA	Protected	LW	Total Length	SubTotal Cost
1	Unit cost/km	\$ -	\$ -	\$ -	\$ -	\$ -		
2	String 1 - Cable Length km	0.825	4.000	9.500	75.000	72.652	161.977	\$ -
3	String 2 - Cable Length km	0.825	4.000	9.500	75.000	73.712	163.037	\$ -
4	String 3 - Cable Length km	0.825	4.000	9.500	69.000	67.958	151.283	\$ -
5	String 4 - Cable Length km	0.825	4.000	9.500	63.000	62.941	140.266	\$ -
6	String 5 - Cable Length km	0.825	4.000	9.500	68.000	67.429	149.754	\$ -
7	String 6 - Cable Length km	0.825	4.000	9.500	79.000	78.852	172.177	\$ -
8	Spare Cable	-	4.000	15.000	39.000	-	58.000	\$ -
9	Total Cable Length (km)	4.950	28.000	72.000	468.000	423.544	996.494	
10	Cable loading ,including all personnel and equipment required to transfer all of the system and spare cable from the suppliers storage facility onto a on standard commercial Telecom Vessel.							\$ -
11	Total							\$ -

Table 4 – Universal Joint (Or Equivalent) Cost Proposal (EXCLUSIVE of all planned joints (factory or UJ), cable transitions, and testing)				
ID	Item Description	Quantity	Unit Cost	SubTotal Cost
1	Universal Joints	17mm LW Cable to 17mm LW Cable, 24 fibers (spare option)	5 Complete Kits	\$
2	Universal Joints	17mm protected Cable to 17mm protected Cable, 24 fibers (spare option)	5 Complete Kits	\$
3	Universal Joints	17mm SA Cable to 17mm SA Cable, 24 fibers (spare option)	2 Complete Kits	\$
4	Universal Joints	17mm DA Cable to 17mm DA Cable, 24 fibers (spare option)	2 Complete Kits	\$
5	Universal Joints	17mm LW Cable to TE Subcom SL 21mm LW Cable, 24 fibers (initial spare)	6 Complete Kits	\$
6	Universal Joints	TE Subcom SL 21mm LW Cable to TE Subcom SL 21mm LW Cable, 24 fibers (initial spare)	2 Complete Kits	\$
7	Universal Joint	Miscellaneous Consumables recommended by supplier		\$
7	Total Estimated Cost for Universal Joints			\$

APPENDIX A - Project Straight-Line-Diagram

SHDAS Straigh-Line-Diagram

Date: 13-Nov-14

Cable Summary (km)			
Type	SLDs	Spare	Total
DA	24,000	4,000	28,000
SA	61,950	15,000	76,950
Protected	429,000	39,000	468,000
LW	423,544	0,000	423,544
Total	938,494	58,000	996,494

