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Precision Electro-Optomechanical Cable Assembly for a Towed Array

EOM Project Includes New Deep Submergence Hybrid Connector Pair

By Amy Brown • Michael Einhorn • Carl Stevens

Electro-optical (EO) cable terminations provide the advantage of combining a variety of sophisticated capabilities into a single subsea connection. These custom cable assemblies must simultaneously pass power and data and withstand extreme environmental and performance requirements, while preserving the integrity of delicate optical fibers. Among the most challenging EO assemblies are those that also require mechanical termination for a tow cable to a towed body, i.e., electro-optomechanical (EOM) terminations. These applications demand a termination strong enough to bear all towing and handling loads and still be able to perform reliably over time in the extremes of the marine environment.

(Left) Strength member's armored wires meticulously bent around the mechanical insert to optimize mechanical load-bearing capabilities.

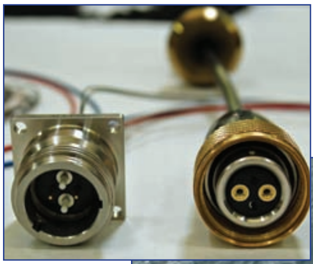
(Right) BIRNS ETA-I certified photonics technician terminates the assembly, applying epoxy on each optical ferrule to secure the optical fiber in place.

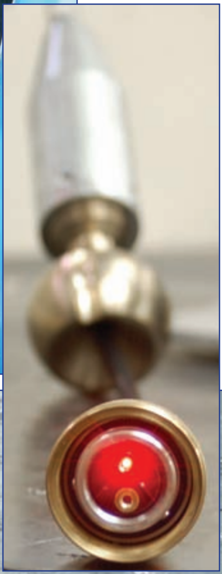
EOM Assembly Requirements

In 2012, BIRNS Inc. (Oxnard, California) was asked to develop a unique EOM cable assembly for the tow cable of a high-performance passive towed array, Northeastern University's (NU) Ocean Acoustic Waveguide Remote Sensing (OAWRS) receiver system. The OAWRS receiver project was initiated in 2009 when a team of NU scientists and engineers from the commercial sector commenced developing the receiver array suite as a lightweight acoustic system for rapid, wide-area monitoring and measurement of the ocean environment. The system was tailored as a general purpose, mobile, remote-sensing tool to study marine life, oceanography, geologic and geophysical properties of the ocean environment, as well as anthropogenic noise in the ocean and its effect on marine life.

Einhorn Engineering PLLC (Seattle, Washington) was selected to provide the mechanical engineering services required to design and oversee fabrication of the handling system. This included specification of a custom tow cable and wet side junction box subassembly. The OAWRS system's EOM tow cable consisted of two single-mode fibers, four power conductors and a rotation-resistant, over-armor package. The specialized mechanical and electrical terminations required for the project presented unique technical challenges, as the wet side junction box design required very tight length tolerances for the hybrid electro-optical connector termination. In response, BIRNS created a fabrication plan to address proper installation of the existing ball-and-socket mechanical termination, as well as termination and over molding of the EO connector, while maintaining the demanding finished-assembly tolerances. Additionally, BIRNS developed a new deep submergence hybrid BIRNS Millennium 3O-2F2-FR (flanged receptacle) and mating CP (cable plug) connector pair, incorporating two single-mode optical fibers and two 16-AWG electrical pins. The connector pair has a 6-kilometer depth rating.

As in any EOM assembly, it is critical to create the system so that the viability and performance of both the electrical and optical conductors are ensured. Since the OAWRS array was to be operated at depths of 200 meters for weeks at a time, a particularly robust solution was necessary. The mechanical termination had to provide defense for the delicate conductors of power and information as they transited from





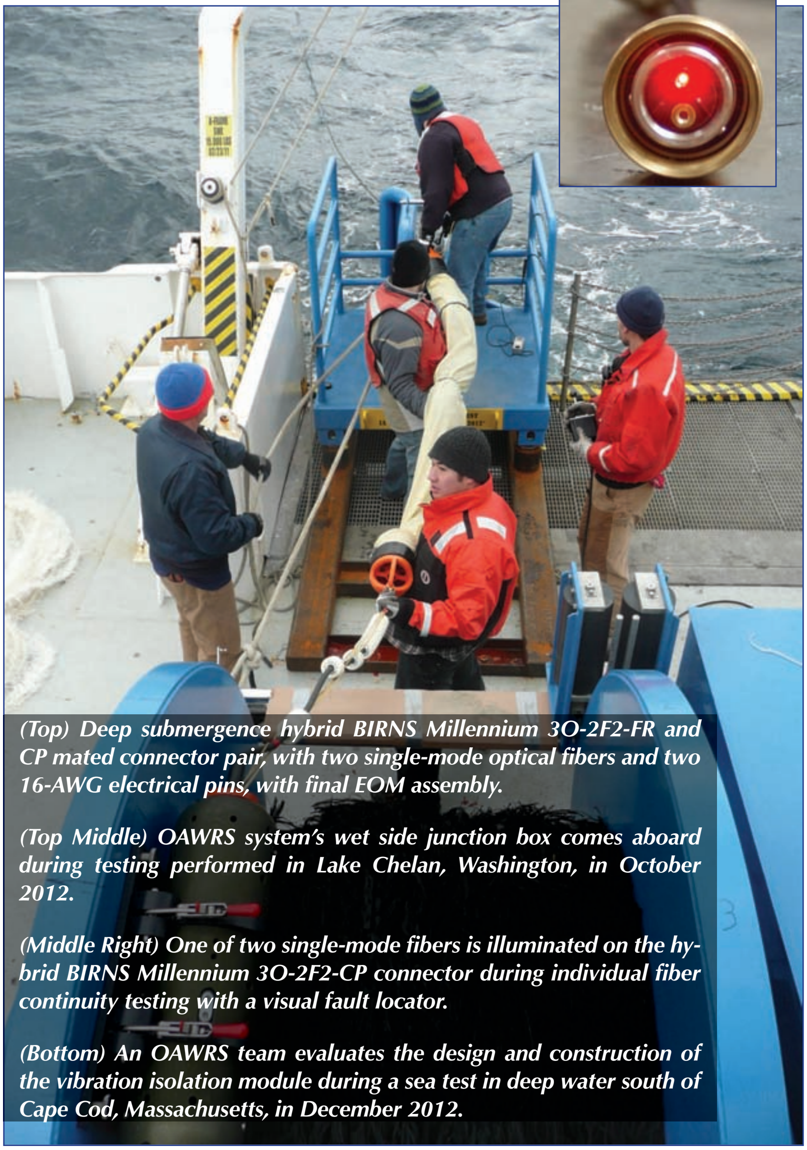
the protection of the armored strength members to the connection point on the wet side junction box. One challenge with the OAWRS design was the very tight tolerance on the subcable terminated length, which was only 12 inches (+/- .25 inches). The design dictated a severe space constraint between the ball joint of the mechanical termination and the connector due to the small package size (26 inches long by 8 inches diameter) and the location of the pressure vessel (9.44 inches long by 7.50 inches diameter) within the housing, which required finesse and precision during the complex termination process.

The OAWRS system was to be applied in both standalone, passive sensing applications, as well as paired with the OAWRS Source Array in active sensing deployments. The receiver array equipment suite included the synchronized hydrophone array, which allowed for high-resolution directional sensing over wide areas and a handling system designed to be quickly mobilized on a vessel of opportunity. Therefore, the system called for one single-mode fiber to transmit the array data with a second, backup fiber. The connector design was finalized with the inclusion of two optical fibers to allow for seamless transition to the backup and two 16 AWG electrical power conductors. The connector development process began with terminating the single-mode optical fibers for the FR used in the wet side junction box, as there was no overmolding or mechanical termination needed for the FR. The FR was fully assembled and terminated inboard with 16 inches of stranded copper wire and optical fiber with FC/PC connectors installed. Once the optical and electrical terminations were done, the FR could then be tested and set aside until the rest of the assembly was complete.

Assembly Development

Stress in a cable assembly can become concentrated where the load path changes, as is the case with the ball-and-socket joint used on this project, and is therefore the location where the most care must be taken to smooth out those changes. The termination allowed the cable strength elements and core to exit in a straight line, and BIRNS's technicians worked to effect a gradual, continuous transition from the strength wires to the socket area, keeping the EO wires and fibers in a uniform arrangement. The cable's strength member was carefully spread and shaped to maximize its surface area.

The initial mechanical termination included meticulously bending the strength member's armored wires around the mechanical insert to optimize mechanical load-bearing capabilities. Once the mechanical insert chock was prepared and the cable core complete, the technicians could determine the relative length needed for the corresponding fibers. The mechanical termination was fully complete at this point except for its final chemical adhesive potting, which would come after the optical and elec-



(Top) Deep submergence hybrid BIRNS Millennium 3O-2F2-FR and CP mated connector pair, with two single-mode optical fibers and two 16-AWG electrical pins, with final EOM assembly.

(Top Middle) OAWRS system's wet side junction box comes aboard during testing performed in Lake Chelan, Washington, in October 2012.

(Middle Right) One of two single-mode fibers is illuminated on the hybrid BIRNS Millennium 3O-2F2-CP connector during individual fiber continuity testing with a visual fault locator.

(Bottom) An OAWRS team evaluates the design and construction of the vibration isolation module during a sea test in deep water south of Cape Cod, Massachusetts, in December 2012.

Einhorn Engineering's team measures potential tow cable loading during the December 2012 Atlantic Ocean mechanical sea trial of OAWRS system. (Photo Credit: Mike Einhorn, Einhorn Engineering PLLC)

trical termination, overmolding and testing.

An ETA-I certified technician optically terminated the assembly, applying epoxy on each optical ferrule to secure the fiber in place and then carefully polishing each ferrule to maximize the connection for precision mating. Each fiber had a 9-micron core that had to be precisely aligned to avoid even the smallest of gaps as large optical losses could negatively impact the performance of the OAWRS system and its readings. The BIRNS Millennium connector in this system had typical loss measurements of -0.2 decibels.

Electrical termination was then performed by BIRNS technicians certified to both J-STD-001 Class 3 and WHMA-A-620-A Class 3. Since the design called for two 16 AWG pins to carry 300 VDC to the array, precision was required for the termination of each conductor on the connector face. Each solder pot was insulated with glass reinforced epoxy (GRE) part way up the shaft to eliminate electrical interference between circuits. After wire termination, heat-shrink tubing was used to cover the entire conductive area ensuring a completely insulated termination.

The connector overmolding, which followed, was a two-step process and took place in BIRNS's NAVSEA PRO-020 certified molding facility. The first was an inner layer of a potting compound to provide mechanical stability, protect against pressure and avoid microbending or shifting of the delicate optical fibers. All cable can be damaged by even one bend under load across a radius that is too small, but electro-optical cable is particularly susceptible to such bending. Where an electromechanical cable can be weakened by a short radius bend, the same bend can break the optical fibers in an electro-optomechanical cable. The second step was an outer layer of protective polyurethane overmolding.

Testing, Conclusion

Once the overmolding process was complete, comprehensive system testing was performed: electrical testing, including insulation resistance (IR) and continuity tests, per MIL-STD-1344, along with optical testing per ANSI/TIA/EIA-455. After successfully passing all requisite tests, it was time to complete the remaining step of the mechanical termination. This final, irreversible step involved casting or potting the inside body of the mechanical termination with two-part thermosetting epoxy resin.

The completed assembly was a robust EOM termination anticipated to have a long service life. Initial acoustic characterization of the hydrophone array was completed in May 2013. This followed an October 2012 mechanical shakedown in Lake Chelan, Washington, and a December 2012 integration test on the RV *Cape Hatteras* in deep water south of Cape Cod, Massachusetts. ■

Amy Brown is the director of corporate communications for BIRNS Inc. and is responsible for developing and managing a comprehensive set of strategic external marketing, media relations and internal communications programs. She has held marketing leadership roles for companies in the marine electronics industry since 2004.

Michael Einhorn worked as a mechanical engineer for the Naval Civil Engineering Laboratory and Naval Facilities Engineering Service Center (NFESC) before starting Einhorn Engineering PLLC in 2008.

Carl Stevens, a civil engineer, worked at NCEL and NFESC and has been with Einhorn Engineering since its founding. Einhorn Engineering has consistently been involved in ocean engineering research and development projects, with an emphasis on marine launch and recovery systems for both vehicles and towed arrays.