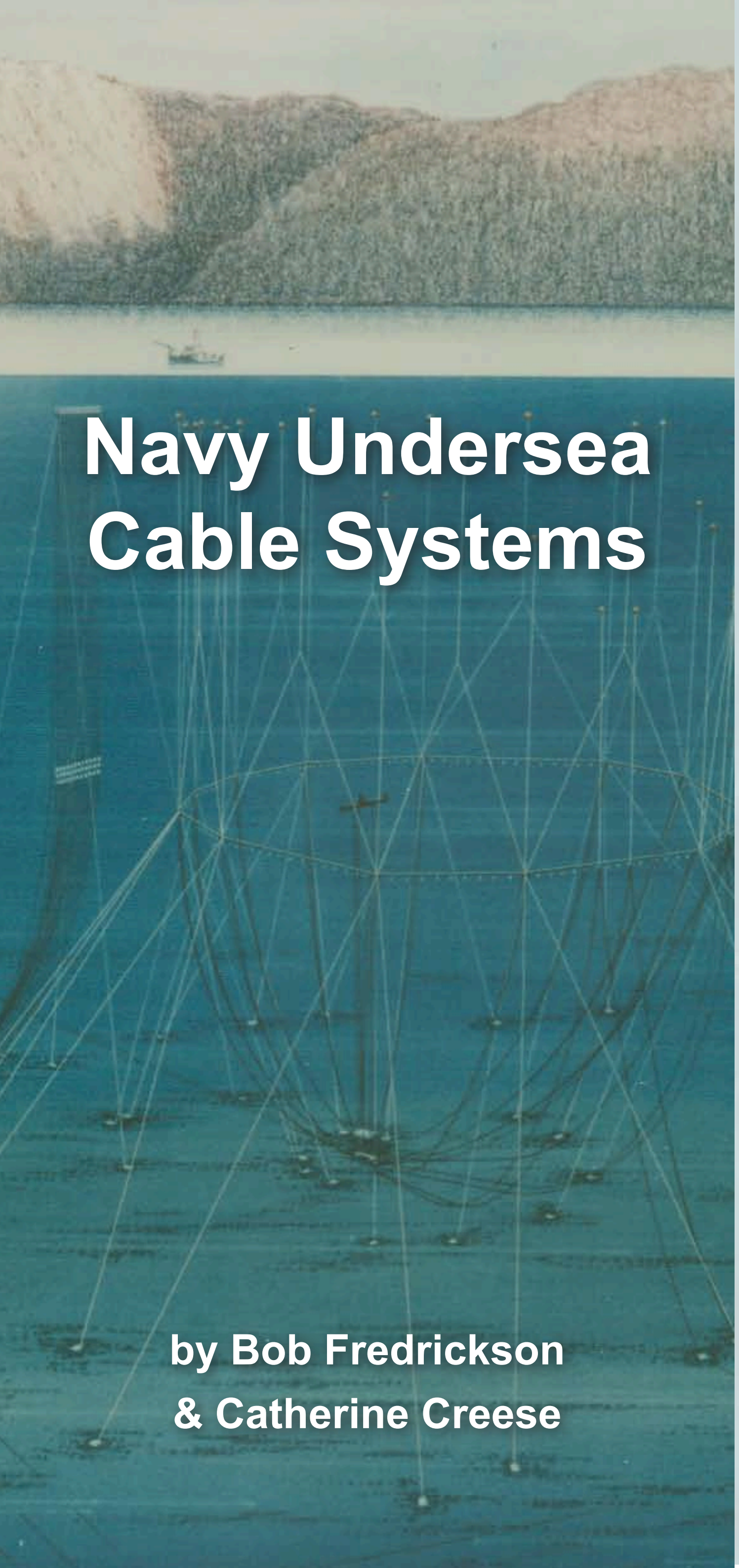

Navy Undersea Cable Systems

by Bob Fredrickson & Catherine Creese

Introduction

The U.S. Navy uses underwater cables in a wide variety of systems, not only for subsea communication and power transmission, but also for precise placement and orientation of acoustic sensors suspended high above the seafloor. Every situation has different design parameters determined by project purpose, location and materials. Each of these unique projects presents its own challenge to the Naval Facilities Engineering Service Center (NAVFAC ESC), the Navy's shore and ocean facility technical center. In this article we describe a sample of the design issues considered in Navy cable projects, and some solutions that the Ocean Facilities Department of NAVFAC ESC devised to resolve them. *The views expressed here are solely the authors' and do not necessarily reflect the policy of the U.S. Department of Defense (DoD), the U.S. Navy, or its components.*

Naval Facilities Engineering Service Center

Because of the importance of these underwater cable systems and the cost to install, maintain and repair them, the Navy's planning and engineering efforts are significant. The NAVFAC ESC, headquartered in Port Hueneme, California, is tasked to provide worldwide support for the Navy's shore, ocean and waterfront facilities. Within NAVFAC ESC, the Ocean Facilities Department provides a wide range of marine services. It is responsible for developing the Navy's capabilities in the design, construction, maintenance, and repair of fixed ocean facilities, focusing on:

* Seafloor Engineering
* Anchor Systems
* Ocean Structures
* Ocean Construction
* Underwater Cable Facilities
* Mooring Facilities
* Magnetic Silencing Facilities
* Underwater Inspection
* Shore Based Hyperbaric Facilities

Examples of Navy Cable Systems and their Challenges

Design and Installation of a Complex Suspended Array System[1]

The Intermediate Scale Measurement System (ISMS), situated in Lake Pend Oreille, Idaho, is a major test facility that provides high quality measurements of the structural acoustic response of submarine models. The data guides the Navy's development of the next generation of submarines to make them more stealthy and affordable. ISMS (Figure 1) is comprised of a complex system of acoustic arrays suspended in 1200 feet of water. A network of underwater electrical and fiber optic cables connect these arrays to shore approximately 2.5 miles away. One quarterscale buoyant submarine models are hauled down into the center of the array to conduct testing and to collect data. The cable support structures that make up the array system encompass an area the size of a football stadium.

1 R. Zueck, R. Brackett, A. Smith, D. Shields, *Construction of a Large Underwater Acoustic Array*, Offshore Technology Conference, 1996

Installation of the ISMS proved to be extremely challenging and ultimately drove the design of the structure. Numerical modeling and simulation played a vital role in verifying and optimizing the installation procedures. The relative placement of more than 150 sensors within the array required precise positioning in order to meet system performance criteria. To achieve this precise positioning, the array was assembled underwater, one component at a time, without the use of deepwater divers. The installation effort required a technically advanced positioning system, a specially- built project barge and unique deployment methods, including the simultaneous use of a pair of ROVs. In addition, the installation and replacement procedures were designed to be similar to allow for reliable maintenance of the system components.

This incredibly complex cable structure was installed by NAVFAC ESC in the fall of 1993 and spring of 1994. The installation work was completed on schedule and significantly under budget. Although this project was completed over a decade ago, it is still operating successfully. It is an excellent example of how careful planning and the use of numerical modeling and simulation can be used to reduce risk and to successfully construct highly complicated underwater cable systems.

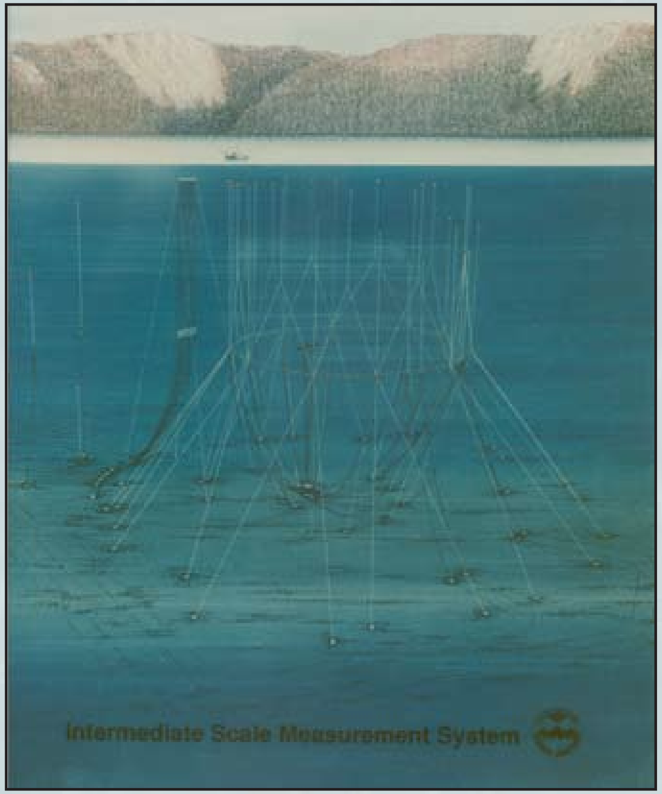

Figure 1 ISMS array configuration

Pulling Three Armored Cables through a Single 4,000 Foot Bore[2]

San Nicolas Island is owned and operated by the Navy as a major element of the Point Mugu Sea Range. Located approximately 65 miles southwest of Point Mugu, California, the island is extensively instrumented with tracking radars, electro-optical devices, telemetry, and communications equipment necessary to support U.S. fleet training and weapons testing.

2 S. Black, B. Cable, R. Fredrickson, D. Warren; *Horizontal Directional Drilling of a Cable Shore Landing at San Nicolas Island, California*; Oceans 2004 Conference.

Two sub-sea fiber optic cables known as the Fiber Optic Communication Underwater System (FOCUS) cables transmit communications and test data between the island and Point Mugu on the mainland. Due to a history of cable failures in the near shore environment, NAVFAC ESC implemented repairs to the existing FOCUS cables on the island in June 2004. The much needed repairs included the horizontal directional drilling of 4000 feet of new seashore interface conduit and the installation of three new fiber-optic cable segments. Two of the new shore ends were spliced into the existing FOCUS cables offshore while the third cable was reserved as a spare.

A unique aspect of the project was a decision to drill a single sub-sea conduit and to install all three single armor cables within it. This decision was driven by a combination of logistical, environmental and financial factors. First, the horizontal drilling process requires a significant volume of fresh water and San Nicolas Island has a very limited water supply (in fact, NAVFAC barged an additional 100,000 gallons of water to the island in order to complete the drill). In addition, San Nicolas is a very ecologically sensitive island and is home to several endangered plant and animal species. Drilling only one bore reduced the environmental footprint of the project and also the amount of time spent on the island performing the construction. Lastly, the cost of drilling only one horizontal bore and having only one cable pull operation is significantly less expensive than drilling three separate bores and pulling three cables independently. Based on these factors, it was decided to accept the increased risk of pulling all three cables simultaneously.

The challenge was to accurately predict the cable pulling tensions involved with the installation of three SL21 single armor cables (each approximately 3.5 cm in diameter) into a single 14.6 cm inside diameter conduit. This calculation was critical to ensure that the cables could be pulled through the sub-sea bore/conduit without becoming stuck or damaged. A failure would have been catastrophic to the project and would have jeopardized operation of the strategically important San Nicolas Island range activities. The cables were simultaneously deployed from the installation vessel offshore then carefully pulled through the sub-sea conduit to the beach. Throughout the pull, measured tensions were very close to those calculated and the cable installation was completed as planned.

Design and Installation of a Deep Water Suspended Array System[3]

The South Tongue of the Ocean Acoustic Measurement Facility (STAFAC) is currently under development and will be the U.S. Navy's first east coast subsurface moored acoustic signature measurement facility. STAFAC will measure and characterize the acoustic signatures of subsea moving targets. The challenge for STAFAC is to moor the the dual acoustic array system in 4500 feet of water at a remote site approximately 70 miles from shore.

3 W. Bartel, M. Greise, *Design of a Subsurface Moored Acoustic Array in Deep Water*, Oceans 2007 Conference

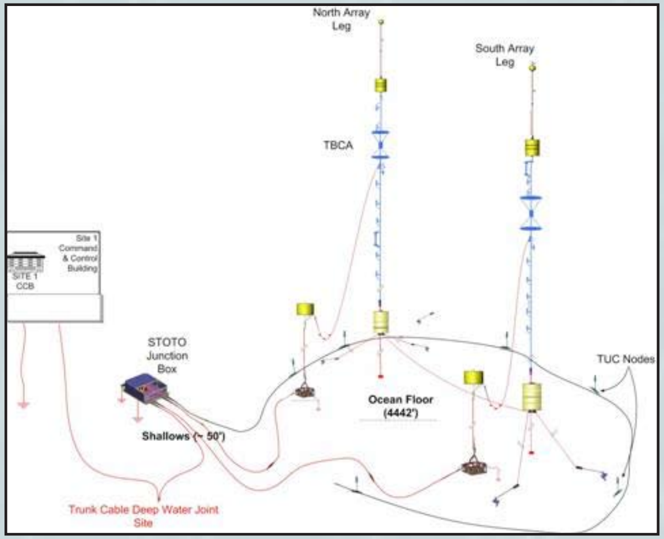

Figure 2 STAFAC array configuration

As shown in Figure 2, the "goal post" array configuration will be buoyed above a subsurface mooring system and must provide the stability required for safe navigation, accurate tracking, sensor orientation and stability to meet measurement accuracy requirements. A unique feature of the mooring is to allow periodic servicing of the array sensors by use of a sliding counterweight cable mechanism which alleviates the need to recover the main mooring legs. Relative positioning of the dual arrays bottom mooring components at this depth requires a very unique mooring configuration design and a well- designed deployment plan. As with ISMS, numerical modeling and simulation played a vital role in the design and installation planning of the system. The STAFAC system is currently scheduled to be installed in April and May 2008.

Development of a Standardized Undersea Distributed Network System[4]

NAVFAC ESC recently awarded Phase II of a three phase contract to Ocean Design, Inc. (ODI) to develop a standardized undersea module known as the Gateway system. The design goal of Gateway is to use existing commercial offtheshelf parts in an innovative way to make a basic set of standardized undersea modules. Gateway is capable of being assembled into an infrastructure that will support a variety of oceanographic sensors and allow them to be deployed over a wide variety of ocean floor characteristics. The system is designed to handle at least 95% of the sensors available today including those for oceanographic and climatological monitoring, power transmission, communication, port security and defense purposes.

Gateway uses a standard 10 kV DC power supply to power undersea telecommunications cables. This allows those who are deploying sensors to either install new cable or to retrofit decommissioned communications cables. The three subsystem modules are a hub Node, a sensor node and a shore station, and their key components are the cables, connectors and sensors. The deployment topology is trunk and branch, with trunk lengths of more than 2000 km. This type of configuration will be capable of providing power and communications infrastructure for as many as 121 individual sensors. Another unique feature is that the modules will be

4 R. Bennett, S. Evangelides, J. Morreale, D. Symonds, J. Henson, J. Wilson, *Undersea Distributed Networked System: An Enabling Power and Communications Infrastructure Technology*, Oceans 2007 Conference

designed to support conventional interfaces needed to connect to sensors using standard telecom protocols. In this way we hope to have an 'open architecture' that will be easily accessible to all end users.

Phase I funded the development of operational requirements, the basic design of the system, and the design of the test components. Thus far in Phase II, the hub and node have both been successfully benchtop tested. At the end of Phase II in late 2008 the components will be tested again under pressure in a test tank. Phase III in 2009 will culminate with an ocean prototype test for a typical application.

Cable System Protection

We describe here just a few of the many unique and complex Navy cable projects. In order to protect them from other seabed activities, NAVFAC ESC works with the Navy Seafloor Cable Protection Office (NSCPO) before, during and after installation. NSCPO, another office of the Naval Facilities Engineering Command, strives to deliver sufficient positioning information to mariners and the commercial cable industry so that they can avoid the project locations. NSCPO is the official point of contact for all U.S. Navy (and other Department of Defense) ocean cables[5]. Its mission includes protection of the Navy's interests with respect to ocean cables by representing these interests to industry. By providing a single point of contact and management of a comprehensive database of cable systems, the NSCPO is uniquely positioned to answer queries from commercial cable installation planners, surveyors and installation contractors in order to minimize possible damage to Navy cable systems.

In order to ensure that new commercial cable projects are routed clear of any U.S. Navy cable systems, NSCPO requests system planners and installation contractors to contact them early in the planning process. All data provided to NSCPO will be treated as commercially proprietary. For more information on these projects or NAVFAC ESC capabilities please contact the NSCPO.

5 C. Creese, *The U.S. Naval Seafloor Cable Protection Office "Call Before You Dig!"*, Submarine Telecoms Forum, issue 29, November 2006.

Bob Fredrickson is the Director of the Ocean Engineering Division at the Naval Facilities Engineering Service Center in Port Hueneme, CA. He is responsible for management and oversight of a wide variety of unique Navy ocean facilities projects such as those featured in this article. Prior to his current position, Bob was the manager for environmental quality technology transfer for the Naval Facilities Engineering Service Center. He has 22 years engineering and management experience with the U.S. Navy. Bob is a graduate of the University of California at Santa Barbara where he earned a Bachelor of Science Degree in Mechanical Engineering.

Catherine Creese has worked for NAVFAC as the Assistant Director of the Naval Seafloor Cable Protection Office since May, 2006. Prior to working at NSCPO, she held positions in cable system route engineering, permitting and sales at Tyco Telecommunications (US) Inc. She was a delegate on the Executive Committee of the International Cable Protection Committee for four years and was a Director of the North American Submarine Cable Association. A former Coast Guard officer, Catherine is a US Coast Guard Academy graduate with a bachelor's degree in Marine Engineering. Catherine also holds a master's degree in Technology Management from Stevens Institute of Technology.

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