Shallow Water Training Range

Robert Reid
Naval Undersea Warfare Center Division Newport

ABSTRACT

During the cold war, undersea warfare (USW) was perceived as a large-area, deep-water operation. The need for USW has recently shifted to the shallow water, littoral environment. Consequently, US naval forces must train to operate in these littoral environments where regional conflicts are most likely to occur. In light of these requirements the Shallow Water Training Range (SWTR) has been initiated. Telemetry is used in the following areas of SWTR: fiber optic, microwave, RF and underwater. Only phase 1 of 8 phases of the program is executing therefore SWTR is a good opportunity for telemetry industry involvement.

KEY WORDS

SONET ATM, OC3, Digital Signal Processing, over the horizon RF Communication

INTRODUCTION

The US Fleet has decided to develop and install Shallow Water Training Ranges (SWTR) on the East Coast and West Coast of the continental United States. Undersea-instrumented ranges provide a training climate of high accuracy localization of participants involved in a naval operation. This high accuracy real-time operation can only be accomplished on a precision underwater range. The shallow water however limits sensor performance, weapons utilization, and tactical maneuvering. The SWTR provides the operational capability to allow USW training and assessment under these adverse conditions for air, surface and subsurface vehicles.

The primary SWTR mission will be to support Fleet readiness through training and tactical development of submarine, surface ship, and aircraft USW**.** Secondary missions will include training in shallow water, regional conflict operations involving naval special warfare (NSW), electronic warfare (EW), mine warfare (MIW) and amphibious warfare (AMW) mission/operational capability areas. Additionally, joint mission areas that may also be supported include joint littoral warfare, and joint surveillance and warning. The SWTR will also provide operators, units, and staffs with real-time data as well as timely post-exercise analysis, evaluation, and feedback data as an input for training and to

permit sensor performance evaluation, refinement of tactics and to focus requirements and acquisition efforts.

Telemetry of both data and voice as well as networking communications are required throughout SWTR. There are several areas that need innovative solutions in order to accomplish the requirements of SWTR. Key technologies are underwater SONET ATM, underwater acoustic telemetry and over the horizon RF communications. The 3 technology areas listed above are needed to support the operational requirements of SWTR. The SWTR program consists of 8 phases, 4 on the East Coast and 4 on the West Coast. There will be an initial phase on each coast followed by expansion phases. Thus far only the initial EC-SWTR contract has been awarded. There still remains an opportunity for the telemetry industry to get involved with the SWTR program. Each of these areas will be discussed.

THE SWTR SYSTEM

SWTR consists of two main components an In-Water Subsystem (IWS) and a Shore Electronics Subsystem (SES). The IWS is made of underwater acoustic receivers and transmitters called Bunkers because of their unique shape. The Bunkers have been designed to withstand fishing hooks and anchoring. The Bunkers contain 4 hydrophones each sampled at 104375 Hz, providing an acoustic bandwidth of 8-40 kHz. (The low end of the frequency band has been high pass filtered to eliminate the noise created by USW sonars aboard submarines, surface ship and the dippers of helicopters). The Bunker has a transmitter integrated into the unit as well. There are low frequency transmitters (1.5-4 kHz) and high frequency transmitters (8-13 kHz) located in respective Bunkers. The Bunkers receive in-water pings generated by participants on SWTR. These cooperate ping signals are required to accurately position the underwater vehicle on the SWTR. The underwater vehicles are submarines, torpedoes or USW targets. Analog data from the hydrophones is then digitized, ATM formatted and telemetered to the SES over fiber optic cable at an OC3 rate. The data from the 4 hydrophones per Bunker and 13 total Bunkers on a single mode fiber optic string is multiplexed and routed to an optical receiver and demultiplexer in the SES. The SES receives the data, performs a detection on the pings and tracks the underwater vehicles. Figure 1 provides a graphical depiction of the SWTR currently under development for the East Coast EC SWTR. The IWS of EC-SWTR will be located off of Marine Corps Base, Camp Lejeune, NC.

SYSTEM DESCRIPTION & EC SWTR CONCEPT

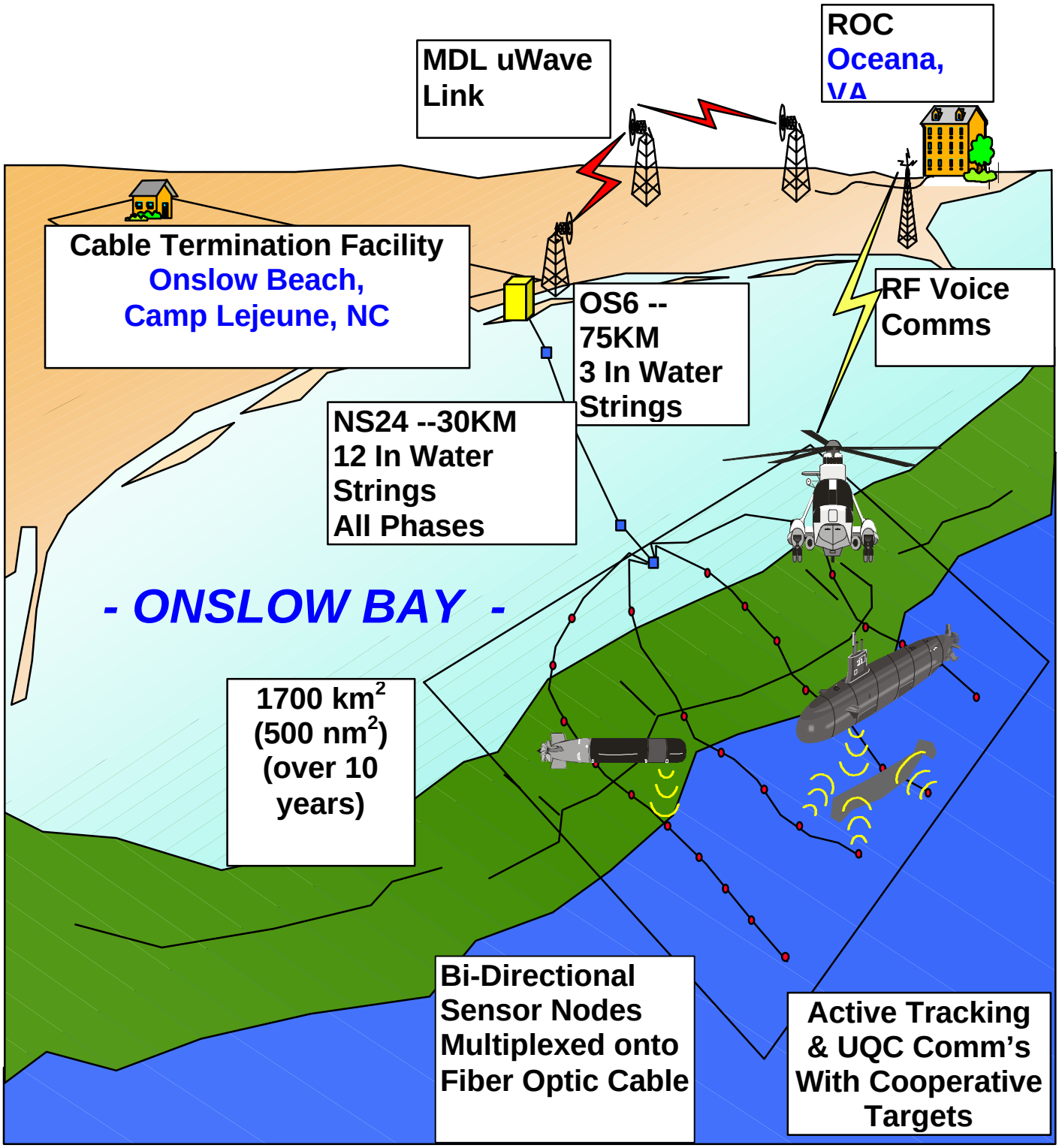

Figure 1 – EC SWTR System Configuration

The SES also has the capability to send commands and signals out to the Bunkers for the purpose of transmitting. This transmission capability is ½ of the Underwater Acoustic Telemetry Modem. The other ½ of this system is located aboard submarines on the SWTR. A 3kHz data link is available to transfer data from the SWTR to the participant submarine using a half-duplex protocol. Other warnings and remote control of USW targets are capabilities that the Bunker transmit function provides.

Integrated with the SWTR is an in-air communications system located at the Range Operations Center (ROC) in Oceana VA. The ROC utilizes communication towers located at Camp Lejeune called the Starling Site and on the outer bands of North Carolina to communicate with ships and helicopters on SWTR. The in-water instrumented area of SWTR however is some 60 nmiles off shore therefore there is a real challenge to communicate with surface and low flying air combatants from these 400 foot towers available to the ROC.

FIBER OPTIC TELEMETRY

The in-water data transfer mode utilized is SONET ATM at an OC3 rate. A collapsed ring is currently being used requiring 2 single mode fibers. Data from a total of 64 hydrophones can be multiplex onto this collapsed ring. Each hydrophone is A/D converted at a rate of 104375 Hz with 16 bits of data. Along with the hydrophone data there is the overhead bits required by the ATM. From the SES, commands including system timing are sent to initiate the in-water sampling process as well as transmit commands and signals. The SWTR program requires highly reliable fiber optic telemetry. Highly reliable because the cost to repair in-water systems such as SWTR is prohibitive.

UNDERWATER ACOUSTIC TELEMETRY MODEM

An Underwater Acoustic Telemetry Modem (UATM) is also planned as part of the SWTR. Preliminary work has been done with the UATM however the exact approach is not yet settled on. Basically a Quadriture Phase Shift Keyed (QPSK) of a Multiple Frequency Shift Keyed (MFSK) approach will be implemented. The initial use of the UATM will be to support the Virtual Torpedo Program. VTP simulate the virtual launch and run of an MK48 ACDAP torpedo. The UATM provides wire commands to a submarine with a Hardware-In-The-Loop simulator operating in Newport. Below is the data needed to be transferred for VTP:

1. Message Header for each message sent to modem = 10 bytes
2. TELCOM for 2 weapons = 8 bytes/block x 4 blocks/sec x 2 secs x 2 weapons + 4 byte header =132 bytes
3. Posits for 3 participants = 20 bytes/participant x 3 participants = 60 bytes
4. Event Message (worst case - freeform) 52 bytes/message = 52 bytes

5. Encryption Overhead (not usable for data) = 60-70 bytes

Grand Total = 324 bytes (and add 10% for minimal growth/errors ~360 bytes)

Data is downlinked to the Bunkers from the submarine at a center frequency of 17 kHz and uplinked from the Bunker at a center frequency of 10.5 kHz.

IN-AIR COMMUNICATIONS

The Range Operations Center is required to communicate with ships and low flying aircraft on the ECSWTR. The range however is some 60 nmiles offshore. The largest onshore tower available for RF communications is only 400' tall. A solution to this communication problem is required. Some of the possibilities are:

- A taller tower at the Starling (or elsewhere) capable of line of site to the range area for voice and Large Area Tracking Range (LATR) data
- An offshore barge to relay in-air comms and LATR track data to Starling
- Use of SAT Comms to provide voice communications
- Use of an Aerostat to relay voice and LATR data
- An off-shore tower putting the junction box on the tower along with an antenna and relay electronics
- An Unmanned Autonomous Vehicle or plane relay capability
- A Bunker with an underwater which that pops up a relay antenna

A practical solution to this issue is required.

SUMMARY

There are several areas that need innovative solutions in order to accomplish the requirements of SWTR. Key technologies are underwater SONET ATM, underwater acoustic telemetry and over the horizon RF communications. The 3 technology areas listed above are needed to support the operational requirements of SWTR. Solutions to each of these issues have not been completely resolved therefore SWTR is interested in innovative solutions from the telemetry.