



*By Dr. Frank Chan, Carl Lindstrom, David Swanick, and Dr. Michael Visich
Photo by PH2 Alan D. Monyelle*

As the Navy enters the 21st century, the submarine's role in achieving the information superiority required to support the goals of *Sea Power 21* and *FORCENet* will increase dramatically. A growing number of submarine missions will be devoted to taskings for Intelligence, Surveillance, Reconnaissance, and Targeting (ISRT), with distributed off-board sensors and autonomous vehicles playing a key role in supplementing on-board sensors and extending their effective range. Moreover, the submarine, as a critical operational node, can pass the resulting information to command nodes and other networks as required. Correspondingly, the importance - and the capabilities - of above-surface sensors are growing rapidly.

The Changing ISRT Mission

Submarine ISRT sensors were employed during the Cold War largely to support the Submarine Force's primary mission - symmetric anti-submarine warfare (ASW) against the Soviets and their allies in well-defined OPAREAs. In the post-Cold War environment, instead of being just an enabler for ASW, submarine ISRT has become a mission all to itself, providing top-level national leaders timely intelligence on an enemy's forces, dispositions, and infrastructure, as well as on his intent, before hostilities occur. In July 2000, the Submarine Force published its new vision document, *Submarines... The Road Ahead*, which predicted that maintaining the relevance of submarines in this new century will require capabilities for developing information, as well as those needed for access and power projection. Submarines will leverage their enduring attributes of stealth, endurance, agility, and firepower not only to gain their own access, but to establish the conditions that will enable access for follow-on forces. Because a submarine can operate in the littorals undetected for extended periods, it offers a unique capability to fill gaps in coverage that would be impractical or impossible for other assets to cover.

Much of our submarine mission time today is devoted to battle space preparation.

Key attributes of a successful mission are:

Acquiring awareness of militarily significant events in the battlespace - status of enemy forces, operations, facilities, weather, terrain, and the electromagnetic spectrum

Providing timely information required by the commander to make decisions and employ weapons and other systems precisely

Above-Water Sensors ... and High-Density Contact Management

For own-ship safety, surface attack, and early warning, submarines have had periscopes, radars, radio direction-finding loops, and radar-warning receivers for much of their existence. Increasingly, however, advanced electro-optical imaging sensors that can extract maximum information from the adversary's visible and thermal energies are needed to conduct ISRT missions. Submarine imaging plays an important role in all mission areas, but successful accomplishment of many ISRT missions requires careful positioning in confined littoral waters. A 24/7, all-weather imaging capability that extends beyond the visible spectrum is imperative for safe ingress or egress movements and can provide imaging products available from no other source.

Particularly for "high-density contact management" in a cluttered littoral environment, these capabilities are even more important today than they were during World War II and the Cold War. Commodore Scott Van Buskirk of COMSUB-DEVRON TWELVE has described high-density contact management as "four simple words that mean fast-paced, stress-filled hours for submarine tracking parties and sleepless nights for commanding officers," and it represents the top operational safety and security issue for today's Submarine Force in both littoral and deep water environments.

To further complicate the issue, operating in the littoral presents challenges to the submarine regardless of contact density, with problems posed by the environment, sensor limitations, and the nature of contact management itself. Improvements in submarine imaging systems and submarine electronic warfare (EW) systems show significant promise for attacking the high contact-density challenge, largely by regaining signal-to-noise ratio losses and reducing operator overload in the littorals.

Submarine Imaging Systems

Periscopes have historically played an important tactical role on U.S. Navy Submarines. The Type 18 and the Type 8 periscopes are the primary "hull-penetrating" periscopes used in the fleet today and are employed on all SSN-688 and *Seawolf* (SSN-21)-class ships. The *Ohio* (SSBN-726)-class employs one Type 8 periscope and a Type 15 periscope. Both the Type 18

and the Type 8 are undergoing significant improvements – a video upgrade package known as SUBIS for the Type 18 periscope, and an infrared (IR) camera upgrade package for the Type 8 periscope.

Major new developments for tomorrow's Navy include the Photonics Mast non-penetrating periscope, the AN/BVS-1, which has been engineered for the USS *Virginia* (SSN-774) class. The system brings a variety of ISRT mission-enabling capabilities, including infrared and visual imaging, digital image processing features, laser range finding, special stealth features, and a very capable antenna suite with broad spectral coverage and monopulse direction finding. From an operator's perspective, the primary difference between a conventional penetrating and a non-penetrating periscope system, such as the Photonics Mast, is that the operator of the Photonics Mast system is seated at a console and has joystick control of the system.

In general, submarine-imaging requirements can be grouped into ship's safety and tactical intelligence-gathering categories, with some overlap in between.

Safety-of-Ship Imaging System Requirements Primarily for situational awareness, required functionalities include visual search; contact detection, recognition, and identification under most weather conditions; navigation support; real-time imagery analysis; and imagery enhancement.

Imaging System Requirements for ISRT

Tactical intelligence demands the highest-quality imagery from submarine electro-optical sensors. Additional capabilities provide the means for high-fidelity post-mission reconstruction and detailed information-extraction. Major considerations include optimal utilization of electro-optical sensors, preservation of image quality, and follow-on, multi-sensor data fusion.

The Submarine Tactical Requirements Group (STRG), chaired by Commodore Van Buskirk, has most recently outlined submarine requirements for the former. Not surprisingly, significant

emphasis is on high-density contact management. Technical objectives that follow from the STRG requirements include optimizing video and still frame imagery resolution; maximizing the automation of the imagery detection, acquisition, classification, and tracking processes; reducing operator data manipulation; adequate imagery storage and retrieval capacity; providing necessary tactical alerts and recommendations; and introducing periscope remote control. These capabilities will be provided to the fleet, as part of an ongoing modernization plan for all tactical platforms.

Submarine imaging systems also play a strong role in extending the reach of submarines. Imaging systems are the “eyes” of the submarine and collect ISRT information while on station. That information is stored for subsequent analysis or immediately passed to the submarine Electronic Warfare System and Exterior Communication System (ECS) for transmission to the national and theater command networks. The existing mechanisms for image transfer are limited but are under review as part of recent Sea Power 21 and FORCENet initiatives. Today’s imaging sensors onboard U.S. Navy submarines can capture high-resolution video and still imagery. Imagery-capture capabilities differ among the submarine classes, but eventually all submarines will have a similar capability provided by high-resolution color, infrared, and low light level cameras. The operator has the capability to view the imagery in an unprocessed mode or can invoke image-processing algorithms to improve the representation. In addition, in the Photonics Mast system (AN/BVS-1), the operator can invoke real time image-enhancement features to improve imagery viewed at the inboard consoles.

The STRG requirements will drive the existing submarine imaging systems towards commonality with the Photonics Mast system. Algorithms have been developed to help reduce operator fatigue. Additional capabilities will be provided in the Imaging Advanced Processor Build (APB) initiatives. Those initiatives are also driven by the STRG requirements and include a periscope remote control capability and an automatic detection and tracking capability. Imagery acquired by the system will also be selectable for viewing in appropriate areas outside the control room, such as

CO/XO staterooms and the wardroom.

Submarine Assured Access Electronic Warfare Systems

With an increasingly important role of submarines in today's joint warfare, capable onboard Electronic Warfare (EW) sensors and systems that can intercept and process electromagnetic signals are vital. Submarine EW modernization efforts have begun to improve submarine capabilities significantly and are being coordinated with other communities to maximize their utility through commonality.

Advances in commercial electronic technologies have taken submarine EW systems from closed architecture, stove-piped hardware to an integrated, open, and scalable architecture. New antenna and radio-frequency technologies have increased signal intercept capabilities by offering greater coverage of the frequency spectrum at increased standoff ranges, resulting in a greater probability of mission success. Moreover, stealth technologies have considerably reduced the radar signatures of current submarine masts and sensors, offering a significant reduction in vulnerability while operating at periscope depth.

The future Submarine Force will soon enjoy a full range of above-water sensor capabilities.

Reliable, real-time wireless connectivity between the forward-positioned submarine, the battle group, and off-board sensors will be a necessary enabler to extract the maximum advantage inherent in the submarine platform. Furthermore, the Rapid COTS Insertion approach will be crucial to the fleet for upgrading or reconfiguring its capabilities to provide the interoperability needed for the effective execution of joint missions.

The authors are all employees of the Naval Undersea Warfare Center in Newport, R.I., working in the Submarine Electromagnetic Systems and Undersea Warfare Analysis Departments. Dr. Chan is the I&EW Technology

Manager; Mr. Lindstrom is the Imaging Technical Design Agent (TDA); Mr. Swanick is the EW Program Manager; and Dr. Visich is an ISR Operations Analyst.

Table of Contents