

UNDERSEA WARFARE

U. S. S U B M A R I N E S ... B E C A U S E S T E A L T H M A T T E R S

GOING TO EXTREMES

ICEX Showcases the Submarine Force's Arctic Capabilities



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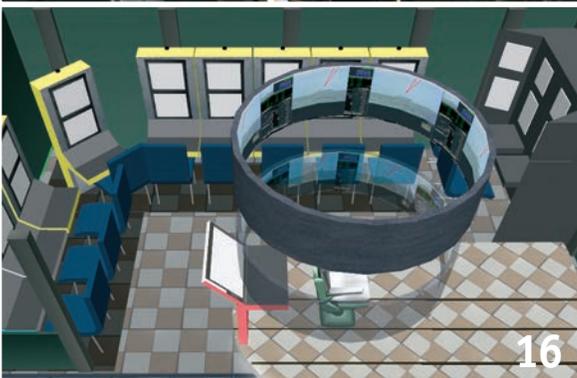
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USS *New Hampshire* (SSN 778) on the surface during ICEX 2011.

Photo by Cmdr. Christy Hagen

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FORCE COMMANDER'S CORNER

"We will continue to stay engaged, doing what the Submarine Force does most effectively for the U.S. Navy—getting on point, gaining awareness of the environment, walking the terrain and sending information back to the rest of the Navy and Joint Force."

Vice Adm. John Richardson, USN,
Commander, Submarine Forces



Team,

This edition of UNDERSEA WARFARE Magazine highlights our interest in staying engaged in the Arctic—an area of the world that will only grow in importance as new navigation routes and natural resources become available. Those of you who are experienced Undersea Warriors will know that we've had a long relationship with the Arctic, operating in this region regularly since USS *Nautilus* transmitted her historic message, "*Nautilus: 90 North*," on August 5th, 1958.

Since that time, we've done more than 25 ice exercises (ICEXs) in the Arctic, expanding our ability to navigate, communicate and operate in this challenging area of the world. We will continue to stay engaged, doing what the Submarine Force does most effectively for the U.S. Navy—getting on point, gaining awareness of the environment, walking the terrain and sending information back to the rest of the Navy and Joint Force. By virtue of our dedicated long-term efforts, if called on short notice, we'll be there, and we'll know what we're doing—read more about it inside.

The big news since my last letter is that the Submarine Force has promulgated the Design for Undersea Warfare. This is our framework for action in operations and warfighting, now and into the future. The Design outlines three major lines of effort:

- **Ready Forces:** Provide undersea forces ready for operations and warfighting
- **Effective Employment:** Conduct effective forward operations and warfighting today
- **Future Force Capabilities:** Prepare for future operations and warfighting into the future

Much has been made of the Future Force Capabilities line of effort, and for good reason. It outlines our plan for platforms, payload volume, payloads, people and force posture—the "five P's"—in the future. For those looking for our acquisition and investment strategies, this is where you find our priorities.

But as the Type Commander, I'm also super-excited about the Ready Forces and Effective Employment lines of effort. Here is where we unleash the creativity and initiative of the Force to push our warfighting ability to new levels. It is here that we harness all undersea forces to identify what we must do more of, what we must change, and what we must eliminate, to become better—more effective—weapons in the nation's arsenal.

This is not a passive endeavor. We all must actively look for ways to align our energies in this effort—to put our shoulders to the task and push. We must look for new ways to inspire and train ourselves and our teams to dominate potential enemies to the point where they choose not to take up the fight. That's how deterrence happens.

I am very confident that once we get this flywheel spinning, we'll see the incredible levels of performance that will keep our potential enemies back on their heels. Our Undersea Forces will continue to own the undersea domain. There are no havens or bastions we can't penetrate to establish undersea superiority. As you can see in this issue, that includes the Arctic.

A handwritten signature in black ink, appearing to read "John Richardson". The signature is fluid and cursive, with a long horizontal flourish at the end.



UNDERSEA WARFIGHTING

(The following is from the executive summary of Undersea Warfighting, an important new publication on basic submarine doctrine issued by Commander, Submarine Forces, in July 2011. The full text of Undersea Warfighting is available at [http://www.public.navy.mil/subfor/hq/PDF/Undersea Warfighting.pdf](http://www.public.navy.mil/subfor/hq/PDF/Undersea%20Warfighting.pdf).)

The Navy's undersea warfighters bring a set of tools and capabilities to U.S. national security that are unique and indispensable. Enabled by stealth, surprise and boldness, undersea forces provide impact and influence far out of proportion to their size and quantity. When our lethal and undetected undersea force operates in concert with the visible power of carrier strike groups and the expeditionary capacity of the Marine Corps, the Navy-Marine Corps team provides a formidable, flexible and daunting power projection force.

The role played by the undersea forces on this team is centered upon the military advantages provided by undersea concealment. Whether the water is deep, cold and empty arctic waters or shallow, warm and crowded tropical waters; whether it is peacetime or wartime; whether it is calm or stormy—virtually everything our undersea forces do is to exploit concealment to enhance deterrence or warfighting capability. This concealment enables a wide variety of undetected operations, permits the penetration of enemy defenses, allows attacks to be conducted with surprise at the time and place of our choosing, promotes survivability, and creates uncertainty and ambiguity that greatly complicate enemy planning and operations.

But none of these advantages or attributes can be achieved without the tireless efforts of smart, audacious warriors. Our undersea

forces must be manned by a cadre of undersea professionals with special technical and military expertise, skill at employing stealth, self-sufficiency, initiative, a penchant for tactical innovation, and aggressive warfighting tenacity. These bold undersea warriors ensure that our exceptional undersea forces are ready to fight on short notice, can gain non-provocative early access far forward, exploit the full undersea maneuver space, seize the initiative with offensive action, and quickly adapt to changing situations, including the dynamic chaos of war.

As undersea warriors, it is important that we understand the nature of this unique role we play, and the importance it has for the security of our Nation. Although the technologies, the adversaries and the locations have varied over history, the fundamental military purpose of our undersea forces has remained constant: *to leverage the concealment of the undersea environment to provide military advantages for the United States.* The skill set of the undersea professionals that deliver this military advantage is likewise unchanging.

The purpose of *Undersea Warfighting* is to provide our undersea warriors with a shared professional foundation and perspective that will serve as a common bedrock upon which we build training, exercises and peacetime operations. This robust foundation will enable a smooth transition from peace to war should that be necessary. And to minimize the chance that such a war should be necessary, this foundation will help ensure that there is no question in the mind of any potential adversary about the lethality, survivability and effectiveness of U.S. undersea forces.

Our undersea warriors are professionals characterized by:	Our undersea systems exploit the advantages provided by undersea concealment:	Our undersea forces support their role in national security by demonstrating:
<ul style="list-style-type: none"> • Technical ingenuity and integrity • Military expertise • Skill at exploiting stealth • Self sufficiency • Initiative • Tactical creativity • Aggressive tenacity 	<ul style="list-style-type: none"> • Undersea domain reach • Undetected operations • Penetration of adversary defenses • Surprise • Survivability • Ambiguity and uncertainty 	<ul style="list-style-type: none"> • Sustained readiness to fight • Non-provocative early access far forward • Full exploitation of the undersea maneuver space • Ability to engage at the time and place of our choosing • Emphasis on offensive firepower • Adaptability to changing situations • Ability to exploit chaos and confusion

UNDERSEAWARFARE

The Official Magazine of the U.S. Submarine Force

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UNDERSEA WARFARE is the professional magazine of the undersea warfare community. Its purpose is to educate its readers on undersea warfare missions and programs, with a particular focus on U.S. submarines. This journal will also draw upon the Submarine Force's rich historical legacy to instill a sense of pride and professionalism among community members and to enhance reader awareness of the increasing relevance of undersea warfare for our nation's defense.

The opinions and assertions herein are the personal views of the authors and do not necessarily reflect the official views of the U.S. Government, the Department of Defense, or the Department of the Navy.

Contributions and Feedback Welcome

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CHINFO Merit Award Winner



Silver Inkwell Award Winner

LETTERS TO THE EDITOR

In keeping with **UNDERSEA WARFARE** Magazine's charter as the Official Magazine of the U.S. Submarine Force, we welcome letters to the editor, questions relating to articles that have appeared in previous issues, and insights and "lessons learned" from the fleet.

UNDERSEA WARFARE Magazine reserves the right to edit submissions for length, clarity, and accuracy. All submissions become the property of **UNDERSEA WARFARE** Magazine and may be published in all media. Please include pertinent contact information with submissions.

Send submissions to:

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FROM THE EDITOR,

The Washington Nationals baseball team recently added a submarine-related tradition to their home games. **UNDERSEA WARFARE** Magazine visited Nationals Park in Washington, D.C., to see this new addition, and we challenged our Facebook fans to guess what this mysterious tradition could be.

Mike Ragsdale said, "They are going to play a sub 'dive' horn if the Nationals hit a home run or win, as opposed to fireworks."

Mariacor Ruediger wondered, "Does it have to do with there being a baseball pitch named the 'submarine'?"

Andy Brinkmeier said, "It is the tradition of flying a broom upon returning to port to signify 'sweeping the seas' clean of the enemy. Similar to the home team 'sweeping' a series of baseball games."

To see if anyone guessed right, turn to page 30.

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SAILORS FIRST



Crewmembers from **USS New Hampshire (SSN 778)** look on as their Commanding Officer, Cmdr. John McGunnigle, pins dolphins on Petty Officer 3rd Class Erik Felipe Olvera during ITEX 2011.

Photo by Cmdr. Christy Hagen

ICEX 2011

Meets the Challenges of the Arctic



The United States has long recognized the strategic importance of the Arctic. This remote and inhospitable region is likely to grow more important in the 21st century, as nations vie to exploit its untapped resources, and climate change raises the possibility of opening new shipping lanes in the far north. The Arctic Ocean and its surrounding seas are fundamentally a maritime domain, and therefore a prime responsibility of the U.S. Navy. The dense canopy of sea ice that covers much of the region, even in summer, precludes most surface operations, so the responsibility for operating and, if necessary, waging war beneath the ice falls to the U.S. Submarine Force.

American submarines have operated under the Arctic ice for purposes such as inter-fleet transit, training, and cooperation with allies for more than 50 years. Since USS *Nautilus* (SSN 571) made the first polar transit in 1958, the Submarine Force has completed more than 25 major Arctic exercises involving an ice camp. These ice exercises (ICEXs) routinely include personnel from Britain's Royal Navy, and many have included a British submarine.

This year's exercise—ICEX 2011—took place in the Beaufort Sea during the last two weeks of March. As usual, the exercise was sponsored by the Director of Submarine

Warfare (OPNAV N87), and the San Diego-based Arctic Submarine Laboratory (COMSUBPAC Detachment ASL) was responsible for planning and coordinating the entire effort—including the establishment of the temporary ice camp and the emplacement of a tracking range on the ice to monitor the movements of the participating submarines.

The Submarines

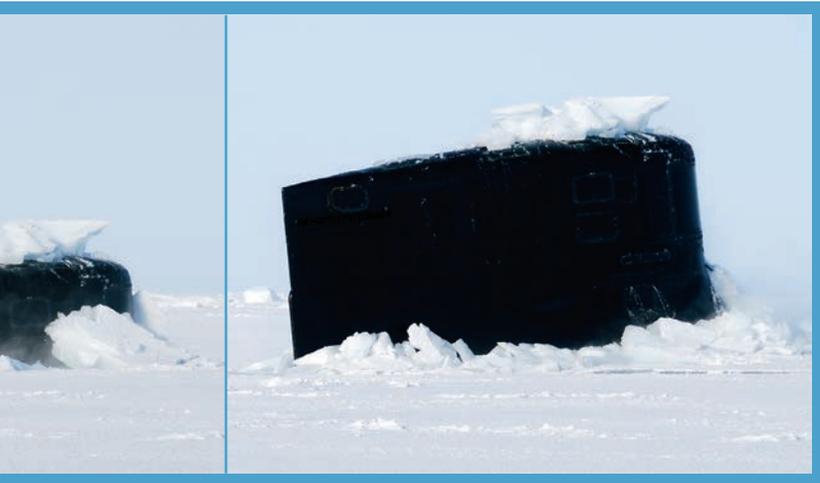
The two submarines chosen to demonstrate their operational and warfighting skills in ICEX 2011 were USS *New Hampshire* (SSN 778), a *Virginia*-class boat homeported in Groton, Conn., and USS *Connecticut* (SSN 22), a *Seawolf*-class submarine homeported in Bremerton, Wash. Before transiting to the Arctic, each received a suite of temporary alternations (TEMPALTs) consisting of sensors specially designed by the Arctic Submarine Lab to facilitate under-ice operation. These included upward-looking side-scan sonar and an underwater camera. ASL experts also embarked on the submarines to provide technical support for the TEMPALT equipment, to train the crews in operating it, and to make their expertise and experience in Arctic operations available to the submarines' command teams.

Connecticut, no stranger to the Arctic, had the added challenge of navigating through

the shallow water of the Bering Strait. A shallow-water transit—or, for that matter, any evolution that calls for a submarine to navigate in close proximity to the ice overhead—requires a high-frequency active (HFA) sonar with an ice-keel avoidance (IKA) mode. This enables the submarine to detect and avoid “ice keels,” ridges of sea ice that project farther down into the ocean than most of the ice pack.

Connecticut carried a TEMPALT called ORCA (Operationally Reliable Capability—Arctic) designed to improve the longevity and performance of the HFA sonar's IKA mode in Arctic conditions. Testing ORCA's effectiveness was one of the highest priorities of this year's ICEX, and initial data reported by *Connecticut* and by embarked ASL test personnel indicated that it significantly improved IKA longevity and performance.

When the submarines arrived at the ice camp, a helicopter from the camp located the most suitable areas for them to surface for embarking and debarking test support personnel and visitors. *New Hampshire* was directed to an area of open water and slush designated “Water Works.” *Connecticut*, with her specially strengthened sail, was directed to an area designated “Marvin Gardens,” which had two to three feet of ice for her to break through. Marvin Gardens



(Above, left to right) *Connecticut* (SSN 22) surfaces through the ice. Photos by Cmdr. Christy Hagen.

New Hampshire (SSN 778) at “Water Works.” Photo by Cmdr. Christy Hagen.

was selected because it had ample room for *Connecticut*—and also because its ice was thick enough for people to walk on safely, but not so thick that it took a long time to clear off the hatches after surfacing.

New Hampshire was the first *Virginia*-class submarine to take part in an Arctic tactical development (TACDEV) exercise, and only the second to be tested in the Arctic. USS *Texas* (SSN 775) had already conducted the initial cold-water and under-ice testing for the class in the fall of 2009, and the information gathered in that earlier deployment proved invaluable for *New Hampshire* and for Matt Pesce and Kevin Searls, the ASL arctic operations specialists (AOSs) assigned to her. The AOSs provided *New Hampshire*'s commanding officer and crew with pre-Arctic classroom training and supported their at-sea work-up. They also assisted Submarine Squadron Four with Arctic certification of the submarine.

When *New Hampshire* departed her homeport, she was trained, equipped, and ready to support all the test objectives of ICEX and the Naval Sea System Command (NAVSEA)'s *Virginia*-Class Program Office (PMS 450). The *Virginia* class is designed to operate in all environ-

ments, including the Arctic, and PMS 450 sponsored ICEX 2011 testing to evaluate the submarine and her systems over the course of a full spectrum of operations in the Arctic environment. Submarine Development Squadron Twelve also participated in the testing to glean more knowledge about best procedures for operating the *Virginia* class under the ice. Like *Connecticut*, *New Hampshire* achieved most of her test objectives during the complex two-week testing schedule.

The Ice Camp

As usual, ICEX 2011 established an ice camp to serve as the base for its test program. From there, the officer in tactical command (OTC) controlled all operations, and under his authority, the exercise director coordinated all testing. The OTC was Capt. Rhett Jaehn, deputy director of operations for Commander, Submarine Force. The exercise director was Jeff Gossett, the Arctic Submarine Lab's deputy director. ASL also provided an officer in charge and assistant officer in charge of the camp, and it contracted with the Applied Physics Lab of the University of Washington (APL/UW) to construct and operate the camp. ASL person-

nel provided logistic support for the camp out of Prudhoe Bay (Deadhorse), Alaska.

APL/UW set up a tracking range to monitor and record the submarines' positions relative to one other, which greatly facilitated testing and post-exercise analysis. Camp personnel also located deep ice keels in the surrounding area suitable for testing ice-detecting sonar and directed the submarines to those features.

In addition to technical experts, the 25 “permanent” camp staff included support personnel ranging from the camp doctor to the cooks hired by APL/UW and the Sailors from Submarine Squadron Eleven who helped build the camp, unload supplies, and do whatever else needed doing. More than 100 other people came and went, embarking on or debarking from the submarines, conducting tests, or engaging in scientific research.

The six watchstanders of the range safety team ensured that all submarine evolutions, aircraft operations, and field parties were conducted safely. Three range safety officers (RSOs) had the primary responsibility for communicating with the subs and monitoring their movements. Their three assistants (ARSOs), in addition to helping with the



Photo by Cmdr. Christy Hagen

Distinguished visitors at “Marvin Gardens”: (left to right) Capt. David McFarland, USN, senior military assistant to the Under Secretary of Defense (Comptroller); Rep. Jo Bonner (R-Ala.) and Rep. Ander Crenshaw (R-Fla.), both members of the House Appropriations Committee’s Defense Subcommittee; Secretary of the Navy Ray Mabus; Capt. Roger Isom, Navy Office of Legislative Affairs; Director of Submarine Warfare (N87) Rear Adm. Michael Connor; Ms. Jamie Lynch, House Armed Services Committee staff; Undersecretary of Defense (Comptroller) Robert Hale; and Thomas Oppel, special assistant to the Secretary of the Navy.

submarines, were responsible for communicating with aircraft, helicopters and field parties outside the camp.

The range safety team was international. The RSOs were Cmdr. Paul Acquavella, U.S. Navy, who had previous ICEX experience, Lieutenant Commander Steve Murphy, Royal Navy, and Lieutenant Commander Mike Mangin, Canadian Navy. The ARSOs were Hector Castillo, a U.S. Navy civilian from ASL, who also had previous ICEX experience, Chief Petty Officer Reggie Hammond, Royal Navy, and Petty Officer 2nd Class Patrick Huot, Canadian Navy. To build teamwork and avoid any misunderstandings due to different ways of operating, each RSO worked with an ARSO of a different nationality. (Another member of the Canadian Navy, Lieutenant Commander Phil Collins, embarked in *Connecticut* and visited the ice camp during the course of the exercise.)

Distinguished Visitors

The Arctic operating environment is of growing interest not just to the Navy, but also to other warfighting communities. ICEXs, which showcase the Submarine Force’s Arctic capabilities in that environment, therefore tend to be of great interest to senior leaders of the U.S. defense community. ICEX 2011 was no exception. A variety of civilian and military defense leaders took the opportunity to gain insight into this sort of operation.

Connecticut was honored to host Secretary of the Navy Ray Mabus, Under Secretary of Defense (Comptroller) Robert Hale, Rep. Ander Crenshaw (R-Fla.), Rep. Jo Bonner (R-Ala.), and Rep. Larry Kissell (D-N.C.). *New Hampshire* hosted Under Secretary of the Navy Robert Work, Under Secretary of the Army Joseph Westphal, Deputy Secretary of Energy Daniel Poneman, Rep. Hank Johnson (D-Ga.), and Rep. Buck McKeon (R-Calif.), chairman of the House Armed Services Committee.

ICEX 2011 also provided an opportunity for senior uniformed leaders like Rear Adm. David Titley, the oceanographer of the Navy, Rear Adm. Nevin Carr, the chief of naval research, and Rear Adm. Christopher Colvin, commander of the Seventeenth Coast Guard District, to observe submarine operations in this rare setting and witness first-hand the infrastructure required to build and live on an ice camp in the Beaufort Sea.

Arctic Research

ICEX 2011 provided a venue for a variety of research on the Arctic. A project sponsored by the Office of Naval Research (ONR) in collaboration with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, N.H., and the Naval Research Laboratory (NRL) measured sea ice thickness and snow depth with unprecedented thoroughness.

Submarines can use upward-looking sonar to measure the draft of the ice—how far it extends below sea level—but they cannot measure its freeboard—how far the ice and snow rise above sea level. Aircraft can use radar to measure the freeboard, and this can be done by satellites as well. However, the only way to measure draft and freeboard together and determine the actual thickness at any given location is to drag sensors across the surface. And where the thickness is too great for any sensor to measure, the only recourse is to drill holes and take direct measurements.

ICEX 2011 was the first time that all of these methods—measurement from below, above, and on the surface—have been applied to the same stretch of ice so the results can be compared. To ensure that everyone measured exactly the same stretch of ice, a four-person team went out from the ice camp to establish a line on the surface. Aircraft from both NRL and the National Aeronautics and Space Agency (NASA) then overflew the line, and the submarines later followed it from below. Comparing the data produced by each method promises to significantly improve our understanding of the accuracy of all the sensors involved.

ONR also backed another program in which embarked Arctic Submarine Lab personnel deployed expendable conductivity-temperature-depth (XCTD) probes to study the salinity and temperature of the upper 1,000 meters of the water column.

It is difficult to overstate the importance of ICEX both as an opportunity for submariners to experience a unique operating environment of growing strategic importance and for the Submarine Force to see how its boats and their equipment and software match up to that environment's unique demands.

Finally, ONR supported thesis research by two students from the Naval Postgraduate School in Monterey, Calif. Lieutenants George Suh and Brandon Schmidt did nine days of field work on how the shape of ice keels might contribute to the mixing of water layers down to 100 feet and whether ice keels can drive down fresh water from the surface during peak melting season.

The lieutenants placed specially designed sonar at four sites around a surface mound that indicated the presence of an ice keel to map the keel's underwater contours in high resolution. They also placed instruments on the "downstream" side of the keel to continuously record temperature, conductivity, and water velocity. The combined data will let them estimate the vertical movement of heat and salt and relate it to the keel's size and shape. That should help to determine whether a large ice keel actually contributes to mixing, and if so, to quantify the effect.

What ICEX Achieved

It is, of course, impossible to measure on any one scale the value of all of the research,

experience and lessons learned from any given ICEX, much less to rank it against previous exercises in the series. If nothing else, the varied hardware and software that different submarines and submarine classes bring to these events over the years makes it impractical to compare them.

But it is indisputable that regular Arctic exercises are the only way to ensure that each new submarine class and system upgrade that becomes available for employment in real-world operations has been tested in the unforgiving conditions of the Arctic Ocean. Each successive ICEX also helps ensure that the Submarine Force continues to have a sufficient number of officers and enlisted personnel with experience operating under those conditions.

Because there are always new developments that require Arctic testing, every ICEX invariably has a number of "firsts." ICEX 2011's technical milestones included the first operational test of the ORCA ice keel avoidance sonar, the first submarine operation in the Arctic using only version 8.3 of the Voyage Management System (VMS) for

both deep-water and shallow-water navigation, and the first Arctic operational test of the Deep Siren system, which enables an operational commander to quickly send tactical messages to a submerged submarine. There was also a significant operational milestone: the first winter transit of the Bering Strait by a *Seawolf*-class submarine.

It is difficult to overstate the importance of ICEX both as an opportunity for submariners to experience a unique operating environment of growing strategic importance and for the Submarine Force to see how its boats and their equipment and software match up to that environment's unique demands. Along with its predecessors, ICEX 2011 helped ensure that any submarine crew called upon to transit or fight in the Arctic in areas of extensive ice cover will have the practical knowledge, validated procedures, and proven systems they need to carry out their mission.

Larry Estrada is the director of the Arctic Submarine Laboratory. Jeff Gossett is the deputy director of the Arctic Submarine Laboratory. Both are former submarine officers.

Each year, ICEX personnel come up with a theme for naming ice camp berthing huts like those below. This year, they were named for tropical islands like Oahu and Tahiti.



Photo by Cmdr. Christy Hagen

ICEX 2011 was the first to use social media, including Facebook, Twitter, and interactive blogging. Jeff Gossett, the exercise director, published a series of posts on Navy Live, the official blog of the U.S. Navy. The following excerpts from those posts provide a glimpse of the submarines and submariners engaged in this interesting and demanding exercise. Readers can find all of the posts from ICEX 2011 on the original blog at <http://navylive.dodlive.mil>.

Bloggging from Below Zero

March 14 — ICEX 2011 Step 1: Build the Ice Camp

"The ice camp is really taking shape. We have 9 of the 11 berthing huts built along with our two largest buildings—the mess hall and the command hut. The team on the ice has really done a terrific job to complete this much construction in a little over a week.

"In addition to the APL/UW [Applied Physics Laboratory of the University of Washington] camp workers, we've gotten an assist this year from Submarine Squadron Eleven. A few months ago, we asked to borrow a few good sailors from Submarine Squadron Eleven to help build the camp and handle aircraft loading and unloading in Prudhoe Bay. Squadron Eleven didn't just give us five good Sailors; they gave us five of their best. They have really shown how good our Navy people can be, even in circumstances as totally alien as the Arctic. Not only that, but when heavy snows knocked out the generator at one of the Prudhoe Bay hotels, they volunteered to shovel out the generator from a snow bank to help restore electricity."



From left to right, Submarine Squadron Eleven Sailors Petty Officer 2nd Class Steven Oyarzabal, Petty Officer 2nd Class Manual Reynoso, Petty Officer 3rd Class Philip Dicaldo, Petty Officer 2nd Class Harold Brown, and Petty Officer 3rd Class David Watson.



U.S. Navy photo

March 15 — The Submarines are Here!

“At about 3:30 this morning, USS *New Hampshire* (SSN 778) called on the underwater telephone to say that she’d arrived. We spent a couple pre-dawn hours ensuring that her tracking range was working. At dawn, Randy Ray, our camp officer-in-charge, and a team took off in the helicopter to find a place for the boat to surface. He found a nice open-water feature about five miles northeast of camp. We relayed its position to *New Hampshire*.

“Just after *New Hampshire* headed off to its surfacing location (“Water Works”), USS *Connecticut* (SSN 22) called in to announce her arrival—a day early. We checked out her tracking range system and then had her run a predetermined pattern to determine the limits of the range.

“Meanwhile, *New Hampshire* had surfaced at Water Works and moored to a nearby floe. They stayed moored a brief time to exchange riders. She was doing different testing on the trip up to the camp than she will here at the camp and needed a different group of people onboard to support it.

“Their time on the surface was highlighted by a visit from their squadron commander, Capt. Mike Bernacchi. Capt. Bernacchi is familiar to many of us here at the camp—he commanded USS *Alexandria* (SSN 757) when it operated at our 2007 camp.

“Once *New Hampshire* dove, both boats settled in for a night of surveying the underwater ice conditions near the camp to help prepare for the start of their testing....

In a later post, Gossett described the surfacing of *Connecticut* (SSN 22) the following day:

“*Connecticut* surfaced on Wednesday [the day after *New Hampshire* arrived] to exchange riders. She did a great job of positioning in the feature we selected (what we call ‘Marvin Gardens’). While *New Hampshire* surfaced through slush and moored alongside a thicker

floe, *Connecticut* busted through two and a half feet of ice. We were then left with the problem of clearing the ice from the deck to allow her to open her hatch. Nick Michel-Hart, Keith Magness, and Paul Aguilar from APL/UW attacked the ice with chainsaws, picks, crow-bars, and shovels to burrow down through 30 inches of ice in about an hour. One more example of how almost everything has to be done differently in the Arctic.”



U.S. Navy photo

(Top) USS *New Hampshire* (SSN 778) at “Water Works.” (Above) From left to right, Capt. Mike Bernacchi, Commander, Submarine Squadron Four, on top of the ice camp’s command hut, flanked by Lt. Cmdr. Koepp, his ops officer, and Bruno, the camp mascot.

March 20—Complex Operations at ICEX

"We've been busy. Friday, we had a group of media arrive at the camp—a reporter and a photographer from the Reuters news service; two freelance photographers; and a Navy media specialist. They spent all day and Friday night at the camp learning about and documenting life at an ice camp...

"Then Saturday, they were joined by a delegation of 12 VIPs headed by the Secretary of the Navy and including the Under Secretary of Defense and three congressmen. Together, they watched *Connecticut* break through the ice again at Marvin Gardens. The VIP delegation boarded *Connecticut* for the night, while the reporters embarked aboard *New Hampshire*.

"This was a complex operation requiring our support teams' traveling to both surfacing sites, getting our visitors to Marvin Gardens, transporting the reporters to Water Works to board the *New Hampshire*, then getting all of our people home, along with 18 Sailors from the boats who we hosted overnight to help make room onboard. The helicopter crew flew almost non-stop to move all of these pieces around the Arctic chessboard and to complete it all before sunset grounded them for the night. And at the end of an exhausting day, we had 18 curious Sailors at APLIS wanting to know everything about camp life.

"Then, today, we did it all over again in reverse. The Sailors are back onboard their submarines, and our visitors are headed home, all taking with them the memories of an Arctic adventure and a new appreciation for the work the Navy is doing here in the North.

"Both of the submarines are submerged again and continuing with our testing program."

March 21—The Water Works Team

"In the last post, it mentioned that the ice camp sends teams to support the submarines' surfacing. What are these teams, and why are they required?"

"First, I'll talk about Randy Ray's 'Water Works Team' that supports *New Hampshire's* open-water surfacing. Although *New Hampshire* is capable of finding open water herself, it is much quicker to do that from a helicopter than the narrow field of view from the submarine's upward-looking sensors. Open-water features large enough to fit a submarine into are scarce—so scarce that it took our helo search party an hour to find one on Saturday.

"With a good site located, the team passes the location and description of the feature to the command hut, where it is relayed to *New Hampshire*, and she heads that direction. Our team lowers an acoustic beacon into the water to help *New Hampshire* home on



New Hampshire crewmen toss a line "ashore."

their location and an underwater telephone so they can talk directly to each other.

"*New Hampshire* is then guided into Water Works, hovers beneath the feature, and gracefully ascends to the surface. But simply having *New Hampshire* on the surface is not enough to exchange people and equipment between the submarine and 'shore.' To do that, *New Hampshire* has to moor to the ice floe. While she maneuvers into a mooring position, the Water Works team augers (drills) holes into the ice and drops metal pipes into the hole. When *New Hampshire* is alongside, they toss their mooring lines to our party, who attach the lines to the mooring pipes.

"With the mooring complete, we can swing a brow from the ice to the ship, allowing people to get on and off. But the party can't just pack up and come back to the camp at this point. They have to stay on station until the submarine is ready to dive so that they can remove the brow and cast off the mooring lines. So when I talk about surfacing *New Hampshire*, that means a long cold day on the ice for some of our dedicated ice camp personnel."

March 22—The "Marvin Gardens Team" Clears the Ice

"In the last post, I talked about our Water Works team. We also have a 'Marvin Gardens team' for *Connecticut's* through-ice surfacing. What is different about this team?"

"Picking the right place for a submarine to surface through the ice (Marvin Gardens) is a balance between several factors. It has to be big enough for the submarine to fit in with a little bit of elbow room. It needs to be thick enough for people to walk on safely, but thin enough that we can clear the ice from the hatch in a reasonable amount of time.

"Before *Connecticut* arrived, we identified two good surfacing sites for her. The best—Marvin Gardens 2—



Clearing ice from *Connecticut's* hatch.

was over a mile long, a quarter mile wide, and about two feet thick. *Connecticut* used that for her first four surfacings. But, by Monday, the continued ice growth in that area made the ice almost three feet thick, so we found a thinner area—Marvin Gardens 3.

“When *Connecticut* is going to surface, Hector Castillo’s Marvin Gardens team goes out ahead of time to prepare the area. In addition to the homing beacon and underwater telephone, their most important tool is a shovel. For this Arctic mission, Arctic Submarine Laboratory equipped *Connecticut* with an upward-looking underwater camera. By shoveling a mark in the snow, the Marvin Gardens Party can designate exactly where in the feature they should surface. This mark is normally a simple ‘X,’ but on Monday, we used a ‘22,’ reflecting *Connecticut's* designation as SSN 22.

“After *Connecticut* breaks through the ice, the ice clearing team from APL/UW removes the ice from above their deck hatch. So, with the deck covered with ice, how do we know where the hatch is? Simple—before the boat sailed, we took a string and measured the distance from the aft end of the sail to the center of the hatch. Works every time. Very often in the Arctic, the low-tech solution is the best solution.”

March 25—Your Questions About ICEX Answered

“One of the advantages of posting and linking these posts on social media is that the readers have an opportunity to ask questions on topics that I haven’t thought to discuss. This post will answer some of those questions.

“We had several questions from readers whose fathers are serving on the submarines....

“Q. One asks whether their father’s duties as a machinist mate would be different while he is operating at the ice camp.

“A. Not really. The machinery operates the same here as it does anywhere. Your father is still standing the same watches and carrying out the same tasks.

“Q. Another asks a related question about how cold it is in the submarine now, and whether their father is able to stay warm.

“A. Don’t worry. Your father is nice and warm. The submarine is at the same temperature as in any other ocean—boats normally keep their thermostat at about 72 degrees and can overcome any outside or seawater temperature.

“Q. Another daughter asks whether it is scary.

“A. Not scary at all. I’ve been under the ice on submarines over 20 times and don’t remember any of the crewmen ever being afraid. When your father comes home, he will probably use words like ‘exciting,’ or ‘adventure,’ or ‘once in a lifetime,’ but not ‘scary.’

“Q. The same daughter asks how hard the ice is that *New Hampshire* is surfacing through, and whether it is difficult to break through.

“A. For this exercise, *New Hampshire* is only surfacing through either open water or slush. The thickest they will surface through is about the same as a snow cone or a Slurpee. *Connecticut* is surfacing through 2-3 feet of ice. This is about as hard as a sheet of sidewalk concrete. Given that *Connecticut* weighs several thousand tons, is as big as a 10-story building, and has a specially strengthened sail, these breakthroughs are not difficult at all.”

March 28—ICEX Is Nearing the End

“Only one day to go until the camp ends. There are a couple more tests we need to do. Both boats need to do a final surfacing to swap out their riders for the post-camp events, then we all go our separate ways. Only problem is that we’re totally engulfed in fog & snow. We can’t get the planes out to the camp from Prudhoe Bay, and we can’t fly the helo to the submarines. So we’re stuck here. Doesn’t look like the boats will be leaving here on schedule, and we at the camp may be a little late getting home.

“Many times, I’ve found that you can’t always do what you want up here—you can only do what the Arctic allows you to do....

“Of course, ten minutes after I wrote those words this morning, the skies suddenly cleared, and we were back in business. That just helps reinforce the point I was making above about working in the Arctic....

“...It’s been hard work in an extremely harsh and unpredictable environment.

“But everyone here has loved the experience.”

Ohio Replacement Submarine Technology



Photo courtesy of Northrop Grumman Naval and Marine Systems

In the Summer 2009 issue of *UNDERSEA WARFARE*, Capt. David Kriete discussed the need for a follow-on submarine to replace the *Ohio*-class ballistic missile nuclear submarines (SSBNs), which will begin to reach the end of their service lives in the late 2020s. Since that article's publication, the *Ohio* Replacement Submarine Program has made substantial progress, laying the initial foundation for the program. The recapitalization of the nation's sea-based strategic deterrent was validated by the 2010 Nuclear Posture Review. On Jan. 10, 2011, the *Ohio* Replacement Program entered its technology-development phase when the Principal Deputy Undersecretary of Defense for Acquisition, Technology and Logistics, Frank Kendall, signed the program's Milestone A Acquisition Decision Memorandum. During this phase, the program will establish requirements and continue design and technology development efforts that will ultimately lead to a ship construction contract.

The *Ohio* Replacement SSBNs will remain in service through the 2080s. The program developing these ships is faced with the chal-

lenge of incorporating technologies that are both sufficiently advanced to meet threats that will be fielded in the coming decades and sufficiently mature when construction starts to avoid costly redesign work. These demands must be balanced against the Navy's fiscal constraints, and design, construction and life-cycle costs must therefore be minimized from the very beginning. The critical strategic deterrent mission of the SSBNs requires these platforms to operate stealthily and sustain high operational availability, with long deployments followed by a rapid crew exchange and a short maintenance-upkeep period prior to the next patrol. The *Ohio* Replacement submarine will continue to fulfill this mission while incorporating cost-effective and reliable systems that are advanced—yet technologically mature.

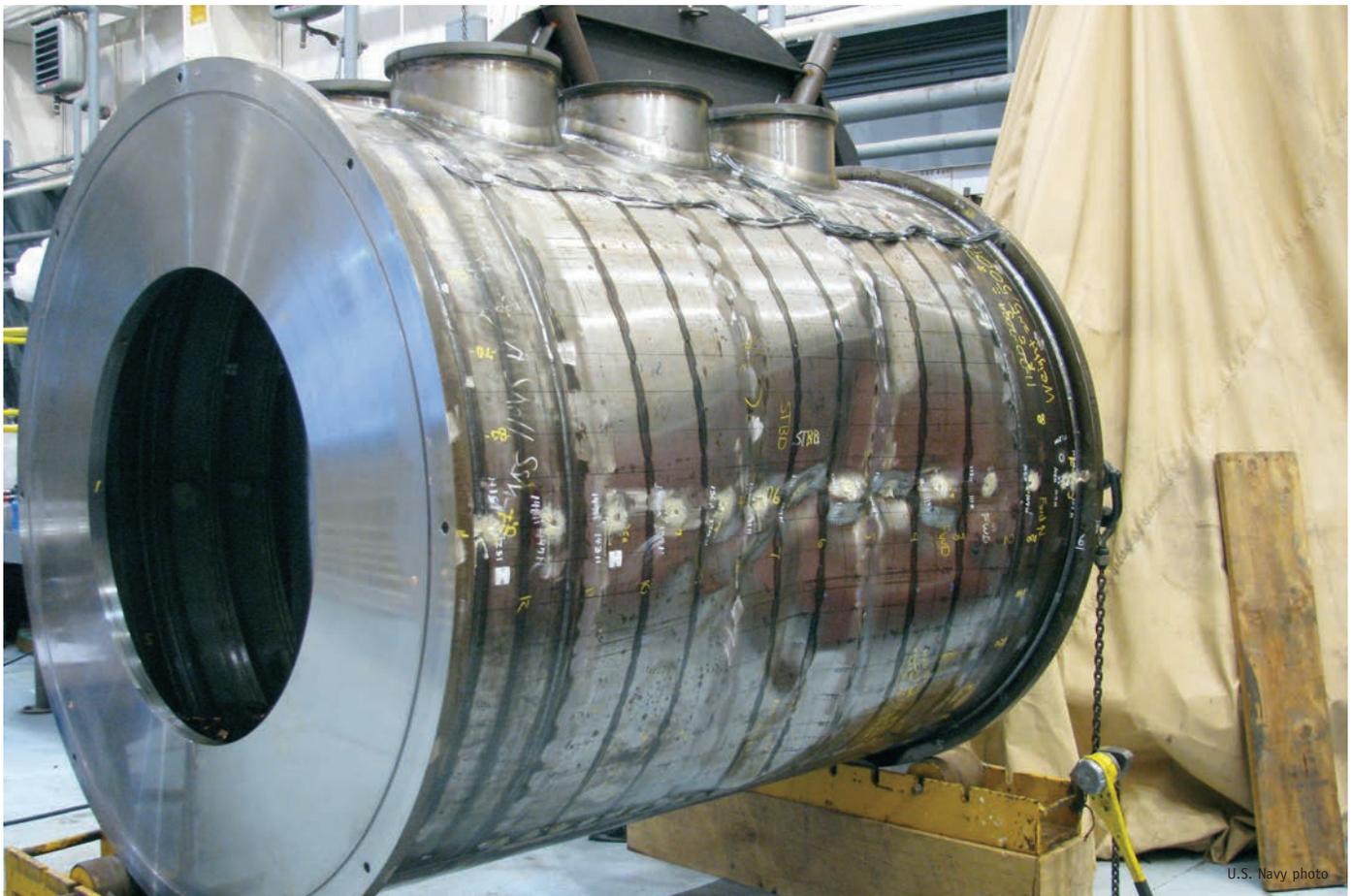
The opportunity to incorporate technology into the *Ohio* Replacement SSBNs is constrained. Beginning in 2027, the Navy will begin retiring *Ohio*-class SSBNs at a rate of one per year. To ensure that the Navy can fulfill its strategic deterrence requirements, the first replacement must be ready for its initial patrol in 2029. To meet this

(Above) A prototype missile tube produced by Marine Systems in Sunnyvale, Calif., part of Northrop Grumman's Naval & Marine Systems Division.

(Opposite) During a baseline hydrostatic pressure hull test, the *Ohio* Replacement Missile Compartment Pressure Hull Research and Development Model was successfully tested to collapse at NSWC Carderock's High Pressure Test Facility at West Bethesda, Md.

requirement, the Navy initiated the *Ohio* Replacement Submarine Program in 2010 to begin the design and development work required to reconstitute the sea-based component of the strategic deterrence triad (which consists of land-based, aircraft-based, and submarine-based nuclear weapon systems). Design, prototyping, and technology development efforts will continue to ensure sufficient technological maturity for lead ship procurement. The current Navy program begins detailed design efforts in 2015, with construction start in 2019, delivery in 2026, and the first strategic deterrence deployment in 2029.

Although the detailed requirements for the *Ohio* Replacement SSBN are still being



U.S. Navy photo

developed, the platform's key attributes are known and validated. These include:

- **Survivability:** the ability to survive against a determined future adversary
- **Persistent secure presence:** mission-based positioning for weapon application against multiple potential adversaries, independent of logistical support
- **Tailorability:** the ability to rapidly integrate new weapons, sensors, and electronic systems
- **Adaptability:** technical and operational flexibility for mission or life-cycle upgrades

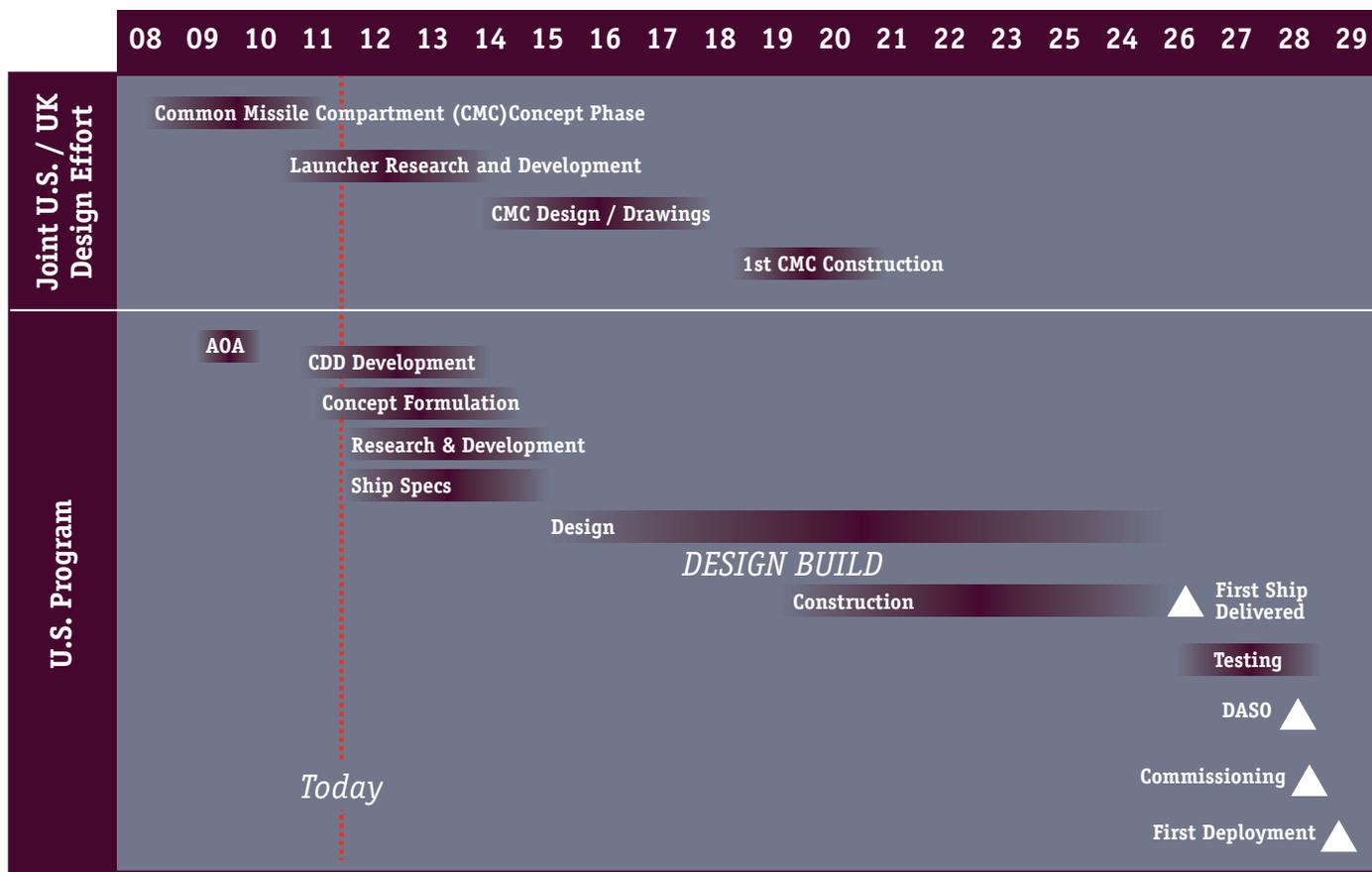
All of these attributes must be affordable. The sea-based strategic deterrence mission must be accomplished with the allocated national and Navy financial resources over the lifecycle of the platform. The Navy is committed to reducing total ownership cost (TOC)—i.e., all the costs associated with research, development, procurement, operation, logistical support, and demilitarization of systems and the supporting infrastructure over

[T]he Navy will leverage new techniques in an industrial base that has evolved to be markedly different from the one that produced the existing *Ohio*-class SSBNs. The *Ohio* class was developed and designed in the 1960s and 1970s, prior to the advent of computer-aided design and electronic visualization technologies used for the *Seawolf* (SSN 21) and *Virginia* (SSN 774) classes and the *Ohio* SSGN conversion programs.

the full life cycle—as a way to achieve the efficiencies that will allow the Navy to afford the future fleet. One facet of minimizing TOC is obtaining sufficient service life from the ships being designed today. The *Ohio* Replacement SSBN has a projected operational life exceeding 40 years, much like the extended lifetime of the existing *Ohio*-class SSBNs, but without requiring a mid-life refueling.

To achieve these key attributes, the Navy will leverage new techniques in an industrial base that has evolved to be markedly different from the one that produced the existing *Ohio*-class SSBNs. The *Ohio* class was developed and designed in the 1960s and 1970s, prior to the advent of computer-aided design and electronic visualization technologies used for the *Seawolf* (SSN 21) and *Virginia*

Fiscal Year



This timeline shows the ongoing efforts of the *Ohio* Replacement Program. U.S. Navy graphic.

(SSN 774) classes and the *Ohio* SSGN conversion programs. At the same time, the industrial base supporting the new class is significantly smaller and challenged by many years of low-rate submarine procurements and the significant time since construction of the last *Ohio*-class SSBN.

To provide an affordable and capable submarine, the *Ohio* Replacement design efforts will build on the successes of prior submarine programs, using a “Design, Build, and Sustain” process. This concept incorporates early consideration of fabrication, life-cycle support, and user inputs during design in order to minimize cost through construction and the life of the program. This process has been proven to reduce design change orders and shorten construction time and costs. The *Ohio* Replacement Program will also leverage techniques used during the successful *Virginia*-Class Program cost-reduction efforts. In addition, the *Ohio* Replacement Program will apply the results of the recently started reduction-of-total-ownership-cost (RTOC) initiative for the *Virginia* class

to reduce both acquisition and in-service costs. The *Ohio* Replacement Program has been funded for—and has established—a design-for-affordability (DFA) effort. Design for affordability is an engineering-driven, aggressive cost-reduction effort to lower total ownership costs (design, acquisition and life cycle). The DFA effort has dedicated teams to establish cost objectives, establish technical baseline, develop a cost-benefit assessment process, assess existing “design, build, and sustain” efforts, assess *Virginia* DFA/RTOC initiatives, develop a DFA process, and implement *Ohio* Replacement DFA initiatives.

To ensure that new technologies are properly investigated and matured prior to the beginning of the *Ohio* Replacement’s design, the Naval Sea Systems Command (NAVSEA) Undersea Technology Program Office (SEA 073R) established a research, development, and prototyping (RD&P) plan in 2008. The plan examined the enduring characteristics of the SSBN and sought to leverage existing submarine R&D and developmental programs. Additionally,

the RD&P planners coordinated with the Office of Naval Research (ONR), the Defense Advanced Research Projects Agency (DARPA), and Small Business Innovative Research (SBIR) efforts to leverage their development investments and take advantage of their broad spectrum of experience and technical expertise.

The *Ohio* Replacement RD&P plan is focused on candidate solutions with consideration of current and future national and undersea threats, technological maturity, initial and life-cycle affordability, and potential for upgradeability in light of changing operational conditions and constraints. The plan will leverage the significant investments made in technology for the *Virginia* class and the affordability initiatives put in place to reduce the procurement cost of later *Virginia* blocks.

The RD&P plan focuses on key factors—driven by naval architecture constraints—design margin, construction techniques, and available material solutions that affect final design and configuration and cannot be readily upgraded once the ship is built.

These factors must be carefully examined to balance performance, cost and technical risk. Key areas addressed in the RD&P plan include:

- Propulsor: small- and large-scale vehicle prototyping and testing to support performance characteristics, and considerations of improved propulsor maintainability
- Hovering and ship control: thrust vectoring, electrically actuated control surfaces, and stern configuration tradeoffs
- Application and integration of *Virginia*-class submarine technology such as a large-aperture bow (LAB) sonar array, hull arrays, and sail arrays
- Improvements in maintainability and reliability of submarine towed-array handling systems
- Corrosion control and monitoring capabilities to mitigate maintainability issues, vulnerabilities and susceptibilities
- Manufacturing, assembly, alignment and joining of missile tube sections

To ensure that the *Ohio* Replacement remains a viable strategic deterrent into the 2080s, the ship's systems that support the hull, mechanical, and electrical (HM&E) attributes require test facilities and knowledgeable personnel to design, test, fabricate and complete full-scale qualification efforts. The *Ohio* Replacement Program will use existing Department of Defense facilities, including those managed by the Naval Research Laboratory (NRL), Naval Surface Warfare Center (NSWC), Naval Undersea Warfare Center (NUWC), and several industrial and shipyard sites to perform early evaluation of ship systems and subsystems as part of the *Ohio* Replacement RD&P plan.

Where possible, the *Ohio* Replacement's non-propulsion electronic systems will use electronic systems common to all submarine classes, and keep them current using the successful business model established for the Submarine Warfare Federated Tactical Systems (SWFTS). These systems utilize commercial off-the-shelf components and are on a regular technology insertion (TI) and advanced processor build (APB) cycle that ensures that they remain state-of-the-practice. This business model allows for rapid introduction of new capabilities through an open architecture on a system of systems.

The *Ohio* Replacement program will

also incorporate universal modular masts (UMMs) that allow for the ability to rapidly integrate new systems and capabilities as they become available.

Building On a Strong Foundation and Evaluating New Technologies

Among the technologies being assessed for the *Ohio* Replacement are composite components, a Command and Control Center (CACC) arrangement common with *Virginia*-class Block IV, and a re-designed stern.

By replacing steel with composites in non-pressure hull applications, the Navy could realize both acquisition and life-cycle savings, while possibly reducing the ship's weight. Under an SBIR contract, NAVSEA is working with industry on submarine bow domes that would not require a large autoclave for curing the components. Non-autoclaved dome technology could allow development of a larger composite dome for the *Ohio* Replacement without significant investment in a unique manufacturing facility.

The Navy is evaluating common CACC arrangements for both the *Virginia*-class Block IV and the *Ohio* Replacement Submarine Program. A common arrangement will allow the Navy to take advantage of advances in computing and display power to be able to reconfigure the command and control spaces for the operational mission while decreasing heat and power loads on the ships' hotel services. The Navy is also considering decoupling display and control stations for the Common CACC through the use of cold rooms for the racks of computer servers. In doing so, the Navy would enhance the flexibility for control center arrangements and could thereby improve the servers' reliability and maintainability, reduce costs, and allow more time- and cost-effective upgrades without disrupting control center operations while in-port. From an operational standpoint, the arrangement and equipment in these spaces will be consistent across submarine classes, such that a Sailor could perform the same routines on SSNs and SSBNs.

Many variations of stern control surfaces have been incorporated in the world's submarines over the years, including the traditional cruciform design and X-Stern. Presently, the Navy is considering a twin-rudder design, the H-Stern, for potential use on the *Ohio* Replacement. The H-Stern

configuration offers potential for reducing disturbances to the propulsor inflow and could enable improved ship maneuverability using smaller—but more numerous—control surfaces and actuators.

The manufacturing and assembly of the *Ohio* Replacement missile tubes represents another area where we are examining cost and technology very closely. With an eye on construction efficiencies, the Navy is researching a new integrated tube and hull (ITH) technique for assembling the common missile compartment (CMC). The ITH configuration would incorporate cast or forged missile-tube hull flanges, automated welding and assembly, and an advanced manufacturing and positioning capability to enable groups of four missile tubes—"quad packs"—to be integrated horizontally prior to installation on the ship, and then installed as single modules into the ship hull section. The ITH technique would allow these tubes to be largely outfitted off hull prior to assembly in the missile tube quad packs, saving construction and outfitting costs. Previously, the Navy built SSBNs by top-loading the missile tubes into the hull section, requiring extensive welding within the hull, which is more expensive than employing modular construction and doing the same work on a shop floor.

Our Mandate

The Navy must attend to every detail to ensure that the *Ohio*-Class Replacement meets its strategic requirements in the most cost-effective and efficient manner possible. While leveraging off the *Virginia* class to the greatest possible degree, the Navy will continue to mature required technologies to ensure that this critically-important strategic deterrence asset can carry out its mission into the 2080s.

Capt. Bishop is the Program Manager for the *Ohio*-Class Replacement Program (PMS 397) at the Program Executive Office for Submarines in Washington, D.C.

Undersea Warfare in Virtual Worlds

Enhancing Design, Analysis, Experimentation and Training

Introduction

The last two decades have witnessed dramatic advances in technology to aid system design, analysis, experimentation and training. Building on the computer-aided design (CAD) revolution of the 1990s, a new and more human-centric technological revolution is allowing people to collaborate in many new ways. This broader revolution has already created virtual environments that combine the power of CAD—the foundation for most synthetic environments—with technology such as Web 2.0, gaming engines and distributed modeling and simulation.

These are not just more capable synthetic environments, but fully immersive “virtual worlds” (VWs) where people can come together to innovate. Distributed teams can now design, create and experience any workspace they choose, while enjoying full social interaction with each other both by voice and by visual presence. Today’s VWs

are laying the foundation for full human immersion into synthetic environments akin to those portrayed in popular science fiction films such as *Tron* (1982), *The Matrix* (1999) and *Avatar* (2009).

Since 2008, the Naval Undersea Warfare Center (NUWC)’s Newport Division has been investigating the potential of rapidly evolving VW capabilities across all of its mission areas. A team of Newport Division engineers and scientists have been working closely with industry, academia and other military branches to demonstrate ways in which VWs can enhance collaboration and innovation in undersea warfare. The team is exploring many uses for VW technology, but this article focuses on examples of how it can support collaborative engineering in the design of submarine command and control, in the visualization and analysis of command information, in human-in-the-loop experimentation, and in a variety of tactical training.

VW Characteristics

Simply speaking, a virtual world is a three-dimensional (3-D) computer environment—often created in real time by the user community—where users are uniquely represented on screen as themselves and can interact with other users. A key trait is that this environment is immersive, letting users feel as if they truly reside in this “world” along with other users. Web 2.0 in particular has allowed VWs to become social environments where users interact both audibly and visually. The Web 2.0 toolset provides a blank palette for users to create and control their own environment based on their individual interests, needs, and requirements. A VW is a user-created experience.

The military must of course be able to deploy VWs within a fully secure network. Driven by operational requirements, by the requirement to safeguard classified information, and by specific information assurance (IA) mandates from the Naval Network Warfare Command (NETWARCOM), the Navy is working closely with commercial-off-the-shelf VW vendors such as Linden Lab (creators of the popular *Second Life™* VW) to ensure their products are IA-compliant. The result is a variety of VW configuration options, ranging from public Internet VWs like the 64-acre “Virtual NUWC” campus in *Second Life™*, to for-official-use-only VWs like *Teleplace™* and *Second Life Enterprise™* behind the NUWC firewall, to VWs like *OpenSimulator™* on classified networks.

Figure 1. VW Program Manager Steven Aguiar on a virtual USS *Virginia* (SSN 774). All graphics courtesy of NUWC Newport Division.





Figure 2. A photo-realistic avatar (*left*) in Second Life™ created from digital photographs like the one at right.

Collaborative Engineering

The fundamental requirement for collaborative engineering—i.e., for various scientists and engineers to contribute successfully to a common design—is clear and natural communication channels. In a virtual environment, just as in the physical world, participants must see and hear each other, present ideas to each other, and share content. Today's VWs satisfy these requirements.

VWs represent users as 3-D avatars. An avatar can look photo-realistic, as in Figure 2, and can even track and represent facial expressions. This helps immerse users into the virtual space and give them a greater sense of presence. VWs also support voice and instant messaging within the virtual environment for clear and easy communication. The addition of application-sharing and Web integration allows users to easily share existing 2-D content and media, such as presentations, documents, images and Web-based applications. These capabilities form the basis for robust virtual conferencing and collaboration.

VWs give any existing organizational network—whether a private, secure enclave or the open Internet— an immersive interface that facilitates remote and distributed interaction. In other words, any participant on the network can interact with any other participant as if they were in the same physical space, regardless of their actual location. Some VWs like Second Life™ even provide simple Microsoft PowerPoint™-like build tools so that participants can easily collaborate to build content in real-time. User-generated content is the power of Web 2.0. In addition, a number of VW products support the reuse of existing 3-D models in wire mesh formats created from external 3-D modeling applications like the Computer-Aided Three-dimensional Interactive Application (CATIA). This allows participants to avoid having to rebuild complex models in the VW.

Designing Submarine Command and Control (C2)

Historically, designers of submarine attack centers have built small-scale physical mock-ups to help them visualize and evaluate the three-dimensional spatial relationships involved in command and control. Figure 3 shows a design team gathered around a small-scale replica of that sort in 1982. But building a physical model was costly and time-consuming. Furthermore, it did not represent human interaction within the space, so a full-scale plywood mockup eventually had to be built for actual humans to validate preliminary findings from the miniature version.

In contrast, designers can now lay out a submarine attack center in a virtual world where avatars can represent real-world human interactions. Moreover, not just the design team, but all stakeholders—including the fleet, government civilians and contractors— can potentially collaborate in designing,

building, and assessing this virtual layout. Depending on the situation, a single designer could interface with the VW on everyone's behalf, or any given number of participants could interface with it in a distributed fashion through their unique avatars.

A good example of collaborative design is the week-long arrangement studies workshop that the Information Architecture for Improved Decision-Making (IA4IDM) Program held in Groton, Conn., in October 2010. At that event, submarine crews, with the aid of C2 subject-matter experts and cognitive scientists, generated ten separate Command and Control Center (CACC) arrangements in real-time. Figure 4 shows one such arrangement, with ship control moved aft and a 360-degree overhead display provided for the command function. In this depiction, the virtual CACC is kept simple and block-like to emphasize function and location and deemphasize chassis and monitor details. The shipbuilder, General Dynamics Electric Boat, later implemented the fleet's ten conceptual arrangements in CAD to ensure that they could be built (with appropriate modifications).

The design process is iterative, with each successive design linked to source material such as 3-D models of its hardware, documentation of its software systems, and related websites. The resulting "design" is not a single model but a documented evolution of the design process that captures its pedigree, as in Figure 5. Persistent linkage to source

Figure 3. An attack center design team in 1982.



U.S. Navy photo

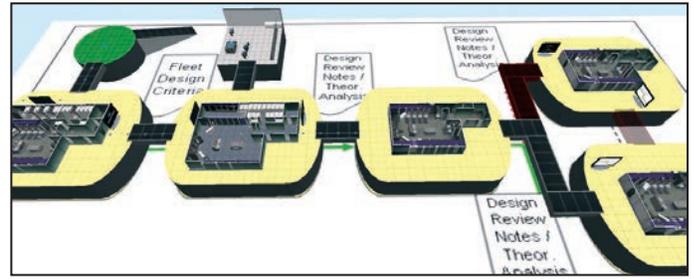
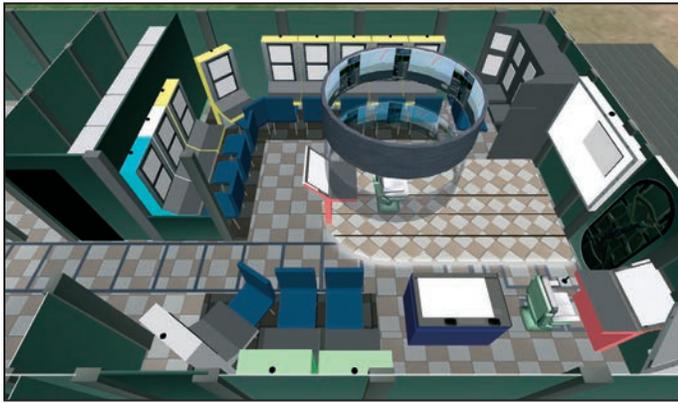


Figure 4 (left). A fleet-generated CACC using a VW model.

Figure 5 (above). A collaborative environment in Second Life™ documenting the evolution of a submarine C2 center.

material provides knowledge management. As each arrangement decision is reviewed, a complete evolutionary string affecting that decision is available as a walk-through.

Submarine C2 Visualization and Analysis

The next step in the design phase, visualization and analysis, aims to understand all the components that affect C2 decision-making in a *Virginia*-class CACC. Beyond simple console arrangement, C2 is affected by information architecture components such as workspace, human communications, human-system interface (HSI), team structure, work flow, task flow, automation and training. The goal is to expose each architecture component's effect in a specific mission scenario. For example, in the notional ASW mission string shown in Figure 6, human communications are depicted as green (visual), blue (audio), white (control) and purple (electronic) information paths from earliest detection (in theater) to a command decision. Other components such as task flow can be shown by linked, dynamic "mind maps" located above the appropriate member of the watch team.

The intent is, first, to play a high-fidelity recorded event within a fully virtual environment, then to expose a particular mission string (e.g., an ASW kill chain), showing only the information architecture components that are affecting the command decision at any given time. This helps determine which metrics to employ in an actual experiment and to document the performance expected from a future CACC design.

Submarine C2 Experimentation

In December 1984, a concept-of-operation exercise (COOPEX) to support the development of submarine advanced

combat systems used actual watchstanders to show how fleet personnel would interact with the proposed system's highly advanced operational characteristics. The COOPEX succeeded in defining when and how watchstanders would use individual consoles and how the team would operate. Other full-scale C2 experiments have since taken place to validate CACC designs, but all this has required a good deal of time and money.

Similar human-in-the-loop experimentation can be performed more cost-effectively in a VW. A VW can show the communication mechanisms and model the physical space. It has also demonstrated the ability to support interaction with real or simulated hardware and software systems, which is essential for full C2 functionality. For example, virtual network computing (VNC) makes any system running a VNC server accessible from any other computer connected to the same network, giving users full interactive control of the remote system by mouse and keyboard. Virtual-world service providers like Teleplace™, and, more recently, Second Life™, have successfully integrated VNC into their VW platforms. Consequently, once a virtual CACC (or any other physical space) is mocked up in a VW, the systems that drive the displays can be connected, visible, and fully accessible from within the virtual world.

NUWC's Newport Division leveraged this capability in a proof-of-concept pilot study to assess the potential for supporting a fully interactive CACC in a virtual COOPEX. In August 2009, it ran an experiment to assess the performance of fleet operators in a VW compared to the physical world. Two groups of fleet personnel, each group containing two operators, performed submarine target

motion analysis (TMA) to identify, classify and track a contact. Each team ran through a TMA scenario twice—accessing the submarine combat system both from actual CACC hardware and through the virtual CACC. Figure 7 shows the virtual COOPEX setup, with the users' avatars sitting at a virtual console focusing on a virtual screen connected to real tactical hardware. VNC allowed fleet operators to control the virtual screens with a standard keyboard and trackball.

The results were very positive, indicating that the operators performed equally well with both the virtual and the real system. Novice operators with no prior experience on the specific CACC version used in the experiment found that using the virtual C2 system improved their performance with the actual CACC hardware. Expert operators experienced medium to high levels of confidence in the decisions they made using both systems. The only noticeable drawback of using the virtual system was a lag of up to one second due to VNC. The proof-of-concept experiment indicated that the C2 dynamics within a remote, distributed virtual environment are comparable to those within an actual physical environment. This should be equally true for experiments at the platform level, at the theater level, or combining both levels.

Tactical Training

Training and curriculum design have long focused on traditional methods such as lectures and textbooks, but a VW can provide very effective and engaging learning spaces. VWs can accurately represent reality (e.g., simulating a tactical scenario), and they can present content in ways that make it easier to understand. They have demonstrated the ability to provide virtual classrooms, both

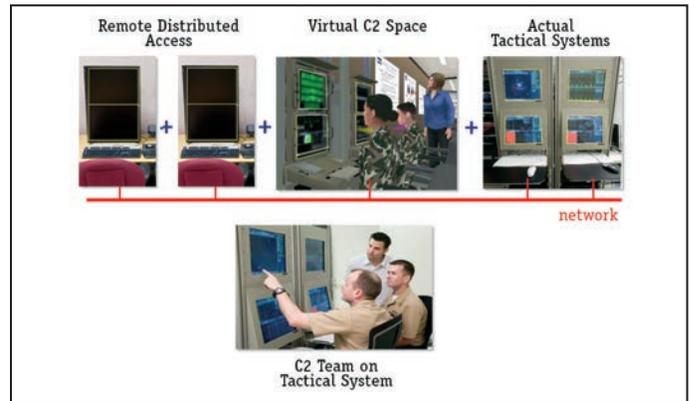
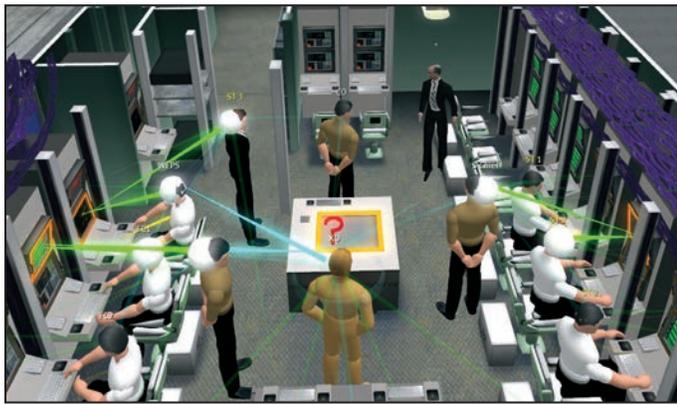


Figure 6 (left). Visualization of C2 information flow in a submarine CACC. Figure 7 (right). Virtual COOPEX setup. Figure 8 (below). The immersive TMA training module at the Naval Submarine School.

remote and distributed; remote connectivity to subject matter experts; rehearsal and gaming of submarine scenarios; training in maintenance procedures; visualization of a curriculum (e.g., in situ demonstration of theater-level tactics); and, most recently, business process training.

One way to take full advantage of the virtual part of VW technology is to create an immersive learning space with a visually engaging and interactive environment that represents information in the best way for learning, even if it is not realistic. For example, a prototype was created in 2009 to teach the fundamentals of TMA to submariners, focusing on parameter evaluation plot (PEP) theory and pattern assessment. By simply reconstructing a PEP image slowly in three dimensions while simultaneously showing the family of hypothetical track solutions each cell represented (shown in Figure 8), it helped users understand how a PEP cell with a particular solution and quality maps to the more familiar geo-space. The ability to walk into the PEP image and move

a pointer (a large steel ball) enabled users to interrogate the differences between different parts of the image.

NUWC's Newport Division is working with the Submarine Learning Center and the Naval Submarine School to enhance current A-school TMA training by creating an innovative training environment that includes the immersive TMA module. This will let operators observe how a problem in the real waterspace is translated into a 3-D plot and eventually to a 2-D plot in the submarine system. While the effectiveness of this training compared to traditional PEP instruction is being evaluated, the insight it is providing into PEP construction and pattern dynamics is attracting increased notice in the submarine TMA training community.

Implications and Conclusion

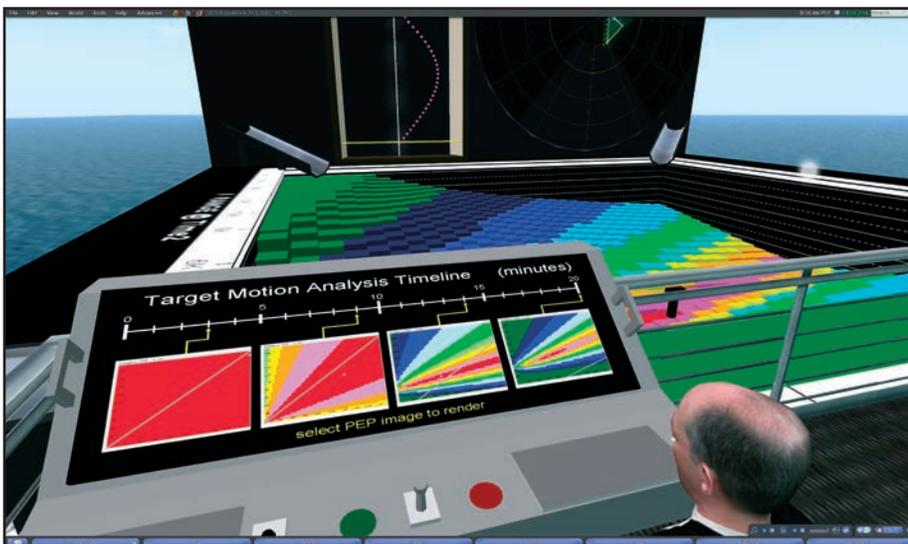
Any new technology encounters barriers to widespread adoption, and VW technology is no exception. Information assurance is criti-

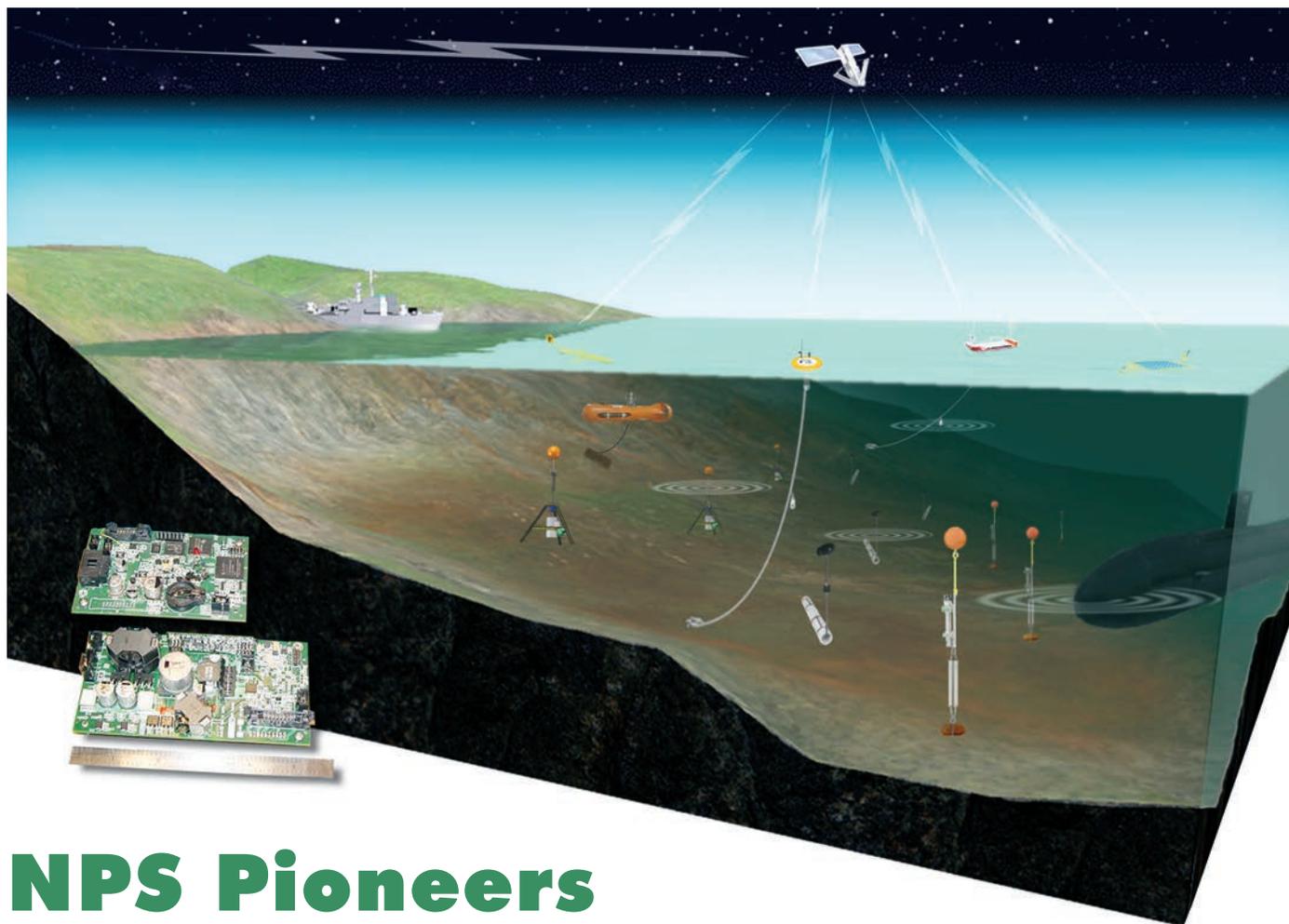
cal, especially as this technology makes its way to the warfighter. But what is essential to protect Navy information can constrain the exploitation of key VW social features such as Voice over Internet Protocol (VoIP) and instant messaging (IM). The challenge is to bring the military and VW industry partners together to develop and deploy secure VWs.

Another challenge, perhaps even more profound, is the psychological and sociological implications of moving work—conferencing, training, collaboration, experimentation—into an immersive environment where users appear as avatars rather than physical presences. This is less daunting for “digital natives” accustomed to working in virtual environments, but others will no doubt find it difficult at first. Virtual world acclimation—as opposed to training—will therefore become an increasingly important field for research.

Advances in VW technology offer the U.S. Navy promising and cost-effective opportunities to conduct design, analysis, experimentation and training with unprecedented levels of collaboration. While research into the efficacy of virtual worlds is still in its early stages, the technology has already been applied to a number of programs with positive results. Users have reported increases in the rate of innovation and levels of collaboration that would otherwise be unaffordable. NUWC's Newport Division will continue to work closely with industry, academia and the military to explore how this technology can best support the fleet and advance the Navy's undersea superiority.

Donald McCormack is the technical director of the Naval Undersea Warfare Center. Steven Aguiar is the program manager of NUWC's Virtual World Program. Philip Monte is the technical lead of the Virtual World Program.





NPS Pioneers "Seaweb" Underwater Sensor Network

In his 2009 guidance on executing the Maritime Strategy, Chief of Naval Operations Adm. Gary Roughead emphasized the importance of what he called "decision superiority."

"We must ensure Navy forces have decision superiority, particularly in intelligence, surveillance and reconnaissance (ISR), command, control, communications and computers (C4), information operations (IO), and cyber warfare."

In today's operational environment, achieving decision superiority is not so much a matter of enhancing any given sensor system, but rather of integrating autonomous sensor systems into coherent networks to provide timely and relevant information for any level of decision-making the situation requires. The Navy's concept

for achieving this goal is called FORCEnet, which it defines as:

"The operational construct and architectural framework for naval warfare in the information age, to integrate warriors, sensors, networks, command and control, platforms, and weapons into a networked, distributed combat force, scalable across the spectrum of conflict from seabed to space and sea to land."

The Naval Postgraduate School (NPS) is on the cutting edge of the effort to bring the FORCEnet concept to the undersea environment. Its Seaweb research, development, test and evaluation program focuses on the use of underwater acoustic communications to integrate distributed autonomous ocean sensors into wireless, wide-area underwater networks. The mission and composition of

the resulting distributed system can vary widely—it may even include submarines—but because the underlying principles and technologies remain the same, NPS uses the generic term "Seaweb" for any such system.

Every Seaweb system includes the three basic building blocks for an infrastructure capable of performing persistent, distributed undersea sensing: autonomous underwater sensor nodes, which can be either fixed or mobile; repeater nodes, which employ underwater acoustic modems; and radio-acoustic communication (Racom) gateway nodes. (The illustration above shows the compact electronics of an acoustic modem (*above*) and a Racom gateway (*below*) compared to a 6-inch ruler.)

A gateway node, typically located at the sea surface, includes both an acoustic modem

Through a decade of engineering experiments and sea trials in diverse maritime environments, NPS, in collaboration with SPAWAR Systems Center Pacific and other research partners, has advanced Seaweb to the point where it not only routinely demonstrates maritime surveillance, but also permits remote-control of instrumentation, oceanographic sampling, underwater navigation, anti-submarine warfare (ASW) and even submarine communications at speed and depth.

and a radio modem capable of supporting two-way digital communications in real time between the underwater Seaweb domain and the outside world. The gateway node may communicate with manned or unmanned platforms on the surface, in the air and in space, as well as with remote facilities ashore. Whatever path its communications take, the gateway node's two-way capability not only gives the appropriate commanders real-time, actionable data from the Seaweb domain, but enables them to control the Seaweb network for optimal sensing.

But Seaweb is more than a scalable sensor net. Through a decade of engineering experiments and sea trials in diverse maritime environments, NPS, in collaboration with SPAWAR Systems Center Pacific and other research partners, has advanced Seaweb to the point where it not only routinely demonstrates maritime surveillance, but also permits remote-control of instrumentation, oceanographic sampling, underwater navigation, anti-submarine warfare (ASW) and even submarine communications at speed and depth.

"Seaweb is a realization of FORCEnet in the undersea battlespace," said NPS Research Professor Joseph Rice, the program's principal investigator. "Seaweb is the product of interdisciplinary R&D [research and development] involving underwater acoustic propagation, sonar systems engineering, transducer design, digital communications,

signal processing, computer networking, and operations research. Our original goal was to create a network of distributed sensors for detecting quiet submerged submarines in littoral waters, where traditional ASW surveillance is challenged by complex sound propagation and high noise. But as Seaweb technology developed, its broader overarching value became evident."

For example, in a 2001 Fleet Battle Experiment, a U.S. attack submarine serving as a cooperative target for Seaweb ASW sensors was itself equipped as a Seaweb node. Thus instrumented, the submarine was able to access the deployed autonomous nodes as off-board sensors. While transiting at speed and depth, the submarine was also able to communicate through Seaweb with the command center and a collaborating maritime patrol aircraft.

"In effect, the Seaweb network served as a cellular communications and sensor infrastructure for the submarine," Rice said.

A major advantage of an undersea wireless network is the flexibility it affords mission planners and theater commanders to appropriately match resources to the environment and mission at hand. For example, a number of Seaweb experiments have demonstrated the ability to combine fixed sensor nodes with unmanned underwater vehicles (UUVs). In addition to serving as a mobile sensor node, a UUV can perform a number of other useful functions within the network.

"The UUV can serve the fixed nodes as their deployment platform, their gateway node, or as a mule for delivering and recovering large volumes of data," Rice explained. "In turn, the fixed network can support UUV command, control, communications and navigation."

Another example of the flexibility of Seaweb networks is the networking of surveillance sensors with meteorological and oceanographic (METOC) sensors to improve the performance and relevance of both. The ready availability of local METOC data enhances the effectiveness of the underwater surveillance assets, and networking with other assets also helps the METOC sensors operate more effectively.

Seaweb's wireless architecture allows ASW sensors to be distributed sparsely, to cover a wide area, or deployed more densely, to monitor a chokepoint or to achieve a level of resolution that will permit them to serve as a tripwire for engaging potential targets. It can also interconnect the undersea sensors deployed by different government agencies or even different countries. For example, in a current international project known as "Next-Generation Autonomous Systems," Seaweb is interconnecting ASW sensors from several NATO nations to form a single integrated network.

"In short," Rice points out, "Seaweb integrates undersea warfare systems across missions, platforms, systems and nations."



U.S. Navy engineers service the battery box of a radio-acoustic communication (Racom) gateway node during the “Bayweb 2009” experiment in San Francisco Bay.

Major attributes of Seaweb’s architecture are its low cost, its suitability for rapid deployment from a variety of platforms, and its ability to autonomously self-configure into an optimal network. Through a “build-test-build” spiral engineering process and through rigorous sea testing of diverse configurations of underwater sensors and Seaweb modems, the effort is honing the blueprint for a multi-purpose, two-way undersea communications architecture that can cover wide areas and is environmentally adaptive, energy efficient, cost-effective and expendable.

“Seaweb has now been exercised in over 50 sea trials,” Rice noted. “The system has proven to be effective in very shallow water, such as the Intracoastal Waterway, and in water up to 300 meters deep off the coasts of Nova Scotia, San Diego, Long Island and Florida. It has been demonstrated in the Pacific and Atlantic Oceans, in the Mediterranean and Baltic Seas, in Norwegian fjords and under the Arctic ice shelf.”

Multi-agency trials in a maritime domain awareness environment demonstrated Seaweb’s ability to provide useful front-end input for decision-makers. They showed that a distributed network of *in situ* sensors in the area being monitored can complement remote sensors and enhance commanders’

situational awareness. This makes commanders more effective by helping them complete the classic decision-making sequence known as the OODA loop—which stands for “observe, orient, decide, act”—more rapidly and more in tune with the developing situation.

The year before last, Rice and his students completed a two-part “Bayweb 2009” experiment to test the use of Seaweb’s undersea communication technologies in San Francisco Bay. They collaborated with the U.S. Coast Guard to install a Seaweb Racom gateway on an operational navigation buoy in the center of the Bay. Bayweb 2009 used a cellular telephone modem as the radio portion of the gateway module and connected it to a Seaweb acoustic modem mounted to the bottom of the buoy.

In addition to demonstrating the network architecture and testing system performance in the Bay environment, Bayweb 2009 used networked current sensors placed near the seabed to measure the strong currents around Angel Island and shared the resulting data with oceanographers. The Naval Postgraduate School’s partners in this effort were the University of California, Berkeley; University of California, Davis; San Francisco State University; Monterey

Bay Aquarium Research Institute; the Space and Naval Warfare Command’s Systems Center, Pacific; the Office of Naval Research; and the U.S. Coast Guard.

It is not uncommon for Seaweb researchers to deliberately stress the network to the point of failure in order to identify and eliminate weaknesses. Bayweb 2009 put a lot of stress on the system. “Due to the high levels of shipping and wind and flow noise from currents up to four knots, San Francisco Bay presented a challenging test environment and a learning opportunity for our students,” Rice said.

Some of Rice’s NPS students are working on a new “Deep Seaweb” concept that is adapting the littoral Seaweb network to the deep ocean. An important aspect of that project is enhancing submarines’ ability to communicate while submerged.

“It’s of utmost importance to the Navy to maintain submarine communications, but all existing communication methods are severely limited without compromising either speed or depth, or both,” said Lt. Andrew Hendricksen, a submariner and an operations analysis student at NPS. “Once deployed, Deep Seaweb is the one option that allows stealthy, two-way submarine communications while maintaining both depth and speed. A number of sea trials have proven Seaweb works as a detection network that can be expanded for two-way communications with undersea assets—submarines and UUVs—in the deep ocean. My thesis research is developing an algorithm that can show the best places to put it to get the coverage you want to achieve the purposes you want—for sub detection, sub communications, tsunami warning, etc.”

Another NPS student, Lt. Jeremy Biediger, is exploring the advantages of deploying Deep Seaweb hydrophones in deep ocean trenches to passively detect quiet targets at the sea surface.

“The main advantages of deploying Deep Seaweb networked acoustic sensors along deep ocean trenches for barrier or tripwire coverage of submarines and of surface and semi-submersible vessels are reduced ambient noise and thus relatively high signal-to-noise ratio,” explained Biediger.

“It’s great working with Professor Rice because he’s a research professor who’s really involved with the ASW community and the system commands, so you get to meet and work with many of the top people in those communities,” Biediger added. “What

I learned will be of great benefit to my future career as an engineering duty officer, especially on the acoustics side, as very few universities have acoustics programs, and the Naval Postgraduate School is unique in acoustics with naval applications.”

“Future undersea sensor grids will enable navigation of submarines and autonomous underwater vehicles,” Rice noted. “Seaweb technology could also support submarine communications, networked torpedo connectivity for ASW engagement from launch platforms at long standoff, communication among unmanned underwater vehicles in mine-countermeasure operations, and any undersea warfare system that requires data telemetry for command and control.”

The NPS Seaweb program’s primary sponsor is the Office of Naval Research, with additional support from the Office of the Secretary of Defense. NPS Seaweb research collaborators in 2010 included SPAWAR Systems Center, Pacific; the University of Texas Applied Research Laboratories; the NATO Undersea Research Centre; Canada’s Defense Research and Development Center, Atlantic; the Norwegian Defence Research Establishment; the Technical Cooperation Program (TTCP), a five-nation defense research and development collaboration involving Canada, Australia, New Zealand the United Kingdom, and the U.S.; and Teledyne Benthos, Inc.

“The goal is for Seaweb technology to support the operational community,” Rice stressed. “In the near term [in 2011], we’ll be testing networked passive ASW sensors against a cooperative diesel-electric submarine in the Mediterranean Sea.”

Submarines will continue to run silent and run deep, but in the future they will share their watery domain with a grid of autonomous systems. In fact, they will be a critical part of that grid. Submarines will be responsible for deploying fixed autonomous sensors and unmanned undersea vehicles. They will benefit from the enhanced decision superiority afforded by these off-board systems and by communication gateways to distant command centers. The Seaweb that submarines cast beneath the ocean will magnify their current domination of the undersea battlespace.

Barbara Honegger is a military affairs journalist with the Office of Institutional Advancement at the Naval Postgraduate School.

Recent Students Participate in Seaweb Research at Naval Postgraduate School



The Naval Postgraduate School’s 2010 student Seaweb team with Seaweb principal investigator Joseph Rice outside Spanagel Hall, which houses the new Undersea Warfare laboratory. Left to right: Singapore Navy Maj. Meng Chong Goh, Lt. Jeremy Biediger, Lt. Andrew Hendricksen, Professor Rice, Royal Thai Navy Lt. j.g. Pongsakorn Sommai and Ens. Bill Jenkins.

NPS Research Professor Joseph Rice leads Seaweb multidisciplinary research in undersea acoustic propagation, communications and networks. He has been a U.S. Navy research engineer at SPAWAR Systems Center (SSC), Pacific, since 1981, developing digital signal processing and numerical modeling concepts for solving undersea acoustics problems. From 2001 to 2007, Rice also held the SSC Pacific Chair of Engineering Acoustics at NPS, before becoming an NPS Research Professor of Physics.

More than 20 Naval Postgraduate School students have participated in Seaweb research and published master’s theses reporting their work. The students shown carried out the following work in support of the Seaweb effort:

Republic of Singapore Navy Maj. Meng Chong Goh, an acoustical engineer, wrote his thesis on event-driven simulation and analysis of the “Seastar” underwater local-area network.

Lt. Jeremy Biediger, a physicist, wrote his thesis on the advantages of deploying “Deep Seaweb” hydrophones in deep ocean trenches to passively detect stealthy semi-submersibles and high-speed surface vessels, both of which have been used to smuggle drugs.

Lt. Andrew Hendricksen, a submariner and operations analyst, wrote his thesis on optimizing deployment of “Deep Seaweb” acoustic networks for two-way submarine communications with underwater assets at speed and depth.

Royal Thai Navy Lt. j.g. Pongsakorn Sommai conducted research on using a “Seastar” acoustic local-area network to transmit magnetometer data for autonomously detecting submarines. Seastar local area networks can act as subnets in a wide-area Seaweb network.

Ens. Bill Jenkins, an acoustical engineer, wrote his thesis on the time/frequency relationships of short-range underwater acoustic modem communications in shallow water.

In addition, Lt. Scott Thompson (not pictured), a physicist, modeled sound propagation for “Deep Seaweb” a deep-ocean acoustic network exploiting the ocean’s natural deep sound channel (DSC) and reliable acoustic path (RAP) to transmit and receive data through a very-wide-area network.

Located atop Point Loma in San Diego, Calif., the Arctic Submarine Laboratory (ASL) has a long and storied history. For more than six decades, it has developed, maintained, and improved equipment and procedures for operating submarines in the Arctic. Although ASL is a detachment of the Pacific Fleet Submarine Force (COMSUBPAC), it serves as the Arctic “center of excellence” for the entire U.S. Submarine Force.

Its unique skills, knowledge and expertise enable submarines to operate safely and effectively in the harsh environment at the top of the world.

The Arctic Submarine Laboratory

The Navy's Arctic Center of Excellence

ASL plays an important part in developing doctrine and procedures for Arctic operations. It supports all Arctic submarine deployments. It coordinates major submarine ice exercises (ICEXs), including the setting up of an “ice camp” on the ocean surface for each of these events. It supports the installation of specialized Arctic equipment and technology in submarines, and it conducts test and evaluation in support of operations under the Arctic ice pack and in the surrounding marginal ice zone, where open-ocean phenomena such as waves affect

the dynamic properties of the ice cover. In addition to these wide-ranging efforts on behalf of the Submarine Force, ASL also serves as the principal liaison between the Navy and civilian scientific organizations for the cooperative program called Science Ice Exercise (SCICEX), which permits U.S. submarines deploying to the Arctic to contribute to civilian scientific research.

The Early Years

The Arctic Submarine Lab traces its roots to 1940, when the Navy Radio and Sound

Laboratory was established in San Diego. In 1941, on the eve of U.S. entry into World War II, Waldo Lyon (1914-1998) became the organization's first Ph.D. physicist. Under his direction, the Sound Division tested, repaired and modified submarine equipment and harbor defenses in the Pacific. In addition to obvious fields like hydrophysics and high pressure physics, the lab's undersea work extended into less obvious areas like X-ray physics, low-temperature studies, and Arctic geophysics. In 1945, the Radio and Sound Lab was amalgamated into the



Battery Whistler in 1948, before conversion to a lab facility.



Dr. Waldo Lyon, ASL's founder and long-time guiding light.



The Battery Whistler lab facility in 1961.

new Naval Electronics Laboratory (NEL). Under Lyon's direction, the Submarine Studies Branch of NEL's Research Division conducted hydrostatic pressure research that contributed to the eventual development of deep ocean exploration vehicles, and it developed 250 kVolt X-ray equipment for observing the Bikini Atoll atom bomb tests.

Meanwhile, the Arctic was becoming a high priority. The Cold War pitted the U.S. against the Soviet Union, the first military rival to confront America directly across the Arctic Circle. Arctic operations meant ice, an infamous hazard to navigation that submariners usually tried to avoid. During World War II, German U-boats had avoided detection by hiding under ice floes in the Gulf of St. Lawrence, but the polar ice pack was another matter altogether.

That began to change with Operation Highjump, the third Antarctic expedition led by U.S. Navy polar explorer Rear Adm. Richard Byrd. "In 1946," Dr. Lyon later recalled, "I got a letter asking if there was any research I wanted to do in conjunction with the expedition. I said, yes, try a submarine in the cold water down there." Lyons designed and tested suitable oceanographic equipment and a primitive under-ice sonar—essentially a fathometer mounted to look up rather than down—and NEL installed them in USS *Sennet* (SS 408). With Lyon onboard, *Sennet* joined Operation Highjump and tested the sonar's ability to support a future under-ice dive.

This set the stage for Operation Blue Nose, an unprecedented Arctic submarine cruise in the summer of 1947. Embarked in the submarine tender *Nereus* (AS 17), Rear Adm. Alan McCann, Commander, Submarine Force, Pacific, led *Boarfish* (SS 327), outfitted with Lyon's equipment, plus *Caiman* (SS 323) and *Cabezon* (SS 334)

During the series of test dives that *Boarfish* carried out, Lyon served as the Navy's first "ice pilot," an embarked expert with the technical and procedural know-how to train a submarine's crew for under-ice operations and advise her commanding officer on carrying them out. From 1947 to his last under-ice mission in 1981, Lyon would spend a great deal of time with tons of frozen water overhead.

through the Bering Strait and up to 72° 15' North Latitude. With McCann embarked, *Boarfish* became the first submarine to dive beneath the Arctic ice.

During the series of test dives that *Boarfish* carried out, Lyon served as the Navy's first "ice pilot," an embarked expert with the technical and procedural know-how to train a submarine's crew for under-ice operations and advise her commanding officer on carrying them out. From 1947 to his last under-ice mission in 1981, Lyon would spend a great deal of time with tons of frozen water overhead. In 1948, he returned

to the Chukchi Sea in USS *Carp* (SS 338), and the following year he led the first joint U.S.-Canadian Arctic scientific expedition through the Bering Strait in USS *Baya* (AGSS 318), a World War II fleet boat converted for research.

Lyon also set out to establish a dedicated Submarine Research Facility. In 1948, he acquired Battery Whistler, an obsolete coastal artillery installation atop Point Loma built during World War I to defend San Diego harbor. Designed to hold heavy 12-inch mortars, the battery was basically a large open pit with a strong concrete floor, ideal for supporting heavy equipment and an ample test pool. Initial construction got under way in 1952. The Navy moved the super-pressure chamber it had completed in 1945 to the new complex. Later modified for pressure testing down to 40,000 feet, the chamber was used to test equipment for vessels like the pioneering research bathyscaph *Trieste* and the Navy's deep submergence rescue vehicles.

The Workhorse Years

Sophisticated cryogenic capabilities made the Submarine Research Facility the heart of Arctic submarine research for several decades. Cold rooms supported tests such as those that solved the problem of icing on submarine snorkel-head valves. In 1959, an experimental pool 75 feet long, 30 feet wide, and 16 feet deep was completed. The pool had a cryostat for growing sea ice and a chamber under the bottom for testing sonar sensors and oceanographic instruments. It proved useful not only for research on under-ice sensors, but also for studying the properties of the ice canopy itself, such as its brine content and elasticity, which are critical for any submarine attempting to break through to the surface. However, it was not until

1969 that the Submarine Research Facility at Battery Whistler was formally renamed the Arctic Submarine Laboratory. Dr. Lyon became ASL's first director, a post he would hold until 1984, when he stepped down to become the lab's chief scientist.

Meanwhile, nuclear power had transformed Arctic operations. The limited submerged endurance of diesel-electric boats restricted under-ice operations to the outer fringes of the ice pack. The famous January 1955 message from USS *Nautilus* (SSN 571)—“Underway on nuclear power”—removed that limitation. In 1957, *Nautilus*, with Dr. Lyon embarked, dove under the ice and reached 87° North Latitude before a gyrocompass failure forced her to turn back. The following year, Dr. Lyon embarked in *Nautilus* again as the chief scientist and ice pilot for Operation Sunshine, a submerged trans-polar crossing from Point Barrow, Alaska, to the Greenland Sea. During that transit *Nautilus* reached the North Pole on Aug. 8, 1958. In 1959, Lyon embarked in USS *Skate* (SSN 578) for the second Arctic transit, in which *Skate* became the first boat to surface at the Pole. These historic crossings paved the way for over 100 subsequent high Arctic missions, each one supported by personnel of what would become the Arctic Submarine Lab.

In the 1960s, the facilities at Battery Whistler began to make major contributions to submarine design, starting with the pioneering *Sturgeon* (SSN 637) class. When *Sturgeon* was commissioned in 1967, she had the most advanced and complete set of Arctic features ever fielded up to that time, including a hardened sail, rotating sail planes, and masts positioned for under-ice sailing. Later boats of the class also had the sophisticated BQS-14 ice-avoidance sonar installed as original equipment. In 1974, ASL added a dedicated sea ice model basin, which supported subsequent ship design testing through ice breakthrough tests with a scale model of the *Seawolf* (SSN 21)-class sail.

But submarine design remained only one aspect of ASL's work during this busy period. The lab also contributed to the testing of weapons, evaluating the under-ice capabilities of the MK-37 heavy torpedo and the MK-48 torpedo that replaced it. It expanded sensor capability, integrating pulsed sonar into the follow-on BQS-14A version of the BQS-14, and developing pulsed multi-beam sonar (APEX) for under ice navigation. Meanwhile,



U.S. Navy photo

USS *Helena* (SSN 725) in the Arctic in 2009, with a bulge for the side-scan sonar visible on her sail.

it ensured that its own facilities remained state-of-the-art. Extensive modifications of the research pool facilitated efforts that ranged from studying the physical properties of true sea ice to developing sonar technology for remote acoustic measurement of ice thickness and evaluating icing problems on the Improved *Los Angeles* class. And of course, ASL continued to support Arctic submarine operations, which now included multi-ship and even multi-national deployments. In addition, the lab took on the responsibility of supporting the Arctic submarine operations of Britain's Royal Navy.

Transitioning to a New Era

As the millennium approached and the Submarine Force began to field multiple combat system configurations among different classes, ASL's role transitioned from developing Arctic systems to evaluating delivered systems. As a result, ASL no longer required the dedicated lab facilities at Battery Whistler. In 1993, it began to deactivate all cryogenic and hydrostatic test facilities as the first step in closing the site. In 1998, it turned Battery Whistler over to another Navy activity.

However, ASL's Arctic operational expertise was still required to validate the performance of new submarine classes and their sensors and equipment in cold water and under the ice. For example, the lab supported both the initial Arctic tests of the

BSY-1 combat system in the Improved *Los Angeles* (SSN 688I) class and similar testing of the BSY-2 in the *Seawolf* (SSN 21) class.

The 1990s also saw extensive collaboration with the civilian scientific community. In 1993, ASL planned and conducted a pilot Submarine Arctic Science Ice Exercise (SCICEX), in which the Navy made a *Sturgeon*-class submarine available for conducting academic research. After this proof-of-concept cruise, the Submarine Force, the National Science Foundation, and the Office of Naval Research signed a memorandum of agreement (MOA) under which five more dedicated SCICEX Arctic deployments were carried out from 1995 to 1999. These missions produced some of the data on which our current understanding of Earth's changing environment is based.

The SCICEX Phase II MOA, signed in 2000, introduced “SCICEX accommodation missions,” which, unlike the dedicated cruises of the 1990s, take place in the course of normal military deployments. ASL plays a key role in planning and executing the accommodation missions, which enable the Submarine Force to continue supporting civilian scientific investigation of the Arctic environment. With the assistance of the submarine crew, the embarked Arctic operations specialists from ASL—heirs to the “ice pilots” of the past—collect data for dissemination to the scientific community during periods when this activity does not



ASL Arctic Operations Specialist Travis King at a side-scan sonar console installed in the torpedo room of USS *Connecticut* (SSN 22)

interfere with any military aspect of the deployment.

Funding for Arctic research and development has declined in recent years, but Arctic operations remain a critical part of the Submarine Force mission. ASL's two departments—Engineering and Operations—continue to help give U.S. submarines all the capability they need to operate safely and, if necessary, fight effectively in the Arctic. ASL personnel assist the Submarine Force in conducting operations, coordinating test and evaluation, and implementing technical improvements.

Engineering TEMPALTs

Continuing a long tradition of developing and testing under-ice equipment, ASL's Engineering Department is responsible for the installation, removal and life-cycle support of the temporary alterations (TEMPALTs) installed in submarines before an Arctic operation. The department modifies commercial off-the-shelf (COTS) equipment for this purpose. The current suite of Arctic TEMPALTs consists of a COTS side-scan sonar system, an underwater camera, a conductivity-temperature-depth (CTD) recorder and a precision bubble.

The upward-looking, high-frequency side-scan sonar TEMPALT provides a continuous qualitative image of the ice canopy above the submarine, identifying and mapping

ice features where the boat could surface if necessary. The system consists of an external electronics bottle mounted within the sail, side-scan transducers installed either on the sides of the sail (in the *Los Angeles* and *Virginia* classes) or on the foredeck (in the *Seawolf* class), inboard electronics installed on a torpedo room skid plate, and monitors in the control room to display side-scan output.

The Submarine Remote Video System (SRVS) TEMPALT is an upward-looking, low-light video camera mounted externally beneath the cap of the sail. When there is sufficient light, this provides an image of the ice canopy above the submarine, which is very useful when the submarine is surfacing through the ice. The SRVS TEMPALT includes a power supply box and video monitor in the control room.

The SeaBird instrumentation TEMPALT is a conductivity-temperature-depth (CTD) recorder installed in the sail for real-time measurement and display of the oceanographic properties of the local seawater, such as temperature, conductivity, sound velocity, density, and depth. A software package written by ASL uses this data to detect salinity and temperature fronts during transit and to help maintain the ship's trim during surfacing operations. In addition to the externally mounted SBE 49 integrated CTD sensor, the SeaBird TEMPALT includes electronics installed in

the free-flood area of the sail, a deck unit and PC on a skid plate in the torpedo room, and a video monitor for viewing CTD data in the control room.

Providing Arctic Expertise

ASL's Operations Department has an integral role in planning and scheduling all U.S. Arctic submarine missions, as well as those conducted by the Royal Navy. The Arctic operations specialists (AOSs) who staff this department deploy with every submarine that operates in the Arctic to help train their crews and advise their commanding officers. The operational experience and Arctic expertise of an embarked AOS is important not only for safe navigation, but also for demonstrating new or improved systems and for evaluating and enhancing the under-ice performance of each new submarine class.

In 2009, an embarked AOS trained the crew and advised the commanding officer of USS *Texas* (SSN 775) when she conducted the first Arctic testing of a *Virginia*-class submarine—including the class's first open-water vertical surfacing—applying lessons learned from previous Arctic testing of the Improved *Los Angeles* and *Seawolf* classes. Most recently, the Operations Department coordinated complex multi-ship tests of USS *Connecticut* (SSN 22) and USS *New Hampshire* (SSN 778) in ICEX 2011, with an AOS embarked in each submarine and others assigned to the ice camp. (See the ICEX 2011 article on page 4.)

Submarine operations in the Arctic will always present unique challenges. The presence of an overhead ice canopy alters the way a submarine navigates, communicates, maintains habitability, and engages an enemy. This exceptional environment demands a comprehensive, specialized program for safety, training and readiness-assessment. The TEMPALTs and Arctic operations specialists provided by the Arctic Submarine Laboratory make that program possible. Carrying on the long tradition of scientific, engineering, and operational excellence that helped open the Arctic Ocean for submarines more than half a century ago, ASL helps guarantee that this critical region will remain a maritime domain of the U.S. Submarine Force for the foreseeable future.

Larry Estrada is the director of the Arctic Submarine Laboratory.

USS *Boise* Wins Battenberg Cup



Photo by Petty Officer 2nd Class Danna Morris

USS *Boise* (SSN 764) received the 2010 Battenberg Cup award as the best all-around ship in the U.S. Atlantic Fleet. Her competitors included the aircraft carrier USS *Harry S. Truman* (CVN 75), representing Commander, Naval Air Force, Atlantic, and the amphibious warfare ship USS *Nassau* (LHA 4), representing Commander, Naval Surface Force, Atlantic. *Boise* is only the third submarine to win the Battenberg Cup.

“*Boise* was outstanding this past year. They approached every challenge in a dedicated and very thorough way,” said Vice Adm. John M. Richardson, Commander, Submarine Force, Atlantic. “Every member on the *Boise* team knows their job and knows they are valued by their command and the Navy as national treasures. *Boise’s* integrity and humble sense of purpose really set them apart as an example for others to follow.”

The Battenberg Cup was originally awarded to the winner of a regular rowing race between the U.S. Navy and Britain’s Royal Navy, which British Admiral Prince Louis of Battenberg established in 1906 to honor the “good fellowship and wonderful entertainments” he and his men had received on a visit to the U.S. The boat race was discontinued in 1940 due to World War II, but in 1978, Atlantic Fleet Commander Adm. Isaac C. Kidd, Jr., revived the Battenberg Cup as an Atlantic Fleet award for operational excellence.

Throughout 2010, *Boise* and her crew performed exceptionally across a myriad of challenging operations and initiatives, both in port and at sea. She successfully completed an accelerated deployment preparation period after completing a demanding docking selected restricted availability. While deployed to two different theaters of operations, *Boise* achieved all operational objectives, maintained an operational tempo of 84 percent, steamed 34,800 nautical miles and had zero missed mission days. The submarine flawlessly executed three missions vital to national security that provided key decision-making intelligence to combatant commanders.

During the 2010 calendar year, *Boise* earned the 2010 Commander, Submarine Squadron Eight Battle Efficiency “E” award. She also received the Engineering “E,” Navigation “N,” Communications “C,” Supply “E,” and Medical “M” awards for departmental excellence.

Senior Chief Stephen Capps, chief of the boat, credits *Boise’s* success to her crew. “The crew is how the work gets done, and without a good crew guided in the right direction, it does not matter what other aspects of planning, leadership, and equipment you have in place,” he said. “We asked the captain when he relieved to let the chiefs run the ship so the officers can fight the ship, and, honestly, we have not looked back. The challenge now, in the midst of all the accolades, is continued success, and the determination to not rest on our laurels.”



Photo by Petty Officer 2nd Class Danna Morris

(Top) (left to right) Vice Adm. John M. Richardson, commander, Submarine Forces, and Cmdr. Brian L. Sittlow, commanding officer of USS *Boise* (SSN 764), look on as Chief of the Boat Stephen Capps and Petty Officer 2nd Class Kevin Galvin hold the Battenberg Cup plaque presented by Adm. John C. Harvey, Jr., Commander, U.S. Fleet Forces Command. (Above) *Boise* crewmembers pose with the Battenberg Cup after the July 11 presentation ceremony at *Boise’s* homeport of Norfolk, Va.

Changes of Command

USS Jacksonville (SSN 699)
 Cmdr. Nathan B. Sukols relieved
 Cmdr. Tyler L. Meador

USS Olympia (SSN 717)
 Cmdr. Michael J. Boone relieved
 Cmdr. Michael R. Coughlin

USS Oklahoma City (SSN 723)
 Cmdr. Andrew G. Peterson relieved
 Cmdr. Aaron M. Thieme

USS Florida (SSGN 728) (G)
 Capt. David Kirk relieved
 Capt. Thomas Calabrese

USS Alabama (SSBN 731)
 Cmdr. Kevin Schultz relieved
 Cmdr. James Crosley

USS Nebraska (SSBN 739) (B)
 Cmdr. Jason Wartell relieved
 Cmdr. Gerhard Somlai

USS Tucson (SSN 770)
 Cmdr. James E. O'Harrach, Jr. relieved
 Cmdr. Gary W. Pinkerton

USS North Carolina (SSN 777)
 Cmdr. Richard G. Rhinehart relieved
 Cmdr. Wallace E. "Wes" Schlauder

Qualified for Command

Lt. Cmdr. Michael Bemis
 COMSUBRON ONE

Lt. Cmdr. George Howell
 USS Key West (SSN 722)

Lt. Cmdr. Craig Karsch
 COMSUBRON SEVENTEEN

Lt. Cmdr. Richard Lesiw
 COMSUBRON SIXTEEN

Lt. Cmdr. Nathan Luther
 USS La Jolla (SSN 701)

Lt. Cmdr. Carlos Martinez
 COMSUBRON ONE

Lt. Cmdr. Matthew Rivera
 COMSUBRON SEVEN

Lt. Cmdr. Kristofer Westphal
 COMSUBRON SEVENTEEN

Lt. Brandon Oberling
 COMSUBRON SIXTEEN

Lt. John Thorpe
 COMSUBRON ONE

Lt. Timothy Williamson
 COMSUBRON SIXTEEN

Qualified Nuclear Engineer Officer

Lt. Clifford Jessop
 USS Texas (SSN 775)

Lt. Joseph Leonelli
 USS Connecticut (SSN 22)

Lt. Andrew Valerius
 USS Columbus (SSN 762)

Lt. Dustin White
 USS Hawaii (SSN 776)

Lt. Christopher Wozniak
 USS Ohio (SSGN 726) (G)

Lt. j.g. Daniel Bellomo
 USS City of Corpus Christi (SSN 705)

Lt. j.g. Brett Berens
 USS Alabama (SSBN 731) (G)

Lt. j.g. Manuel Caballero
 USS Topeka (SSN 754)

Lt. j.g. Patrick Cashin
 USS Seawolf (SSN 21)

Lt. j.g. John Coleman
 USS Olympia (SSN 717)

Lt. j.g. Keenan Coleman
 USS Louisiana (SSBN 743) (B)

Lt. j.g. Brett Desmond
 USS Alabama (SSBN 731) (B)

Lt. j.g. Philip Diette
 USS Tucson (SSN 770)

Lt. j.g. John Flynn
 USS Nevada (SSBN 733) (B)

Lt. j.g. Adam Frisch
 USS Maine (SSBN 741) (B)

Lt. j.g. Alexander Hagness
 USS Olympia (SSN 717)

Lt. j.g. Richard Hunt
 USS Louisiana (SSBN 743) (G)

Lt. j.g. Robert Johnson
 USS Olympia (SSN 717)

Lt. j.g. Cameron Lindsay
 USS Texas (SSN 775)

Lt. j.g. Timothy Merrick
 USS Nevada (SSBN 733) (B)

Lt. j.g. James Rapuzzi
 USS La Jolla (SSN 701)

Lt. j.g. Nicholas Smith
 USS Albuquerque (SSN 706)

Lt. j.g. Scott Tedrick
 USS Louisville (SSN 724)

Lt. j.g. Damon Turner
 USS Nebraska (SSBN 739) (G)

Lt. j.g. Eric Whicker
 USS Nebraska (SSBN 739) (G)

Line Officer Qualified in Submarines

Lt. j.g. Kevin Africa
 USS Nebraska (SSBN 739) (G)

Lt. j.g. Anthony Ardito
 USS Columbus (SSN 762)

Navy Lays Keel for PCU Minnesota



The Navy celebrated the keel-laying of Pre-Commissioning Unit *Minnesota* (SSN 783) on May 20 at Huntington Ingalls Industries–Newport News Shipbuilding (HII-NNS) in Newport News, Va.

Ship sponsor Ellen Roughead, wife of Chief of Naval Operations Adm. Gary Roughead, had her initials welded onto a steel plate that will be permanently affixed to *Minnesota's* hull. "We are honored to have Mrs. Roughead as *Minnesota's* sponsor," said Rear Adm. (sel.) Michael Jabaley, program manager for the *Virginia* class. "The keel-laying marks the beginning of a special relationship between Mrs. Roughead, this submarine, and her crew. Her dedication and support of our Sailors and their families is admirable and will pay dividends for the Submarine Force for years to come."

The keel-laying is *Minnesota's* first major event since construction began in February 2008. The tenth submarine of the *Virginia* class and the last of the Block II construction contract, *Minnesota* is on track to continue the *Virginia*-Class Program's trend of early deliveries.

Lt. j.g. Zachary Buzzatto
 USS Louisville (SSN 724)

Lt. j.g. Matthew Chung
 USS Nevada (SSBN 733) (G)

Lt. j.g. Andrew Clingman
 USS La Jolla (SSN 701)

Lt. j.g. Jeffrey Cornielle
 USS Texas (SSN 775)

Lt. j.g. Chase Dillard
 USS Nebraska (SSBN 739) (B)

Lt. j.g. Evan DiPetrillo
 USS Greenville (SSN 772)

Lt. j.g. John Dubiel
 USS Bremerton (SSN 698)

Lt. j.g. Brian Dunn
 USS Nevada (SSBN 733) (G)

Lt. j.g. David Ferris
 USS Ohio (SSGN 726) (G)

Lt. j.g. John Freeman
 USS Connecticut (SSN 22)

Lt. j.g. Daniel Goodwin
 USS Greenville (SSN 772)

Lt. j.g. Tristen Hannah
 USS Louisiana (SSBN 743) (G)

Lt. j.g. John Hartsog
 USS Charlotte (SSN 766)

Lt. j.g. Kevin Henderson
 USS Ohio (SSGN 726) (G)

Lt. j.g. Robert Hoard
 USS Bremerton (SSN 698)

Lt. j.g. Joshua Hricik
 USS Ohio (SSGN 726) (G)

Lt. j.g. Michael Joiner
 USS Tucson (SSN 770)

Lt. j.g. Kristopher Kellogg
 USS Olympia (SSN 717)

Dive Klaxon Joins Major League Baseball



Photo by Olivia Logan

A high fly ball! Going...going...AWOOGAH! AWOOGAH! AWOOGAH! This season, the Washington Nationals introduced a new tradition—sounding a submarine dive klaxon after every home run and at the end of every win.

It was a natural for a team that plays ball just a couple blocks from the Washington Navy Yard. “The military live in our community and provide a huge service to our country,” said Andy Feffer, the organization’s chief operating officer, so Nats’ management asked themselves, “How do we take iconic moments and do something unique to Washington, while highlighting the military?”

The Nats consulted their neighbors at the Yard, who recommended a dive klaxon because it is distinctive, recognizable—and loud enough to engage the crowd. “Even if you’re not at the game,” Feffer said, “you should be able to listen and know that sound.”

The Nats used to celebrate homers and wins with fireworks. Feffer called substituting the klaxon a “strategic decision about their relationship with the military and iconic moments in the park.” Press box staff sound the three-blast signal twice for every celebration—and they’re pleased to say they’ve done it quite a bit this season.

The dive klaxon perched high up behind home plate at Nationals Park.

Lt. j.g. Kristopher Labrunda
USS Columbus (SSN 762)

Lt. j.g. Stephen Leff
USS Tucson (SSN 770)

Lt. j.g. Christopher Lindahl
USS Greenville (SSN 772)

Lt. j.g. Vincent Linley
USS Houston (SSN 713)

Lt. j.g. Forest McLaughlin
USS Louisiana (SSBN 743) (B)

Lt. j.g. Nicholas Miller
USS Louisville (SSN 724)

Lt. j.g. Jacob Montoya
USS Montpelier (SSN 765)

Lt. j.g. Lawrence Overway
USS Ohio (SSGN 726) (G)

Lt. j.g. John Patrick
USS Maine (SSBN 741) (G)

Lt. j.g. Chad Rawlings
USS Bremerton (SSN 698)

Lt. j.g. William Richardson
USS Louisville (SSN 724)

Lt. j.g. Alexander Sayers
USS Louisville (SSN 724)

Lt. j.g. Luke Scholl
USS Alabama (SSBN 731) (G)

Lt. j.g. Evan Seyfried
USS Greenville (SSN 772)

Lt. j.g. Brendan Smith
USS Santa Fe (SSN 763)

Lt. j.g. Henry Tran
USS Nevada (SSBN 733) (B)

Lt. j.g. Nathan Tyler
USS Ohio (SSGN 726) (B)

Lt. j.g. Matthew Wadden
USS Ohio (SSGN 726) (G)

Lt. j.g. Steven Weiner
USS Connecticut (SSN 22)

Lt. j.g. Andrew West
USS Ohio (SSGN 726) (B)

Lt. j.g. Ryan Whipple
USS Nevada (G) (SSBN 733)

Limited Duty Officer Qualified in Submarines

Lt. Jason Allnutt
USS Maine (SSBN 741) (B)

Lt. Charles Caldwell
USS La Jolla (SSN 701)

Lt. j.g. Rob Koernke
USS Henry M. Jackson (SSBN 730) (B)

Supply Officer Qualified in Submarines

Lt. j.g. Jeremy Magrum
USS Ohio (SSGN 726) (B)

Lt. j.g. Jonah Petrinovic
USS Albuquerque (SSN 706)

Lt. j.g. Jason Thomas
USS Jefferson City (SSN 759)

Ensign Robert Gardner
USS Alabama (SSBN 731) (G)

Special Recognition—Junior Officers of the Year

Lt. Gary Adams
USS Greenville (SSN 772)

Lt. Jeremy Alley
USS Georgia (SSGN 729) (G)

Lt. Seth Cairo
USS Asheville (SSN 758)

Lt. Derek Fletcher
USS Tucson (SSN 770)

Lt. Thomas Hawkins
USS Boise (SSN 764)

Lt. Gregory Marvinsmith
USS Maine (SSBN 741) (B)

Lt. Brian Pennington
USS Jimmy Carter (SSN 23)

Lt. Timothy Perkins
USS City of Corpus Christi (SSN 705)

Lt. Robert Ryan III
USS Jacksonville (SSN 699)

Lt. Justin Stepanchick
USS Ohio (SSGN 726) (B)

Lt. j.g. Adam Carter
USS Wyoming (SSBN 742) (G)

Lt. j.g. David Green
USS Emory Land (AS 39)

Lt. j.g. Bradley Rempfer
USS Frank Cable (AS 40)

Lt. j.g. Brian Ross
USS Montpelier (SSN 765)

Lt. j.g. Gregg Singer
USS Pittsburgh (SSN 720)

Reserve Component Submarine Sailors of the Year

Petty Officer 1st Class Delmas Rowe
Naval Reserve Unit Emory S. Land
Detachment D in Denver, Colo.

Petty Officer 1st Class Russell Chilcoat
Naval Reserve Unit Pacific Strike
Group Operations in Denver, Colo.



Photo by Olivia Logan

(Left) Naval Historical Foundation Board Member Dr. Barbara Pilling cuts the ribbon to open the Covert Submarine Operations exhibit, accompanied by (left to right) Director of Naval History Rear Adm. Jay DeLoach, USN (Ret.), Naval Historical Foundation (NHF) President Vice Adm. Robert F. Dunn, USN (Ret.), NHF Chairman Adm. Bruce DeMars, USN (Ret.), and Naval Submarine League Chairman Adm. Richard W. Mies, USN (Ret.).



Photo by Olivia Logan

(Right) A Cold War submarine veteran describes the "Maneuvering Room" display to his family.

Cold War Submarine Exhibit Opens at Washington Navy Yard

The National Museum of the U.S. Navy is developing a new Cold War Gallery in the Washington Navy Yard's historic model basin building to showcase the service's role in confronting the Soviet Union from 1946 to 1991. One of the first exhibits to grace this new space is "Covert Submarine Operations," which opened June 18.

A full-scale Trident I missile in flight configuration greets visitors entering the Cold War Gallery. This was previously displayed in "Fast Attacks and Boomers: Submarines in the Cold War," an exhibit shown at the Smithsonian Institution's National Museum of American History to mark the Navy's submarine centennial in 2000.

"Covert Submarine Operations" remounts many items from that popular Smithsonian exhibit, including the attack center, crew's dinette, sonar room, maneuvering room console, and crew berthing from a Cold War nuclear submarine. The most whimsical item is undoubtedly a piano installed during construction in USS *Thomas Edison* (SSBN 610), one of the first ballistic missile boats—a creative way to alleviate the tedium of early deterrent patrols!

A Russian submarine mated with a U.S. submarine rescue system for the first time June 7. The successful mating during the Bold Monarch 2011 submarine rescue exercise demonstrated the Russian boat's compatibility with the U.S. Submarine Rescue Diving and Recompression System (SRDRS). Bold Monarch 2011, which took place off the coast of Spain from May 30 to June 10 was the first NATO exercise of any sort to include a Russian submarine.

Russian sailors join U.S. submarine rescue personnel in the Pressurized Rescue Module of the SRDRS.



Photo by Petty Officer 2nd Class Ricardo Reyes

Missouri Sailors Assist Tornado Victims

Eight USS *Missouri* (SSN 780) Sailors left Groton, Conn., for Joplin, Mo., June 1, to help out in the wake of the devastating May 22 tornado. The Sailors took a week of voluntary leave to remove debris and help homeowners recover belongings. They also coordinated the efforts of other volunteers in partnership with Americorps, the American Red Cross, and the Missouri State Emergency Management Agency.

“After our first day in Joplin, it became clear to all members of the *Missouri* team that our decision to volunteer in Missouri and assist not only the citizens of Joplin, but the entire state, was the right one,” said Chief Petty Officer Mike Shea. “It further strengthens the strong ties between USS *Missouri* and our namesake state.”



Photo by Lt. J.g. Ryan Sullivan



Photo by Lt. J.g. Ryan Sullivan



Photo by Lt. J.g. Ryan Sullivan

(Top) The eight USS *Missouri* Sailors who volunteered to assist with clean-up after the tornado that struck Joplin, Mo., pose with Americorps leaders amidst the wreckage. (Above left) Remnants of a truck wrapped around a tree show the tornado’s devastating force. (Above, right) Chief Petty Officer Michael Shea carries a log while Chief Petty Officer Andy Scott and Petty Officer 2nd Class Travis Fitzgerald help civilian volunteers clear a backyard.

Submarine Tenders on the Move

This spring, U.S. submarine tenders accompanied attack submarines on visits to two ports of call that U.S. subs have not customarily visited.

USS *Emory S. Land* (AS 39) arrived in Goa, India, on April 22 as part of the Navy’s theater cooperation and good will mission. During her stay, the tender provided support for USS *La Jolla* (SSN 701), performing minor equipment adjustments and providing some quality-of-life items to the crew’s eating and living spaces.

Crewmembers of both ships participated in community outreach events, planting trees and playing in a basketball game with a local club team. The visit also included ship tours and a reception onboard the tender.

USS *Frank Cable* (AS 40) anchored off Hong Kong on May 14 to support USS *Hampton* (SSN 767). *Hampton* was the first U.S. submarine to visit Hong Kong in more than three years. *Frank Cable* has recently visited a number of foreign ports to support submarines deployed in the Western Pacific.

While in Hong Kong, personnel from both ships participated in home improvement projects at several centers for the physically and mentally handicapped. *Frank Cable* also helped facilitate morning exercises with children at a local orphanage. Both ships hosted tours, and *Frank Cable* held a distinguished visitors’ luncheon.

Norfolk Submarine Squadrons Consolidate

The two Norfolk, Va.-based submarine squadrons formalized their consolidation into a single squadron in a late-April ceremony at Naval Station Norfolk. Submarine Squadron Eight (SUBRON EIGHT) consolidated under Submarine Squadron Six (SUBRON SIX), with Capt. Frank Cattani, the SUBRON EIGHT Commander, transferring his leadership role to Capt. Eugene P. Sievers, Commander of SUBRON SIX.

SUBRON EIGHT was originally commissioned in February 1946, in Groton, Conn. It was decommissioned in December 1969, but was recommissioned in August 1979 in Norfolk. SUBRON SIX will now be the immediate superior in command for all of the six submarines homeported in Norfolk: USS *Albany* (SSN 753), USS *Boise* (SSN 764), USS *Montpelier* (SSN 765), USS *Newport News* (SSN 750), USS *Norfolk* (SSN 714), and USS *Scranton* (SSN 756).

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Submarine Junior Officers of the Year



What does it take to be selected as a Submarine Junior Officer of the Year (JOOY) from among the roughly 1,000 junior officers serving in submarines and submarine tenders? You need to have professional skills and personal deportment outstanding enough to win the nomination of your ship's commanding officer. Then you need to demonstrate complete mastery of mariner skills and the tactical employment of your ship. Finally, you need to be selected by your squadron commander.

In early April, the 15 JOOYs who emerged from this rigorous process in 2010 and their significant others spent a week in Washington, D.C., meeting senior naval leaders, attending events that included the D.C.-area Submarine Ball, and getting in a bit of sightseeing on the side. While the 2010 JOOYs were visiting the Pentagon for meetings with naval leaders, UNDERSEA WARFARE Magazine had a chance to ask them what attracted them to submarines and continues to make a submarine career satisfying.

Lt. j.g. Bradley Rempfer, assigned to USS *Frank Cable* (AS 40), is currently qualifying as an engineer officer of the watch in the Navy's Limited Duty Officer Program. He enlisted in the Navy 16 years ago, inspired by his grandfather's stories of serving on a battleship in World War II. He said the Submarine Force has given him a "better quality of life, more job opportunities and better money."

Submarine Squadron Seventeen's Lt. Gregory Marvin Smith, from the Blue crew of USS *Maine* (SSBN 741), graduated from Harvard with degrees in chemistry and physics, a certificate in Spanish and varsity letters in water polo and lacrosse. As if all that weren't enough, he enrolled as a nuclear propulsion officer candidate after his sophomore year. "Military service was something important to me," he said. "I led a comfortable life growing up, and I wanted to earn that lifestyle."

Submarine Squadron Six's Lt. j.g. Brian Ross, from USS *Montpelier* (SSN 765), selected submarines at the Naval Academy ('05) after two midshipmen cruises because he found the relationship between officers and enlisted Sailors "without walls of rank." He still finds that true. "I know when people's birthdays are, how many kids they have, their wives' names," he said. "It's really like a family." He also loves the adventure and opportunity to see the world, adding, "I don't know of any other job that has such potential for job satisfaction."



(Top) Submarine JOOYs and their significant others with Chief of Naval Operations Adm. Gary Roughead. (Above) Marine Gen. James Cartwright, vice chairman of the Joint Chiefs of Staff, greets the Submarine JOOYs. Photos by Olivia Logan

(Right) Submarine JOOYs and significant others pose with Vice Chief of Naval Operations Adm. Jonathan Greenert around a model of USS *Virginia* (SSN 774). Photo by Petty Officer 1st Class Christopher Church.





Submarine Museums and Memorials



The Naval Undersea Museum

Keyport, Washington

The Naval Undersea Museum in Keyport, Wash., is more than a submarine museum. It is an official U.S. Navy museum showcasing a wide range of naval undersea endeavors. The artifacts it displays range in size from a microscope slide of a baby starfish to the 95-ton Deep Submergence Vehicle 1, which greets visitors outside the building. Also outside are the sail of USS *Sturgeon* (SSN 637), the large steel endbell (end cap) from the Sealab II undersea habitat, and the research submersible *Deep Quest*.

Inside, some exhibits feature nuclear submarine operations. In the reconstructed control room of USS *Greenling* (SSN 614), visitors can look through two periscopes, sit at the ship control panel and operate the dive and drive consoles, and hear commands to the helm. “The Trident Family: Service and Sacrifice” exhibit, designed to give an idea of what life is like for submariners on patrol and for family members who remain behind, includes a standard three-bunk rack, a halfway night box of goodies, a First Kiss Kit and familygrams.

Submarine heritage is also on display. The World War II exhibit features a torpedo data computer, which was once so secret the Navy would not allow it to be photographed. Nearby is the original battleflag of USS *Sealion II* (SS 315), the only U.S. submarine ever to sink a battleship. The

museum has one of the best collections of historic torpedoes. Among the ten torpedoes on display are the Navy’s first operational torpedo—the 1890 Howell—which used a flywheel to propel it; the MK 14 steam torpedo, which was the workhorse of World War II; and today’s MK 48 ADCAP.

The museum covers other naval undersea activity as well. A new exhibit called “The Skin They’re In: U.S. Navy Diving Suits” displays contemporary and historic diving suits. Other diving exhibits showcase modern and historic diving helmets, a complete Mark V diving rig, an atmospheric diving suit and a two-man open diving bell.

The sea itself is the subject of the Ocean Environment exhibit. Hands-on activities demonstrate the sea’s physical properties, such as buoyancy, pressure, light, sound and salinity. A microscope with slides of starfish and diatoms gives an idea of the fascinating creatures that make up the ocean’s web of life.

The museum also houses a research library with more than 6,000 reference books related to naval undersea history, science and operations.

From researchers to children, from submariners and submarine veterans to civilian tourists, the Naval Undersea Museum has something for anyone interested in what America does and has done in the ocean depths.

www.history.navy.mil/num