THE SUBMARINE REVIEW
JANUARY 1996

PAGE

FEATURES

ARTICLES

DISCUSSIONS

REFLECTIONS

BOOK REVIEWS

A Quarterly Publication of the Naval Submarine League

EDITOR'S COMMENTS

The January '96 issue of **THE SUBMARINE REVIEW** opens with a commentary on *thinking outside the box*, and goes on to offer several examples and the benefits to be gained. The lead feature is by the Commander in Chief of the U.S. Special Operations Command and he likens submariners to his special forces because each has to do their thinking by expanding the common military mindset. He says that both groups have to rely on individual initiative and doing the unexpected. He points to that necessity in the execution of sensitive missions and in the daily business of staying alive and remaining non-proactive and effective at the forward end of national policy. We are indebted to General Downing for drawing the analogy and for reminding us of both the challenge and the thrill of submarining.

Admiral Chiles' speech at the Fortieth Anniversary of the Fleet Ballistic Missile program also cited a success of initiative in the refusal of the Navy to be stopped by technical difficulty or bureaucratic inertia in achieving the spectacular results of our strategic submarine force. Determination and teamwork on the part of the scientific, industrial, managerial and operational parts of the greater submarine community—public and private, military and civilian—came together to solve huge engineering and schedular problems. There is also a lesson there that none of us should forget.

In addition to the two four-star presentations on *thinking outside the box*, three articles from submarine Lieutenants make specific arguments for the future of the Submarine Force by doing just that. **THE SUBMARINE REVIEW** is fortunate among the military press to get this kind of informed input from the go-to-sea, run-the-boats active duty junior officers. The experience level, advanced education and plain talent which makes up the current crop of deckplate leadership in the Submarine Force is truly impressive. Whether the subject is grand strategy, tactical innovation, or hardware design and operation, the Division Officer/Department Head viewpoint has to be respected by the entire submarine community.

We also have an over-the-horizon look at a possibility for a future submarine power source, and in the Discussion section there are two cautionary comments about the way submarine doctrine and submarine design are now headed. That is not to say that any of those three opinions argue against the general thrust of current developments, but each offers *a thought from outside the box*.

The Book Review section in this issue is somewhat unusual in that both books are memoirs by famous submarine admirals, and both are reviewed by submarine admirals. Admirals Barrett and Rindskopf have each given a personal sketch of the works of Admirals Galantin and Calvert, respectively, and recommend the books from their unique on-the-spot perspectives.

Jim Hay

FROM THE PRESIDENT

This edition of the **REVIEW** continues the superb strides toward the degree of excellence which the editor, Jim Hay, has pursued with a vengeance. Possibly one of the best articles which I have read recently, is one by an Army general. At the NSIA Clambake in New London last fall, General Wayne Downing, USA CINC, US Special Operations Command, gave a keynote address which was much different than those of any of his keynote predecessors and yet was certainly as interesting as the best. I hope you will find it as thought-provoking as I.

In October, the Strategic Systems Program celebrated their 40th Anniversary. Admiral Hank Chiles, Commander, US STRATCOM, the first naval officer to lead the US Strategic Forces tells of the tremendous achievement which the POLARIS success represented, in a reprint of his speech at that event. The combined efforts of our military planners and our civilian industry, aided in no little way by the high priority given the project by the President and the CNO, Admiral Arleigh Burke, culminated in a stealthy strategic deterrent which was successful as a technical milestone and, for 35 years through today, has been the ultimate success as a deterrent.

You may be interested in an update of the Defense Authorization Bill: the Authorization Bill authorized the SSN 23, the third and last of the Seawolf class. The House-Senate Conferees adopted a program to:

> "...use technological innovation and competition to ensure the Navy's next generation of attack submarines will be more capable than current and next generation Russian submarines..."

The primary components of this program are:

- Build a series of four SSNs at one/year from '98 through '01.
- Use the current NAS as the baseline: incorporating "new technologies".
- Both EB and NNS will build two SSNs each.
- After the four SSNs, "...price competition will be the basis for awarding production contracts...for the production buy of 2003"

The Authorizers then "included" Advance Procurement (AP) money for the 1998 submarine at EB and some AP for the 1999 sub at NNS. Additionally, $100 million was included in "R and D" for the Advanced Research Projects Agency (ARPA) to work on these advanced technologies.

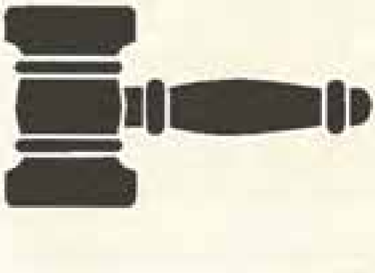
The Appropriations Bill had previously included split SCN funding for the SSN 23 and AP for the New Attack Submarines.

All in all, I believe, the submarine force leaders feel they were treated fairly after some very difficult discussions.

By the time you receive this **REVIEW**, Rear Admiral Denny Jones will have completed an excellent tour in OP N87 during a very intense and hectic time. He will have been promoted to Vice Admiral and "shuffled off" to Omaha to be the Vice Commander of STRATCOM. He did an exceptional job for the Submarine Force and has been a good, strong and valued supporter of the Naval Submarine League.

Hope all of you have a superb 1996!

Dan Cooper



THE SUBMARINE REVIEW IS A PUBLICATION
OF THE NAVAL SUBMARINE LEAGUE

NAVAL SUBMARINE LEAGUE • Box 1146 • Annandale, VA 22003
(703) 256-0891 FAX (703) 642-5815 E-Mail: subleague@aol.com

THE WHITE HOUSE

WASHINGTON

October 3, 1995

On behalf of all Americans, I am pleased to extend congratulations as you celebrate the fortieth anniversary of the Fleet Ballistic Missile Program.

The outstanding successes of the Polaris, Poseidon, and Trident programs were made possible by your superior technical and managerial expertise and your unwavering devotion to duty. These programs have helped to form the foundation of our nation's strategic defense, making our submarine-launched ballistic missile force the finest in the world.

As members of the Fleet Ballistic Missile Program, you can take great pride in your many contributions toward peace and the deterrence of nuclear war, and I salute you for all that you do to help protect our great country.

Best wishes for a memorable anniversary.

Bill Clinton

THINKING OUTSIDE THE BOX

by GEN Wayne A. Downing, USA
CINC US Special Operations Command

As you read this, some of you may be wondering what a special operator might have to say to the submarine community, but I offer that there are many similarities between my world and yours.

When one considers the operating parameters within which special operations forces (SOF) and submarines work—small numbers; stealthy; quite often in the dark and in adverse weather; reliant on surprise; specially selected, trained, and dedicated people—especially great people, because once we launch our units, we can't control them—those connections become obvious.

In fact, our definition of special operations seems to apply to the Submarine Force; "...operations which encompass the use of small units in indirect or direct military actions that are focused on strategic or operational objectives. They require units with combinations of specialized personnel, equipment, training, or tactics that exceed the routine capabilities of conventional military forces."

The relationship between submarines and SOF goes back 50 years, but beyond the typical operations we conduct together, I'd like to examine how we both support operations by offering the Theater or JTF commander options outside what many consider the normal operating box—that environment in which we are most comfortable—and in doing so, how we provide answers to some of the unique challenges facing the nation.

A fact of our new world *disorder* is that our mission focus seems to be converging—as the Navy continues to replace the organizational vision spelled out in the Maritime Strategy with that found in Forward...From the Sea, operations in the littoral come to the fore, and the opportunity for joint work between our forces is more frequent and enlarged.

Indeed, our subordinate units report a greatly increased willingness of sub skippers to explore new means of solving old interoperability issues. That trend will only increase as we find more synergistic answers to challenges. Internationally, probably the most profound challenge that we confront is dealing with two competing and different types of threat. One is a well-equipped nation-state which requires high tech capabilities that can quickly and precisely attack high value targets. But we also face threats which have no viable conventional military or national centers of gravity, as was the case in Somalia, Rwanda, and Haiti. Here threats are subnational groups, disintegrating social structures, disease, and environmental degradation.

Some classify such threats as fourth generation warfare—where the forces needed to fight a nation-state are usually not appropriate to address these latter threats. As the world watched the perfor mance of our high tech forces, armed with precision weaponry, the likelihood of being challenged in fourth generation warfare is increasingly likely. It is safe to say that future aggressors would indeed be foolish to attack our strengths, but will target vulnerabilities. Indeed, our experience in Somalia is a case in point, in which our Achilles Heel was our political will to sustain the effort—our national objectives could not be accomplished in Somalia without further bloodshed that would be unacceptable to the American people.

The task is to find sufficiently flexible, adaptable forces that can operate effectively against both types of threat. In nation-state, or maneuver war, both SOF and the Submarine Force clearly provide an answer along with other, conventionally armed and organized forces, sometimes as a force multiplier, and sometimes in an economy of force role. Conversely, both our communities play roles in fourth generation warfare; in SOF, our language capabilities, cultural awareness, and regional orientation make us highly effective in these sensitive, often ambiguous environments. The submarine provides an ideal platform for clandestine infiltration, exfiltration, and C^2; and, as a visible—with its presence announced—manifestation of American commitment, it could influence combatants to attempt to find political solutions. The combination of our credible, and sometimes incredible people, harnessing of new wave technologies, and high states of readiness are constant reminders to potential adversaries that there will be consequences to their actions.

We both bring an aspect to warfare that allows the attack of strategic and operational targets in unconventional ways, and do so by thinking outside the normal operating box. I do not mean that we ignore the teachings of Mahan, Douhet, or Clausewitz, but that the Chinese general Sun Tzu holds greater relevance to small communities like ours which seek selective engagement.

Sun Tzu suggests to us the indirect approach, which attacks enemy vulnerabilities rather than strengths; deception, which shows an enemy what he expects to see, rather than what is; the requirement to know and understand an enemy (and ourselves) that transcends intelligence preparation of the battlefield; and the use of the unorthodox to complement the orthodox.

The National Defense University will soon publish an interesting piece by Commander Frank Borik entitled Sun Tzu and the Art of Submarine Warfare. In it, Borik posits a successful Chinese naval engagement against the U.S. Navy based on the 2,500 year old teachings of Sun Tzu. The essence of this clever essay is that the *indirect* approach will offer unique options that can help limit the conflict by bringing it to an early end; and that "...while submarines can't *command* the sea in the Mahanian sense, they can deny command to our enemy, and thus be decisive in his defeat." Just as neither submarines nor SOF are war winners, they play a significant role in war termination.

Borik suggests any number of means to attack the vulnerabili ties of a high tech, modern navy—ours, in this case. Running through his essay is a psychological theme; namely, that with a perfect understanding of the behemoth, the upstart Chinese Navy could use the enemy's own strength against him, and ultimately defeat the enemy's strategy. Just as mines in the Persian Gulf exerted a certain psychological influence on our actions, the possibility of submarines in one's AOR *[Ed. Note: Area of Responsibility]* engenders a whole set of concerns, and thus actions.

In special operations, we bring similar pressures to bear on an adversary. Sometimes just the presence or suggestion of SOF in his rear areas causes the enemy to engage in self-defeating behavior. We also exploit his fears through the use of psychological operations, or PSYOP. In wartime, PSYOP seeks to defeat the enemy—to reach the pinnacle of military excellence as Sun Tzu saw it, which is to subjugate the enemy's force without fighting. Some of you may have seen a particular theme we used to great effect in our leaflet campaign in the Gulf War, when we targeted specific Iraqi units for B 52 attack—we told those units we would bomb them, and then did exactly that. The result was a definite loss of confidence in the Iraqi's chain of command, which was powerless to protect their soldiers from pre-announced attacks.

Of greater significance was the influence this process had on adjoining units who witnessed the entire action—and then were targeted themselves. Our *market research* among POWS after the fact showed us that 98 percent of the scores of thousands of Iraqi POWs saw leaflets, 80 percent believed, and 70 percent were induced to surrender by them. We think Madison Avenue would love to have those kinds of numbers to sell soap! It's important to note that the bombing effort would have happened with or without the PSYOP connection; that addition, however, was an excellent example of the force multiplier effect PSYOP had on the larger effort, and how SOF complemented a conventional operation to great synergistic effect, just as the British submarine force did during the Falklands/Malvinas War, and as did our own submarines during the Gulf War with TLAMs.

I am struck by the great similarities between submarines and special operations; as the columnist George Will says, submarines demonstrate how crucial, subtle, and varied the political use of armed force can be—submarines can be covert, meaning non-provocative, and sustained. An adversary might know they are there, but never where, which is exactly the situation the Iraqis faced when we put special reconnaissance patrols behind the lines in Desert Storm. Similarly, geographic CINCs or Ambassadors also quite often use SOF when a small presence or host country deniability is desirable, which a large conventional force would preclude. SOF is quite often the only force which is politically, and sometimes psychologically, acceptable. A hallmark of our special operators is their understanding of the sometimes strategic nature of individual actions; we will only accept and retain people with the maturity to understand their role in the larger picture, and act accordingly.

The unorthodox nature of undersea warfare strikes a resonant chord, as well; David Bushnell's TURTLE of the American Revolution; the Confederate HUNLEY; UDT launches in WWII and Korea; SEAL operations in Vietnam; British submarine infiltration of special reconnaissance elements into Argentina; in all, submarine operations have been integral partners with special operations in offering complementary options to the Theater Commander. Surgical, fast, and world-wide attack capabilities are also strikingly similar characteristics of our forces.

In preparing for this article, I was interested to read that the U.S. Submarine Force in WWII was only two percent of the

Navy, yet had an influence against our enemies all out of proportion to its size. Today's SOF is also a minute element of our force structure, accounting for only 1.4 percent of DoD manpower and 1.2 percent of the budget, but SOF is quite often the force of choice in politically sensitive environments. One need only consider the year old operation in Haiti to see where SOF complemented the initial effort, and then became the vanguard in helping to restore a democratic government, responsive to the people of that troubled nation.

The most striking commonality between submarines and SOF, however, is the independent nature of your operations, in which each boat is launched to accomplish its solitary mission, just as we launch our forces—properly trained, equipped, and supported, to be sure, but on their own. Mission orders are supplemented by the freedom to use one's initiative within the parameters of the commander's intent. In WWII, submarines carried out surveillance, reconnaissance, evacuation and resupply, infiltration and exfiltration of agents, and combat search and rescue—all of which are doctrinal missions for SOF.

In fact, throughout modern history, submarines have supported special operations; during Korea, submarines launched and recovered people into North Korea; in Vietnam, similar missions were executed successfully. And several submarines were dedicated SOF support platforms, like PERCH, TUNNEY, or GRAYBACK. Today, POLK on the East Coast, and KAMEHAMEHA in WestPac provide dedicated support to theater SOF.

We have our own fleet of free-flooding wet submersibles in Navy Special Warfare. SEAL Delivery Vehicles, or SDVs, are craft that allow infiltration of very small numbers of SEALs. But we anticipate a surge in mission effectiveness when we receive the newest platform, the Advanced SEAL Delivery System, or ASDS. The prototype is scheduled for delivery in 1997, with Initial Operational Capability in 1999. The ASDS is a dry submersible—a true mini-submarine that uses Deep Submersible Rescue Vehicle technologies—that will allow us to infiltrate a SEAL squad to an enemy harbor and act as a host for up to several days, as compared to hours in the current SDV; and in which the SEALs are exposed to a very unforgiving environment for the entire transit to and from the objective area. Of course, these are not stand-alone capabilities—they require the submarine fleet in direct support, without which it would truly be *mission impossible*.

That relationship is both tactical and intellectual. Last November we co-hosted a conference with the Fletcher School at Tufts University on the *Roles and Missions of SOF in the Aftermath of the Cold War*. One of our speakers, and a contributor to the collection of essays that came from the conference was Jim Turner, the President of Electric Boat.

In it, Jim explores the commonalities between SOF and submarines I've mentioned earlier, and lays out the special warfare capabilities being designed into the new SSN 21 class. As many of you know, SEAWOLF will go beyond the current ad hoc, or retrofitted nature of our current designs. And as importantly, the New Attack Submarine now being designed will offer an integral nine man lock out chamber, dedicated stowage space for SOF equipment—which is a very real blessing if you've ever seen Klepper Canoes or CRRCs stowed in current subs—and space reserved for a special purpose mast or antenna.

Jim also posits a New Attack Submarine variant that would be designed with hull plugs for specific missions. A special warfare variant could accommodate a large number of special forces personnel, their gear, and even vehicles! Beyond the delivery and recovery of these troops, the vessel could be a viable C^2 platform for the mission commander, offering a clandestine or covert option to the warfighting CINC that no other platform could deliver.

Other innovations in future designs could put a chamber in the sail for undersea, surface, or even air vehicles; and could embed high-data-rate antennae in the skin of the vessel, all of which make the submarine a much more stealthy and versatile platform. I have even heard of a proposal that would put as many as 100 special operations troops aboard a future submarine.

My point is that these are not merely examples of making submarines more effective and flexible—no, these innovations are the product of the type of thinking that has given the submarine community the reputation it enjoys and deserves. Unconventional, pushing the envelope, independent, and utterly professional—qualities that we believe fairly describes special operators as well. As we look to the future, we see a continuing, close relationship between our communities of like-minded operators as we develop new tactics and techniques to exploit our unique capabilities.

And finally, I want to talk about our greatest asset—those people out there, in every ocean, with every fleet, and in countries and environments most alien to our culture and sensibilities.

Again, our paths converge, as we attract, or perhaps they self-select in equal measure, wonderfully talented and adventurous people to join our ranks. Indeed, even the names we use—the Silent Service or the Quiet Professionals—bespeak a psychological kinship beyond coincidence. It is no coincidence that we both have very rigorous selection programs for our personnel. Given our operating parameters—independent, long range, sustained duration—we simply must have people whom we trust to do the right thing without fail, and without exception.

I began this piece by stating that some may wonder what a special operator would have to offer the submarine community, and I hope I've answered that question; our operating parameters, flexibility, and the range of options we offer to support conventional operations guarantee our continued viability. As long as we collectively offer the nation the courageous and creative likes of the David Bushnells and Francis Marions; the Hunleys and the John Singleton Mosbys; and the Hyman Rickovers and the William Donovans, our place is secure. As our interests, and indeed our utility to the nation coverage, I dare you to be unconventional about the challenges that face us—push the envelope, and keep thinking outside the box. ■

1996 SSN INACTIVATIONS

USS BLUEFISH (SSN 675) on February 1, 1996 at Pearl Harbor.

USS NEW YORK CITY (SSN 696) on February 1, 1996 at Portsmouth Naval Shipyard.

If any members of the League are former shipmates of the above ships, or if you live in the vicinity of the yards, please consider showing your support by attending the ceremonies.

STRATEGIC SYSTEMS PROGRAM

Address by
ADM H.G. Chiles, Jr.
US STRATCOM
October 5, 1995
40th SSPO Anniversary

Tonight we're here to honor giants. For when the technological history of America is finally written, the feats of those who achieved the successful marriage of the long range ballistic missile to the world's first true stealth platform, the nuclear submarine, will receive their just dessert, their recognition as giants. It was a monumental task; we marvel today at this achievement in five years.

At the program start, the setting was grim; Cold War increasingly frigid; Soviets had developed *the bomb*; had massive land based missiles; long-range bombers; large number of submarines; launched the first earth-circling satellite Sputnik in 1957; put missiles on diesel submarines in 1958.

Rear Admiral Raborn was assigned as Director of Special Projects in early December 1955. In his top secret Letter of Guidance (now declassified) of 2 December 1955, the CNO stated (I'll quote in part):

> "1. It is quite evident that we must move fast on this fleet ballistic missile and that our present schedules for shipboard launching are not good enough..."
> "2. In view of the fact that the President wants a report monthly, I, of course, will want a report weekly and, like the President, I will want it to be a **progress** report." (My edit: **there will be progress**.)
> "3. If Rear Admiral Raborn runs into any difficulty with which I can help, I will want to know about it at once along with his recommended course of action... If more money is needed, we will get it. If he needs more people, those people will be ordered in. If there is anything that slows this project up beyond the capacity of the Navy Department we will immediately take it to the highest level... In taking this type of action we must be reasonably sure we are right and at least know the possible consequences of being wrong because we will be disrupting many other programs in order

> to make achievement in this one if we are not careful. That is all right if we really make an achievement."
>
> "4. The Air Force has got a tremendous amount of enthusiasm which they demonstrate behind their project and we must have even more..."
>
> "5. The next report on this should be made by somebody who is enthusiastic, who gives evidence of his enthusiasm, and whose knowledge demonstrates that he has a thorough grasp of the problem and is pushing ahead just a little bit faster than anybody else could." Signed: Arleigh Burke.

Rear Admiral Raborn became the Director three days later.

Raborn was enthusiastic and the special projects team pushed ahead and delivered. The team was remarkably successful—a government-industrial partnership of immense productivity; methodical and relentless in their pursuit of technologically sound, innovative solutions to difficult problems. Renowned for rigorous examination of scientific fact, they cut apart a Skipjack class submarine hull to add a 126 foot long missile compartment to the original 290 foot length to build a *monster* sub of 6000 tons (Tridents are now 18,000 tons but these were three times the size of our World War II fleet boats). They added SINS (ship's inertial navigation system), O^2 generators, air purifiers, built lightweight reentry vehicles with thermonuclear warheads. They perfected gas launch techniques; conducted 85 tests of the new missile. They always concentrated on the high level, long-range objectives without forgetting the details, accepting technical risk when system payoff would be large and safety allowed, capitalizing on better than average expected results. They expected and learned from failures, planned for their resolution and got all the team involved. The team knew they were individually successful only if they were collectively successful. They capitalized technically and programmatically from day one through the development of all six missile generations to today's Trident II—on time, competent, astute, forward thinking.

Originally working toward a 1965 initial deployment, after Sputnik Raborn was told, *we need this sea-borne missile five years sooner*. His answer was entirely fitting: *we'll deliver, but with a 1200 mile missile*. They did. GEORGE WASHINGTON deployed in November 1960. By 1965, Special Projects had put three generations of missiles to sea. You're well aware we built

41 of those original SSBNs named for presidents, heroes (military and civilian) each with 16 nuclear tipped missiles: more firepower **on one submarine** than ever used in all the wars of recorded history. Warships one and all, designed to be terribly effective in war. But for almost 35 years they have been a most effective instrument of peace between the superpowers of our time—peace ships! Never fired in anger. It was only fitting that the Navy's first ballistic missile submarine was named for George Washington, who stated in 1790 "to be prepared for war is one of the most effectual means of preserving peace." Wise words then. Wise words now. Sun Tzu over 2000 years ago said it a little differently: "to subdue the enemy without fighting is the epitome of skill."

Now we have made 3190 patrols, by my calculation 85,000 man-years submerged, an overwhelming amount of patriotism and dedication to duty—6380 good-bys and homecomings—**a lot of honeymoons**. We know we could not have achieved this record without the encouragement, loyalty, dedication of superb young Americans and their families. There have been many firsts. Remember the innovation of family grams to sailors on patrol (they're how wives communicate to submerged sailors). Some are legend like: "Wine is on the chill—I am on the pill—have abstained since February—is Polaris really necessary." This record could not have been achieved without the hard work of our crews, of our contractors, support ships, bases, repair facilities, logistic and missile facilities and SSPO.

We've changed. The abrupt Cold War end was a prime mover. Gone are the original 41 SSBNs of the '60s after a lifetime of deterrence. In April 1992 we had 23 SSBNs operational. Now 16. All Tridents. Our bases at Holy Loch, Charleston, Guam, and Rota are closed. Our missiles are detargeted, bombers are off alert, ICBM silos are being destroyed in the USA and in Russia. We gave Russia a guillotine to cut the wings off nuclear bombers. Both countries are well on their way to reaching START I limits early. I carry a launch button for Russian SS 17. When the Russians gave me the button they said, "Don't worry, we cut the wires off." Our partnership with our loyal British allies, and our SSPO-industrial partnership remain.

During the Cold War our submarines provided 40 percent of the country's strategic warheads. Now we're working toward a START II warhead percentage of 50 as the Navy's contribution to our country's strategic nuclear forces. This is an all Trident force with a bigger, better, and much more accurate missile—the fifth and sixth generation on strategic submarines named for states—which is historically the way we name battleships in this country. And truly Tridents are the battleships of the 21st century with enormous missile power—capable of almost unlimited cruising range, hidden in the ocean's depths, virtually undetectable by any potential adversary. And instead of a strategic fist fight between the Navy-Air Force implied by Admiral Burke's 1955 letter, I sit behind General LeMay's desk. Out of respect, I won't put my feet on it (I'm afraid the lightning bolt would split the roof). So we have a single warfighting CINC in charge of all our strategic forces—planning, coordinating—ensuring deterrence is appropriate to the world situation. Yesterday it was a pleasure to be submerged on USS GEORGIA with all Navy and Air Force task force commanders.

But wait—I said the Cold War's over—and some believe we should scrap our strategic nuclear forces—expedite beating swords and missiles into plowshares and Roman candles for Cold War victory celebrations. A famous author in his remarks at our 3000th patrol celebration in 1992 addressed this issue:

> "Why is this? Why, with the Cold War won, do the boats still go out? The answer is because freedom is still not free. Because America's security must be protected. Because there are thousands of nuclear warheads in Russia, in Ukraine, in Belarus and in Kazakhstan. Warheads that, if ever launched, can still destroy America's cities and her way of life in half an hour. So however warm our relations might grow with the new former Soviet republics—however close our friendships become—we will always, always place our faith in our boomers. And not in anyone else."

Of course that was Colin Powell, at the time Chairman of the Joint Chiefs of Staff.

These awesome weapons remain important blunt instruments of national strength. They're weapons we hope we'll never have to use, but they enable our President to deal from a position of immense power on the world stage with a cast of actors including some characters who only understand raw power. Remember that when Russia and the U.S. reach START II force levels of 3500 strategic nuclear weapons hopefully sometime early in the next century there are still likely to be over 15,000 nuclear weapons in Russia—because no formal arms control agreement reduces the non-strategic nuclear weapons or the stored warheads. Yes, there are likely to be regional confrontations that may involve American forces. Yes, our President twice in the last five years has made strong statements to potential aggressors that if they used weapons of mass destruction against U.S. forces or our allies that Americans would demand the strongest response. In neither was the term nuclear weapon used. That term was unnecessary. The assertion implied a very strong response.

Further, our weapons serve as an umbrella of extended deterrence for our allies—commitments that serve and have served us exceptionally well for many years. And the weapons are a hedge to reversal of intentions in countries with the capability to destroy our country or our allies (much can change in the next five years, look what's happened in the last five).

So today, the industry-government partnership of the Navy's ballistic missile program continues. We've come a long way in 40 years; weathered many storms. I'd hope that Red Raborn, Levering Smith, and others who made this program their life gaze with fondness on our current status. We face forward—ever mindful that the price of liberty is eternal vigilance and as long as that's true our Navy ballistic missile forces will be called on to keep that vigil: unseen, unheard, unnoticed: the epitome of stealth—ready—powerful. Hopefully, always peace ships. The motto of our command is *Peace...is our profession*. It also was the motto of the Strategic Air Command.

I salute you giants who built this program and those who make it work today on your 40th anniversary. God bless your efforts for the peace and freedom of our country. As you slide down the banister of life, may all the splinters be in the right direction. ■

SEA CONTROL AND SUBMARINES IN THE 21st CENTURY

by LT Daniel J. Hurdle, USN

The radical transformation of United States naval strategy and force structure predicated on the lessening of East-West tensions is well under way. A formidable open ocean force, ready and able to contest sea control with a major maritime threat, appears anachronistic given current national goals and perceived threats. The strategic necessity for a Mahanian navy, particularly in an environment of diminished threat and fiscal austerity, is unclear. As a result, current naval doctrine mandates a smaller but more multi-faceted navy ideally suited to projecting power ashore in regional conflicts around the globe.

Any probable use of naval power by the United States in the foreseeable future will involve some form of intervention in regional conflicts, be it amphibious landing, aerial strike, sealift, special operations, or local sea control in shallow water. As outlined in Forward...From the Sea[1], the Navy of today and tomorrow will be specifically tailored to accomplish these missions. It seems heartening, then, that the strategy and force structure emerging from a period of frenetic downsizing and disarmament will be suited to, and capable of handling, the threats it will face.

Yet, it is reasonable and prudent to consider the possibility that there may be risks inherent in any strategy which deviates from the Mahanian principles of open ocean sea control which have dominated naval strategic thought since 1890. The analysis which follows explores the relevance to modern strategy of major navies contesting command the seas, particularly in terms of the consummate sea control weapon: the submarine.

The End of History?

As the shockwaves from the collapse of the Iron Curtain and Soviet Russia spread across the globe, Francis Fukyama in The End of History and the Last Man posited his sensational and now-famous question: "Is history over?" Fukyama used the word

---

[1] Department of the Navy, Forward...From the Sea (Washington, DC: Government Printing Office, 1994).

history not in the manner most would understand, but rather in a Hegelian sense. Following the demise of communism and victory of democracy, he essentially asked if major ideological conflict, or Hegelian history, between nations had ended. In his view, authoritarianism and totalitarianism had proven they could not survive and democracy had prevailed as the only viable political philosophy.

Fukyama's thesis, if correct, would have a profound effect on strategic thought. Certainly a world devoid of ideological tyrants and populated mainly by democratic regimes, historically unlikely to fight one another, would have a very low likelihood of major, global wars. From a naval perspective, the prospective need to wrest or protect sea control from another maritime power would be nonexistent. A navy based on regional conflict intervention, however, maintains its relevance. When Fukyama theorized that major ideological conflict would cease, he was not saying that all conflict would cease (a misunderstanding for which he is often inappropriately criticized). In the normal flux of human and nation-state affairs, local or regional conflict remains likely and a naval strategy based solely on this seems particularly appropriate.

But what if Fukyama is wrong? China represents one quarter of the world's population and its governmental ideology is certainly hostile to democracy. Muslim fundamentalism and the authoritarian governments it generally produces are very much alive and growing. Rabid nationalism seems always to lie just below the surface in many European countries and might produce governments decidedly hostile to the West. It certainly could be argued that fervent and expansionist nationalism, particularly in a powerful country such as Russia, represents a major global threat.

As these current examples demonstrate, the *end of history* may be an intriguing idea, but is also an altogether unlikely one. When one factors in the possibility that with time new ideologies will emerge and old ones evolve, then the probability of perpetual peace seems remote indeed. If Fukyama is wrong, then traditional questions about how to establish and maintain an enduring peace remain as valid as ever. And strategic means of deterrence designed to preserve peace, such as command of the sea, remain critical now and in the future.

The Origins of War and Strategic Deterrence

Why do wars start? Or, perhaps more appropriate in this analysis, what must be done to preserve the peace? Donald Kagan in On the Origins of War and the Preservation of Peace provides an answer, as well as issuing a profound warning highly relevant to the Navy and the Submarine Force today.

Kagan presents a cogent and compelling case that wars are a relatively normal condition between states who naturally contest the distribution of power. Wars arise always because they are not adequately deterred. In five case studies (the Peloponnesian War, Second Punic War, First and Second World Wars and the Cuban missile crisis), he analyzes the crises up to the onset of war and identifies the critical failure that allowed (or nearly allowed) the collapse of peace. Consistently, one or more nations failed to adequately perceive or predict a strategic threat, lacked the will to take the necessary action while facing difficulties or constraints, and proved unable to generate an adequate deterrent capability.

Considering the strategic threat, it is entirely reasonable for the Navy and the Submarine Force to ask: Who is the threat? Who needs to be deterred? The answer must consider both potential threats existing today and those, given the normal behavior of states throughout history, which may emerge in the future. According to Kagan, "The current condition of the world, therefore, where war among major powers is hard to conceive because one of them has overwhelming military superiority and no wish to expand, will not last" (emphasis added).[2]

China and Russia affect the global distribution of power today. Germany and Japan, when they inevitably establish military power on par with their economic might, and possibly one or more Muslim states will affect the power distribution soon. Their strategic impact must be considered. For the Navy, it may be reasonable to assume that one or more of these states will again possess the capability to contest open ocean control of the sea.

It is, of course, insufficient only to assess the strategic situation. A nation also must have the will and the capabilities to act on the assessment. Prior to World Wars One and Two, ample evidence existed that the strategic balance had shifted and a deterrent response was needed. Before World War One, Britain took action to strengthen its Navy but did little about its Army.

---

[2] Donald Kagan, On the Origins of War (New York: Doubleday, 1995), p. 568.

This proved a critical mistake because only a large standing army pledged to aid France would have deterred continental war. Prior to World War Two, British leaders utterly lacked the will to either recognize the emerging threat or allocate the (painfully) scarce resources needed to bolster its armed forces.

Prior to both tragedies, nations which could have prevented the wars were convinced that they lived in a time when no threats existed and war was unthinkable. This was especially true prior to the Second World War. Domestic circumstances and the scarcity of resources created a need to believe that deterrence in peace was unnecessary. In the end, the lack of both will and capability resulted in horror. The analogies to the United States today are troubling and certainly worthy of consideration.

Sea Control and the Preservation of Peace

In contemporary America, economic distress, fiscal discipline and an isolationist tendency make military choices dedicated to preserving an existing peace difficult. Resources devoted to military missions in real regional conflicts seem to produce more concrete returns and thus are easier to justify. For example, a submarine constructed and operated to deter another power from developing or exercising a sea control capability produces far less tangible results than the submarine which launches a Tomahawk strike against a terrorist state, or mines a harbor.

Also, the United States is tempted to count on rearmament on the eve of a renewed strategic threat. Submarines are extremely vulnerable to this danger. Any cessation of submarine production would likely cause an infrastructure atrophy such that no submarines, or only a very few, could be built for a long period of time. As John Keegan pointed out in The Price of Admiralty, "The era of the submarine as the predominant weapon of power at sea must be recognized as having begun."[3] No other platform can match the submarine's sea control ability. Thus, too few submarines means a significant lessening of the Navy's ability to exercise sea control against a maritime threat. Nor can the Navy effectively interdict the huge numbers of merchants and their warship escorts necessary when attempting to economically strangle a foe.

---

[3] John Keegan, The Price of Admiralty: War at Sea from Man of War to Submarine (London: Hutchinson, 1988), p. 274.

Production is not the only worry. Suppose the current strategic environment continues unabated for ten years. Further suppose that during those years, research and development of sensors, weapons and ship systems is entirely devoted to submarines in a regional conflict support role. Also, during those years, all submarine training and inspections are directed toward this mission. At the end of the decade, the Navy's submarines excel at Tomahawk strike, SEAL delivery, mining, active sonar and anti-diesel prosecution.

But were a large sea control threat to emerge, the ability to carry out ASUW and open ocean ASW would have suffered severely and would take years to rebuild. Technological development and production have associated time lags of many years, and the institutional memory and body of knowledge of the Submarine Force accrue over generations of personnel.

Kagan's warning is clear and should be heeded. The will and capability to present an effective deterrent, despite the cost, even in peace, is the only way to preserve that peace. As Colin Gray details in The Leverage of Sea Power, **the Navy's role as a deterrent force and preserver of global peace rests on sea control. And if one accepts that the diligent maintenance of a deterrent to conflict is required, then so too must one accept the constant need to command the seas.** *(Emphasis added by Editor.)* The Navy and the Submarine Force must be ready, having properly balanced that need against competing strategies such as regional intervention.

Toward a Naval Strategic Balance

Without a doubt, the United States Navy and the Submarine Force have control of the seas today. Whether in littoral waters or in the open ocean, no threat or potential threat can contest American naval power. Any attack submarine could smoothly shift gears from a battle group support and strike warfare platform in a regional conflict to an open ocean ASW platform maintaining the sea lines of communication. The governing strategic document of the Navy, Forward...From the Sea, while focused primarily on the projection of power ashore, still includes a naval sea control role.

Clearly, the deterrent leverage of sea power currently exists and, as a result, the proximity of global conflict seems distant. So, too, was it prior to the Second Punic War for the Roman

Empire. Yet in the space of a few years which included the failure to recognize the reemergence of a strategic threat and the inability to maintain an adequate deterrent, the Romans were at war with Hannibal.

A deterrent sea control ability certainly will be difficult to maintain in this relatively peaceful period. The immediacy of other missions demands attention and resources. But unless the Nation, the Navy and the Submarine Force strive to achieve a balance of missions, a balance that preserves our command of the seas, we too will meet our Hannibal. ■

TRIDENT SUBMARINE AS A SPECIAL WARFARE PLATFORM: A Medical and Operational Overview

by LT Joseph K. Weistroffer, MC, USN

Recently off the Hawaiian coast, USS NEVADA (SSBN 733), a Trident missile submarine, conducted special warfare operations. A 27 man Marine Reconnaissance Force performed a wet deck launch and *snag-and-tow* operations proving the Trident submarine is an acceptable launch platform.

USS NEVADA's exercise with the Marine Reconnaissance Boat Company has merely opened the door for future joint operations between Trident submarines and special warfare forces. The bottom line is that a Trident is a more stealthy, faster moving platform able to deliver more fighting fire power than the current submarines being used in such a manner. The true beauty lies in the political reality that several vessels of this submarine class will soon become available for such missions since their retirement from their current strategic offense mission has been decided upon as a policy matter.

NEVADA's special warfare operation was the first such exercise ever conducted from a Trident submarine. I participated in the underway portion of this maneuver as the Submarine Squadron Medical Officer. I have participated in previous Fleet Marine Force beach assault maneuvers as both a Marine Infantry Platoon Commander and as a Staff Officer for a Navy Fighter Air Wing. My direct involvement in such operations as submarine physician, infantry officer and fighter pilot offers a unique perspective of this operation and the feasibility of the Trident submarine as a special warfare platform.

Surfaced deck operations are nothing new to the Submarine Force. This method of deploying special warfare troops (Marine Reconnaissance Forces; SEAL units) has been tested on multiple occasions for many years. There are basically three different categories of surfaced deck operations: fairwater planes launch, dry deck launch and wet deck launch. These are not to be confused with submerged launch operations which usually employ dry deck shelters and SEAL delivery vehicles (SDVs). As the name implies, a fairwater planes launch uses the fairwater planes as the launching surface with access gained from the sail hatch above. This method is employed with heavier sea states to minimize the amount of seawater taken in through open deck hatches. The decreased diameter of the sail hatch and extra distance traveled vertically make this a less suitable delivery technique unless dictated by sea conditions. In contrast, a dry deck launch will use one or more of the boat's deck hatches to bring men topside. The insertion team assembles their gear on deck and then shoves off from the surfaced submarine as if it were a pier or beach.

Similar to this, a wet deck launch uses the deck hatches to bring men topside where gear is assembled and prepared for launch. The difference comes when the submarine deploys the rubber boat special warfare teams by performing a static dive, submerging beneath the loaded rubber raiding craft staged on deck. The main tactical advantage of a wet deck launch over the previous two is less time spent on the surface. Currently, only fleet ballistic missile submarines (SSBNs) are authorized for wet deck operations. The flattened deck superstructure housing the strategic missile hatches provides an adequately sized platform to assemble the raiding craft, mount outboard motors and to load supplies, munitions and personnel. The deck's plateau shape also contributes to the stability of the rubber raiding craft during the submerging/deploying portion of the evolution. The rounded deck of a fast attack submarine (SSN) is too small and slick when frequently awash to safely accomplish the task of launching a special warfare team using the wet deck technique. Though NEVADA was the first Trident to engage in surfaced deck launches, such operations have been performed from other SSBNs in the past. Several Lafayette class SSBNs including KAMEHAMEHA and JAMES K. POLK have been converted to special warfare platforms and modified to carry one or two dry deck shelters. These modified vessels can also be used in submerged launch operations with SEAL delivery vehicles.

Surfaced launch operations are often accompanied by snag-and-tow operations. With snag-and-tow, lines attached to the rubber raiding craft are engaged by the extended, and above water, periscope of the submerged submarine, towing the engaged raiding craft over a specific distance and course. Such a maneuver is performed to launch a special operation force from a surfaced submarine at a distance to preclude submarine detection. The deployed raiding craft are towed to their objective by the submerged submarine which is much more difficult to detect. Snag-and-tow is also utilized to recover raiding craft upon completion of their mission. After a successful rendezvous, the submarine would snag-and-tow the raiding craft and slowly surface below them. Once on deck, the equipment is stowed and the submarine/special warfare team proceeds to their next objective.

Thus NEVADA was tasked to conduct "special warfare operations with US Marine Corps (USMC) for at sea training". While at Pearl Harbor, 27 Marine reconnaissance troops (one officer, two corpsmen and 24 Marines) boarded NEVADA and loaded out four combat rubber raiding craft, outboard motors, fuel bladders and weapons. The raiding craft and fuel bladders were stowed securely in the missile hatch superstructure while the munitions were brought below decks and stored in the torpedo room. The outboard motors are submersible only to 60 feet and had to be stowed below decks. Sleeping quarters were provided in crew's berthing. The crew's mess and lounge were designated for briefing spaces and the Marine contingent received required radiation health instruction and shipboard indoctrination.

The operation commenced with clear skies, no weather concerns, mild sea conditions, and minimal currents. A member of the ship's crew was designated as the safety swimmer and was topside with two deck personnel to aid the Marines in retrieving their gear stowed in the missile hatch superstructure. Personnel went topside with their gear via an escape trunk hatch located in the missile compartment. When the four boats were rigged for launch, the submarine began its static dive submerging with as little forward momentum as possible--simply dropping straight down from beneath the rubber craft.

The tow attempt was successful and the raiding craft were towed for a distance of two nautical miles.

It can be concluded that the Trident platform would be an excellent addition to the special warfare community. It is a natural evolutionary step in special warfare insertion tactics with multiple advantages and minimal disadvantages over current delivery platforms. A product of more modern and sophisticated technology than the current special warfare modified SSBNs, the Trident is quieter, faster and equipped with more advanced communication gear and navigation equipment. Not only is this class of submarine newer and in better repair than its older counterparts, but it also was designed to require less maintenance and provide for a quicker turn-around time between deployments. The Trident is a bigger platform, so the possibility exists for an entire Marine Reconnaissance Boat Company to be launched from her spacious decks. In the past, size and space available aboard the submarine has been a limiting factor in troop size and composition. The Trident's size now makes limiting factors out of other issues like insertion site set-up-time of the surface deck. This distinction opens whole new pages of tactical applications to a reconnaissance unit's capabilities. But with this larger size comes one disadvantage, an increased draft of 35+ feet versus 26+ feet. A difference accentuated when maneuvering the Trident's 560 foot length.

Though the operation was successful, there is always room for improvement. This is the reason for performing such operations routinely in peacetime. The time tested adage is still true: you fight like you train, so train like you fight. Operationally, standard operating procedures should be developed to provide the most expeditious static dive for this newest class of SSBN. There is the technical difficulty of accomplishing this maneuver while keeping a level deck. This class of SSBN naturally assumes a nose down attitude when submerging because of the placement of certain ballast tanks. Also critical while submerging this class of submarine is flooding paired port and starboard ballast tanks evenly, otherwise the possibility exists that the ship's deck will not stay level and roll either to port or starboard. Man overboard drills will also be a high priority, especially for the snag-and-tow operation and the eventual recovery of the raiding craft. A quick and well executed man overboard maneuver may be the difference between life and death for an unfortunate individual lost from a raiding craft. Further training of similar launches will help perfect the stowage of necessary gear, and more importantly, the unstowing of such gear just prior to its use. Timing is very important in clandestine operations and the less time a submarine has to spend on the surface the less chance of detection.

The envelope of operations for a Trident submarine acting as an insertion platform is dictated by the ship's 35 foot draft and maneuverability in conjunction with the combat rubber raiding craft striking radius. Like POLK and KAMEHAMEHA, shallow water operations (30 fathoms) are possible with a Trident, but very shallow water operations may be limited. By convention, the raiding craft define their combat radius by the maximum distance they can travel on one fuel bladder. For planning purposes, 20 to 30 miles is often used. This number is effected by craft loading and weather conditions.

The submarine could be loaded out with troops and equipment in port and deploy for long periods of time. More likely, the submarine will be loaded with just equipment in port and the special warfare troops will not make extended cruises. Combat troops prefer to hone tactical skills and push physical readiness up to the very last moment before an operation. Most commanders feel both physical and tactical preparedness drop quickly when their men are deployed aboard ship. For this reason, troop underway time is often kept to the bare minimum. With the Trident able to cover some 500 miles per day, the troops could be loaded at an intermediate port before proceeding to the insertion site. They could also use the current technique of being transferred at sea by ship or being dropped into nearby water by a helicopter or C130. This transfer would occur in a relatively secure operating arena and then the submarine would steam in one to two days to the insertion site. The Trident's ability to steam swiftly but silently allows for many options. The ship to submarine method of troop loading is the most viable if larger numbers of troops are to be transferred. To air drop over 100 individuals would be risky and should be considered only for smaller insertion teams.

Medical concerns include the numerous possibilities for injury when dealing with special warfare operations. Orthopaedic injuries are common in tactical operations involving ground troops: separations, tears, hyperextensions, strains, and fractures of all types (stress, simple, comminuted, compound). The possibilities for blunt trauma on the pitching deck of a submarine at sea are high, not only for the deploying forces, but also for the ship's deck crew. The combination of manual labor with heavy lifting and a wet, slippery, pitching deck can be very dangerous. Throw in a mix of turning screws from both landing craft and submarine, lines parting under heavy loads and several bladders filled with gasoline and one does not have to look far for the possibility of a catastrophic event. Blast injury would be a major area of concern had munitions been involved and this will need to be considered for future operations. The storage, transfer, and staging of munitions in the submarine and in the raiding craft should be conducted with the utmost care and concern. Munitions inflicted wounds become an even greater concern when the mission is not merely a training exercise. Gunshot, stab and fragment wounds, crush injury and amputation can all be expected in a wartime situation.

The weather and water temperatures off the Hawaiian coast are almost always agreeable and were not of major concern in this operation. This assuredly will not always be the case. Hot, humid weather raises the risk of heat stoke and heat exhaustion. Stormy weather and ice decrease deck footing and increased the likelihood of trauma or a man being thrown overboard. Hypothermia is another significant threat in a cold, wet environment and a grave concern in Northern seas with or without a man overboard. In such operating environments, it would be imperative that medical personnel be trained and proficient in treating immersion hypothermia. Advanced Cardiac Life Support (ACLS) training would also be beneficial.

The risk of trauma in the special warfare environment is so substantial that the corpsmen assigned to both the submarine and the deploying forces should be trained in ACLS. An operation requiring launch, snag-and-tow, shore landing, battle maneuvers and ending with submarine rendezvous and recovering is dangerous enough that a medial officer's presence should be required onboard the submarine. Having a surgeon onboard may be beneficial if operationally indicated (i.e., anticipated heavy casualties or remote launch objectives with little chance for medevac).

Other shipboard systems influence the health of those living within the highly controlled environment of a submarine. The thought of using the Trident to launch an entire Marine Reconnaissance Boat Company would increase the number onboard twofold. The performance parameters of the submarine's atmospheric control devices are great enough that doubling the number of people aboard ship would not cause an undo health risk. The oxygen generators, carbon dioxide scrubbers, and carbon monoxide burners all would be able to readily handle the load posed by the proposed additional crew. The ship's evaporators which produce fresh water for both crew and propulsion plant also have sufficient reserve.

The submarine can easily tailor its menu to provide a less expensive, better tasting high calorie/carbohydrate meal and should be the sustenance of choice for troops deployed aboard the submarine for any length of time. Refrigerated and frozen goods are the limiting factor for food storage. Though canned and dry goods can be kept almost anywhere aboard ship, limited food provisions are traditionally the critical variable in determining the length of a nuclear powered submarine's deployment.

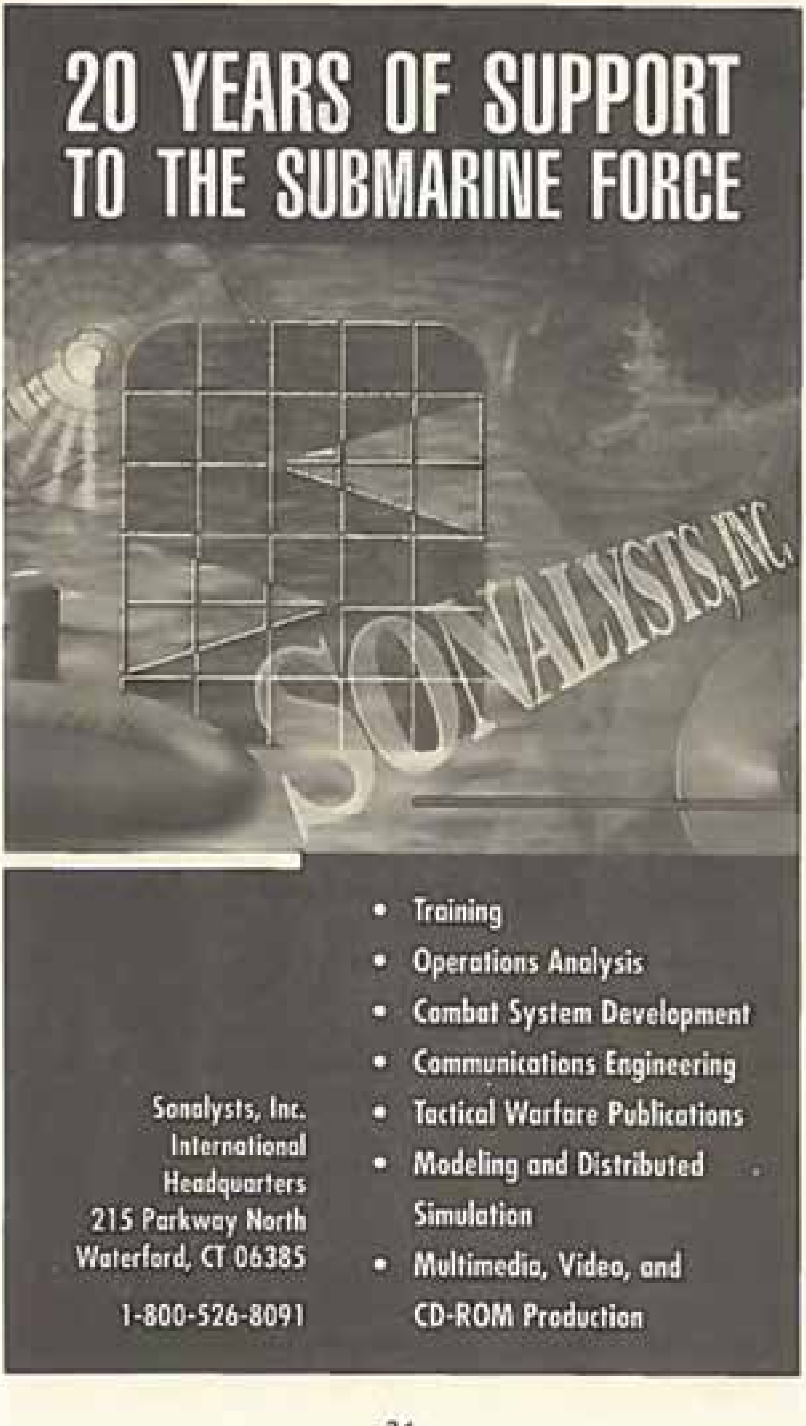
Though the Ohio class boats are an outstanding platform, they were designed to launch missiles, not Marines. With several modifications their usefulness would increase. As previously mentioned, 27 Marines were brought onboard and were easily berthed without the need for hot-bunking. The ship felt that with sufficient air mattresses, they could have easily accommodated twice as many Marines without hot-bunking. It is conceivable that even without berthing modification that up to 120 Marines could be deployed with ingenuity. In the future, on a modified Trident without missiles, there would be no need for the Weapons Department and the assigned 20 to 25 sailors (Missile Technicians) nor for their working spaces which includes a rather large missile control center. The Navigation Department would also be reduced in manning numbers and space requirements, reflecting the downgraded mission requirements when the ballistic missiles are removed. This reduction in the Weapons and Navigation Departments would free up to 30 to 35 beds that could accommodate up to 70 people if using hot-bunking. The vacant missile control spaces and a portion of the navigation spaces could easily be converted to briefing, exercise, office, lounge or study space as well as additional berthing space. The upper missile compartment space now considered a high radiation area and off-limits to personnel would lose such designation without Trident missiles housed in the missile tubes. This space would then be available for additional berthing if needed. It is realistic to consider the possibility of deploying an entire Marine Reconnaissance Boat Company of 150 people onboard a modified Trident submarine.

Storage space is a prime asset onboard a submarine and doubling the number of people onboard can tax even the best load masters. With extra space requirements for people, berthing, toilets, showers, food, medical supplies, weapons, munitions and the remaining gear needed for an assault, storage space is at a premium. As with the previous class SSBNs modified for spec war, the missile tubes are an excellent space to convert to stowage for necessary gear. The tube could be made accessible from above as well as below decks. Weapons could be stored in appropriate containers placed in a myriad of spaces once used for Trident missile operations to include missile control or the D5 void space located in the bottom of the missile launch tubes. Munitions could be kept in appropriate storage containers in the torpedo room. They could be lowered to the compartment just as torpedoes are and then the container could be properly secured. Modified empty missile tubes would also offer an acceptable location for munitions storage. The superstructure above the missile compartment already offers voluminous space, probably sufficient to house all the necessary rubber raiding craft and fuel bladders, though a modification in enlarging hatch sizes would increase accessibility and decrease set up time during the actual launch operation.

The outboard motors routinely used by the special warfare community come in two general sizes, 35 and 55 horsepower. For this operation, the smaller of the two was used and, as previously noted, needed to be stowed below decks. There was some difficulty in getting this equipment below because the engine housing barely fit through the escape hatches even following the removal of the bubble skirt and ladder. There is some question whether the larger engine would actually fit through the escape trunk hatches without further modification of either the engine or the hatch. The outboard motors could be kept in a modified missile tube since they are capable of being pressurized, this would preclude seal rupture at depths greater than 60 feet.

Modification of the missile tubes could also greatly increase the Trident's capability as a special warfare platform by allowing for submerged deck operation. The focus of this paper has centered upon surfaced deck operations, but the addition of several dry deck shelters would be an incredible expansion of the Trident's versatility. Submerged deck operations entail forces leaving the submarine while the vessel is submerged, greatly decreasing the possibility of detection of either the submarine or the inserting forces. The escape trunks could be used, but were designed for two people. A third or even fourth individual could probably be added considering the trunk's 70 inch diameter and 65 inch height. These trunks currently have two atmosphere pressure gauges, one for trunk pressure and another for inside hull pressure. A third gauge monitors air regulator discharge pressure. The trunk is wired for two way communications via the 32 MC circuit. Like the SSN 688 class, the escape trunk hatches open forward into the water stream utilizing a spring balanced mechanism and thus the ship must have very little headway to allow opening. With modification, it is conceivable that the missile tubes could be used for lock-in/lock-out procedures. Use of the missile tubes would allow more people to lock-in/lock-out and the tubes sideways-opening, hydraulically powered doors could be opened while the ship is moving forward. The depth control and speed characteristics during such maneuvers are similar to those of POLK and KAMEHAMEHA. The addition of several dry deck shelters would allow the use of SDVs, two man mini-submarines used by special warfare troops. It is also important to note that the Trident's high pressure (HP) air banks used in lock-in/lock-out procedures for breathing air is not approved for charging SCUBA bottles. The escape trunks have a diver's air connection for breathing, diving gear or pneumatic tools to be used outside the hull with a regulator set at 5 to 100 psi over ambient. But the pressurization/supply design for the HP air banks is similar in design to the SSN 688 class and thus would need a filtering system before such air could be used to charge SCUBA bottles. A modified Trident though would have enough room to add a HP air SCUBA charging system. These are but a few of the issues that would need to be addressed before converting the Trident submarine for submerged deck operations.

This recent surfaced deck launch and following snag-and-tow operations shows that the Trident submarines will be an excellent addition to the capabilities of the special warfare community. Its technological advances, increased performance envelope, decreased maintenance requirements and greater troop carrying capacity make it a formidable non-strategic weapons platform. The conversion of several submarines to this mission will augment the tactical fighting strength of this country's armed forces. Some time will pass before the final decision is made to convert one or more Tridents to a platform from which surfaced as well as submerged launch operations may be routinely conducted. In the interim, surfaced deck operations, to include launch, snag-and-tow, and recovery operations, need to be continued. Only through trial and error will a set of standard operating procedures be established and refined to allow a timely surfacing, set up, wet deck launch, static dive without pitch and roll, snag-and-tow and recovery. ■



20 YEARS OF SUPPORT
TO THE SUBMARINE FORCE
SONALYSTS, INC.
• Training
• Operations Analysis
• Combat System Development
• Communications Engineering
• Tactical Warfare Publications
• Modeling and Distributed Simulation
• Multimedia, Video, and CD-ROM Production
Sonalysts, Inc.
International
Headquarters
215 Parkway North
Waterford, CT 06385
1-800-526-8091

INFORMATION OVERLOAD

by LT Michael Bernacchi, USN

Thoughts on taking advantage of the booming computer industry to provide ship drivers with critical information without overloading the users.

Information and processing systems in the civilian industry continue to get bigger, stronger, and faster. It would be possible to replace an entire submarine's fire control and sonar system with smaller, cheaper PC equivalents. One of the Naval Undersea Warfare Center's main foci is on development of new submarine systems that incorporate this civilian industry and technology. This shift in focus cannot be applauded enough. In a recent statement at the SubSchool Change of Command, Rear Admiral Tobin of CNET, stated the Submarine Force should be leading the computer revolution. Submariners are continually frustrated by having to operate warships in the 1990s based on 1970s and '80s technology. In the civilian world, if manufacturers such as the automobile companies operated in this manner, they would be out of business. Similarly, operating the Submarine Force using out-of-date technology is not only less efficient, but it is more costly. Cost benefit analysis, as well as anecdotal evidence from manufacturers and supply officers, point out that the upfront cost of replacement is often high, however, the cost of continually repairing out-of-date equipment is usually higher in the long run.

As the Submarine Force moves into this technological explosion our processing power will greatly increase leading to the ability to display more and more information. Over the next few years as the successors to the Pentium™ processors come out this power will only continue to grow—leading to the display of even more information.

The real question becomes how to use this power to process and display large amounts of information in the most efficient means possible, to improve the ship's performance and enhance the ability of her crew. In the succeeding sections, an outline is presented of how quantitative, as well as qualitative, human factors engineering should be applied to the accomplishment of the above stated goals. I will be drawing not only on my naval experience, but also experiences at the University of Michigan (where I recently completed two M.S. degrees in Nuclear Engineering, and Industrial and Operations Engineering—concentrating in human factors.) At Michigan, we studied such issues as they relate to civilian nuclear power control and manufacturing system controls.

The outline will cover: 1) a brief description of Human Information Processing and Basic Information Theory; 2) Perceptual Attention Organization and Processing; and 3) Spatial Perception, Cognition, and Display of Spatial Information.

Human Information Processing and Basic Information Theory

There are seven basic parts to the model of human information processing. They include: sensory processing, perception, working memory, long term memory, decision and response selection, response execution, and attention resources.

Each one of these categories is an entire book unto itself and would be impossible to cover in a single paper. The point of presenting this model is to establish a basic flow path for information processing. Using this model as a guide, ideas on how to measure and improve information processing by manipulating the different components of the model are explored.

The main problem with the current Navy submarine developmental programs is that the programs rely on *feel good* human factors engineering. Sailors are questioned on what they need and would like to see implemented on new systems. The designers then try to accommodate the stated needs. This is an excellent first step, for who knows what is wrong or needed in a system better than the operators? Industry often executes the exact same process leading to results which are often dramatic. However, this is where the Navy appears to stop the development process, unlike the manufacturers. Worker input should be the starting point, not an ending point, to the development process for information display systems.

Once the inputs have been received, designers need to develop display systems to take advantage of spatial perceptions and cognitions. By manipulating the displays it is possible to take advantage of common perceptions and cognitions to allow greater processing speeds. These new displays can then be mathematically tested to determine which are the most beneficial. The bottom line is that by altering the display, processing of information can be improved. These improvements can be tested mathematically vice just *feeling* to see which is better.

An illustration of a mathematical method for measuring information transmitted, equivocated, polluted by noise, and finally received is information theory. Given that every event on particular display has a given probability (p_i) of being transmitted, the information conveyed by a stimulus (or stimuli) in bits (H) = $\log_2 1/p_i$. With this equation, it is possible to calculate the average information conveyed (H_{ave}) by series of events with different probabilities, like a series of warning alarms. This is the source strength or transmission signal of the original information. The signal is now influenced by equivocation losses (or loss of the signal during transmission) which will degrade the received signal. The original signal also suffers corruption from noise that enters the transmission channel. All of these factors can be measured to determine which system transmits the clearest signal to the operator thereby improving the processing of information. This method of measurement also will give a quantitative measurement of the maximum amount of information a person can process for a given display system.

The main point of this section is to show that there are mathematical methods that quantitatively analyze human factors information. The mathematical analysis needs to be integrated into the initial development of new systems. This quantitative data can be used to compare different display systems and offer directions in which these systems can be improved.

Perceptual Attention Organization and Processing

The amount of information received from a display is not only dependent on the display presentation but on the operator monitoring the display. The key to successful information processing of multiple signals is parallel processing and time sharing attention resources. Perceptual attention can be thought of as a spotlight. General scanning of a particular display can be thought of as a wide beam search. Then, when there is a need to focus on something in greater detail the spotlight goes into a narrow beam focus. The designer's objective is to make the display easy to search for important information which will lead to a narrow focus, yet still allow for big picture understanding. This is no easy task!

The ability to exercise supervisory control sampling of a panel while standing a watch is considered an art. If the operator is highly trained, it is assumed that almost all types of casualties can be prevented by observation of trends in the instrumentation readouts. The operator will detect a problem in the infancy stage and proper action can be taken to avoid it from escalating. It is therefore imperative that some optimal sampling rate be developed.

Recently, a study of radiologists having varying degrees of expertise was conducted to determine why some were better than others. The basics of scanning an x-ray are taught at every medical school and hospital in the country. So why is there such a difference in radiologist expertise? The radiologists were not sure of the reason even after sharing their respective techniques. A test was conducted on a series of x-rays where the radiologist's eye movement patterns were recorded. The results showed that the better doctors had similar scanning techniques that were done on a subconscious level. Developing a scanning pattern that is optimal for a display panel usually takes an operator several years. The Navy should take some of the best operators for all systems (including nuclear) and scan their eye movements to determine an optimal pattern. This pattern would have a twofold benefit. First, it would allow designers to position information identified in the scan pattern in a specific way which would enhance the ease of processing. Second, this pattern could then be used as a prototype to help younger operators.

Another aspect that has a direct impact on the panel is pre-attentive processing and perceptual organization. By using Gestalt's efforts to identify a number of basic principles that cause items to be pre-attentively grouped together on a display, instruments that have similar information (i.e., pressure, temperature, flowrates, or bearing, frequency, signal-to-noise ratio) can be grouped together to have a display organization that follows a logical pattern. This approach is extremely helpful when a person is just starting to learn the system. Even if the operator does not know exactly where the instrument reading is located, if the basic outline of the control panel is understood, he will know where to look. It also enhances the ability to parallel process information.

An example would be to have a 3-D holographic display of all ships movement and position parameters. The OOD could immediately orientate the ship with reference to the environment. Environmental parameters such as SVP, fronts and eddies could also be included along with contact solutions so that the OOD could get the big picture in a few seconds. This would enable the OOD to make decisions faster while integrating all information available to the ship in one easy to interpret display. A projection of future position based on changes in parameters (i.e., speed, depth, and/or course) would allow the OOD to see if the decision he just made, or will make, is a safe one and if not allow him time to change it **before** a catastrophe. The system could even be set to monitor ship status in lieu of the given environment and warn the OOD if he is possibly making an unsafe decision. Many civilian industries use this preventive type of computer aided safety programming.

Another idea for an integrated computer display system would be one for sonar. While at Michigan, I had the opportunity to work with some amazing software products used for sound analysis. Instead of actually having all of the electronic components to make filters, and amplifiers, the program let the components be modeled mathematically in the computer with precision results. Almost all of our sonar processing equipment could be replaced with a computer software program. Imagine all the processing equipment removed and replaced with four or five PCs. The program could interpret the incoming signal faster than a sonar operator could and present to the operator just the vital information minus the noise. Based on the signal received the computer could classify, estimate range (with a series of algorithms based on current sonar and ranging techniques), determine course and speed, resolve bearing ambiguity, determine arrival path, and classify transients all in a second. The sonar operator would have more time to concentrate on just the evaluation of the computer's interpretation of the signal since the computer is doing more of the work. Additionally, a software drive system would allow more flexibility in the event of a hardware casualty.

Another idea that takes advantage of perceptual organization is that of object displays. There is an illustration in Reference A, demonstrating Stroop's theory that several dimensions belonging to a single object will guarantee their parallel processing. Applications of Stroop's theory will improve performance if parallel processing is required and can be related to a system. The figure is an example of related factors in a nuclear reactor.

The base, steady-state operation of the system is illustrated by a standard geometric figure—in this case an octagon. When one of the factors falls out of alignment, this distorts the geometric figure drawing attention to the problem. The distortion can be made in such a way that it then directs the operator's attention (focusing it) to further indications or controls to correct the problem.

These are just a few ideas on how the improved processing power of the computer can be used to display massive amounts of information in a concise way that will not overload the operator. The applications of these ideas will be examined further in the conclusion.

Spatial Perception, Cognition and Display of Spatial Information

The idea of compatibility between perceptions, as represented on a display, and cognition are very important in ship system displays and nuclear control panels, because if something were to go wrong, the stress factor on the operator explodes exponentially. It is imperative that the compatibility be as close as possible to limit the chance of a mistake. There are countless numbers of instruments that are integral to each other when trying to obtain the status of the ship or reactor. To have the compatibility of proximity, displays that are usually viewed in sequence to ascertain the condition of the system must be located close to each other. There is a problem in the fact that in order to be consistent with display organizational expectations that compatibility of proximity has to suffer a little. It is not possible to put display parameters right next to each other if they are organized by function, there is simply not enough room. So to minimize the impact of non-compatibility of proximity for instruments that are part of an integral evaluation, the displays must be integrated as previously stated, and instrument blocks for similar systems located as close as possible to each other. This way the watch-stander will be monitoring groups of integrated displays in the time it formerly took to view the components that made up a non-integrated display and integrate them mentally.

The net result of all of this, is that by having integral displays organized in a way where compatibility between perceptions, as represented on a display, and cognition are preserved the operator will be able to absorb more information with less chance of error.

Conclusions

These have been just a few ideas in an effort to advocate a more proactive scientific approach to information display systems based on human factors engineering. Finding bottleneck areas of operator performance based on information overload and discovering ways to solve these problems is what a more scientific approach to human factors will give the Submarine Force. It is this type of practical application of human factors theories that has already proven useful to civilian industrial organizations. A great deal of time and money has gone into, and continues to be spent on the development of new systems. The limiting point in these designs is the workload that one operator can handle while stationed at a control panel. Once this workload has been determined, the Submarine Force must engineer solutions to the operator's limitations, allowing the workload to be increased without a decrease in performance. Human factors engineering is the key component to successful engineering solutions to the information overload problem.

Besides the benefit to the operator, a more proactive role in solving the human factors problems early in the design stage will save money. Manufacturers often live by the concurrent engineering rule of 10. This rule states that it is ten times more expensive to fix a problem once it has gone to the next stage of development. This rule seems to be true also for the development of submarine systems. The information explosion is going to overwhelm operators unless solutions are found. It is cheaper to design them into the systems on paper than to correct the problem after the system is already built. By understanding human perception and processing capabilities it is possible to design displays that present a tremendous amount of information in a concise manner. The key is to let the computer do the work, and then be smart about how the information is displayed, taking full advantage of the graphic processing power of the computer. The only way to accomplish all of the above stated goals is to have a dedicated staff of human factor engineers involved with all aspects of the design process.

Our submarine sailors are the most formally educated, extensively trained, and skilled submariners in the world. We have a one hundred year old legacy of greatness upon which to build. Our Submarine Force constantly handles any challenges that arise. We owe it to the sailors to develop the most modern and comprehensively designed systems possible. With systems designed in such a manner, run by the finest sailors in the world, the Submarine Force will be able to meet and exceed the high standards of the past. ■

REFERENCES

A. Wickens, C.D., Engineering Psychology and Human Performance. New York: HarperCollins, 1992.

B. Lui, Y., and Wickens, C.D., "Visual Scanning With or Without Spacial Uncertainty and Time-sharing Performance". Proceedings of the 33rd Annual Meeting of the Human Factors Society. Santa Monica, CA: Human Factors Society, 1989.

C. Dauch, R.E., Passion for Manufacturing. Dearborn, MI: Society of Manufacturing Engineers, 1993.

D. Senders, J.W., "Visual Scanning Processes". Unpublished doctoral thesis, University of Tilburg, Netherlands, 1980.

E. Stroop, J.R., "Studies of Interference in Serial Verbal Reactions", Journal of Experimental Psychology, 1935.

F. Wachtel, P.L., "Conceptions of Broad and Narrow Attention". Psychological Bulletin, 68, 1967.

ERRATA TO NSL DIRECTORY

Due to a program error, the following names were inadvertently dropped from the 1996 NSL Directory:

Donald R. Thomas
CDR USN
1925 Kaster Court NE
Bremerton, WA 98310-3852

James D. Thomas
420 N. Mitchell Court
Liberty Lake, WA 99019-9407

James G. Thomas
CAPT USN(Ret.)
16551 Corte Paulina
Poway, CA 92064

Robert E. Thomas
CAPT USN(Ret.)
3712 Southernwood Way
San Diego, CA 21076

AN UNDERSEA COASTAL SURVEILLANCE SYSTEM

by

John Parish
Senior Program Manager
Loral Federal Systems

Wayne Nielson
Regional Manager
Cable & Wireless Marine

Scott Jensen
Business Development Manager
Alliant Techsystems

Warren Hollis
Chief Engineer
Undersea Surveillance
BBN Systems and Technologies

After the Second World War, the U.S. Navy recognized a need to significantly improve their anti-submarine warfare (ASW) capability. During the war, the German U boats roamed free on the high seas and lurked off the U.S. harbors, virtually undetected except when they were on the surface and close enough to a ship or aircraft to be spotted visually. Therefore, a special study was commissioned that resulted in the Hartwell Report. This discussed, among other things, the phenomenon of acoustic transmission in the ocean and the ability to recognize various types of ships by their acoustic emissions. A national strategy was developed to acquire wide-area undersea surveillance. This became known as the Sound Surveillance System (SOSUS) and the first site was commissioned in 1954. At that time, the extent of the emerging Cold War was not yet fully recognized. Over the years, additional sites were commissioned and the U.S. Navy and some of its closest allies achieved an effective counter to the growing submarine threat.

Through the 1960s and 1970s, while the Cold War was escalating, SOSUS proved to be the force multiplier that gave the U.S. Navy an ASW superiority. Surveillance had been established in both the Atlantic and Pacific oceans, and work was ongoing to field a mobile extension called SURveillance Towed Array Subsystem (SURTASS). SURTASS joined SOSUS in 1984, and the combined name for these two systems became the Integrated Undersea Surveillance System (IUSS). The IUSS continued to be an effective force multiplier right up to the end of the Cold War when the Berlin Wall fell. With the Cold War over and the balance of power shifting, the U.S. Navy refocused ASW efforts to a regional conflict capability. Work by the U.S. Navy in ASW during the 1990s has emphasized warfare in shallow littoral water.

These regions are typically acoustically harsh areas. Over the past few years, they have been studied and considerable progress has been made in understanding the acoustical characteristics of these difficult regions.

The point of this short historical review of undersea surveillance is to emphasize how important long range strategic planning is to effective ASW. In most cases, the U.S. Navy made the investment in undersea surveillance to keep ahead of an emerging Cold War threat. A similar situation remains today for many nations. Any country that wants to develop an ASW capability should look closely at the U.S. Navy's success in undersea surveillance and include it as part of their strategic planning. Surveillance relieves some of the burden on tactical assets (ships, aircraft, etc.) for open ocean search. The tactical assets can then be used more intelligently, and to much better effect, by follow-up prosecution on known threat targets that have already been classified and localized by area surveillance.

With the collapse of the Soviet Union and the relaxation of the continual confrontation with the USSR, the need for strategic and very responsive surveillance in the deep oceans—traversed by nuclear submarines, has diminished. Russia does, however, seem intent on maintaining a very credible nuclear submarine force; therefore, the capability to counter an open-ocean, highly sophisticated threat must be maintained. *[Editor's Note: Recent U.S. news media reports have indicated Russian submarine activity in the vicinity of Trident bases in both Washington and Georgia.]*

Today's emphasis on ocean surveillance relates to the rest of the world's (ROW) submarines, a collection of hundreds of conventional boats and several non state-of-the-art nuclear subs. Within this diverse order of battle are some very troublesome threats which have to be detected and tracked by ocean surveillance systems.

The primary ROW subs include export versions of the Russian Kilo class diesel/electric submarine and the German built 209 class. These submarines can conduct very quiet operations while on battery power. Their duration has been significantly improved but is still limited and eventually requires snorkeling which supports detection by surveillance systems.

The conventional submarine is currently undergoing a drastic, perhaps revolutionary, change in design. German manufacturers of the impressive 209 class are now under contract to deliver the initial four units of the new 212 class to the Federal German

Navy. The 212 will incorporate Air Independent Propulsion (AIP), and will represent a very formidable challenge for surveillance systems. With the number of ROW submarines continually increasing, and the quality improving, surveillance systems tailored to the requirements of the many ROW countries is becoming increasingly difficult.

In addition, the requirements for surveillance systems have shifted considerably, from military-only to surveillance of many activities with a potential adverse impact on a nation's stability or economy. These activities include illegal immigration, drug trafficking, terrorism, environmental pollution, fishing violations and even piracy. All of these activities involve ships/craft conducting operations in violation of a country's laws, within the coastal boundaries of the country. Surveillance of a country's coastal waters and harbors must support timely prosecution of violators. The requirements for detection and recognition of contacts involved in these illegal activities is quite different from that of the traditional surveillance against deep ocean going submarines.

These targets of interest vary considerably from one type of activity to another. Illegal immigration might very well be conducted with a relatively small freighter, large enough to transport dozens of people in rather inhumane conditions. A drastically different craft, however, used frequently in illegal drug activities, is the high speed Cigarette boat. These two examples represent quite different requirements for an undersea acoustic surveillance system because the general acoustic frequency spectrums of interest are quite different. Sound associated with propeller noise—the predominant source for underwater acoustic detection—is at low frequency for the small freighter and at a significantly higher frequency for the Cigarette boat.

In addition, the various illegal activities noted above also require a surveillance system to provide localization/tracking information to support evaluation of suspicious maneuvering. With these detection/recognition and localization/tracking capabilities, a properly implemented undersea coastal surveillance system can prove to be extremely beneficial in countering illegal activities which are economic drains on a nation's economy.

Today most nations attempt to find threats (both military and non-military) with tactical platforms. Surface ships, maritime patrol aircraft and helicopters are serving as the current method of surveillance. It is very difficult for a country to deploy these assets over large areas for a long duration as the operational costs quickly became prohibitive. Rather, it would be wiser and more cost effective for a country to utilize these precious tactical assets for follow-up prosecution after a threat has been identified and localized by an Underseas Coastal Surveillance System (UCSS).

Coastal surveillance can be used to detect/recognize and localize/track all surface and subsurface contacts within its assigned coverage space. The preferred surveillance might take the form of a sizable area or a specific barrier. In either case, UCSS will perform continuously—every hour of every day, for years. The cost for surveillance per square kilometer per hour by an area system is a fraction of the cost of surveillance using ship or aircraft platforms.

There are a variety of surveillance systems employed. SOSUS has already been mentioned as the first fixed passive system employed to detect, classify and localize submarines. A more recent addition to fixed systems surveillance is the Fixed Distribution Systems or FDS.

The FDS underwater system was built on commercial fiber optic technology to transmit the high data outflow from the sensors. The signal processing or Shore Segment Information Procession System (SSIPS) developed is based on commercial-off-the-shelf (COTS) and Non-Development Item (NDI) computer hardware and reusable software in workstation configurations.

Where permanent installations mounted on the ocean bottom do not provide the flexibility needed to monitor all threat activity, a mobile system that can bring surveillance assets to any area of the world in a matter of days could solve part of this problem. This is the significant advantage of SURTASS, whose detection capability is provided by a deployable towed array mounted on an ocean-going auxiliary ship class ship.

Other U.S. undersea surveillance systems include the Mobile In-shore Undersea Warfare (MIUS) system to be used primarily for port area security in regional conflicts. And, of course, there is now the development of the Undersea Coastal Surveillance System (UCSS) that we are addressing in this paper.

Certainly the U.S. developed surveillance systems have met the free world's surveillance requirements, but there are also significant offerings from Europe, including systems from Russia, France, England, Germany and Finland.

The first step in building an effective undersea surveillance system, as with any other military equipment, is to understand fully the operational requirements. It is absolutely imperative that all performance requirements of the system be taken into consideration before it is designed. What is the threat to be met? What is the mission? Is the system single purpose or multipurpose? Who is going to use the information from the system and how are they going to use it? What type of follow-up assets, such as aircraft or surface ships, will they be using?

Once the mission requirements are understood, the designer needs to know what the performance expectations are. What probability of detection is wanted, how accurate does localization of the threat need to be, and how responsive from a time-late standpoint must the system be? Is the need for large area surveillance, or surveillance of a specific high value area, or is a barrier or trip wire warning system wanted?

Lastly, the designer needs to understand the acoustic environment where the surveillance is needed. Factors such as depth of water, bottom composition, and surface traffic patterns and density must be known. Ambient noise sources, be they manmade, biological, or weather induced, must be considered and the temperature structure known to account for the Sound Velocity Profile (SVP). Seasonal variations, and transmission loss characteristics, in addition, will all greatly affect system design and ultimately performance. All these factors are then influenced by the various threats and vulnerabilities to the system, such as fishing trawlers, cable landing sites, shore site security, and covertness in installing and operating the surveillance system.

Understanding all these factors is accomplished in a variety of ways. Database reviews of available literature can help focus the efforts. Onsite acoustic and bathymetric surveys of the region will characterize the environment, and modeling will give the ability to analyze various system designs against this data. This is where cost factors come into play (different designs cost different amounts of money), because the reality of all these systems is that they must be affordable and provide optimum performance for the cost. Lastly, before that buy/no buy decision, a demonstration of a small surveillance system in actual waters of interest can ensure that all factors have been considered and give the opportunity to see a system's actual performance in the water of interest.

Over the past five years, the ability to *tailor* undersea surveillance systems to the specific requirements has been greatly facilitated by the introduction of COTS hardware and software systems into the defense industry. With COTS and an open system architecture, the surveillance system design can effectively support the latest upward technology growth as new capabilities become available and can reduce both spare parts requirements and system maintenance costs.

Traditional Navy surveillance systems have generally relied on specialized signal processing and display hardware. The use of COTS hardware takes advantage of the intense competitive environment of the commercial computer marketplace to ensure that hardware costs are continually dropping while the available performance is increasing. Because commercial standards are effective at ensuring compatibility between vendors, solutions are available from the very smallest to the very largest systems, without changing system architecture or incurring excessive integration costs. A standard UNIX workstation is the UCSS basic hardware unit. Every unit has the same type operating systems, disk drives, CPUs, memory and all other essential components. Individual units are tailored to perform their specific function (signal processing, database, operator workstation, etc.) by adding more disks, video screens, or an array processor card according to the functional requirements of the unit. This standardization simplifies sparing and maintenance. Because these are standard commercial units, upgrades are much easier. Commercial vendors realize that upgrades must be simple and foolproof or they will not be able to sell the larger disk or faster CPU. As an example, in a recent upgrade some systems went from a 2.1 Gb disk to a 10 Gb disk as part of normal maintenance. This operation consisted of simply unplugging the smaller and plugging in the larger. CPU upgrades from 50 Mhz to 90 Mhz were equally easy. Building military surveillance systems from COTS hardware offers the opportunity to profit from the dramatic and continuous improvements in commercial systems.

Software systems also are based on modern object oriented programming techniques. Virtually all of the operator interface programming is done in C++ and built on commercial user interface packages. This object oriented approach facilitates the tight integration of multiple operations on a single object. This object approach enhances the tailorability of the system. Every system is at least slightly different: different mission, different sensors, different acoustic processing, different geography, etc. Tailoring a system is easily accomplished by modifying the internal components of these underlying objects. Each object, whether a geographic display, beamformer processing, or acoustic display is individually configurable. These configurations are represented external to the software in a set of system specific configuration files.

The undersea subsystem comprises both acoustic and non-acoustic sensing and data transmission subsystems.

The basic acoustic sensor is comprised of a series of air backed (for shallow water) or oil backed (for deep water) ceramic cylinder hydrophones. The exact number is dependent on the voltage sensitivity required to meet the overall sensor noise goal. If the environment so dictates, non-acoustic sensors such as magnetic and electric field sensors can be employed. The array design is considered once the basic sensor is chosen.

With the need for system protection, usually by burial, the role of the cable route surveyor fundamentally changed. The main objective of the modern survey is to eliminate cable faults and maintain the protection of the surveillance system. Given that trawler fishing damage accounts for a majority of system unavailability, a carefully planned survey and plowability study is the first step to reduce substantially this risk.

By taking all these factors into account, installation of a UCSS can be cost effective and can be carried out in virtually any part of the world.

To date, cable installers have used fairly conventional installation techniques. With the advent of optical systems, cables are becoming smaller. In order to drive down costs, some installation companies have used a *vessel of opportunity* for cablelaying.

In other situations such as relatively shorter systems, a cableship may transport an entire system on a single load, while a smaller vessel of opportunity may require multiple loads. When selecting the vessel, the number of cable loads and handling, the shore-end requirements, and potential weather delays need to be considered.

It can be seen that to develop and install a UCSS that meets all the military requirements is no trivial matter. It requires a relationship between the provider of the system and its users. All the salient factors must be considered and the appropriate trade offs made. Risks must be reduced as much as possible, and a long term, strategic mentality must be adopted to clearly focus on the value of such an investment. ■

SUBMARINES OF THE ST. PETERSBURG MALACHITE BUREAU

by A.M. Antonov

Alexander Antonov is an engineer and Deputy Head of the Design Department with the Malachite Design Bureau in St. Petersburg. He has participated in the design of several advanced nuclear-propelled attack submarines as well as studies for submarine tankers.

> Every design organization has its history which includes projects that were realized and those that remained on the drawing boards. The Malachite Naval Engineering Bureau has produced several generations of submarines behind which stands an original school of design formed in the 40 years of the bureau's existence.

The history of the Malachite Bureau began in March 1948 when Special Design Bureau No. 143 was set up. The bureau's task was to design high speed submarines with new types of power plants as soon as possible. This step was due to the crisis submarines faced as a class of warships at the end of the Second World War. One of the main reasons for this situation was the development of radar equipped anti-submarine forces. As the chief designer of the first Soviet submarines B.M. Malinin put it, "...radars were the broom that swept everything off the surface of the seas. If submarines had any claim to existence, they would have to become submerged boats in the full sense of the word." These prophetic words were written in early 1947. They defined in a nutshell the priorities of submarine design for the 1950s: to turn diving submarines into ships capable of spending long periods of time submerged and traveling underwater at the same speed as surface vessels. Special Design Bureau 143 had to respond to this challenge of the times.

Immediately after it was set up, Special Design Bureau 143, headed by Chief Designer A.A. Antipin began work on a submarine with a steam gas turbine (Whale Project 617). The concept was based on a 7,500 hp Walther engine from a captured submarine. The design also made use of certain technical innovations from German submarine building. The Project 617 submarine was constructed at the Leningrad Navy Yard No. 196 and was tested in the summer of 1952. For the first time in Soviet practice, a submarine was developed capable of traveling underwater at a speed of 20 knots for six hours at a time. The State Commission noted in its report that the Project 617 submarine was unparalleled in the Soviet Navy in terms of speed.

Special Design Bureau 143 also worked our Project 618 of a 19 knot small submarine with a closed cycle diesel at the same time as the steam turbine submarine. However, the design was not put into construction.[1]

The development of high submerged speed submarines opened the way for raising their combat effectiveness. These submarines could catch up with the enemy without surfacing, attack and avoid anti-submarine forces.

However, steam gas turbines and closed cycle diesels failed to meet the requirements. They proved to be unreliable, had a limited fuel supply and could catch fire and explode. The advance of science in the early 1950s made possible the development of a relatively small nuclear reactor for vessels. Not dependent on a supply of atmospheric air, nuclear power plants provided for high power, were relatively small size and lightweight and enabled the submarine to move underwater at any speed for a virtually unlimited time. No other source of power dovetailed so well with the demands of submarine building.

Work on the country's first nuclear submarine began in September 1952 when groups of designers of submarines and nuclear power plants started to develop the future vessel virtually from scratch. The groups were headed by V.M. Peregudov and N.A. Dollezhal. The outstanding academician A.P. Alexandrov became the program's scientific adviser.

As a result of research, in the spring of 1953, it was shown that a nuclear submarine could be created exclusively on the basis of domestic research and development. Special Design Bureau 143 headed by Peregudov was assigned the task of implementing the submarine's design in practice. Project 627 provided for a set of trials and design work on nuclear power, the submarine's hydrodynamics, development of new structural materials, living conditions on board the submarine and weaponry. The vessel's design was completed less than a year and a half later, and the bureau began to issue the blueprints to build the submarine at North Dvina Navy yard No. 402 (currently known as North Engineering Plant). In the summer of 1958 the K-3 (November class) prototype nuclear submarine, subsequently called LENINSKY KOMSOMOL (Lenin's Young Communist League), set out on its trial cruise. On July 4, 1958 at 1003 the nuclear power plant was put into operation for the first time in the history of the country's navy. The Russian nuclear fleet came into being.

Thus, the first Soviet nuclear submarine was developed in just six years. The same project took the U.S. about nine years.

The government commission, in its report, indicated that the submarine's development "is a major achievement of the country's research and development in underwater vessel building". Compared to the existing diesel submarines, the K-3 was twice as fast, could travel underwater up to 75 times further and could go 50 percent deeper. Thus, with the advent of nuclear power submarines turned from diving to truly underwater vessels.[2]

Subsequently, 12 submarine were built according to the improved 627A Project, forming the basis of the Soviet nuclear submarine fleet. In addition Central Design Bureau 18 developed the nuclear submarines with missiles Project 658 (Hotel class) and Project 659 (Echo I class) on the basis of the power plant and using research and development materials from Project 627A. Essentially these were missile versions of Project 627A.

Some time after the first submarine with a water nuclear plant, Special Design Bureau 143 developed a project of a steam power plant with a liquid metal heat carrier. Before 1955 this project was supervised by Peregudov, and A.K. Nazarov became the Chief Designer in 1955. As opposed to the U.S. Navy, which encountered serious design problems with chemically active sodium in developing the SEAWOLF (SSN 575) submarine, Soviet experts resorted to lead bismuth. As a result, the Project 645 submarine was developed and commissioned in 1963; it was reliable in exploitation and highly maneuverable. As distinct from the water power plant submarines which had numerous bugs in the early period, the K-27 submarine of the 645 Project immediately carried out several autonomous cruises, exceeding planned self-sufficiency. However, the nuclear power plants with liquid metal agents proved to be more difficult in exploitation and required special servicing at base.[3]

Meanwhile, in the early 1960s, the problem of the reliability of water nuclear power plants was solved, and the submarines of the 627 and 627A Projects made a number of long cruises. In July 1962 the K-3 submarine (later named LENINSKY KOMSOMOL) carried out the first Arctic expedition and research the geographical point of the North Pole underwater. A year later, another submarine, the K-181, also visited the Arctic and surfaced in the area of the North Pole. In 1966 the K-133 submarine took part in a group round-the-world navigation and travelled underwater about 20,000 miles in 54 days.

These facts are widely known. It is less well known that Special Design Bureau 143 was a pioneer in introducing missiles on submarines.

In the mid-1950s Special Design Bureau 143 developed the design of the submarine carrier of the P-20 cruise missile (Project P-627A) on the basis of Project 627A. The supersonic aircraft projectile, as the cruise missiles were known at the time, were developed under the direction of well known aircraft designer Sergei Iliushin and had a range of 3,500 kilometers which was 5.4 times further than the range of ballistic missiles of first generation nuclear submarines. In a short period of time, Special Design Bureau 143 solved complicated engineering problems having to do with installing the new weapons on submarines. Project P-627A was completed at the end of 1957, and Yard No. 402 began to build the vessel. Following the latter submarine, Special Design Bureau 143 developed series missile submarines of Project 653 (Chief Designer M.G. Rusanov) armed with two P-20 cruise missiles. Originally it was planned to build four of these submarines, but then the Navy proposed to increase the series to 18 vessels. The lead ship was to be turned over to the Navy in 1962.

However, in 1960 the country's leadership revised priorities in developing missile weapons. Top priority went to the rapidly advancing ballistic missiles, while the P-20 Complex was judged to have no future. The building of nuclear submarines of the P-627A and 653 Project was stopped.

The Malachite Bureau was directly involved in furnishing submarines with ballistic missiles as well. Since 1974 the bureau included the Volna (Wave) Design Bureau (earlier known as Central Design Bureau 16) which, under academician N.N. Isanin, developed the world's first ballistic missile submarine. The effort dates back to 1954 when the bureau began work jointly with Sergei Korolyov's bureau on this project. As a result, as early as 1955, a diesel submarine, the B-67, was reequipped to test R-11FM missile center Project B-611. It was from the latter vessel that the first naval ballistic missile was launched on September 16,

1955. And although the range was not long (250 kilometers), and the missile was launched from the surface, it was decided to arm five diesel submarines refurnished under the AB-611 Project (Zulu V class) with ballistic missiles.

Next, Central Design Bureau 16 developed Project 629 (Golf class) of an ocean submarine armed with new, longer range R-13 missiles. The 23 submarines of this type built in 1959-1962 formed the basis of the Navy's strategic nuclear sea forces (only eight nuclear missile submarines of Project 658 were built). Subsequently, Central Design Bureau 16 did research and development on underwater launched missiles and tested new types of ballistic missiles on floating stands.

Virtually at the same time as Project 629, Central Design Bureau 143 worked on Project 639 (Chief Designer V.P. Funikov) with three R-15 ballistic missiles developed in M.K. Yangel's Special Design Bureau 586 with a range of up to 1,000 kilometers. Special Design Bureau 143 introduced many innovations into the Project 639 submarine: an onboard system of storing missile fuel, missile launching from inside the hull instead of outside (as was the case with Projects B-611, 629 and 658), AC electrical system and others. However, Special Design Bureau 586 stopped working on sea based missiles, giving them up to V.P. Makeyev's Special Design Bureau 385. As a result, work on Project 639 was stopped in December 1958.

At the beginning of the 1960s the Soviet Navy became ocean-going, nuclear and missile carrying. With the Navy's advance into the world's ocean began the confrontation with the navies of the NATO countries.

Giving proper credit to the other side, it is to be noted that the U.S. managed to create the Polaris strategic system. Between 1959 and 1967 the U.S. Navy received 41 nuclear submarines each of which carried 16 ballistic missiles. In view of the growing threat from the seas, Special Design Bureau 143 began work on nuclear submarines of a different type at the end of the 1950s—those designed to fight submarines. These vessels were a response to the new challenge of the times—the missile challenge.

The Project 671 (Victor class) submarine was worked out under Chief Designer G.N. Chernyshev and with the active participation of a group of younger designers. This anti-submarine vessel differed from its predecessors in a number of technical innovations. It was the first single shaft submarine with a X-shaped tail and original design of the forebody which included a large size acoustic antennae and torpedo tubes. The bureau's designers projected a reliable combat vessel capable of operating in any part of the world ocean, including the Arctic. The submarine could travel faster and plunge deeper. Thanks to its moderate displace ment, the Project 671 submarine series was built at the Admiralty Yard in Leningrad and brought through inland waterways to the north to be turned over to the Navy. The Project 671 lead ship was commissioned in 1967, and, on the whole, 15 submarines of this type were built up to 1974.

In addition, in 1969 the Navy received the Project 661 (Papa class) submarine developed by Central Design Bureau 16 (Chief Designer N.N. Isanin) with a set of Amethyst cruise missiles. This was an experimental submarine intended to perfect the technique of manufacturing a titanium alloy hull and a new missile complex.[4]

Meanwhile, life had shown the need to find new ways to improving submarine combat efficiency. In the mid-1960s, Soviet shipbuilders realized the need to radically improve the submarine's capacity to avoid acoustic detection. Unfortunately, the scientific potential to solve this problem was absent at the time. Nevertheless, consistent implementing of measures to reduce noise and anti-acoustic means made it possible to reduce the Project 671 submarine's acoustic field several times. Overall, this submarine proved to be well adapted for modernization and introduction of new weapons and technology.

Submarines of a new kind, the 671RT (Victor II class), began to be delivered to the Navy in 1972. They were distinguished by more powerful and larger caliber torpedoes and missiles, as well as a reduced acoustic field.

In 1977 the Navy began to receive a radically different modification of the submarine, Project 671 RTM (Victor III class), equipped with the most modern electronics, automated combat management system and improved torpedoes and missiles. A set of cruise missiles similar to the American Tomahawk was tested on one of these submarines. These ships turned into truly multi-purpose submarines capable of tackling any combat mission. Thanks to consistent and careful work, the latest submarine modification had a noise level several times lower than the lead submarine of Project 671.

A total of 48 submarines in different modifications of this project were delivered to the Navy by 1992 when their construction was discontinued. The very fact that this submarine series was built for nearly 30 years shows the high potential of the designers' ideas underlying the project.

Another epoch-making vessel for Special Design Bureau 143 Malachite and for the entire submarine building industry was the Project 705 nuclear submarine (Alfa class). The history of this ship also goes back to the turn of the 1960s when, on the initiative of Special Design Bureau 143, it was proposed to develop a highly maneuverable anti-submarine vessel with small displacement. As in the case with project 671, Special Design Bureau 143 advanced many new revolutionary ideas. The ideas were so radical in technical terms that it was necessary for the Academy of Sciences of the USSR and the bureau's old comrade-in-arms, Academician A.P. Alexandrov, to take over scientific supervision of the project. A whole galaxy of academicians—A.I. Leipunskii (nuclear power), V.A. Trapeznikov (automation), A.G. Iosifin (electrical engineering), and N.N. Isanin who became head of Malachite in 1974—took part in developing the ship. Extensive research and development work was carried out in a short time period, making it possible to create a fundamentally different vessel with unique tactical and technical features. An enormous amount of work was done by Chief Designer of the Project 705 submarine, M.G. Rusanov.

The nuclear power plant, using a liquid metal heat agent, provided for the submarine's maximum speed of more than 40 knots. Comprehensive automation enabled the crew to be reduced by two-thirds compared with nuclear submarines of the first generation. The designers developed small size electrical equipment, torpedoes which could be fired at any depth and a non-magnetic titanium hull.

Such a revolutionary ship, however, turned out to be too complicated for industry. The differance in level between research and development and manufacturing had an adverse effect on the submarine's fate. As a result of shortcomings in the nuclear power plant and technological defects, the first submarine was ruined and construction of serial vessels delayed. Extensive additional work had to be done by the new Chief Designer V.V. Romin. In 1976-1981 six submarines were delivered to the Navy. Notwithstanding all the troubles, the Project 705 submarines were technically more advanced than any existing ships. The designs developed for them were implemented on submarines of the next generation.

New multi-purpose submarines of the Bars (which the West called the Akula class) type began to be delivered to the Navy in 1986. These ships of the third generation encompassed the latest achievements of Soviet science and technology. They successfully combined the strong points of submarines of the 671 and 705 Projects.

These beautiful yet intimidating ships are the pride of the modern Russian Navy. They are capable of solving a broad range of combat tasks on the seas. Anti-acoustic means used on Bars submarines have made them the most noiseless and stealthy ships in the Navy. Having inherited the name of Russia's first combat submarines, the modern Bars submarines fly the traditional Russian St. Andrew's flag.

Russian submarine building is going through difficult times today. The deep-going economic crisis and rupture of ties with enterprises of the military-industrial complex in the former USSR, have created serious problems in preserving the existing scientific and technological potential. Even under the circumstances, the Malachite Naval Engineering Bureau remains the leader in Russian submarine building. The bureau is capable of providing the Navy with the means to defend Russia's state interests on the high seas.

REFERENCES

1. V.A. Badanin, Submarines with a Single Power Plan (Essays of History), First Research Institute, Defense Ministry, Russian Federation (Naval Shipbuilding), St. Petersburg, 1993 (in Russian).

2. A.M. Antonov, "The First Nuclear Ships", Gagut: Collected Essays, St. Petersburg, No. 7, 1994 (in Russian).

3. V.F. Bildin, "Experimental Torpedo Submarine of the 645 Project", Morskoi sbornik,, No. 8, 1993.

4. V.I. Zharkov, "The First Missile Submarine", Gagut: Collected Essays, St. Petersburg, No. 6, 1994 (in Russian). ■

LOOKING FORWARD—THERMIONIC REACTORS FOR A REVOLUTIONARY ELECTRIC BOAT

by LT French Caldwell, Sr., USNR(Ret.)

[Editor's Note: The author recently retired from Ingalls Shipbuilding and is carrying forward his studies of thermionics at the University of Tennessee in Knoxville. For more information, he can be contacted via E-mail at FrenchCald@aol.com.]

Introduction

As we move towards construction of the next submarine class, the New Attack Submarine, it is important to begin considering concepts to incorporate in the *submarine after next*. Nuclear thermionic propulsion offers elimination of steam plant components, and the associated weight reduction and space benefits can revolutionize modern submarine design.

A nuclear reactor utilizing thermionic fuel elements is capable of producing electrical energy with no turbine generator machinery—free from vibration, noise and wear of moving parts. All that a thermionic reactor requires is space for the reactor, conduction of waste heat, and electrical components to modify and transmit the electricity for the drive motor and ship's hotel loads. The thermionic fuel elements which produce the electric power are integral to the reactor itself. Without the steam plant, and with the increased reliability of thermionic power, backup emergency systems for propulsion and electrical power can be reduced in size or even eliminated altogether.

The History of Thermionics

In the early 1880s, Thomas Edison encountered a serious problem. His light bulbs burned out prematurely. Quite naturally, short-lived light bulbs disturbed the customers of his fledgling electric company. In the process of solving this problem, he made a significant ancillary discovery, disclosed in this 1884 patent:

> "I have discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent lamp, and said conducting substance is connected outside the lamp with one terminal, preferably the positive one, a portion of the current will, when the lamp is in operation, pass through the shunt circuit thus formed...

This current I have found to be proportional to the degree of incandescence of the conductor, or the candle power of the lamp."

Edison US Patent 307,301

Edison patented his newly discovered effect as an "electrical indicator" for detecting and regulating voltage fluctuations in various parts of his electrical distribution system. Twenty-one years later John Ambrose Fleming used the effect to create the radio tube, thus ushering in the electronics age. Fleming's vacuum electron tube replaced a solid state "coherer" for the detection and amplification of radio waves. By the 1950s the electron tube was rendered obsolete by another solid state device, the transistor.

In the early 1940s, while electron tubes were in wide general use and readily available, Winston Caldwell, Sr. of Nashville, Tennessee, began investigating the use of the heat-driven thermionic emission of electron tubes for electrical power generation. On Sunday, August 9, 1942, he noted in his yearbook: "Made successful test showing that by superimposing a 330 volt DC current on a #80 radio tube a direct conversion of heat to electricity was made." Of course, he was repeating Thomas Edison's old experiment, but he saw in the experiment something more than an electrical indicator. He envisioned a new basic source of electrical power.

Winston Caldwell's study of radio tubes was to provide the answer to a quest he began while studying electrical engineering at Vanderbilt University in 1905. From his early studies he was convinced that there must be a simpler way to generate electricity than building huge dams on the rivers or boiling water to make steam to spin turbines, to turn magnets to move charges, and finally to make electricity flow. Although he did not pursue an engineering career, he experimented with electricity throughout his life. His quest was a long one. He was 70 years old when he was awarded US Patent 2,759,112 for his *Electron Tube Thermoelectric Generator* issued August 14, 1956.

During the period 1953-1956, while his patent application was pending, Caldwell solicited the assistance of General Electric Company in obtaining a gas or vapor filled electron tube with close cathode-to-anode spacing for his experiments. In May 1956 Dr. V.C. Wilson at GE's Schenectady Laboratory began experiments with filament-type electron tubes containing cesium vapor. Cesium vapor diodes proved to be the ideal candidate for thermionic converter development. The Caldwell and Wilson inventions paved the way for extensive thermionic converter research that followed in the period from 1960 to 1973.

While Caldwell and Wilson were investigating gaseous diodes, Dr. George N. Hatsopoulos at MIT applied for a patent for a device that accomplishes thermionic power generation by the magnetic triode concept. Dr. Hatsopoulos founded Thermo Electron Corporation which became a principal investigator of cesium thermionic converters under government R&D contracts. Other principal contractors were General Electric Company, General Atomic Division of General Dynamics Corporation and RCA. From 1960 forward, NASA and the Atomic Energy Commission (AEC) (predecessor to the Department of Energy) pursued the development of thermionic converters for space nuclear power.

The nuclear thermionic reactor program made continued progress. As early as 1964, the AEC reported that General Atomic had reproducibly accomplished the continuous generation of over 75 watts of electrical power with small cylindrical thermionic cells only one inch long and five-eighths inch in diameter. The thermionic reactors under development by the AEC were being designed for operation in the 100 to 300 kilowatt range. The planned reactors were physically quite small—on the order of three feet tall by two feet in diameter.

In 1970 the AEC-NASA nuclear thermionic reactor program showed dramatic progress, but the U.S. had by this time landed men on the moon and effectively won the *space war* with Russia. NASA had placed a thermoelectric (i.e., working on thermocouple rather than thermionic principles) nuclear generator on the moon. Although the moon device only produced 65 watts of electricity, rather than up to 300,000 watts expected from a thermionic reactor of the same size, it met NASA's radio and TV signal power requirements. Because NASA had no foreseeable near term missions that required the amount of power that thermionic reactors would provide, the thermionics program was put on the chopping block.

The thermionic program's demise was detailed in hearings before the Joint Committee on Atomic Energy, Congress of the United States, March 20 and 22, 1973:

Chairman Price: Now under this cutback, is thermionics out entirely?

Mr. Gabriel: Yes, sir; if no additional funding is provided our work on thermionic conversion will be terminated by the end of June this year.

Chairman Price: As director of this program, do you personally feel that there are commercial and even military applications for thermionic conversation that would compel us to continue in this area?

Mr. Gabriel: Mr. Chairman, I am not aware of any military requirements for power plants of this size...

JCAE Hearings 3/20/73, page 2394

In the period 1960 to 1973, more than $100,000,000 was expended on government sponsored thermionic conversion research. Fortunately for modern researchers, the extensive technical reports and data produced in the course of the research provide an excellent database from which to move forward toward practical thermionic applications. Over 100 now-expired U.S. and foreign patents that followed the Winston Caldwell patent add to that base of knowledge.

Back to the Future

The problems inhibiting thermionic converter development up to now are essentially practical ones. Dr. Robert W. Pidd's 1965 testimony is particularly enlightening:

Dr. Pidd: Thermionics is not all that tough. The first device we put together eight years ago produced over five watts per square centimeter. Three years later, we understood why we were getting it. The fact is, we didn't struggle to get that. It happened when we turned it on. The thermionic device is a very practical system. It is self-stable. You don't have to fight to make it work.

Chairman Holifield: What is your problem—metallurgy?

Dr. Pidd: No. Certainly, when we started, the basic problem was materials because reactors had not operated at 1,800 centigrade before. The closest precedents we had were the Rover reactor and the HTGR (High Temperature Gas Reactor).

Since then, we have had enough radiation data to operate at 1800 centigrade for thousands of hours and we have got full radiation now for a 50 kilowat system. I am willing to say now that the temperature materials problems at that power level are over, at 50 electrical [kilo]watts. We certainly need much more data for 500 and 1,000.

Chairman Holifield: Tell me how you construct these thermionic cells?

Dr. Pidd: The way we construct them is as follows... We make a cell which is—first of all, you want a hot surface. We simply make that identical with the fuel element. That is a tungsten cup and we put uranium carbide in it. You have the fissioning material, the source of heat and the thing that wants to get hot all in one. That boils off the current.

Dr. Tape: Give the approximate dimensions.

Dr Pidd: It turns out that the practical dimensions are that it will be greater or no less than two inches long.

Chairman Holifield: Each one?... Then you would have thousands of those.

Dr. Pidd: It depends on the system. For a 50 kilowatt system, 180... For a 5 megawatt system, 54,000.

I was completing the construction of the cell for you. It is this hot fuel element, two inches long, about a half inch in diameter. You surround it, very closely spaced, with a collector to collect the current and that is it.

On our test cells in the laboratory today, we are at 7,000 hours. . In our in-pile test, we are at 2,000 hours... We have not encountered any fuel trouble yet. In fact, that is why I am willing to say that the fuel problem is over. Most of our trouble now is making equipment last that long. Most laboratory equipment does not last more that 1,000 hours. We are having trouble with our environment. We have to purify that more.

Chairman Holifield: What do you mean, purifying the environment? Operating in a vacuum?

Dr. Pidd: Preferably in a vacuum or in a highly purified gas... I had to bring up such mundane things, sir, we need better pumps and they cost $200 apiece.

JCAE Hearings, August 6, 1965

The Importance of Inventiveness

In the 1960s thermionic research, rather than taking the free ranging approach of Edison, researchers adopted a theory of thermionic conversion which precluded full exploration of potential thermionic converter materials. In contrast to the many cases in which scientific theory has led to the development of new and better products, thermionic converter development has been inhibited by the adopted scientific theory.

Because of the strictures of prior radio tube theory, particularly Richardson's 1901 equation as modified by Dushman in 1923, it has been assumed that the voltage output of thermionic converters derives from the difference in work function of the cathode and the anode materials. Accordingly only high work function materials, such as bare molybdenum or tungsten, have been used for the cathode, even though the high work function reduces the flow of electrical current in the converter.

In the 1960s thermionic converter programs, we were back to Edison's problem of keeping electricity flowing in the sometimes unfriendly space of an evacuated enclosure. The inventive mind of Edison kept working at his problem by experimenting with thousands of potential materials until he found a reliable carbon filament derived from a particular type of bamboo. No scientific theory would ever have led Edison to bamboo to solve the problem of the light bulb.

The Politics of Energy

Another problem that may have inhibited development of thermionic conversion in the 1970s is the energy politics. In the mid 1960s Gulf Oil Company bought the General Atomic Division of General Dynamics Corporation and became the major competitor to General Electric Company on the thermionic reactor program. In 1970 the AEC decided to select a single prime contractor for the program. Gulf General Atomic won the competition, and (as detailed in the 1973 hearings of the Joint Committee on Atomic Energy) soon thereafter brought the program to an end.

From Russia, Thermionics for Sale

In spite of the obstacles of oil politics and limiting theory, thermionic power generation research did not die. Throughout the Cold War, there was cooperation between U.S. and Russian scientists in many areas of research, including thermionics. Our avowed enemy used U.S. thermionic research to carry the work forward in the Topaz thermionic reactor project.

In post Cold War technology exchange the Defense Department acquired a Russian built Topaz II thermionic reactor for test and evaluation. The September 1993 issue of Mechanical Engineering Magazine reported on four U.S. thermionic programs: the Thermionic Fuel Element Verification Program (TFEVP), the Advanced Thermionic Initiative (ATI), the Thermionic System Evaluation Test (TSET), and the Thermionic Space Nuclear Power System Design and Technical Demonstration Program.

Currently, the demise of Star Wars missile defense programs and other continuing cuts in space and defense spending again leave this high powered, mighty midget wanting for a space limited customer that needs the power that it can deliver. When the Navy is ready for a silent generator that needs only heat—no turbines, no spinning dynamos, no moving parts—thermionic conversion is ready and waiting.

■

E-MAIL ADDRESSES

If there are any members of the NSL who would like to correspond with other members via E-Mail, please send your E-Mail addresses to the League at subleague@aol.com. We will include them in our April **SUBMARINE REVIEW** as well as a future directory.

FIDO - THE FIRST U.S. HOMING TORPEDO

by Tom Pelick

At the beginning of World War II, the Navy had several torpedoes, including the air launched Mk 13 and the submarine launched Mk 10 and Mk 14. Early in the war, there were distinct problems with the submarine launched straight running torpedoes. There was a depth control problem and an inertial switch problem with the exploder which resulted in many submarines missing their target and occasionally ending in disaster for the launch submarine.

The National Research Council established research facilities at several academic institutions to provide the United States with technical assistance in the war effort. One of these institutions was the Harvard Underwater Sound Laboratory (HUSL). This laboratory was headed by Dr. Ted Hunt with associate directors, Dr. Eric Walker and Dr. Paul Boner. One of the first research projects that the scientific team solved was the depth control problem of submarine launched torpedoes which caused the torpedo to run under the target instead of impacting. Other problems solved included the exploder mechanism.

Submariners found themselves vulnerable for attack after firing torpedoes that did not hit or fail to explode when they did hit. After the Navy notified the Bureau of Ordinance, the Bureau said their calibration procedures were correct and the submariners were not using the torpedoes correctly. The group of scientists quickly discovered that the calibration tests done on the torpedoes had two basic problems. Calibration of torpedoes in a stationary tank of water did not take into account the pressure reduction due to water flow over the torpedoes' pressure transducer. This made the torpedo think it was shallower than it was and therefore ran deeper and under the target. Other depth control problems were traced to flight angle differences between lightweight and heavyweight configured torpedoes. The in-water tests were done with a lightweight configuration with the explosive material removed to permit simpler recovery of the torpedo after the test. The depth transducers were calibrated with the lightweight torpedo but the calibration did not account for the sinking factor of heavyweight warshot torpedoes and the flight angle. (This same problem carried over into other torpedo developments.)

Another problem was that the torpedoes that impacted did not explode, especially those hitting at right angles to the target. Those torpedoes that hit the target at grazing or glancing angles had a greater chance of exploding. It was found that the contact exploder mechanism initially required a firing pin movement vertically in the torpedo at right angles to the impact force vector. This force vector caused the firing pin to rise slowly or stick in the vertical tube, especially when the torpedo was at high speed or hitting the target at 90 degrees. These problems were corrected and the scientists went on to other studies.

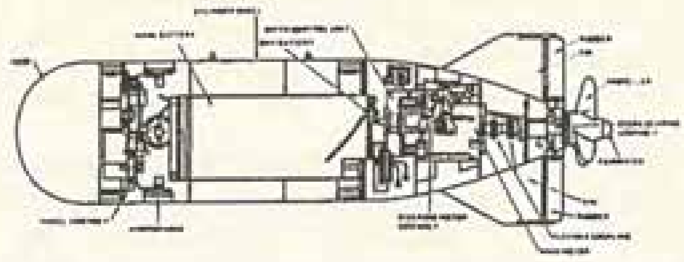
In January 1942, an important breakthrough came as the result of a captured German torpedo, G7e, with an electric propulsion system. The torpedo could not be readily duplicated because of dimensions and other mechanical problems. The concept of an electric propulsion system to a quieter, wakeless torpedo that could not be easily seen by the target or from the air was adopted and became the Mk 18 torpedo. About 9000 of these were built by Westinghouse. The electric torpedo was slower due to the battery weight, but the wakeless feature plus the relative quietness provided more of a stealth weapon than the thermal alcohol engine of the Mk 14 or the thermal hydrogen peroxide engine of the Mk 16.

Early in 1942, Admiral Louis McKeehan of the Mine Warfare Branch of the Bureau of Ordinance came to Harvard with a secret project to build a homing torpedo for use against submarines.

The concept of an acoustic homing torpedo was pursued by the HUSL scientists and engineers. There were two different projects: (1), passive acoustic homing, and (2) echo ranging (active) homing. The first project, FIDO, reached fruition from concept to production in nine months. It was classified as a mine and was given the name FIDO to confuse German Intelligence and also maintain the work at HUSL. The term *FIDO* meant dogged determination of the torpedo to engage the target submarine. The second HUSL project resulting in active homing torpedoes will be discussed in a future issue.

Initial testing of the first prototype FIDO, Mk 24 torpedo, was done by HUSL scientists. The first firing occurred on the first anniversary date of Pearl Harbor. On December 7, 1942, FIDO was successfully tested against a simulated target. Initial test of these torpedoes were made off the New England coast in late 1942 with further tests taking place in Key West, Florida. The torpedo had an electric propulsion system with lead acid batteries giving it a speed of 12 knots and a range, or time duration, of 4,000 yards/10 minutes. The homing system consisted of a set of magnetostrictive transducers at each side of the rounded nose and a vacuum tube homing panel which provided steering depending on the incoming angle of the target's radiated noise. The torpedo was 84 inches in length with a diameter of 19 inches. The torpedo was designed to be an air launched torpedo to combat the German U boat threat operating off the U.S. coast and in the mid Atlantic. Because of weight considerations, FIDO carried a small explosive charge of 92 pounds of HBX-1. The total torpedo weight was 680 pounds. FIDO's mission was to enter a preset passive circle search and home in on the target submarine's propeller noise and disable the submarine, causing it to surface where it could be readily attacked by air and surface ships. It was designed as a mission kill torpedo versus a direct torpedo kill.

The first 500 units were tested by HUSL researchers at Key West, Florida in 1942 to 1943. Bell Labs was the prime producer of the 4,000 Mk 24 (FIDO) torpedoes delivered to the Navy. Originally, 10,000 Mk 24 torpedoes were ordered, but because of the high degree of successes against U boats in the Atlantic and the Pacific, the order was cut back to 4,000 torpedoes. As initial production increased, some slight modifications were made to the Mk 24 torpedo including the use of ceramic transducers and relocating the transducers from the nose to the side of the torpedo. A sketch of the Mk 24 torpedo is shown below.



The HUSL test engineers reported that after test firing one of the early prototype test torpedoes, it immediately began homing in the direction of a distant transiting fishing boat and was lost. After the war, a fisherman found it lying on the bottom. Its homing system was still functional after laying on the bottom for three years.

The Mk 24 torpedo was very successful in helping to decimate the German U-Boat fleet. The advent of the long range Liberator bombers provided air cover into the mid Atlantic where German wolf packs were waiting for convoys. The German Submarine Fleet suffered huge losses due to air attacks by torpedoes in 1943.

According to Jolles[1] listing of Navy torpedoes, the following statistics reflected the success of this torpedo in the Atlantic. Failures of the torpedo were often the result of improper deployment and tactics.

Mk 24 Torpedo Firings Against German U-Boats

	U.S. Navy	Other Allied Forces	TOTAL
Attacks on U-Boats	142	204	346
U-Boats sunk	31 (22%)	37 (18%)	68
U-Boats damaged	15 (120%)	18 (9%)	33

Adapting the Mk 24 torpedo concept into other torpedoes resulted in other passive homing torpedoes, including the submarine launched Mk 27. Attempts were made to try to adopt the Mk 24's homing system to the Mk 16 torpedoes, but the self noise from the thermal propulsion engines which burned hydrogen peroxide was too high and affected the homing system. Electric propulsion torpedoes were more readily adaptable to this new passive homing system. The Mk 24 homing system concept was carried into many other torpedoes that were later built for the Navy. The Mark 27 torpedo was an adaptation of the Mk 24 homing system for submarine launch during World War II. The Mk 27 had fundamentally the same homing system but a longer body carrying a larger warhead. The Mk 27 torpedo will be

---

[1] E.W. Jolle, A Brief History of U.S. Navy Torpedo Development, NUSC TD #5436, September 15, 1978.

discussed in future issues.

One of the original FIDO (Mk 24) torpedoes is on display at the Navy Museum at Naval Underwater Weapons Center, Keyport, Washington and a replica is in the lobby at the Applied Research Lab, Penn State. One of the outstanding achievements of this torpedo development was that it went from concept to production in nine months. Our modern torpedoes take between 10 and 15 years to go from concept to production.

After the end of World War II, Harvard requested that all classified work cease and their buildings be vacated. Harvard was expecting a significant increase in enrollment due to the war's end and the effect of the GI educational bill. Dr. Eric Walker, associate director of HUSL, had accepted a job at Penn state in the Electrical Engineering Department. The Navy, reluctant to lose its scientific technology base, asked Dr. Walker to take about 100 engineers, scientists, and technicians with him. Dr. Walker formed the Ordnance Research Lab (now the Applied Research Lab) in 1945 at Penn State to continue the acoustic torpedo research programs. This laboratory was responsible for conceiving and developing many torpedoes over the years, including the Mk 27 Mod 4, Mk 34-1, Mk 31, Mk 37, Mk 39, Mk 48, Mk 48 ADCAP, Mk 50 etc. Subsequent issues of **THE SUBMARINE REVIEW** will contain information on the development of these torpedoes. ■

[Tom Pelick has worked on submarine related issues for over 37 years. After graduating from Penn State, he became a Faculty Research Engineer at the Ordnance Research Lab. His background includes hydrodynamics, optics, acoustics, electronics, and systems. He was one of the design and test engineers that developed the Mk 48 torpedo, and Technical Directors staff with responsibilities for the homing system. He was instrumental in the development of the Mk 48 ADCAP and the Mk 50 torpedoes. He has ridden 14 submarines collecting data for development of acoustic homing systems and served as the Applied Research Lab's representative on numerous intra-lab research teams and committees. He also serves on a committee of the Underwater Warfare section of the America Defense and Preparedness Association.

BUILDINGS HONOR SUBMARINERS
Part I of II
by RADM M.H. Rindskopf, USN(Ret.)

This monograph is the third in a series in which the heroes are submariners, old and young; or men who helped make the Submarine Force what it is today.

The first document was the Submarine History section of Steel Ships Iron Men, a book of more that 600 biographies of submariners published in 1994 by the Turner Publishing Company of Paducah, Kentucky. The senior officer represented is Admiral Hyman L. Rickover of the Naval Academy Class of 1922. He is, as well, the only deceased officer included.

The second paper was a natural follow-on which included all the ships in the U.S. Navy which were officially designated submarine tenders (AS). There were 35 such ships, of which 16 were named for people. These biographies and the derivation of the names of the other ships—mythological characters or heavenly bodies—form the concluding section of Steel Ships Iron Men.

This monograph describes 54 buildings on nine Naval installations named for submariners, officer and enlisted, and two aviators whose contributions were significant in the development of the Submarine Force and to its success from the Cold War forward. This story is told geographically, commencing with the Submarine Base, New London, Connecticut; journeying down the East Coast, then to the West Coast, and concluding at the Submarine Base, Pearl Harbor.

There are also rooms named in memory of submariners within buildings, named and unnamed. These are presented following the main portion of this paper.

The emphasis in these biographies is on the submarines in which these men served.

U.S. Naval Submarine Base, New London, Connecticut

Grenfell Hall. Grenfell Hall serves as one of the headquarters buildings for Submarine Group TWO.

It was named for Vice Admiral Elton W. Grenfell, born in Massachusetts in 1903, and graduated from the Naval Academy in 1926. He attended Submarine School in 1928, and served in R-4 until 1933. He spent two years in PICKEREL (SS 177) before his tour as Commanding Officer of GUDGEON (SS 211) in which he distinguished himself by sinking the first Japanese submarine, I-173, west of Midway Island, and two merchant ships. After being injured in a seaplane accident in Pearl Harbor, he had command of two Submarine Divisions before the end of the war. He was the first officer to serve as Commander Submarines Pacific and Atlantic, completing the latter tour in 1964. He retired in 1965 and died in 1980. He was awarded the Navy Cross, Silver Star, and a Presidential Unit Citation for his duty in GUDGEON, and a Distinguished Service Medal and three Legions of Merit for post-war duty.

Dealey Center is the movie theater and auditorium for the entire base. It was named in memory of Commander Samuel D. Dealey, born in Texas in 1906, graduated from the Naval Academy in 1930, and Submarine School in 1934. Prior to the war, he served in S-34, S-36, and BASS (SS 164), decommissioning the latter. Early in 1942, he commanded S-20, and in December 1942 commissioned HARDER (SS 257) in which he blazed the way by conducting the first of many *down the throat* attacks against onrushing escorts. For these attacks and others during HARDER's six patrols in which she sank 16 ships of 54,000 tons, Sam Dealy was awarded the Congressional Medal of Honor and four Navy Crosses. HARDER was lost when she was depth-charged by a minesweeper off the Philippines on 24 August 1944.

Morton Hall is the base gymnasium used for a wide variety of events for more than 40 years. It was named in memory of Lieutenant Commander Dudly W. Morton, born in Kentucky in 1907, graduated from the Naval academy in the Class of 1930, and from Submarine School in 1933. He spent four years in S-37, and then successively commanded R-5, DOLPHIN (SS 169) and WAHOO (SS 238). Morton sank 19 ships of 55,000 tons during his six patrols in WAHOO. His fame stems from a daring penetration of Wewak Harbor in New Guinea in January 1943 during which an escort was sunk; and a day-long battle against a convoy of four ships of which WAHOO sank three. She successfully penetrated the Sea of Japan twice but her first effort was thwarted by faulty torpedoes; and the second resulted in her loss after sinking one ship on 11 October 1943. Mush Morton was awarded four Navy Crosses, the Army Distinguished Service Medal, and WAHOO the Presidential Unit Citation.

Cross Hall is the enlisted dining facility. It honors Mess Specialist First Class Joseph Cross who was born in 1920 and entered the Navy in 1942. He made eight war patrols in TI-GRONE (SS 419). He was warded the Bronze Star, the Navy and Marine Corps Medal, and the Navy Commendation Ribbon. He was lost in SCORPION (SSN 589) in June 1968.

D'Allesandro Hall is the Enlisted Men's Club and was named to honor Torpedoman's Mate First Class Vincent L. D'Allesandro. He was ordered to HARDER (SS 257) after Submarine School and was lost on her sixth war patrol on 24 August 1944.

U.S. Naval Submarine School, New London, Connecticut

Vahsen Hall houses the Damage Control Wet Trainer which enables damage control teams to practice repair of damaged piping or equipment under realistic conditions of incoming water, but under the watchful eye of experienced instructors.

Captain George Vahsen was born in New York in 1928, graduated from the Naval Academy in 1952 and from Submarine School in 1954. He served in TRIGGER (SS 564), SKIPJACK (SSN 585), ROBERT E. LEE (SSBN 601), was Executive Officer of THOMAS JEFFERSON (SSBN 618), and Commanding Officer of SARGO (SSN 583). His final tour of duty was Deputy Director of Athletics at the Naval Academy. He suffered a heart attack and died on 24 June 1980. He was awarded two Legions of Merit.

Lewis Hall houses the Radioman Class C School. It was named in memory of Rear Admiral James R. Lewis, born in Indiana in 1929, a 1951 graduate of the University of New Mexico, and a 1953 graduate of Submarine School. Dick served in POMFRET (SS 391), SWORDFISH (SSN 579), HALIBUT (SSN 587), DANIEL BOONE (SSBN 629), and was Commanding Officer of SCORPION (SSN 589) and PATRICK HENRY (SSBN 500). Subsequently, he commanded Submarine Squadron 14 and Submarine Group TWO. He was Deputy Chief of Acquisitions in Naval Material when he died in 1982. He was awarded two Legions of Merit, three Meritorious Service Medals, and the Naval Commendation and Meritorious Unit Citation. Momsen Hall is the Escape Training facility, a shallow water pool which replaced the former base landmark, the 100 foot diving tank. Training is conducted for all aspiring submariners using the

Steinke Hood, the successor to the Momsen Lung.

Vice Admiral Charles B. Momsen was born in New York in 1896, graduated from the Naval Academy in 1919, accelerated because of World War I from his Class of 1920, and attended Submarine School in late 1921. He spent a short tour in O-13, followed by three command tours in O-15, R-24, and S-1. In the inter-war period, Swede Momsen developed the Momsen Lung for escape from sunken submarines, and later as Commanding Officer of the Experimental Diving Unit in Washington introduced helium/oxygen as the mixture for deep diving, a notable advance. He returned to the Pacific, commanding two submarine squadrons prior to taking the first wolfpack of CERO (SS 225), GRAYBACK (SS 208), and SHAD (SS 235) on patrol in September 1943. The pack sank three ships and damaged several for which Momsen was awarded the Navy Cross. He subsequently served as Commander Submarines Pacific and Commander Joint Task Force 7 in the atom bomb tests. He also was awarded the Distinguished Service Cross, the Distinguished Service Medal, and three Legions of Merit. He retired in 1955 and died in 1967.

Street Hall is the Fire Fighting Trainer, named in honor of Captain George L. Street III. He was born in Virginia in 1913, graduated from the Naval Academy in the Class of 1937, and from the second pre-World War II three month class at Submarine School late in 1940. He spent three years in GAR (SS 206) completing nine war patrols. He fitted out TIRANTE (SS 420) as Commanding Officer, made two war patrols and was awarded the Congressional Medal of Honor for his attack at Quelpart Island in Korea on 13 April 1945, in which TIRANTE penetrated the harbor and sank a transport and two escorts with six torpedoes. He was also awarded the Navy Cross, two Silver Stars, and the ship a Presidential Unit Citation. After the war, Street commanded REQUIN (SSR 481), a submarine division and squadron. He retired in 1966.

Gilmore Hall was the School Administration and principal classroom building for hundreds of submarine officers.

It was named in memory of Commander Howard W. Gilmore who was born in Alabama in 1902 and graduated from the Naval Academy in 1926. He attended Submarine School in 1931, and spent his early career in S-48, SHARK (SS 174), and DOLPHIN (SS 169), after which he commanded S-48. He commissioned GROWLER (SS 215) at the time of Pearl Harbor and made four war patrols, sinking over 18,000 tons of shipping before tangling with a patrol boat in a surface action on 7 February 1943. This concluded with Gilmore mortally wounded by gunfire on the bridge, and giving the now-famous order "Take her down". Lieutenant Commander Arnie Schade, Executive Officer, assumed command and brought the damaged ship home safely. For this action, Gilmore was posthumously awarded the Congressional Medal of Honor, as well as two Navy Crosses for his other patrols.

Nimitz Hall houses the Submarine Mission Support Group and the Sonar Technician Submarine (STS) and Electronic Signals Monitoring (ESM) training courses.

It was named in memory of Fleet Admiral Chester W. Nimitz. He was born in Texas in 1885, and graduated from the Naval Academy in 1905. From 1909 until 1912, he served in several gasoline powered submarines as Commanding Officer of PLUNGER (SS 2), SNAPPER (SS 16), NARWHAL (SS 17), and the first diesel, SKIPJACK (SS 24). In 1912, he became Commander Submarine Flotillas Atlantic, the first COMSUBLANT. In his last submarine tour, he commissioned Submarine Base, Pearl Harbor in 1920.

He took command of the Pacific Fleet on 31 December 1941 in ceremonies aboard GRAYLING (SS 209), and hauled down his flag in MENHADEN (SS 377) in November 1945. He was Chief of Naval Operations from 1945 to 1947, retiring after that tour. He was awarded four Distinguished Service Medals and many other decorations from 19 foreign countries. He died in 1966.

Cromwell Hall is devoted to the teaching of the Officers Course. It was named in memory of Captain John P. Cromwell, born in Illinois in 1901, graduated from the Naval Academy in the Class of 1924, and Submarine School in 1927. He served in S-24, ARGONAUT (SM 1), a minelayer, BARRACUDA (SS 163), and commanded S-20 in 1937. His wartime billets were all submarine division commands until, in early November 1943, he was ordered to SCULPIN (SS 191) as Wolfpack Commander, should one be formed. On 29 November Commander Submarines Pacific ordered the wolfpack activated but never heard from SCULPIN. It was not until after the war that the survivors of the scuttled SCULPIN revealed that she had been so severely damaged by depth charges on 18 November that she was forced to fight it out on the surface with a destroyer—and lost. The commanding officer, Commander Fred Connoway, and others were killed, but Captain Cromwell chose to go down with the ship to protect the privileged information he held. He was posthumously awarded the Congressional Medal of Honor and the Legion of Merit.

English Hall is utilized for tactical training, with complete team trainers for the ship's fire control parties. It was named in memory of Rear Admiral Robert H. English, born in Georgia in 1888 and graduated from the Naval Academy in the Class of 1911. He began his submarine career in 1914 when he reported to the gasoline driven D-3, and was in command when the United States entered World War I. He fitted out and commanded O-4 throughout the war. He held submarine division commands prior to World War II, and was Commander Submarine Squadron FOUR and Commanding Officer, Submarine Base, Pearl Harbor in the early months of the war. He relieved Rear Admiral Withers as Commander Submarines Pacific in May 1942, effectively organizing the onslaught against the Japanese naval and merchant ships until he and several members of his staff were killed in a plane crash in the California mountains enroute to a stateside conference on 21 January 1943. He was awarded the Navy Cross for the rescue of an officer trapped in O-5 after an explosion, and a posthumous Distinguished Service Medal for his tour as ComSubPac.

Fife Hall provides sophisticated navigation training for students and ships' teams alike. It employs visual re-creations of actual harbors in which submarines operate, offering exercises under all conditions of light and visibility.

It was named in memory of Admiral James Fife, Jr., born in Nevada in 1897, graduated from the Naval Academy in the Class of 1918, and the Submarine School the same year. He served in S-3 and R-22, and commanded N-7, R-19, and R-18 until 1923. He returned to sea in 1935 in command of NAUTILUS (SS 168), and was Chief of Staff to Commander Submarines Asiatic Fleet when World War II broke out. Ultimately, Jimmy Fife ran the submarine operations out of Brisbane, Australia and was involved in the long battle to correct the torpedo deficiencies. It was during this period that Admiral Fife made many operational moves of his submarines by radio using such calls as "Drum from Fife" when addressing DRUM (SS 228). After the war, he was Commander Submarines Atlantic Fleet from 1947 to 1950. He retired in 1955 after a tour as Deputy Commander in Chief Mediterranean under

Admiral Lord Louis Mountbatten, RN, and died in 1975. For his wide ranging service, he was awarded three Distinguished Service Medals. He bequeathed his estate near New London to the U.S. Navy as a recreation site.

Fluckey Hall serves as the STS and Fire Control Technician (FT) School building, and also houses the advanced sonar and fire control trainers. It was named in honor of Rear Admiral Eugene B. Fluckey, born in the District of Columbia in 1913, graduated from the Naval Academy in the Class of 1935, and Submarine School in 1938. He commenced his submarine career in S-42 and BONITA (SS 165), and commanded BARB (SS 220) from her 7th through her 12th war patrols. After the war, he commanded DOGFISH (SS 350), HALFBEAK (SS 352), and SPERRY (AS 12). He was Commander Submarines Pacific from 1964 until 1966.

For his service in BARB, he was awarded the Congressional Medal of Honor and four Navy Crosses, and the ship the Presidential Unit Citation. BARB sank 16 ships for a total of over 95,000 tons.

Gene Fluckey won the Congressional Medal of Honor on BARB's 11th war patrol. He was a member of Loughlin's Loopers, a wolfpack. Together, Commander Elliott Loughlin in QUEENFISH (SS 392), Commander Ty Shephard in PICUDA (SS 382), and Gene Fluckey in BARB harassed a large convoy off the China Coast in January 1945, firing more than 30 torpedoes in a series of attacks. The pack was finally credited with sinking four ships and damaging two. QUEENFISH and PICUDA departed the area for lack of torpedoes but Fluckey, frustrated in his search for additional targets, decided that an aggressive pursuit close to the coast was required. He was rewarded when he detected many ships in Namkwan Harbor. He penetrated on the surface in water less than 36 feet, firing 8 of his last 12 torpedoes, sinking one ship. He escaped unscathed and after missing a freighter with his last four torpedoes, returned to Pearl Harbor to a royal welcome. He made one more patrol in BARB, ingeniously sinking ships and craft with deck launched rockets, and sending a raiding party ashore which blew up a train with large loss of life. He retired in 1972, and was awarded two Legions of Merit for post-war service.

Wilkinson Hall was dedicated in 1993 as the home of the ET, RM, and TM Class A Schools. It honors Vice Admiral Eugene P. Wilkinson, born in 1918, graduated from San Diego State

College in 1938, and from the Submarine School in 1942.

Dennis Wilkinson was the torpedo data computer operator in DARTER (SS 227) when she and DACE (SS 247) sank three cruisers and damaged a fourth from the major Japanese Task Force proceeding toward the epic battle with U.S. forces attacking the Philippines in October 1944. DARTER ran aground and her crew was rescued by DACE, after which DACE rendered DARTER unsalvageable by gunfire (torpedoes having exploded on the reef). Wilkinson completed eight war patrols. Subsequently, he served in MENHADEN (SS 377) to which the DARTER crew had been ordered, RATON (SSR 270), and CUSK (SS 348), and commanded VOLADOR (SS 490) and SEA ROBIN (SS 407). He was the commissioning skipper of WAHOO (SS 565), one of the post-war fast attack Class, but it was his selection by Admiral Rickover to command NAUTILUS (SSN 571) that made him newsworthy. He proved beyond doubt the efficacy of nuclear power in submarines, and he showed the way for all the highly qualified officers who followed him in the program. He later commissioned LONG BEACH (CGN 9), the first nuclear powered surface ship in the Navy. He was Commander Submarine Force Atlantic Fleet from 1970 to 1972, the last with World War II experience. His final tour was as Deputy Chief of Naval Operations for Submarines (OP 02). He retired in 1974. He was awarded two Bronze Stars, a Silver Star, and the Distinguished Service Medal.

Darby Hall serves as the primary Engineering Building. It was named in memory of Rear Admiral Jack N. Darby, born in Texas in 1936, a graduate of the University of Colorado in 1958, and the Submarine School in 1961. He served in CAIMAN (SS 323), DACE (SSN 607), THEODORE ROOSEVELT (SSBN 600), THOMAS JEFFERSON (SSBN 618), and was Commanding Officer of BENJAMIN FRANKLIN (SSBN 640). He died on 19 January 1987 while Commander Submarine Force Pacific Fleet. Among his decorations were three Legions of Merit, the Defense Superior Service Medal and two Meritorious Service Medals.

Ballou Hall formerly served as the Engineering Building but was vacant at this writing. It is among the six buildings at the Submarine School named for enlisted men. Chief Electrician's Mate William E. Ballou was born in 1911, and served on surface ships, submarine tenders, and NARWHAL (SS 167). He was lost in TRITON (SS 201) on her sixth war patrol in which she operated north of New Guinea along with AMBERJACK (SS 219), and GRAMPUS (SS 207) which also did not return. He was awarded the Bronze Star Medal posthumously for his performance as Chief Electrician's Mate in charge on TRITON's second patrol, and the Silver Star Medal for outstanding performance of duty on four TRITON war patrols.

Pennington Hall houses the Ship's Control and Diving Trainer. It was named in memory of Chief Electrician's Mate Roscoe C. Pennington who was born in Texas in 1924 and enlisted in 1943. He made six war patrols in SEADRAGON (SS 194) and SPIKEFISH (SS 404). He also served in TILEFISH SS 307), CUSK (SS 348), CHIVO (SS 341), and RONQUIL (SS 396). His two final tours were in THRESHER (SSN 593), as chief reactor technician, and in SCORPION (SSN 589) in which he was lost at sea in June 1968.

Bledsoe Hall houses the Basic Enlisted Submarine School, honoring Master Chief Torpedoman Samuel H. Bledsoe, Jr. He was born in 1919 and enlisted in 1940. He served in 10 submarines, including SKIPJACK (SS 184), SEADRAGON (SS 194), QUEENFISH (SS 393), TORSK (SS 423), TAUTOG (SS 199), SABLEFISH (SS 303), JALLAO (SS 368), PATRICK HENRY (SSBN 599), CASIMIR PULASKI (SSBN 633), and JAMES K. POLK (SSBN 645). He was awarded the Bronze Star Medal for his outstanding performance as a torpedoman in charge in TORSK on her second war patrol in 1945. He died in 1987.

McNeill Hall formerly housed the Basic Enlisted School, but is being converted to use as the Nuclear Field Class A School. It was named to honor Chief Electrician's Mate John R. McNeill who was lost in SCAMP (SS 277) in Empire waters in November 1944. McNeill was awarded the Bronze Star for his heroic control of a fire in the maneuvering room of SCAMP on her seventh war patrol in 1944.

U.S. Naval Academy, Annapolis, Maryland

Nimitz Library was opened in 1973, supporting the accreditation of the Naval Academy. It contains over 800,000 volumes, a special collection section which holds much World War II data, and an archives section which holds, among other things, biographies of every Naval Academy graduate. It provides ample study space for the Brigade; and houses the U.S. and International

Studies Center, the Educational Resource Center, and the Photographic Laboratory.

The library was named for Fleet Admiral Chester W. Nimitz, who biography appears under the Submarine Base/Submarine School section.

Hendrix Oceanographic Laboratory is an asset unique to the Naval Academy, providing a wet laboratory with Severn River salt water tanks, and facilities for 24 students conducting individual or team research. YP654 is permanently assigned to the laboratory for data and specimen collection in Chesapeake Bay. Its work is coordinated with geological, biological, and meteorological laboratories in other buildings. It wa dedicated in 1985.

The laboratory was named for Captain Charles N.G. (Monk) Hendrix, a 1939 graduate, and an All-American lacrosse player. Monk graduated from Submarine School in 1941, and served in S-39, STURGEON (SS 187), CARP (SS 338), and MAPIRO (SS 376), completing 12 war patrols. After the war, he was commanding officer of TIRU (SS 416). After attending Scripps Institute, he spent much of his remaining career in oceanography, serving as advisor to the Deep Submergence Systems Review Group after the sinking of THRESHER (SSN 593). He retired in 1963, and taught oceanography at the Academy from 1965 until 1976. He was awarded two Silver Stars, a Bronze Star, and the Navy Commendation Medal. He died in 1976.

Rickover Hall was dedicated in 1975 to house the Division of Engineering and Weapons. It contains laboratories, lecture halls, and classrooms.

It was named for Admiral Hyman G. Rickover who was born in Poland in 1900, and graduated from the Naval Academy in the Class of 1922. He attended Submarine School in 1930 and served in S-9 and S-48, qualifying in submarines. He was selected as an Engineering Duty Only officer in 1937, and served in diverse billets, specializing in engineering until his assignment to Oak Ridge, Tennessee in 1948, which launched him on his meteoric rise in nuclear propulsion. He was retained on active duty in two year increments from 1962 until 1982, at which time he retired with four stars. He was awarded a Gold Medal by Congress, two Distinguished Service Medals, two Legions of Merit and two Navy Commendation Medals, and numerous awards by private organizations. He died in 1986.

King Hall was dedicated on 15 April 1981 to honor Fleet

Admiral Ernest J. King. It serves as the Midshipmen wardroom and now seats 4,480, with cooking and serving facilities capable of accommodating the entire Brigade in 20 minutes or less.

The main wing of the mess, as it was called prior to 1981, was designed in the early 1900s by Ernest Flagg, the architect of Bancroft Hall. The new wing added in 1953 to form a T increased the seating capacity by 50 percent.

Admiral King, born in Ohio in 1878, graduated from the Naval Academy in the Class of 1901. He served in a wide spectrum of ships and shore duty assignments until 1922, when he accepted a billet as Commander Submarine Flotilla Atlantic Fleet. However, prior to assuming the duties, he elected to attend Submarine School as a captain, graduating in June 1922. He then assumed command of Submarine Divisions 3 and 11, and in 1923 returned to New London as Commanding Officer of the Submarine Base for three years, at which time he recommended that the Submarine School course be lengthened from four to six months. He never served in a submarine and was not *qualified in submarines*. His connection with submarines actually began in 1901 when he had an opportunity, with his classmates at the Academy, to ride HOLLAND (SS 1). He gained fame and headlines as the salvage officer in the recovery of both S-51 and S-4, sunk off New England. He became a naval aviator in 1927, and had no further submarine duty. He was early selected for Flag in 1932 after 35 years of service at the age of 54. He became Commander-in-Chief, U.S. Fleet and Chief of Naval Operations (COMINCH/-CNO) in March 1942, was promoted to Fleet Admiral in December 1944, and retired in December 1945. He was awarded the Navy Cross, three Distinguished Service Medals and received awards from 10 foreign countries. He died in 1956.

Vandergrift Cutter Shed was dedicated in 1976 in memory of Captain Jacob J. Vandergrift. It serves today as the maintenance shop for the famous Naval Academy Sailing Squadron.

Captain Vandergrift was born in 1917 in Pennsylvania, graduated from the Naval Academy in 1939, and Submarine School in 1940. He was ordered to PERCH (SS 176) and was still aboard as communications officer at the start of World War II. He was captured by the Japanese and spent the remainder of the war in prison camps in the Empire. PERCH had been ordered to attack the forces invading Indonesia in March 1942, along with most available Allied forces. She was severely damaged by a lengthy series of depth charge attacks by Japanese destroyers in the shallow water near Soerabaja. After a valiant fight, she found herself unable to dive and on 2 March 1942 was scuttled. All the crew was rescued by Japanese destroyers. Nine of the 62 officers and men died in prison. After refresher training, Jake Vandergrift served as Executive Officer of REMORA (SS 487) and Commanding Officer of TILEFISH (SS 307). He later commanded Submarine Division 82, Submarine Squadron 6 and the tender ORION (AS 18). His last tour was as Commander Naval Station, Annapolis, Maryland when he was also Commodore of the Naval Academy Sailing Squadron. He was awarded the Purple Heart for his prison ordeal, and the Navy Commendation Medal. He retired on 3 February 1969 and died on 6 February 1969.

[Editor's Note: This monograph will be completed in the April 1996 issue of the SUBMARINE REVIEW.]

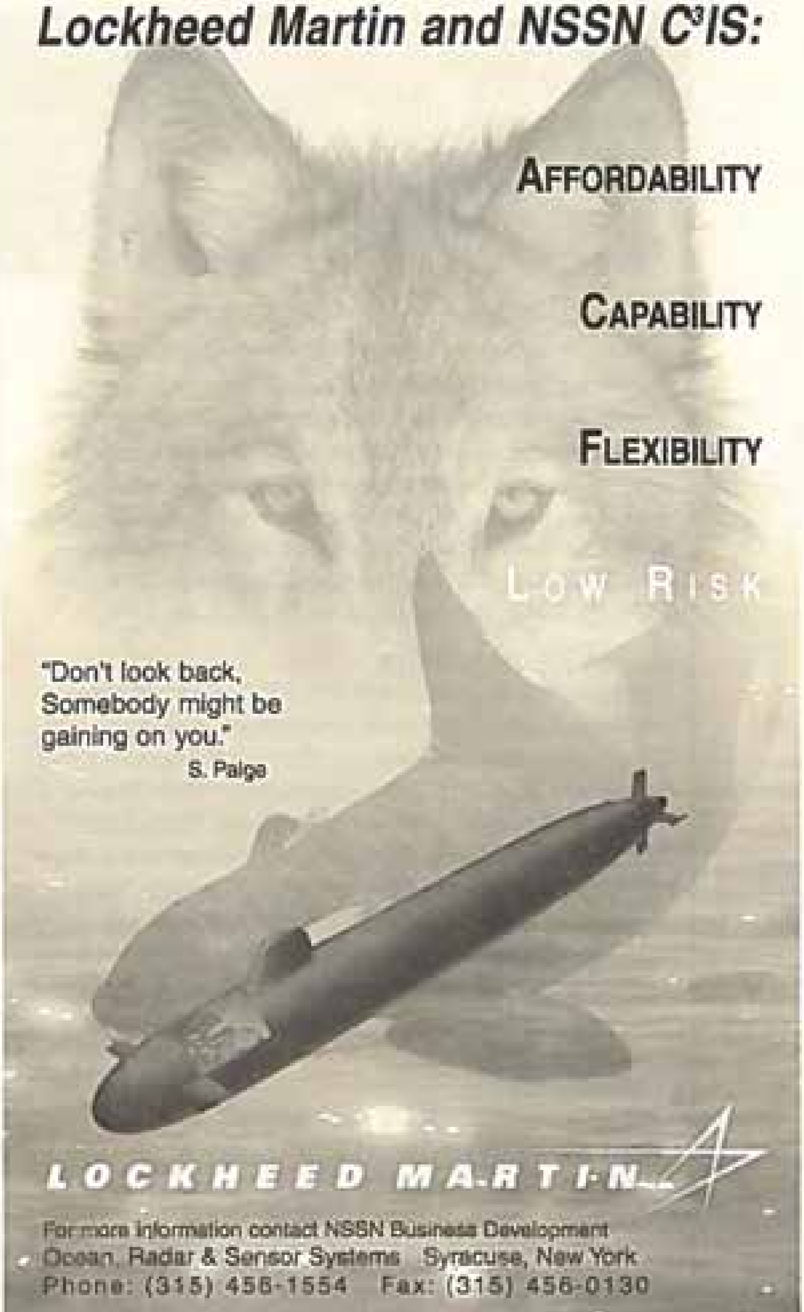
■

REUNIONS

USS BARRACUDA (SST-3) and (SS 205)
USS MACKEREL (SST-2) and (SS 204)
USS MARLIN (SST-2) and (SS 205)
Submarine Squadron 12 Staff
October 17-20, 1996 in Hagerstown, MD. Contact: R.H. Coupe, 3004 Lord Bradford Ct., Chesapeake, VA 23321-4514, (804) 484-0013

USS QUEENFISH (SS 393) and (SSN 651)
February 22-25, 1996 in San Diego, CA. Contact: CAPT Jack Bennett, 550 San Mario Drive, Solana Beach, CA 92075, (619) 755-0701.

USS TRITON (SSRN/SSN 586)
September 4-6, 1996 in Groton, CT. Contact: Ralph Kennedy, 89 Laurelwood Road, Groton, CT 96340, (860) 445-6567.


Lockheed Martin and NSSN C^3IS:
AFFORDABILITY
CAPABILITY
FLEXIBILITY
LOW RISK
"Don't look back,
Somebody might be
gaining on you."
S. Paige
LOCKHEED MARTIN
For more information contact NSSN Business Development
Ocean, Radar & Sensor Systems Syracuse, New York
Phone: (315) 456-1554 Fax: (315) 456-0130

C4I: HOW MUCH IS ENOUGH? HOW MUCH IS TOO MUCH?

by Dr. Richard Thompson

Dr. Thompson is a Research Associate Professor at the University of Maryland at Baltimore, is a member of the Submarine League and a frequent contributor to the ***REVIEW.***

In the October 1993 **SUBMARINE REVIEW** Rear Admiral Holland, USN(Ret.) gave a very succinct and realistic exposition of the importance of C4I (command, control, communications, computation and intelligence) to the Submarine Force, and the need for hardware and doctrine development to optimize its employment in our current era of joint littoral warfare. There seems little doubt that, for the near term at least, Admiral Holland is correct in all respects. For the longer term, however, there may be some significant contra-indications to expanding the resources devoted to C4I, both for the Submarine Force and the armed forces as a whole.

At the moment, there seems no doubt that the large sums devoted to expanding and refining the C4I capabilities of all our armed forces paid enormous dividends in the Gulf War. We had excellent tactical intelligence regarding the Iraqi force dispositions. The Command and control of our forces, due in part to secure, anti-jam communications and the widespread availability of handheld GPS, was overtly superior. While U.S. weapons systems were better and in some cases, decisively better, it is not too much to say that our overwhelming superiority in C4I at all levels was the biggest factor in the Gulf victory.

There is equally little question that we should continue to emphasize C4I in our forces, at least for the near term. As Admiral Holland has pointed out, in near future conflicts we will be likely operating against unsophisticated forces unable to target our C4I systems. Their ability to jam, intercept, or decrypt our communications wiil be modest at best. Their ability to prevent or spoof our intelligence collection systems will also be minimal. Conversely, their C4I arrangements are likely to be an open book: the success of the Gulf War is due in no small measure to the fact that the Iraqi forces were basically rendered blind, deaf and dumb shortly after the assault began. In fact, most armed forces we are likely to face have a rudimentary C4I capability at best. In some sense this works against us, since a ragtag army may not offer high value C4I targets, and may not be particularly hurt as a result of decapitation. A good example is the very decentralized Viet Cong command structure which proved so difficult to fight in Vietnam. We may find ourselves with million dollar weapons and nothing that valuable to fire them at.

Moreover, we should *dance with the one that brung us* in emphasizing C4I as one of our strengths. Our computer, radar, space and guidance technologies lead the world, and we would be foolish if we did not take advantage of these strengths in our weapons, C4I systems and doctrine. It is an axiom of strategy to fight when possible in terrain and conditions which favor you, and not your opponent. For us, this means under circumstances which favor our dominance in C4I: at sea, in the air, in space, in darkness and in open country. Our edge is significantly reduced in built-up areas, in forests, in mountains, or when the weather is bad enough to hamper air operations. The corollary is that our opponents (if they're smarter than Saddam) will seek to fight us under conditions which favor them. Over the last few years we've given lots of thought to fighting jointly in the littoral region, but an opponent with enough room may cede the littoral in order to fight us in more favorable terrain. Some U.S. ground forces are currently training for operations in built-up areas, in the expectation that this is where opponents will choose to fight. We can anticipate that prudent opponents will conduct maritime operations with a view to avoiding the long reach of the Submarine Force and its weapons.

Finally, today it is politically more necessary than ever to have *measured responses* to crises, where visibly overwhelming forces may be considered by the media as threatening and destabilizing rather than deterring. This is also a view often held by politicians. It was surprising and anomalous that CINCCENT was ultimately given as large a force as he needed, including an armored corps from Europe, in the Gulf War. It is more likely in the future that the joint forces commander will be given a minimum force, so he will need to get the maximum efficiency from it, using his C4I systems.

Yet particularly in the long term, there are some significant drawbacks to putting so many of our eggs in the C4I basket. Perhaps first and foremost, lots of people learned lessons from the Gulf War besides ourselves, and we can rely on future opponents to fight smarter than Saddam did. As more sophisticate opponents emerge in the coming decades, they will recognize that C4I is an important and integral part of our warfighting doctrine, and therefore useful to target. Recent top level concern about domestic attack on DoD and infrastructure computers by hacker/ terrorists recognizes only the tip of the iceberg. For instance, many satellite control and tracking facilities are soft, immobile installations which might readily be targets for special forces or terrorist-type groups, even using improvised munitions. How many sites would need to be destroyed before overseas communications were significantly degraded? We note that this danger has been recognized and steps have been taken to make newer systems more secure in this respect, but clearly such factors must be taken into consideration when implementing C4I systems of all kinds.

At the moment, no likely enemy can target most of our C4I systems effectively, but the basic technology of most C4I systems has proliferated widely because much of it is dual-use. The most obvious examples are computers and high frequency communica tions equipment, because their utility is very evident. While of course technology is always changing, one can be confident that if a technology has any non-military use at all, it will be difficult to control its export. The manufacturers want to export to broaden their market, the Commerce Department wants to export because this makes friends for the Administration amongst the defense contractors, and the State Department wants to export because it (presumably) makes other countries love us. Against this team, often defense considerations take a back seat. Thus we can expect the means to intercept, jam, spoof, and even decrypt our C4I systems will also proliferate. Some years ago the People's Republic of China announced that it was going to devote increased effort and resources to developing computer, optical, space and biotechnologies. While there are obviously sound economic reasons for doing this, it is hardly coincidental that most of these technologies have important military applications as well. We can expect that opponents will develop a capability to target our C4I systems for much less effort, time, and money than developing overtly military technology such as nuclear weapons or submarines.

There are other reasons for concern. C4I systems have grown steadily in capability over the last 20 years, but so has their complexity and cost. An increasing fraction of platform weight, power consumption, space, cooling and cost are taken up by C4I systems. The individual systems are enormously more capable than their predecessors, but there seem to be more of them. As computing power, or more precisely, density has increased, C4I has also gotten more computation-intensive. The problem is that computation-intensive has also meant software-intensive. Despite very active efforts at automation of software generation, this remains a bottleneck in new systems development. Writing and debugging a million lines of code is a significant fraction of the cost and development time of new systems. For example, a non-trivial portion of the development costs included in the $300+M price of the McDonnell-Douglas C-17 is the huge amount of code its computers require. Moreover, software is a large part of most system upgrades, and represents a vexing problem in maintenance, repair, interoperability and compatibility. The software upgrade to an existing system which has some unexpected effects or even causes the system to crash is almost a cliché. The engineers work hard to address these issues, but we court disaster by not keeping things simple.

The corollary to using C4I systems more is that they are more vulnerable to intercept and decryption. While it is implausible that any of our current adversaries have the capability to intercept and decrypt our communications, this may not always be so. First, it has been true for centuries and may be taken as axiomatic that the more communications traffic you can intercept, the easier it is to decrypt. It may not be possible for an adversary to succeed in decrypting the traffic with tactically useful speed, but it is easier. To be sure, a major thrust of communications system development has been increasing bandwidth, with the development of EHF, SHF and lightwave communications. While these higher frequency signals are harder to intercept, they also represent more volume, which from a decryption standpoint is imply more grist for the mill. The volume of our communications has gone up. While a submarine up until recently might have received only a few hundred bytes of data per day (and not transmitted at all), a submarine participating in a joint force operation might transmit that much just acknowledging the JTF commander's message. Admiral Holland's prophecy of the National Command Authority expecting real time video of the periscope view doesn't seem farfetched in the least. Yet one video picture is at least a hundred thousand bytes of information: by itself, it is equal to a month's communications from a submarine 15 years ago. Full motion video is 30 of those pictures a second, and because each frame is so similar to the last (the basis of *compression* schemes), one is effectively retransmitting the same message 30 times per second, which makes deciphering significantly easier. One wonders how many bytes a surface vessel, or a flagship, transmits. As we get increasingly *joint*, moreover, the number of nodes increases, and even without decryption traffic analysis can tell an enemy a lot. The decimation of the German submarine force in World War II aided by direction finding and encryption has sensitized our submariners to the risks of communicating; it may behoove the rest of our forces to consider how each byte they transmit contributes to putting enemy ordnance on target. All of this is not to say that a lot of effort has not be expended in making our communications as secure as possible; rather, it is just to point out that the more we talk, the more it is worthwhile for any enemy to listen.

A third issue in the expansion of C4I capabilities is the human factor. Admiral Holland has already touched upon some of the risks inherent in enhanced connectivity: people with diverse backgrounds being brought into the loop, armchair quarterbacking, and rules of engagement reduced to calling the White House and waiting to see what a teenage staffer thinks will play in Poughkeepsie. Moreover, the availability of communications increases the demand for more. A National Command Authority grown accustomed to real time video (and having grown up in the TV era) will not sit still waiting for updates and situation reports.

Two other problems are the lengthening of the chain of command, and rigidifying our operations. Recent experience in Lebanon has shown that given good connectivity, we will make the chain of command excessively long. In that situation, great pride was taken in the fact that a request was bucked up from Lebanon, through Italy, through London, to Washington, and a response returned within a day. Passing operational directives through so many hands is clearly absurd, and such unwieldy chains of command are clearly infeasible without good communi cations. The very successful counterexample of chain of command is the Submarine Force, whose operational chain of command until recently consisted of the fleet Commander, the Type Commander, and the ship's CO. Moreover, the U.S. Submarine Force evolved a practice of selecting commanding officers with great care and then giving them substantial independence in carrying out their orders. The emphasis on initiative in commanders in all U.S. armed forces has widely been viewed as a strength, particularly in comparison to the armed forces of the former Soviet Union and the Warsaw Pact with their very tight central control. Greater communications volume is likely to result in a decrease of initiative in all our armed forces.

A final issue in increased communications is signal-to-noise ratio. As the volume of communication and intelligence goes up, the fraction that is really useful and timely is likely to decrease. Pilots of attack aircraft about to bomb North Vietnam often turned off their radar warning receivers, or more particularly the associated alarms. They did this because the alarms provided no useful information, but were a distraction; the only relevant information was a visual sighting of the surface-to-air missile in time to avoid it. As the volume of communications traffic goes up, how much will be signal and how much will be noise? Admiral Holland points out that there are some forces with evidently little need to talk to one another, but the communications systems will likely permit them to talk, because it's logistically much easier and mandated by joint forces doctrine to give all commands similar communications capability. I would suggest that in the joint world especially, the volume of communications will go up, the fraction of relevant messages will go down, and communications will be viewed as more of a burden and less of an asset by the warriors.

Ultimately, we must answer some questions when we consider the real value added of each new C4I system: is the cost in weight, size, dollars, maintenance, training, watchstanders, and power really worth it in terms of warfighting capability? Will an intelligence system really provide timely, useful information, or just provide reams of data of no use? On the other hand, have we come to rely on a particular system so much that we would be crippled without it? Does having or using these systems increase our vulnerability to countermeasures, jamming, or interception and decryption? How much degradation of our C4I systems can we accept? Finally, how much should we train under scenarios where we have inadequate C4I, or our opponents can decrypt some fraction of our communications? These are questions which are relevant now, because platform lifetimes are now measured in decades. We may find that, in the future, the Silent Service must become silent once again to remain effective. ■

AMERICAN SUBMARINES FROM A RUSSIAN POINT OF VIEW

by Dr. George Sviatov
Captain 1 Rank
Russian Navy, Retired

During the late 1980s the U.S. Navy had more than 90 nuclear powered attack and some 35 ballistic missile submarines. At the beginning of the 2000s the U.S. Navy could have a force of 14 strategic missile nuclear submarines and about 45-55 attack boats, including three Seawolf class attack submarines.

Every analog is conditional; nevertheless, no one can deny the usefulness of analogies. Let us go to surface ship terminology and think of an Ohio class ballistic missile submarine as a battleship with main caliber weapons in its 83 inch Trident D5 missile tubes; a Seawolf class attack submarine as a cruiser with a main caliber weapon battery of large torpedo tubes, and a Los Angeles/NSSN (new nuclear attack submarine) as a destroyer with main caliber weapons in 21 inch Mk 48 torpedoes.

Ohio Class Battleships

The Ohio class ballistic missile nuclear submarines (underwater battleships/aircraft carriers) provide the sea leg of the triad of the U.S. strategic offensive forces. By the turn of the century the 14 SSBN 726 class submarines, each with 24 D5 missiles, will carry almost half the nuclear warheads of the U.S. strategic nuclear arsenal. By virtue of their missile's range and patrol posture, they can deter and destroy a potential aggressor in every region of the world and they are highly survivable. They are also extremely flexible, capable of rapid retargeting of their missiles, using secure and constant communications links.

But in comparison with a strategic bomber and an aircraft carrier they have one, very significant, deficiency: they could not be used for deterring *and* waging a major conventional war. It is at those times when an important shift in submarine warfighting concepts and doctrine takes place; away from deterrence of global nuclear war to the support of U.S. national interests in regional crises and conflicts.

In this respect one can raise a question as to why the U.S. Navy does not use the design philosophy of the Air Force's strategic bombers' or its own aircraft carriers relating to the Ohio class strategic submarines.

That is, in addition to nuclear Trident missiles, why not develop and, if necessary, deploy conventional versions of these missiles?

At the beginning of 1990 I was in Washington and was invited to speak on political-military problems at the Army and Navy Club for journalists writing on naval and maritime subjects.

One of them published the following:

> "Soviet proposes *boomless boomer* for the U.S., Russian Navies
>
> "A senior Soviet academician last week proposed arming nuclear missile submarines with conventional weapons.
>
> > 'If I were Chief of Naval Architecture of the U.S. and Soviet Union, I would propose conventional weapons', said George Sviatov. He is senior research fellow with the Institute of World History of the Academy of Sciences of the USSR.
> >
> > 'You can use a strategic bomber in conventional and nuclear war, but you cannot use a Trident submarine in a conventional war', he said."

The underwater Ohio class battleship has a huge strategic weapons payload which is many times more than on a strategic bomber and comparable with that of an aircraft carrier. With conventional strategic offensive Trident missiles she can effectively participate in deterring and destroying any potential major regional aggressor in any point of the globe.

Another strategic mission could be conceived for the underwater battleship. She can be used in a regional ABM role or/and in a limited territorial ABM role of the U.S. using antiballistic versions of conventional Trident missiles for interception of a small number of ICBMs or SLBMs of a potential nuclear aggressor.

And in addition to, or instead of, conventional Trident-sized Land-Attack Strategic Missiles in the underwater battleship's 24 main caliber missiles tubes it is possible to deploy very Long Range Anti-Ship Missiles with conventional warheads to strike aircraft carriers and other major warships using space-based target acquisition systems.

Seawolf Class Cruisers

SEAWOLF (SSN 21) is the U.S. Navy's most advanced attack submarine design, originally intended as a class of 29 submarines to be built during a ten year period. The end of the Cold War and budget constraints have led to a revision of U.S. submarine planning. Now only a few submarines of this design are expected to be built.

The SSN 21 is significantly quieter than the previous Los Angeles (SSN 688) class, faster, has 26 inch torpedo tubes, and carries twice as many weapons (up to 50 torpedoes or/and full size missiles or 100 mines). She also introduces the advanced AN/BSY-2 combat system which includes a new, larger spherical sonar array, a wide aperture array and a new towed array sonar.

In the era of relatively noisy Soviet nuclear submarines American submarines operated primarily in the passive mode. The appearance of quiet Soviet and Russian nuclear submarines led to a renewed interest in active sonar techniques. The recent doctrinal shift of U.S. naval forces to littoral operations where relatively quieter, non-nuclear submarines could be encountered in adverse ASW environments further increases the need for advanced active sonar systems, weapons, and tactics.

Considering the Seawolf class submarine in the general picture of United States submarine development it is possible to present some kind of a Russian net assessment.

The number one difference between the Los Angeles and Seawolf class submarines is in the latter's search with effectiveness lower self-noise level, better sonars, and the AN/BSY-2 system which will enable the Seawolfs to detect and locate targets at longer ranges. In addition, it can address multiple targets concurrently and reduce the time between detecting a threat and launching weapons.

The number two difference, which correlates with number one, is 26 inch (instead of 21 inch) torpedo tubes allowing the use of new heavier torpedoes (or missiles) similar to the 65 cm wake-homing torpedoes now used on the latest Russian nuclear classes of submarines such as Akula, Sierra, and Victor-III.

With only 30 percent bigger displacement and with lesser length, the U.S. Navy gets a ship which differs from the LOS ANGELES as a cruiser differs from a destroyer. She has 26 inch *guns* instead of 21 inch *guns* and two times more torpedo-size weapons. Her potential weapons payload, considering the bigger caliber, is three times more. Taking into account her advanced sonar and combat system, one can assume that her general combat effectiveness is perhaps six times better than that of the Los Angeles class submarine. Comparing with an Improved 688 class submarine in principle gives the same picture, but it is not relevant because the Seawolf class could have had an additional 12-16 vertical launchers outside the pressure hull without difficulties.

By the way, a naval architectural decision to install 12 Tomahawk launchers outside the pressure hull on the 688I class submarines is a palliative which was very popular on Soviet cruise and even some ballistic missiles submarines. It is possible to do, but it does not allow regular inspection and maintenance of missiles at sea.

The Seawolf class submarine project probably has some deficiencies. Which ones are apparent from the point of view of an outsider.

If one compares the weapons payload of the SEAWOLF with the payload of the LOS ANGELES the result will be in the decisive favor of the former. But comparison of the Seawolf class submarines with the Ohio class or a surface cruiser shows that the relation of her weapons weight to displacement (as a percentage) is much smaller. By increasing her displacement, let us say by about 300 tons, it is possible to increase the number of her torpedo-size weapons from 50 to 100.

Every unbiased naval architect-submariner understands the advantages of one reactor, one propeller, and a single hull architectural scheme. But in American nuclear submarine designing it became a formal religion. It is clear that two reactors, two propellers, and a double hull architectural scheme also have advantages which are obvious with regard to surface ships, aviation and also U.S. WWII submarines.

Another orthodox naval architectural decision in American submarine designing is to use approximately 15 percent reserve buoyancy and put it in several bow and stern ballast tanks, in the absence of an outer light hull around the pressure hull. But a double hull scheme with ring-like ballast tanks and frames outside of the pressure hull, with 30 percent reserve buoyancy and only one bow and one stern ballast tanks could give its own advantages.

Such an alternative to the Seawolf class submarine would have, for example six compartments with five transverse bulkheads (1 - hydroacoustic and living, 2 - torpedo room, 3 - control room and living, 4 - forward reactor and turbine, 5 - aft reactor and turbine, 6 aft torpedo, planes and rudders equipment), eight ballast tanks, and contrarotating propellers. She would have had not only surface but also underwater unsinkability with one flooded compartment.

Such a real revolutionary naval architectural decision (an attempt to implement it in the U.S. took place in the late 1950s on the TRITON nuclear radar picket submarine) could be reached by using hydrodynamic forces of high speeds (even with one flooded engine compartment) and by blowing relevant undamaged ballast tanks which should have kingstons. To do it, it is sufficient to have bulkheads with 50 percent of operating depth pressure strength, some more strengthened ballast tanks, and maybe, a little higher pressure air reserves.

Of course, the SEAWOLF is an excellent submarine with its own architectural scheme, but it seems that for a next generation underwater cruiser with 100 torpedo-size 26 inch weapons such an alternative approach might be reasonable.

Los Angeles/New Attack Submarine Classes Destroyers

Los Angeles is the largest class of nuclear submarines built by any nation, with 62 units in commission, or already decommissioned, or under construction. These submarines will form the backbone of U.S. attack submarine force at the beginning of the 21st century.

The Los Angeles class submarines are fast, have four 21 inch torpedo tubes and carry 25 torpedo-size weapons. The last 31 units additionally have 12 vertical-launch tubes for Tomahawk cruise missiles. Of these, the final 23 Improved-688 submarines are quieter, incorporate an advanced AN/BSY-1 fire control system, and are configured for under-ice operations with their forward diving planes moved from the sail to the bow.

Their standard Advanced Capability (ADCAP) Mk 48 torpedo is a highly capable weapon (it was published that its range is 35,000 yards at 55 knots). It can be used against submarines and surface ships.

These submarines can carry and lay mines. They are launched through torpedo tubes and replace torpedoes on a two-for-one basis. The two principal types of their mines are the Submarine-Launched Mobile Mine (SLMM) and enCAPsulated TORpedo (CAPTOR).

Instead of the deck-mounted artillery of WWII U.S. attack submarines, the Los Angeles class submarines have cruise missiles launched from their torpedo tubes and vertical launchers.

There are two types of anti-ship missiles: the Harpoon with a mine size and range of some 75 nautical miles, and the Tomahawk (TASM) with a torpedo size and range of more than 250 nautical miles.

These submarines can also carry the Tomahawk Land-Attack Missile (TLAM) with a range of 700 nautical miles which provides the capability for long range precision strikes with conventional warheads against shore targets. First used in combat in the 1991 Gulf War, the TLAM proved to be a highly effective weapon.

Here it is not necessary to spend more space relating to the Los Angeles class submarines. Suffice to say that they are the best existing nuclear attack submarines in the world.

It will be better to concentrate attention on the NSSN class submarine and analyze her relationship with the Los Angeles class and the Seawolf class submarines.

In August 1992 the U.S. Navy issued the unclassified report on the new attack submarine in which required military capabilities, quieting impact, maximum speed aspects, and technical risk were discussed.

To reduce displacement and cost of the NSSN class submarine in comparison with the SEAWOLF, the U.S. Navy proposed to retain SEAWOLF's quieting and the sonar detection sensor suites and to reduce weapon payload and weapons delivery rate, maximum speed and depth.

The U.S. Navy analysis showed that the NSSN's submerged displacement could be realistically in the range from 6000 to 8000 tons. The lower level of displacement provided from four 21 inch torpedo tubes with total payload of 26 torpedo-size weapons and the upper level for eight 21 inch torpedo tubes with total payload of 50 torpedoes or full size missiles plus 16 VLS tubes for Tomahawks.

What kind of a Russian viewpoint could be presented relating to the NSSN class submarine in comparison with the Seawolf and Los Angeles classes submarines?

First, it seems that the naval architectural decision of the Seawolf's sonar-weapons complex is optimal for the NSSN. It means AN/BSY-2 sonar/fire control system, eight torpedo tubes and 50 21 inch torpedo size weapons.

Second, 26 inch torpedo tubes caliber is not proper for the NSSN because she is a *destroyer* but not a *cruiser* and the shift to a bigger main caliber means increase of displacement and cost.

Third, reduction of the total torpedo numbers on the NSSN in comparison with the SEAWOLF seems to be unreasonable because their number on the Seawolf class submarines can and should be increased. But 16 VLS tubes for Tomahawks outside the pressure hull should be rejected to reduce displacement and cost and increase the missiles' maintainability and reliability.

Fourth, so far as the NSSN is a *destroyer*, classic American one reactor, one propeller naval architectural scheme would be optimal. So far as her nuclear power plant is designed for a pressure hull diameter and displacement less than SEAWOLF's, its horsepower could be reduced. But, maybe technological progress could provide the same horsepower as on the Seawolf class submarines with lesser weights and sizes. In this case maximum speed of the NSSN would be more than of the SEAWOLF.

Fifth, the reduction of the NSSN's displacement as regard to the SEAWOLF by 1000-1500 tons can be provided mainly by lessening of weight and size of the nuclear power plant, reducing caliber of torpedo tubes, lessening of computers and electronics sizes and by very significant reduction of the crew's number with fully automated control in the power plant's compartments.

And sixth, taking into account a very old love of the author for the idea of underwater (and, of course, surface) unsinkability with one flooded compartment, it is impossible not to suggest for the NSSN a five compartment scheme (1 - sonar and weapons, 2 - control room and living, 3 - reactor, 4 - turbines, 5 - planes and rudder devices), double hull with seven ballast tanks and 30 percent reserve of buoyancy. A possibility should be considered to provide a capability for reactor and turbines to work for some time with the third or fourth compartments flooded.

Conclusions

With the changing character of global strategic nuclear deterrence from assured retaliatory destruction to discriminate deterrence, the number of U.S. strategic deliverable nuclear warheads will be reduced. What would it mean for SSBNs (18,700 tons underwater battleships)? Certainly, a reduction in numbers of the Ohio class submarines or broadening of their mission spectrum, including conventional strategic deterrence and defence and warfighting capabilities from their 83 inch main caliber tubes. So it might be reasonable for the U.S. Navy to consider a program of the SSBN forces' modification, using the approach which the U.S. Air Force always used relating to their strategic bombers. And to begin realization of this program from the four C-4 configured Ohio class submarines which are planned to go out of service in the not-so-distant future.

The U.S. Navy must continue building of the Seawolf class SSNs (9150 tons underwater cruisers) with their 26 inch main caliber because these attack submarines are the best in the world. But to use their big potential capabilities it might be reasonable to consider their modification with 26 inch diameter torpedoes and missiles and a payload of 100 such torpedoes and missiles.

The Los Angeles class SSNs (6927 tons underwater destroyers) are the backbone of the U.S. nuclear attack Submarine Force and the best existing SSNs in the world. Battle characteristics of the NSSN submarine (a 8000 ton destroyer) could be between the modernized Seawolf and Los Angeles classes. With the AN/BSY-2 type combat/sonar system, eight 21 inch torpedo tubes and 50 torpedoes/missiles the NSSN can be affordable and cost effective as a substitution for the Los Angeles class submarines. ■

*** IN MEMORIAM ***

CAPT Raymond W. Alexander, USN(Ret.)

CDR William D. Buckbee, USN(Ret.)

CAPT John R. Lindsay, USN(Ret.)

CAPT William Masek, Jr., USN(Ret.)

ADMIRAL ROY BENSON

by CDR M.S. Terrass, USN(Ret.)

The passing of Admiral Benson led me to recall an amusing true story he told at a time when humor was in short supply. In July 1949, just days out of Submarine School, I was in USS TUSK (SS 426) which was in the newly formed Submarine Development Group II along with COCHINO, CORSAIR, and TORO. The group headed across the Atlantic under the command of Captain Benson, the boats *leapfrogging* most of each day to develop anti-submarine capabilities and tactics. After visits to Londonderry, Rothesay in Scotland, and Portsmouth, England, the group headed north before splitting into two groups—the two Guppies (TUSK and COCHINO) under Captain Benson bound for the Barents Sea, the fleet boats for Greenland.

About noon on a day in late August north of Norway, COCHINO was running as a snorkeling target for TUSK, when she announced over the underwater telephone that she had a problem and was surfacing. The events of the next 14 hours are recounted in the book The Last Cruise by William J. Lederer, an expansion of his two part article in The Saturday Evening Post. In short, COCHINO was racked by a series of battery explosions, subsequently determined to have been due to water getting into the after battery series-parallel switch, which culminated in her sinking moments after TUSK had rescued everyone on board.

During the afternoon TUSK had managed, with difficulty in the heavy seas, to take on board a COCHINO officer, accompanied by a civilian technical representative, sent to apprise us of the situation just before two mammoth waves plunged over the deck in quick succession. Our jury-rigged 21 thread life lines snapped and about 12 TUSK crewmen and the tech rep were washed over the side. Most were about 100 yards away when they could first be seen after the second wave subsided. Over the next three hours TUSK was able to recover those still alive and verify that the six others were beyond rescue. This experience led to the adoption of the deck safety tracks still in use today. Meanwhile COCHINO had managed to regain diesel propulsion and a limited jury-rig steering capability. I assume that the adoption of a means of effective jury-rig steering as a result of this experience likewise continues. So with TUSK as guide for course and COCHINO as guide for speed, we headed for Hammerfest, Norway.

Shortly after midnight COCHINO was again racked by explosions and signalled with a battle lantern to *come quick*. After jettisoning several loaded torpedoes TUSK put her port bow alongside COCHINO's starboard bow. Using the brow secured to COCHINO, and tended on TUSK to prevent its being crushed when the boats rolled together, the entire COCHINO crew, including the badly burned personnel, left their sinking ship quickly, but necessarily one by one. Captain Benitez, as the last to leave, had his moment of hesitation terminated by Captain Worthington's admonition to be quick as it was obvious the ship would sink. Its deck aft was already awash. Chopping all lines and casting off the brow, TUSK backed away as COCHINO sank no more than 100 yards away.

The hours after arrival in Hammerfest were occupied in getting immediate medical attention for the badly burned personnel and trying to explain to the harbormaster, a friendly Royal Norwegian Navy commander, how people had been so severely burned on a ship that did not appear to have suffered any damage. Luckily, because the Navy Department soon publicly announced the loss of COCHINO, Captain Benson did not have to continue the charade for long. It did last long enough for the harbormaster to learn that Captain Benson was of Swedish descent and could understand some Swedish. Once we learned that we would have to wait for several hours for the arrival of a Navy doctor being flown in before we could depart down the fjords for Tromso, the essentials had been taken care of.

The harbormaster then suggested to Captain Benson that it would be appropriate to observe the amenities and call first upon the mayor and then chief of police. This they did and shortly thereafter, with the arrival of the Navy doctor, we were underway for Tromso. The Navy doctor confirmed that the two corpsmen, Doc Riley of TUSK and Doc Eason of COCHINO, had done everything possible until the patients could be hospitalized in Tromso.

Enroute I heard Captain Benson recount the story of his *formal* visits in Hammerfest. The call on the mayor was routine and uneventful. The call on the police chief was something else again! As soon as the harbormaster and Captain Benson entered his office the chief launched into a tirade in Norwegian, a language not all that different from Swedish, directed at the harbormaster for being so tardy in arranging the call (and perhaps for some other shortcomings as well). The harbormaster remained silent until the chief finished. At that point he told the chief that Captain Benson spoke Swedish and could thus understand everything that had been said. Thereupon the face of the police chief turned a very bright red! If I heard any other details about the call and how it ended I have long since forgotten them. ■

A DIRECT LINE TO SECNAV

by Bing Gillette

In the '60s, the submarine Navy ran a private airline to Scotland to transport FBM crews between Quonset Point, Rhode Island and Holy Loch, Scotland. Information concerning the schedule of this transportation system was well orchestrated, so that next-of-kin could meet the incoming FBM crews or *kiss them goodbye*.

Each crew had a communicator telephone *tree* used to notify all families of arrival and departure times. This system functioned very well keeping all dependents informed of the arrival times of incoming crews. However, this effectiveness could prove to be a mixed blessing as the following incident illustrates.

The incoming crew of this particular submarine crew embarked in an aircraft at Prestwick Airport, Scotland, and departed for the United States. The estimated time of arrival (ETA) had been sent and the communicator tree was activated. All hands had been informed and arrangements made for an arrival at Quonset Point, Rhode Island.

However, as Robert Burns once wrote "The plans of mice and men oft go aglae". Such occurred on this particular flight as the plane lost an engine an hour after take off, and had to return to Prestwick. There was no immediate replacement plane available, so no ETA could be predicted. Information on the situation was passed to all the dependents.

The crew flaked out in the airport to await a solution to the problem. The wait extended for several hours, during which time some of the more enterprising crew members were able to find liquid refreshment. One of the more daring members was the ship's cook. He, having imbibed quite a bit, decided to speed things up by calling his wife in Groton, Connecticut. (My experience with submarine cooks indicates that they are individuals who march to their own drummer and are not known for their patience under normal conditions.) He informed his wife that nobody seemed to be doing anything about getting the crew home, and that she should alert the powers-that-be of the situation and get some action taken.

She, being a dutiful and capable Navy wife, decided to go right to the top! As a result, at about 2 AM local time, she contacted the Secretary of the Navy at his home. In rather short succinct terms, coupled with four letter adjectives, she informed him of the situation and suggested that he *get cracking* on a solution.

The Secretary notified the CNO Duty Officer of the situation and suggested he look into the matter. The Duty Officer passed the information on to COMSUBLANT, who in turn, passed it down the chain of command to *yours for action*.

There are two aspects of this incident that were quite surprising to me. First, of course, was the fact that anyone could dial direct to a senior public official at 2 AM at his or her residence without having some form of screening of incoming calls. Apparently, the young lady berated the Secretary for his lack of knowledge and concern about this problem. Fortunately, the Secretary recognized that the young lady was, among other things, suffering from stress. He assured her that remedial action would be taken. The second impressive aspect was how quickly *yours for action* received the message from the Secretary. All links in the chain expedited passing on the information.

The net result was, that some five hours later, a plane, with a replacement engine, was on its way. The dependents were informed and all hands, including the Secretary, could go back to bed. ■

SEA-AIR-SPACE

The world's largest maritime exposition, the Navy League's Sea-Air-Space Systems and Technology Exposition, will take place April 2-4, 1996 at the Sheraton Washington Hotel in Washington, DC. There will be more than 150 exhibits of the latest in technology designed for today's and tomorrow's Navy, Marine Corps, Coast Guard, and U.S.-flag Merchant Marine. More than 10,000 people are expected to attend the three day event. With a theme of *America's Best*, the program also includes addresses by senior Department of Defense (DoD) leaders, special events and five free professional seminars.

The Exposition is open at no charge to active, reserve, and retired U.S. military personnel, civilian employees of the DoD and other agencies of the Federal government, and all Navy Leaguers. For more information, ask for Kathy at (703) 318-0300.

A SUBMARINE BIBLIOGRAPHY

THE SUBMARINE REVIEW started putting together a bibliography of better-known submarine-related books and articles with the January 1993 issue. Now, three years later, we have established beyond a doubt that the amount of published material is more than we can hope to address in any nearly complete manner. It is obvious also that the breadth and depth of interest in submarine matters, as measured both by the written works themselves and by those who have bought, read and collected them, is truly remarkable.

This will be the last scheduled segment of this regular feature and in it we present entries submitted by a number of members which have not been listed previously in this series. The general Bibliography was launched in three sections in the January, April, and July 1993 issues. In October '93, a fiction list was offered and in January and April 1994 a listing was made of a number of submarine articles which had appeared in the pages of the Naval Institute Proceedings. The articles were meant as accompaniment for reprinting the USNI 1966 Prize Essay "The Submarine's Long Shadow", but the sheer volume available was another testament to almost a century's worth of submarine interest.

Special interest listings followed in October of 1994 with a tabulation of books and articles in foreign languages. In January of 1995 a World War II list was presented and in April Torpedo Technology was treated. October of '95 carried a partial list of the Italian Navy's Submarine School Library.

We all recognize that there are a great many more books out there that should be on our list, and we have only begun to tap the submarine-related articles which have appeared in the various public and professional periodicals. Thomas O. Paine, in The Submarine Registry and Bibliography, catalogued over 6,000 books and articles up to 1992. We do intend to offer, from time to time, some selected bibliographies on special interest areas and the submarine literature from individual countries.

Bibliography

Adams, Thomas A. and David J. Lees, Register of Type VII U-Boats. Kendal: World Ship Society, 1991. ISBN 0-905617-60-6

Barnett, Correlli, Engage the Enemy More Closely. New York: W.W. Norton, 1991. LC 90-46009/ISBN 0-393-02918-2

Barrows, Nat A., Blow All Ballast: The Story of the SQUALUS. New York: Dodd, Mead & Co., 1940. LC 40-27428

Bartholomew, C.A., Mud, Muscle and Miracles. Washington: GPO, 1990. LC 89-29806/ISBN 0-945274-03-3

Bergen, Claus and Karl Neureuther, U-Boat Stories. London: Constable & Co., 1931. LC 32-2479

Bush, Harald, U-Boats at War. New York: Ballantine Books, 1955. LC 55-12090

Daniel, Donald C., Anti-Submarine Warfare and Superpower Strategic Stability. Urbana, IL: University of Illinois Press, 1986.

Ellsberg, Edward, On the Bottom. New York: Dodd, Mead & Co., 1929. LC 29-11296

Frank, Gerold and James D. Horan, with J.M. Eckberg, U.S.S. SEAWOLF. New York: G.P. Putnam's Sons, 1945.

Garrett, Richard, Submarines. Boston: Little, Brown & Co., 1977. LC 77-89103

Gray, Edwyn, The Underwater War: Submarines 1914-1918. New York: Charles Scribner's Sons, 1971. LC 76-178234/-ISBN 684-12697-4

Hashagen, Ernst, The Log of a U-Boat Commander. London: Putnam, 1931. LC 31-34793

Hill, J.R., Anti-Submarine Warfare. Annapolis, MD: Naval Institute Press, 2nd Edition, 1989.

Hirsch, Phil, Editor, Killer Subs. New York: Pyramid Books, 1965.

Howarth, Stephen, Editor, Men of War: Great Naval Captains of World War II. New York: St. Martin's Press, 1993. LC 92-43299/ISBN 0-312-08844-2

Hutcheon, Wallace S., Robert Fulton: Pioneer of Undersea Warfare. Annapolis, MD: Naval Institute Press, 1981. LC 80-81094

Jenkins, David, Battle Surface!: Japan's Submarine War Against Australia 1942-44. Australia, Random House, 1992.

Jones, Geoffrey, The Month of the Lost U-Boats. London: Book Club Associates, 1977.

_________, Autumn of the U-Boats. London: W. Kimber, 1984. ISBN 0-7183-0534-5

_________, Defeat of the Wolf Packs. London: W. Kimber, 1986. ISBN 0-7183-0589-2

_________, U-Boat Aces. London: W. Kimber, 1988. ISBN 0-7183-0685-6

Kemp, Paul, Convoy! Drama in Arctic Waters. London: Arms & Armour Press, 1993. ISBN 1-85409-130-1

Konig, Capt. Paul, Voyage of the Deutschland. Hearst's In ternational Library, 1916.

Lockwood, Charles A., Down to the Sea in Subs. New York: W.W. Norton & Co., 1967. LC 66-12798

_________, Sink 'em All: Submarine Warfare in the Pacific. New York: E.P. Dutton & Co., 1951. LC 51-9835

Lockwood, Charles A. and Hans C. Anderson, Hell at Fifty Fathoms. Philadelphia: Chilton Co., 1962. LC 62-8342

_________, Through Hell and Deep Water. Philadelphia: Chilton Co., 1956. LC 56-11388

________, Wake of the WAHOO. New York: Popular Library, 1960. LC 60-8176

Lott, Arnold S., Robert F. Sumrall and Robert S. Egan, USS BOWFIN (SS 287). Annapolis: Leeward Publications, 1975. ISBN 0-915268-05-1

Mallison, William Thomas, Studies in the Law of Naval Warfare. Washington: GPO, 1968. LC 73-9322

Mayers, Colin, Submarines, Admirals and Navies. Los Angeles: Associated Publications, 1940.

Orita, Zenji with Joseph D. Harrington, I-Boat Captain. Canoga Park, CA: Major Books, 1976.

Ott, Wolfgang, Sharks and Little Fish. New York: Pantheon Books Inc., 1958. LC 57-10236

Polmar, Norman, Atomic Submarines. Princeton, NJ: D. Van Nostrand, 1963.

Poolman, Kenneth, Allied Submarines of World War Two. London: Arms and Armour Press, 1990. ISBN 0-85368-942-3

Price, Alfred, Aircraft Versus Submarine. London: William Kimber, 1973. ISBN 7183-0412-8

Preston, Anthony and John Batchelor, The First Submarines. London: Phoebus Publishing Co., 1974.

________, Submarines Since 1919. London: Phoebus Pub lishing Co., 1974.

Rees, Ed, The Seas and the Subs. New York: Duell, Sloan and Pearce, 1961. LC 61-11963

Rickover, H.G., Eminent Americans. Washington: GPO, 1972. LC 72-90503

Robertson, Terence, Night Raider of the Atlantic. New York: E.P. Dutton & Co., 1956. LC 56-5013

Shapiro, Milton J., Undersea Raiders. New York: D. McKay, 1979. LC 79-2153

Showell, Jak P. Mallman, U-Boat Command and the Battle of the Atlantic. London: Conway Maritime Press, 1989. ISBN 0-85177-487-3

Thomas, David A., Submarine Victory: The Story of British Submarines in World War II. London: William Kimber & Co., 1961. LC 63-26921

Terraine, John, Business in Great Waters. The U-Boat Wars 1916-1945. London: Leo Cooper, 1989. ISBN 0-85052-7600

Treadwell, Terry C., Submarines With Wings. London: Conway Maritime Press, Ltd., 1985. ISBN 0-85177-3699

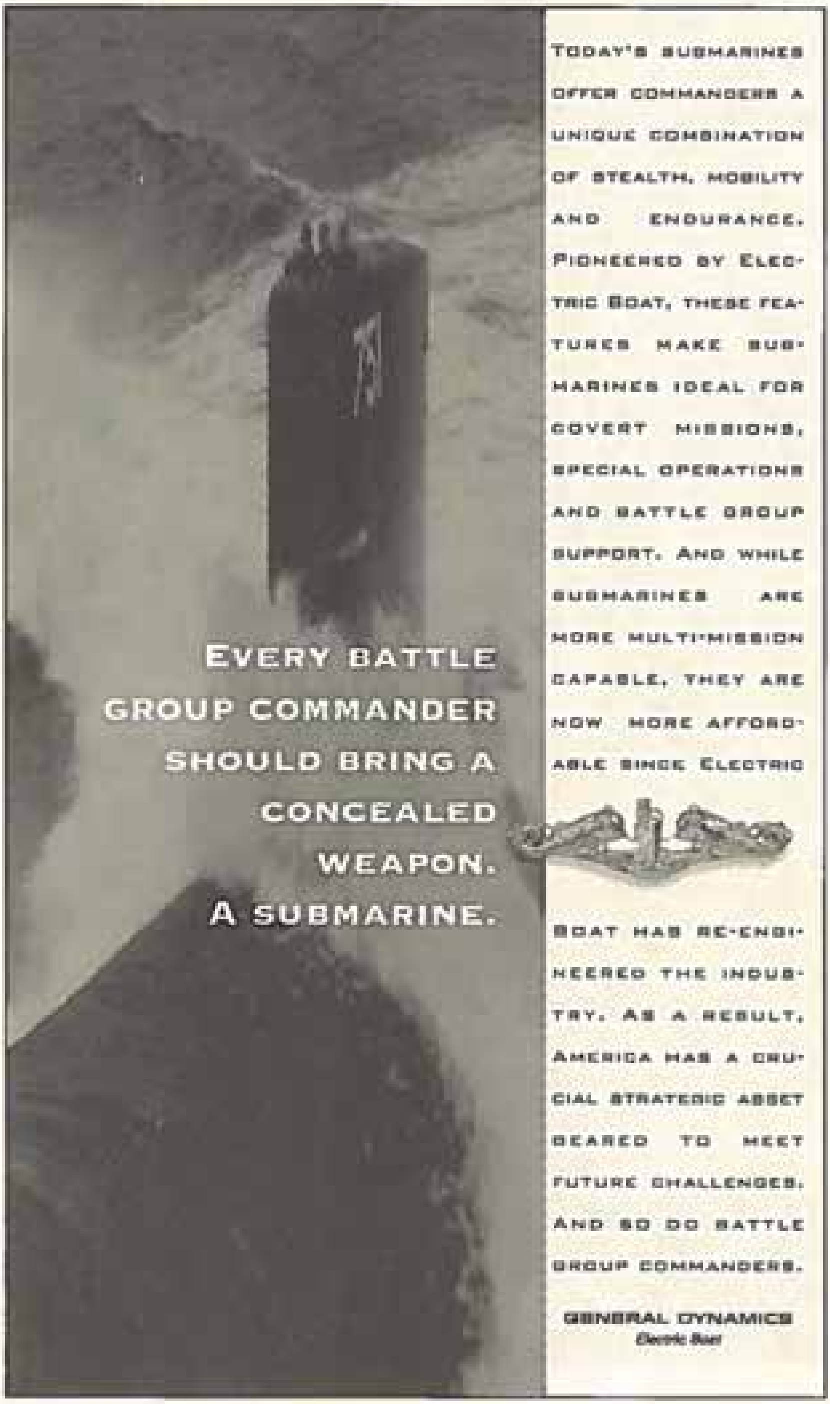
Turner, John Frayne, Periscope Patrol: The Saga of the Malta Submarines. London: George G. Harrap & Co., 1957.

Weir, Gary, Forged in War: The Naval-Industrial Complex and American Submarine Construction, 1940-1961. Washington: Naval Historical Center, 1993. LC 92-40998/ISBN 0-16-038258-0

Whinney, Bob, The U-Boat Peril. Dorset U.K.: Blandford Press, 1986. ISBN 0-7137-1821-8

Wilson, Michael, Baltic Assignment: British Submarines in Russia 1914-1919. London: Leo Cooper with Martin Secker & Warburg, 1985. ISBN 0-436-57801-8

Young, CDR Edward Preston, One of Our Submarines. London: Rupert Hart-Davis, 1952. LC 53-1105


EVERY BATTLE GROUP COMMANDER SHOULD BRING A CONCEALED WEAPON. A SUBMARINE.
TODAY'S SUBMARINES OFFER COMMANDERS A UNIQUE COMBINATION OF STEALTH, MOBILITY AND ENDURANCE. PIONEERED BY ELECTRIC BOAT, THESE FEATURES MAKE SUBMARINES IDEAL FOR COVERT MISSIONS, SPECIAL OPERATIONS AND BATTLE GROUP SUPPORT. AND WHILE SUBMARINES ARE MORE MULTI-MISSION CAPABLE, THEY ARE NOW MORE AFFORDABLE SINCE ELECTRIC BOAT HAS RE-ENGINEERED THE INDUSTRY. AS A RESULT, AMERICA HAS A CRUCIAL STRATEGIC ASSET GEARED TO MEET FUTURE CHALLENGES. AND SO DO BATTLE GROUP COMMANDERS.
GENERAL DYNAMICS
Electric Boat

CORPORATE SPONSORS IN THE SPOTLIGHT

CAE Electronics, Inc.
Member Since 1/12/88

CAE Electronics Incorporated is a world leader in the development and supply of advanced software-based simulation, training and control systems. Building on its expertise in manufacturing state-of-the-art aviation training simulators for every major worldwide commercial carrier, as well as the U.S. Air Force's B-2 bomber and F-117 Stealth fighter, and NASA's Space Shuttle, CAE Electronics has most recently developed applications for advanced marine monitoring and control systems.

The Standard Monitoring and Control System (SMCS) prototype, a software system for turn-key operations of marine engineering systems, is now undergoing hot plant tests at the U.S. Navy's Land Based Engineering Site in Philadelphia, Pennsylva nia. This technologically advanced system is planned by the U.S. Navy for future generations of combatants such as the DDG 51 and LPD 17 platforms. This system represents an integrated, digital, distributed control and monitoring capability for all platform engineering which was delivered to the U.S. Navy under a separate contract in February 1995. Designed as integrated or stand-alone systems, both the SMCS and DCS (Damage Control System) programs offer vastly increased operating and information sharing functions over the most modern systems in the U.S. fleets today, plus the potential to reduce current manning requirements. Based on the success and revolutionary nature of these efforts for the U.S. Navy, the Advanced Research Projects Agency (ARPA) awarded an exclusive contract to CAE in August 1995 to design an advanced Damage Control System for complementing the Autonomic Ship conceptual studies and eventual new construction programs in the next century.

Internationally, CAE is likewise a recognized world leader in the supply of reliable and technologically advanced software programs. As an example, CAE is now playing a major role with GEC-Marconi in proposing a new design for the controls and instrumentation on the British Batch II Trafalgar class submarines to achieve potential construction cost savings. Integral in this effort is the utilization of CAE's Real-time Object-oriented

Software Environment (ROSE) tool, a system which allows the user to represent any hardware system by schematic representation with the input of its particular dynamic operating characteristics using components found in object libraries. In turn, these open architecture generated software models can then be tested and reworked on-the-fly, resulting in extensive man-hour savings over current methods of pre-manufacturing test and evaluation. In the case of the British Trafalgar class submarine these unique CAE capabilities are being employed ostensibly for potential construction cost savings, a reduction in installed cabling and potential platform manpower reductions.

CAE Electronics, as a company, and with its cadre of system engineering and marketing personnel, greatly looks forward to a continuing close working association with the U.S. Navy's development agencies and individual warfare communities towards ensuring that our military capabilities remain second to none both technologically and operationally as our nation exercises its continued global leadership into the next century.

Precision Components Corporation

Member Since 5/24/93

D.C. Fabricators Inc. (DCF), formerly known as DeLaval Condenser, is an operating company of Precision Components Corporation, and is one of the original suppliers to the Navy's nuclear fleet.

DCF has had a long history supplying heat exchanger compo nents to the United States Navy and has routinely supplied main steam condensers and air ejectors for both surface ships and nuclear submarines.

Ever since 1966, every nuclear submarine condenser has been designed and fabricated by DCF. This includes the Los Angeles, Ohio and Seawolf classes. In fact, DCF's early predecessor, C.H. Wheeler, provided the main condenser for the first nuclear SEAWOLF (SSN 575) in 1954.

Like many other defense industry contractors, DeLaval did not expect the rapid pace of downsizing in the purchase of military equipment. The termination of the Seawolf Program in 1992 caused an immediate reduction of the Florence, NJ work force. The company had to adjust.

The first order of priority was to find other work to replace the lost Navy backlog. Having once been a major player in the supply of main station and industrial condensers, DeLaval canvassed these markets for opportunities but their search was unsuccessful because those markets had changed dramatically. Work was limited and very competitive. Years of serving the Navy nuclear customer base appeared to have created a dinosaur.

Crisis is often the mother-of-invention. During the period of downsizing, DeLaval maintained its core capabilities with a limited staff. This now can be considered the beginning of what would turn out to be a stroke of good fortune as Precision Components Corporation (PCC) was in a similar situation 125 miles away in York, PA.

Like DeLaval, it was caught off-guard with the Seawolf termination. It too was a major supplier of nuclear components for submarines. PCC's product line was heavy-walled precision-machined vessel components. PCC's business strategy was similar, and that was to diversify, while maintaining a strong commitment to the Navy Nuclear Program.

Through mutual associations and persistent follow-up, PCC became very interested in DeLaval's design and fabrication capabilities. By February 1995, PCC had concluded a six month courtship by acquiring DeLaval, and changed its name to D.C. Fabricators.

DCF was awarded the design and prototype manufacture of components for the new attack submarine (NAS) program in the Spring of 1995. This contract covers two-and-a-half years of engineering design and fabrication of the main steam condensers and related equipment for the NAS.

DCF's strategic business plan will carry the new young company, with a rich heritage, into the 21st century. DCF intends to build on its traditions, while broadening its customer base. Its business mission is:

> "To be the dominate supplier of heat transfer equipment for the United States Navy, and to use the strengths of design, manufacturing and quality assurance to develop market presence in related industrial and commercial heat exchang-

er and support system applications that require similar custom designs and fabrication of quality components."

DCF's predecessor (DeLaval) developed industry's standard for Navy nuclear shipboard heat exchangers and condensers. This strength has been further enhanced by the recent investment in state-of-art engineering design software, computerized 3-D modeling and finite element stress analysis capability.

The 25 acres Florence, NJ manufacturing complex remains another basic strength. With extensive heavy material handling capabilities, up to 70 tons, DCF excels in exotic metal fabrications and precision machining and drilling application.

DCF is positioned to continue to serve the needs of the Navy Nuclear Program. With the cooperation of a pro-active union, strong worker involvement and commitment, a low cost-of-quality, and attention to engineering detail, DCF is committed to its primary customer.

By being a member of Precision Components Corporation, a family of highly-engineered niche products has been assembled. DCF will focus on exotic fabrications, PCC will focus on heavy-wall precision machining and IAF (Industrial Alloy Fabricators, Richmond, VA) will focus on thin-wall vessels and tanks. Together, these three companies will provide a synergistic force of engineering design talent, exotic metallurgical fabrication technology and high machine center utilization. The sharing of capabilities, with individual business unit accountability, is already producing results.

Today, the future is a much brighter place than it was in the Spring 1992. DCF is adapting to the changing needs of its customers, and the general business environment, and successes are beginning to come its way.

Emerson & Cuming, Inc.

Member Since 7/18/94

Emerson & Cuming Composite Materials, Inc., Canton, Massachusetts, is the leading developer and manufacturer of high performance deepwater buoyancy used in manned and unmanned submersibles, oceanographic research and offshore oil/gas exploration and production.

The company pioneered the development of syntactic buoyancy and over the past 35 years has supplied more than 80 percent of installed deepsea buoyancy worldwide.

Emerson & Cuming Eccofloat ® buoyancy is based on unique, proprietary mixtures of epoxy resins, microscopic hollow glass Microballoon ® microspheres, and pea-sized hollow fiberglass Macroballoon ® macrospheres.

This material is noted for its exceptional isostatic strength, extremely low densities and long life with negligible buoyancy loss. In addition to buoyancy, Eccofloat also imparts acoustic, thermal, electrical and structural properties.

Emerson & Cuming supplied the external buoyant package for the U.S. Navy's TURTLE search and recovery vehicle when it was re-built, and has recently been involved in refurbishing TURTLE. The company is also the buoyancy vendor for SEACLIFF, NAUTILE, ALVIN and both DSRVs.

The firm is currently manufacturing the vehicles for the AN/SLQ 48 Mine Neutralization System (MNS), operational aboard all U.S. Navy MCM Avenger class and MHC Osprey class mine-hunting ships.

Recently, the U.S. Navy explored ways to decrease weight in the free-flood areas of 688I submarines. As a result, custom-fitted buoyancy modules of syntactic material are being installed. Subsequently, Emerson & Cuming contracted to fill the internal spaces in submarine dihedrals, control surfaces and other areas.

The firm has also supplied deepwater cylindrical buoys for the U.S. Navy's submarine performance test range, Atlantic Underwater Test and Engineering Center (AUTEC), off the Bahamas.

In recent years, Emerson & Cuming's technical sophistication has grown on a steep slope. The company has lowered syntactic densities, installed all new equipment, and acquired a fully-instrumented hydrostatic testing capability. It can combine syntactics with high performance thick-section fiber-reinforced polymer (FRP) composites, can provide hardware design and attachment, and can integrate instrumentation in order to deliver packages ready for final assembly or immediate deployment as needed. ■

NAVAL SUBMARINE LEAGUE
HONOR ROLL

BENEFACTORS FOR MORE THAN TEN YEARS

ALLIED-SIGNAL OCEAN SYSTEMS
AMERICAN SYSTEMS CORPORATION
ANALYSIS & TECHNOLOGY, INC.
ARGOSYSTEMS, INC.
BABCOCK AND WILCOX COMPANY
BIRD-JOHNSON COMPANY
BOOZ-ALLEN & HAMILTON, INC.
DATATAPE, INC.
EG&G, WASHINGTON ANALYTICAL SERVICES CENTER, INC.
GENERAL DYNAMICS/ELECTRIC BOAT DIVISION
GENERAL ELECTRIC/N&MS
GLOBAL ASSOCIATES, LTD.
GNB INDUSTRIAL BATTERY COMPANY
GTE GOVERNMENT SYSTEMS CORPORATION
HAZELTINE CORPORATION
HUGHES AIRCRAFT COMPANY
KAMAN DIVERSIFIED TECHNOLOGIES CORPORATION
KOLLMORGEN CORPORATION, E-O DIVISION
LOCKHEED CORPORATION
LORAL DEFENSE SYSTEMS - AKRON
LORAL FEDERAL SYSTEMS COMPANY
LORAL LIBRASCOPE CORPORATION
LOCKHEED MARTIN CORPORATION, BETHESDA, MARYLAND
NEWPORT NEWS SHIPBUILDING
PRC, INC.
PRESEARCH INCORPORATED
PURVIS SYSTEMS, INC.
RAYTHEON COMPANY, EQUIPMENT DIVISION
ROCKWELL INTERNATIONAL CORPORATION
SAIC
SCIENTIFIC ATLANTA, SIGNAL PROCESSSING SYSTEM
SIPPICAN, INC.
SONALYSTS, INC.
TREADWELL CORPORATION
VITRO CORPORATION
WESTINGHOUSE ELECTRIC CORPORATION

BENEFACTORS FOR MORE THAN FIVE YEARS

ADI TECHNOLOGY CORPORATION
APPLIED MATHEMATICS, INC.
AT&T
CAE-LINK CORPORATION
COMPUTER SCIENCES CORPORATION
CORTANA CORPORATION
DIAGNOSTIC/RETRIEVAL SYSTEMS, INC.
HYDROACOUSTICS, INC.
KPMG PEAT MARWICK
LOCKHEED SANDERS INC.
LOCKHEED MARTIN OCEAN, RADAR & SENSOR SYSTEMS
LOGICON-SYSCON CORPORATION
MARINE MECHANICAL CORPORATION
MCQ ASSOCIATES, INC.

PLANNING SYSTEMS INCORPORATED
RADIX SYSTEMS, INC.
RIX INDUSTRIES
SEAKAY MANAGEMENT CORPORATION
SPERRY MARINE, INC.
SYSTEMS PLANNING & ANALYSIS, INC.
TASC, THE ANALYTIC SCIENCES CORPORATION

ADDITIONAL BENEFACTORS

ADAMS ATOMIC ENGINES, INC.
ALLIED NUT & BOLT CO. INC.
AMADIS, INC.
ARETÉ ENGINEERING TECHNOLOGIES CORPORATION
CUSTOM HYDRAULIC & MACHINE, INC.
DYNAMICS RESEARCH CORPORATION
ELS INC.
EMERSON & CUMING, INC.
GUILL TOOL & ENGINEERING CO., INC.
HAMILTON STANDARD SPACE SYSTEMS INCORPORATED
HORIZONS TECHNOLOGY INC.
HOSE-McCANN TELEPHONE CO. INC.
HUSSEY MARINE ALLOYS
ITW PHILADELPHIA RESIN
LUNN INDUSTRIES, INC.
MARINE ELECTRIC SYSTEMS,INC.
PRECISION COMPONENTS CORPORATION
RICHARD S. CARSON AND ASSOCIATES, INC.
SARGENT CONTROLS & AEROSPACE
SOUTHWEST PRODUCTS & COMPANY
UNISYS CORPORATION/ELECTRONIC SYSTEMS
VEHICLE CONTROL TECHNOLOGIES, INC.

NEW ADVISORS

ENS David F. Acquavella, USN
RADM Charles F. Horne, III, USN(Ret.)
CAPT William E. Ratliff, USN(Ret.)

NEW ASSOCIATES

COL Peter E. Boyes, USAF(Ret.)
LT(jg) Andrews S. Decker, USN
Shirley B. Meyerhoff
Brent Rawlins
CDR James D. Sencindiver, USNR-R
Ronald L. Withrow, Jr.

LETTER

SEAWOLF PROGRAM COSTS AND SCHEDULES

Regarding The Submarine Building Program! in the October 1995 **SUBMARINE REVIEW**, it is difficult to understand Rear Admiral Frick's statement that the "Seawolf is a success story...we are going to deliver these complex ships (SSN 21 and SSN 22) on time and within the constraints of the cost cap".

The SSN 21 delivery was originally scheduled for November 1994. The delivery of the lead ship was delayed by at least six months (to May 1995) due to changes in the BSY-2 system configuration. On 1 August 1991 the Navy announced that massive weld failures had been discovered in the hull that would delay completion of the lead submarine at least into 1996. (The cracks in the welding, which were first discovered in June 1991, required the replacement of all welds completed up to that time.)

The latest issue of the Naval Sea Systems Command Quarterly Progress Report (1 October 1995) lists the SEAWOLF delivery date as 24 May 1996—one-and-a-half years after the originally scheduled date. This is hardly "on time".

The cost cap is a more difficult issue, as it has been increased since originally being levied by Secretary of the Navy John Lehman a decade ago. The SEAWOLF contract was increased by $58,825,590 to cover the costs of the defective weld problems; was this increase covered by the cost cap? What was the increased cost of a one-and-a-half year slippage?

Norman Polmar

FROM BATTLEWAGONS TO BALLISTIC MISSILES SUBMARINE ADMIRAL

by Admiral I.J. Galantin, USN(Ret.)

Reviewed by RADM Jack Barrett, USN(Ret.)

In his introduction to Take Her Deep, the wartime story of HALIBUT, Ned Beach pictures its author, Ignatius Joseph Galantin known as Pete, as a wartime skipper who knew how to tell a story so that it speaks the truth to all who remember how it was. Admiral Crowe, former Chairman of the Joint Chiefs of Staff, recommends Submarine Admiral as a "must" for anyone interested in the making of U.S. strategy and security policy, describing Admiral Galantin as a competent warrior and peacetime strategist. This reviewer can testify to both views, having had the privilege of serving under Pete Galantin in HALIBUT and for three separate tours in the Washington bureaucratic maze from which military policy, budgetary and force levels, weapons systems, personnel policies and eventually operational readiness, or lack thereof, evolve.

As his Gunnery Officer and Torpedo Data Computer operator on HALIBUT I first witnessed his superb, dispassionate analysis of the Mk 14 torpedo fiasco. As Ned Beach so aptly stated: "Many skippers, especially in the early days tortured themselves with self-doubt when seemingly well managed attacks brought only failure and depth charges. Some completely lost confidence in themselves and their crews. Galantin simply redoubled his efforts." This same firm, persistent, determined, dispassionate analysis of submarine technical and operational policy and problems on the national and international scene marked Admiral Galantin's future stellar naval career. It is fascinating that the same naval officer who had, with many others, fought an unprecedented submarine war with a terribly defective torpedo would be a leader in the creation of a submarine weapon system of unprecedented reliability.

Submarine Admiral documents Galantin's deep involvement in the four phases of the evolution of the submarine in our Navy: (1) trial and error, 1900-1940; (2) proof in combat, 1941-45; (3) wishful thinking, 1946-1954; (4) new dimensions, 1955-79. His career afloat and ashore stretched from the 629 ton O boats through the era of R and S boats, through the bewildering search for an effective *fleet* boat, through (intense) combat at sea, to the new age of nuclear powered 6900 ton attack boats and 8200 ton ballistic missiles submarines.

His three tours of shore duty in the Pentagon office of the Chief of Naval Operations (OPNAV) were each as the head of successively more senior and more responsible submarine billets. As a commander he was Head, Submarine Maintenance Branch (OP 433). As a captain he was assigned as Head, Submarine Warfare Branch (OP 311), the senior pro-submarine post in OPNAV, with an allowance of only three officers and one civil servant secretary. His *Troubled Waters* chapter on working for Admiral Arleigh Burke (Chief of Naval Operations) in this billet while advancing the strategic concepts of the submarine role in anti-submarine warfare and as a guided missile carrier (Regulus) is fascinating reading as are his *The Rickover Equation* and *The Ultimate Deterrent (Polaris)* chapters for those interested in the development of submarines in both their ASW role and in their strategic deterrent role.

In 1961 Rear Admiral Galantin became Director of Submarine/-Anti-Submarine Warfare (OP 31), the last officer charged with these competing missions before they were separated into two separate offices under the Chief of Naval Operations. In 1962 he relieved Rear Admiral Raborn as Director, Polaris Special Projects Office responsible for the development and production of the strategic deterrent system of 41 ballistic missile submarines and their associated support systems. Programmed development, scheduled invention and concurrent production with industry were the order of the day based on our Navy's 60 years of submarine experience with a long tradition of persistence, innovation, resolute operation and effective maintenance. Under Galantin's leadership and direction the Special Projects Office produced on schedule a completely reliable and operationally tested deterrent weapon system of utmost historical and international priority. His chapters on *The Politics and Polaris* and *The Special Relationship* (United States/United Kingdom Polaris/Poseidon Submarine Deterrent Program) is a must reading for professional naval officers and all others interested in operating in the Washington bureaucratic maze and in the international and joint arena.

One lays down Submarine Admiral with the feeling that Pete

Galantin learned well from his days as Captain of the Fencing Team at the Naval Academy and from his assignment as submarine liaison officer a thousand miles from the sea in wartime China where he was first exposed to intense high level political and interservice conflict. He was a master in fencing with the powerful political and military figures of his time. We are grateful for his long and productive service to our Submarine Force, to our Navy and to our country. This Chicago lad is personally grateful for having had Pete Galantin as his model of a naval officer and gentleman.

Submarine Admiral is a well written, well documented personal narrative of submarine development through times of breathtaking change in war, both hot and cold. Readers of **THE SUBMARINE REVIEW** will find it fascinating and a key book for their submarine library. It is published by the University of Illinois Press and can be ordered through most book stores for approximately $25.00. ■

SILENT RUNNING

My Years on a World War II Attack Submarine

by James F. Calvert, Vice Admiral USN(Ret.)
John Wiley & Sons, Inc.
New York, Canada, Australia 1995
ISBN 0-471-12778-7

Reviewed by RADM M.H. Rindskopf, USN(Ret.)

Book reviews in **THE SUBMARINE REVIEW** can be written by (1) World War II submariners, (2) post-war submariners, (3) other Naval officers, (4) knowledgeable civilians, or (5) lay civilians.

In this review you will get (as they say in the Chinese restaurants) one from category (1) and one from category (5). I chose this route because I found myself reliving the War in DRUM (SS 228); and perhaps biased by nostalgia. I thought that comments from a senior member of the Administrative Staff of the Anne Arundel County, Maryland Public Library might give us an outsider's viewpoint.

I have known Jim Calvert since he joined the Torpedo and Tactics Department of the Submarine School Staff in 1945 which consisted of Commander Chester Nimitz, Jr., Lieutenant Commander Mike Rindskopf, and Lieutenant Dennis Wilkinson—all under the Officer-in-Charge, the ubiquitous Captain Freddie Warder.

In a nutshell, Jim Calvert's Silent Running is an exciting book written in down-to-earth language by a junior officer in JACK (SS 259). It takes JACK from Electric Boat in New London down the East Coast to the Pacific via the Panama Canal, through eight war patrols, three of which earned JACK the Presidential Unit Citation. There are simple charts showing JACK's track on each key patrol and location of her actions. These assist those unfamiliar with geographic details of the Western Pacific. It concludes with an unbelievable tale while Jim Calvert was Executive Officer of HADDO (SS 255) at the surrender ceremonies in Tokyo Bay.

The things which produce nostalgia for me provide you with a guide for reading the book, but they do not include all the interesting events about which Jim has written.

- He made the first eight runs in JACK, fleeting up from fifth officer to Executive Officer.
- He was the Torpedo Data Computer Operator (the key man in the Fire Control party) throughout his tour—even when Exec.
- He stood the 00-04 and 12-16 watches for a long time.
- He put his first skipper, Lieutenant Commander Tommy Dykers, Class of 1927, on a pedestal as the epitome of a leader, a skilled periscope handler, and a fearless, aggressive attacker.
- He was lavish in his praise for those officers and leading crew who made JACK the ship she was.
- He like depth charging no more than the rest of us submariners, and was not bashful in stating that there were times when he was "plain scared".
- JACK encountered two German U-boats in her passage down the East Coast; played cat and mouse; and never saw them again.
- She had an exciting, rewarding first patrol off the Empire during which her survival was in the balance.
- She suffered from the miserable performance of the Torpedo Mk XIV and its installed Exploder Mk VI.

- She sank a sampan by gunfire and captured two prisoners.
- She refitted three times in Australia.
- She ended the war with 15 ships sunk and ranked ninth in tonnage.

JACK early on patrolled on the surface, expanding her search area by utilizing the high periscope. But, more importantly, she perfected the night surface attack using her surface search radar with superlative results. She made multiple attacks, often expended all her torpedoes and, after the torpedoes were made right, achieved a very high hit percentage.

Jim gives much credit for JACK's success to the experience and continuing training support of her Division Commander, Commander Freddie Warder, the former skipper of SEAWOLF. As a Captain and Squadron Commander, Freddie would influence Jim Calvert's career in most significant ways.

Jim relates many conversations with peers and seniors, recalling the gist when he could not remember the words exactly, but he is modest at the same time. After a casualty plagued second patrol which produced no sinkings, he quotes on page 103 from the War Patrol Report Endorsement which is critical of JACK's actions. What Jim did not do was quote from Commander Warder's Endorsement after the first highly successful patrol:

> "The excellent performance of JACK on her first patrol reflects the great zeal and industry of the Commanding Officer during the fitting out and training of this new thorn in the side of the Japanese. The Division Commander congratulates the Commanding Officer, Officers and Crew for their splendid ship, their fighting spirit and the results achieved." (Three ships sunk for 24,255 tons and one damaged.)

The Squadron Commander and Commander Submarines Pacific concurred.

To iterate, Jim Calvert has done a great job in telling his and JACK's story. I detected one technical error (missed by other experts). On page 66, he explains how torpedo depth was set at the TDC and transmitted electrically to the tube and torpedo. This is true, as he says elsewhere, of gyro angles. But NavPers 16164A, prepared by the Submarine School when I was the Officer-in-Charge in 1960, depicts how the depth is set manually at the tube, with interlocks preventing firing until the spindle is withdrawn.

I offer two comments, not criticisms. Because JACK concentrated on surface search and night surface attacks, there is some repetition in the telling of the exciting chases. Secondly, I know that romance sells books and the story of Kathie in Freemantle is true. Yet, perhaps because I knew the ever-smiling Nancy for so many years, I wish this aspect had been played down.

Finally, Jim's title suggests evasion after attacks, deep and quiet, until the Japanese ASW forces were discouraged by loss of contact and departed. In point of fact, that's not what JACK did. My title would have been Right Full Rudder, All Ahead Flank.

Now read what my category (5) lay civilian thinks about Silent Running.

As a civilian, I found Admiral Calvert's account of his experiences and that of his fellow officers and men aboard the submarine JACK to be both an engaging narrative that holds together like a novel and a retelling of patrols that forcefully drives home the realities of his boat, the sometimes faulty equipment and weapons, and the single-minded attention to sinking as much Japanese tonnage as possible.

Calvert was a junior officer on JACK from mid-1943 to near the end of the war when he was transferred to HADDO to be its Exec. There is very little humor in this book. Relief from the intensity of the hunt is provided by interesting commentary on the Navy's bureaucracy, particularly the Bureau of Ships, the modernizing of the boats between patrols, and the contributions of reserve officers.

What clearly comes through is the submariners' sense of purpose, discipline, leadership, and teamwork.

Admiral Calvert's writing is easy to read and ideas flow smoothly throughout. I read the book in two sittings—it is too good just to nibble at. ■

MEMBERSHIP APPLICATION

Individual Membership Rates:

Regular (including Retired Military)

- ☐ 1 year — $25.00
- ☐ 3 year — $68.00

Active Duty, students, and naval Reserve Active Status (Drilling)

- ☐ 1 year — $15.00
- ☐ 3 year — $41.00

Life Membership Rates: (ALL)

- ☐ 34 years and under — $585.00
- ☐ 35-50 years old — $475.00
- ☐ 51-65 years old — $320.00
- ☐ 66 years and older — $175.00

NAVAL SUBMARINE LEAGUE

Corporate Membership

1 - 50 employees	$ 400.00
51 - 100 employees	$ 800.00
100 - 500 employees	$1,200.00
over 500 employees	$1,600.00

Donor/Corporate Contribution

(in addition to dues)

- ☐ Patron — $1,000.00
- ☐ Sponsor — $ 500.00
- ☐ Skipper — $ 100.00
- ☐ Advisor — $ 50.00
- ☐ Associate — $________

<u>**Persons residing outside the U.S. please remit an additional $15.00 per year for mailing costs**</u>

The Naval Submarine League is a tax-exempt, Virginia not for profit corporation.

Two-thirds of Memberships Dues and 100% of donations are tax deductible

MEMBERSHIP APPLICATION

NAVAL SUBMARINE LEAGUE
P.O. Box 1146
Annandale, VA 22003
(703) 256-0891

Date ______________

I hereby apply for membership in THE NAVAL SUBMARINE LEAGUE. I certify that I am a citizen of the United States or a citizen of an allied country ______________

____
Signature

Name ______________________________
Rank, Service, if applicable

Address ______________________________

____

Phone (Business) ______________ (Home) ______________

Employer and Address ______________________________

____

____

Position/Title ______________________________

I was introduced to the Naval Submarine League by ______________

ENCLOSED MONIES

- ☐ __________ Membership Dues
- ☐ __________ Donation

See Reverse Side for Rates

Your membership will bring you ....

- The Submarine Review
- Avenue to keep current on submarine issues
- Ability to contribute to public awareness of submarine capabilities
- Association with a dedicated group of people
- Invitation to Annual Meeting
- Forum for Exchange of thought on submarine matters

MEMBERSHIP APPLICATION

Individual Membership Rates:

Regular (Including Retired Military)

- ☐ 1 year — $25.00
- ☐ 3 year — $68.00

Active Duty, students, and naval Reserve Active Status (Drilling)

- ☐ 1 year — $15.00
- ☐ 3 year — $41.00

Life Membership Rates: (ALL)

- ☐ 34 years and under — $585.00
- ☐ 35-50 years old — $475.00
- ☐ 51-65 years old — $320.00
- ☐ 66 years and older — $175.00

Corporate Membership

1 - 50 employees	$ 400.00
51 - 100 employees	$ 800.00
100 - 500 employees	$1,200.00
over 500 employees	$1,600.00

Donor/Corporate Contribution

(in addition to dues)

- ☐ Patron — $1,000.00
- ☐ Sponsor — $ 500.00
- ☐ Skipper — $ 100.00
- ☐ Advisor — $ 50.00
- ☐ Associate — $________

Persons residing outside the U.S. please remit an additional $15.00 per year for mailing costs

The Naval Submarine League is a tax-exempt, Virginia not for profit corporation.

Two-thirds of Memberships Dues and 100% of donations are tax deductible

NAVAL SUBMARINE LEAGUE
P.O. Box 1146
Annandale, VA 22003
(703) 256-0891

MEMBERSHIP APPLICATION

Date ______________

I hereby apply for membership in THE NAVAL SUBMARINE LEAGUE. I certify that I am a citizen of the United States or a citizen of an allied country ______________

____
Signature

Name ______________
Rank, Service, if applicable

Address ______________

____

Phone (Business) ______________ (Home) ______________

Employer and Address ______________

____

____

Position/Title ______________

I was introduced to the Naval Submarine League by ______________

ENCLOSED MONIES

☐ ______________ Membership Dues

☐ ______________ Donation

See Reverse Side for Rates

Your membership will bring you ....

- The Submarine Review
- Avenue to keep current on submarine issues
- Ability to contribute to public awareness of submarine capabilities
- Association with a dedicated group of people
- Invitation to Annual Meeting
- Forum for Exchange of thought on submarine matters

Johnson Controls... the acknowledged global leader for integrated facility management.

At Johnson Controls, we know leadership. And with more than 325-million square feet under our integrated facility management umbrella, we also know outsourcing.

How did we become the world-wide facility management leader? Well, we didn't do it alone — we did it in partnership with the best customers in the world. Thanks to our client base, including the U.S. Navy at Subase Bangor, Subase Kings Bay, the Atlantic Undersea Test and Evaluation Center, the National Maritime Intelligence Center and at Naval Air Station Patuxent River, we are now the acknowledged facility outsourcing provider of choice.

Why? Because our customers know that they can focus on their core competencies and missions while we focus on bringing innovation and efficiency to their facilities. And that's the Johnson Controls difference. We can do it all...and we can do it all very well.

Isn't it time to consider the acknowledged global leader for integrated facility management?

JOHNSON CONTROLS

NAVAL SUBMARINE LEAGUE
P. O. Box 1146
Annandale, Virginia 22003

NON-PROFIT ORG.
U.S. POSTAGE
PAID
PERMIT No.124
ANNANDALE, VA

Merrill H. Dorman
CAPT USN(Ret.)
7305 Colony Point Road
Norfolk VA 23505