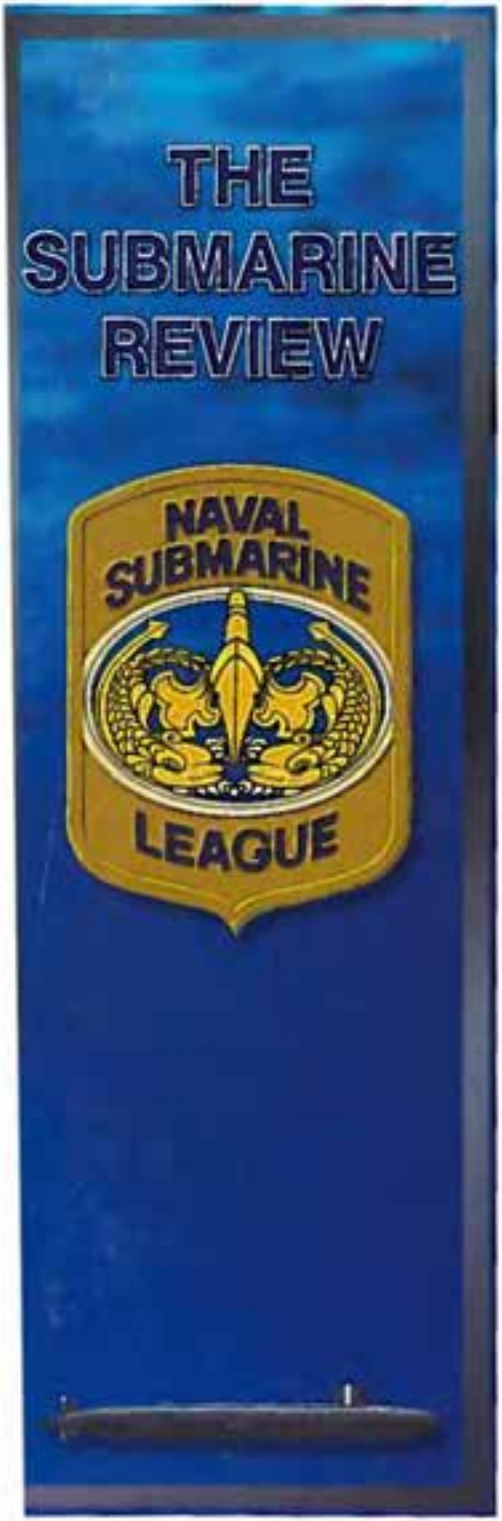

OCTOBER 2002

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Undersea Dominance for the 21st Century

EDITOR'S COMMENTS

This October 2002 issue of **THE SUBMARINE REVIEW** features four pieces for thought by all in the submarine community. The really big picture is illuminated for us by Captain Sam Tangredi, currently at the National Defense University and a frequent contributor to these pages. Captain Tangredi's subject is *Globalization* and he discusses both what that means and its effect on us. This subject is becoming ever more important to all. There have been major demonstrations against it and lots of words from the pundits about it–both pro and con. Perhaps all of that, however, has served only to cloud the two most important facts about *Globalization*: it is real and it is here. Captain Tangredi has addressed it in our own terms and has shown how it can be expected to influence all naval operations. The thoughtful planners among us will do well to read his article as one base for projecting future submarine needs and tasks.

A somewhat more focused view is offered by Captain Bill Norris in his comments of the future for submarines and their employment of nuclear weapons. Here again there are some facts to be recognized clearly before considering this facet of future planning. The first fact is that nuclear weapons are here and will not be dis-invented. The second fact is that they can be a prime response mechanism to the use of any *weapons of mass destruction* (the often mentioned and quite inclusive WMD) against America or its Allies. The third fact is that submarines, SSNs as well as SSBNs, are the first avenue for any future deployment/employment of nuclear weapons. This is clearly a subject worthy of thoughtful consideration, and just as clearly it is one not widely appreciated by many in the submarine community.

The third thought-piece in these FEATURES is about the question of **how many submarines we can get—and when.** That's really at the top of the list of concerns for anyone in the submarine community. Captain Mark Gorenflo has set out the problem in basic words and numbers. He has shown that getting to a force level of 68 SSNs first and upping that to 76 later, as the so-called

JCS Study recommends, will not be an easy sell for us nor any easy option for the Navy. In fact, he calls the use of those figures as a requirement a "non-starter". He makes the point with "radcon math" logic and we all should recognize that while the Joint Chiefs made a good, realistic estimate of the need for SSNs, if the nation's defense funding structure continues its normal path, it is for practical purposes an unachievable end. The companion point made here is that several things can be done to help correct the problem. Here again, the suggestions offered are clear, are doable and should be taken to heart.

The fourth FEATURE is by Rear Admiral John Butler on the efforts by NavSea's submarine technology folks to hasten the introduction of developmental hardware into the fleet. Rather than treat it as a brief by the leader of that group the **REVIEW** sets it with other important think-pieces because the heart of the matter is that technology is more than that which is currently available in hardware. Staying on the cutting edge of *what-can-be-done* and translating that in a meaningful, expeditious manner into *what-is-being-done* is a tough job which has to be a thorough and thoughtful team effort involving both sides of the Requirements equation. The policy people setting the *pull of needs* have to work with the hardware folks working the *push of capabilities*; and it has to be done in the cold light of best estimates of the far-term future as well as that which is visible on the horizon. Getting it done is probably more important than getting it perfect.

Among the ARTICLES of this issue can be found a lot more to think about as well. Rear Admiral Denny Dwyer, Director of Strategic Systems Programs, gives us an outstanding run down on the status of SSP's ongoing work and future directions. With responsibilities for both conventional and nuclear weapons systems, SSP is one of the technological leaders in the struggle for *transformation*. Admiral Dwyer's "State of the Programs" was put together for the annual in-house summary for his own team. It was recommended to us by several members familiar with those presentations as being one of the very best and of real interest to the wider submarine community.

Two skippers of Attack Submarines spoke to the Annual

Symposium in June and their "Comments from the Fleet" are also included here. One of the boats had been in the Med and Arabian Gulf in late 2000 and early 2001, returning to U.S. waters before the attack on 9/11/01. The other spent a full tour Indian Ocean and Arabian Gulf after the attack and during the operations into Afghanistan. Both COs had tales of "above and beyond" performance by their crews and both encountered new and different challenges due to the War on Terrorism, whether deployed and on the line or standing ready for a rapid re-deployment.

Dr. Anthony Wells comments more broadly on the War on Terrorism in his article U.S. Naval Power and the Pursuit of Peace. He specifically puts forth a wider field of view in which submarine capabilities and operations may be set in the context of WMD and international terrorism. His observations of the foundations in international law and precedent for action against those with both capability and intent to do harm are particularly timely.

And as a last exhortation to tough thought about the future read Dr. George Sviatov's piece about the newest Russian submarine and think what some of those performance specs mean to us. If all that heavy stuff about the future leaves you wanting a return to the good old days don't miss Captain Ned Kellogg's story of BONITA, of the little K-1,K-2 and K-3, class as a participant in the atom bomb tests of 1958.

Jim Hay

FROM THE PRESIDENT

The July issue of **THE SUBMARINE REVIEW** focused on honoring Admiral R.L J. Long, a mentor to many of us. I am pleased that we are able to continue tributes to him in this issue and commend them to your reading. Admiral Long had a tremendous impact on our Navy, the Submarine Force, and all of those fortunate enough to serve with him.

We have completed all our major events for 2002 and, by all measures, they were very successful. Our Submarine Technology

Symposium featured remarks by Admiral Vern Clark, the CNO, who commented on a wide variety of subjects, giving special attention to the future operations of the SSGN. Admiral Bowman's challenge to "Get Real", presented at STS, has been packaged with COMSUBPAC's remarks on current fleet needs into a special pamphlet that will be sent to our national leaders and decision makers.

The 20th Anniversary Celebration and Annual Symposium featured the presentation of our first Distinguished Submariner Award to Admiral James D. Watkins. Mrs. Janet Watkins graciously accepted the award for her husband. The Honorable Gordon England, Secretary of the Navy, addressed the attendees relating the relevance of the Navy and the Submarine Force to the war on terrorism.

The Annual Symposium had a record 27 exhibitors from our corporate benefactors, Navy activities, and two complimentary exhibits for the Dolphin Scholarship Foundation and Submarine Officers Wives Club of Norfolk with their Dolphin Store. We featured the introduction of our Centennial table book, *UNITED STATES SUBMARINES*, with a book signing and sales table where most of the Chapter authors were present to autograph their work. This year, during the annual symposium introductions, the concept of Breakout Sessions featuring the advanced technologies being developed by the submarine acquisition community was introduced. This effort was made possible by the support of six program managers, sponsored by RDML Mike Sharp, PEO Mine and Undersea Warfare, and RDML John Butler, Commander, Naval Undersea Warfare Center.

Our Awards program continues to identify superb candidates who represent the very best in our Submarine Force. Mr. James E. Turner, formerly the President and Chief Operating Officer of General Dynamics, was recognized as our Distinguished Civilian. This year's competition was reflective of those serving the Force with ten outstanding candidates considered for the award.

Finally, we conducted several business meetings starting with a first combined Advisory Board and Chapter Presidents meeting with the Chairman of the Board, Admiral Frank Kelso. This group

suggested that we review our mission and goals to ensure that the League is supporting appropriate activities and events and that our current bylaws authorize what the League should be doing. Our Board of Directors received several reports regarding League finances that were initiated early in the year. First, the Finance Committee reported the results of a thorough budget review that was able to reduce our projected deficit by about $40K. Second, the Board-appointed Finance Committee, headed by Tom Schievelbein, President of Northrop Grumman Newport News, reported the results of their review of the Corporate Benefactor Dues schedule. The subcommittee did excellent work and proposed changes to the dues structure. They also suggested that corporations be give the opportunity to sponsor specific events or functions. These changes have been submitted to the Board for approval and will be sent to our Corporate Benefactors as part of the 2003 renewal package.

We continue to e-mail regular NSL UPDATES on items of interest to all submariners. This mechanism is used to inform you of events by related organizations that offer opportunities for professional and social interaction. If you are not receiving these UPDATES, please provide the office your e-mail address and inform us of any change. Also, please keep your mailing address information current. We routinely receive returned mail and you miss out on the benefits of your membership because the USPS will not forward **THE SUBMARINE REVIEW** to a new address.

As we reflect on the current events in these uncertain times, we should continue to get the story out that the submarine is the "crown jewel" of our defense arsenal, and your Naval Submarine League will continue to promote the building, manning, operation and support of these superb weapon systems.

Jan and I wish you all a wonderful fall season.

J. Guy Reynolds

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FEATURES

GLOBALIZATION AND NAVAL OPERATIONS: SEVEN CRITICAL EFFECTS

by CAPT Sam J. Tangredi, USN

[Editor's Note: In November 2002, the National Defense University will publish a major study entitled "Globalization and Maritime Power." With initial funding from the Department of the Navy and contributions by over 30 noted experts, this book represents an extensive examination of the direct effects and implications of globalization for military (particularly naval) operations, including undersea warfare. The following article summarizes the seven "globalization effects" that form the research design for the study. Interested readers are invited to request a copy of the study by e-mailing its editor at <tangredis@ndu.edu>.]

Prior to September 11, 2001, many Americans viewed globalization as exclusively an economic phenomenon. Suggestions that globalization held profound national security implications were largely confined to debates that might be considered esoteric by those outside the defense intellectual community.[1] Publicists of globalization, such as journalist Thomas Friedman, did point to the "hidden fist" of U.S. military power as being critical for providing the global security necessary for the flourishing of democracy and free markets.[2] But even his (relatively few) cautionary comments seemed to be drowned out by the exuberant trumpeting of a world in which geo-economics had replaced geopolitics.[3] The idea that globalization, economic interdependence, the spread of democratic governance, and the development of a global-cosmopolitan culture, would all combine to make for a more peaceful world was becoming quite widespread.

As the expression goes, what a difference a day makes. The terrorist attacks of September 11 and the subsequent anthrax scare succeeded in making evident the dangerous *dark side* of globaliza-

tion to the American, and indeed, the world public. Global communications, efficient air transportation, borderless financial transactions, and the rights and freedom of movement afforded by democratic governance (even to non-citizens)—all considered practical attributes of the globalization phenomenon—were used to help kill thousands of people and strike at the symbolic hearts of American and global commerce and defense

Assessing the Problem

Recognizing the existence of potential security implications, the Institute for National Strategic Studies at the National Defense University commenced its study of globalization in 1999. Part of this research was funded by the Department of the Navy, ensuring a maritime flavor towards the examination of globalization and the national security decision-making process. The first phase of the project was a look at globalization from a grand strategy perspective and was published in June 2001 as *The Global Century: Globalization and National Security*. Among the implications identified in the first phase was indeed the impact of global terrorism as a prime transnational threat (obviously, no one predicted the form it took on September 11).

Later that year, work began on a second phase—an operational view of globalization effects, soon to be published as *Globalization and Maritime Power*. The primary challenge in crafting an operation view is to determine what, in fact, are the *direct effects* of globalization on military and naval operations (as opposed to merely the indirect effects of a changing global economy). Direct effects—if properly identified—are tangible factors upon which the Department of Defense could base its plans and force structure decisions. In that sense, the second phase study is an attempt to bring previously-identified theoretical insights to a level of analysis one step closer to that of actual defense policy-making. It is this effort at developing a sort of *news you can use* for decision-makers involved in determining the future of America's naval and maritime power that differentiates the second phase study from the myriad academic books concerning the popular subject of globalization.

What is Globalization?

The inevitable opening question of any such assessment is: *what exactly do you mean by globalization?* Some may see globalization as an ill-defined term, with myriad potentially conflicting definitions.

For the purposes of the *Globalization and Maritime Power* study, globalization is defined in two complementary ways. As a phenomenon, globalization is defined as a substantial (some would say unprecedented or exponential) "expansion of cross-border networks and flows."[4] Such "flows" may include the creation of a global financial market, expansion of democratic governance, or the increasing ubiquity of the internet and other forms of communications via modern information technology. Perhaps the simplest definition along these lines comes from scholars John Baylis and Steven Smith: "By globalization we simply mean the process of increasing interconnectedness between societies such that events in one part of the world more and more have effects on peoples and societies far away."[5] Although the U.S. Department of Defense has yet to formulate an official definition for globalization, the Defense Science Board provides one very close to Baylis and Smith, defining globalization as "the integration of the political, economic, and cultural activities of geographically and/or nationally separated peoples."[6]

Most scholars see previous eras of globalization (notably in the years prior to the First World War), but view the contemporary flavor as being unique due to the "revolution in information technology, accompanied by the spread of personal computers and the instant availability of information."[7] This revolution in information technology has a much-discussed counterpart—the *revolution in military affairs*. But whether or not contemporary globalization represents a historically unprecedented state of world affairs, it must be admitted that it does seem to lead to a fundamentally different international system than existed during or immediately following the Cold War.

This leads to the second, complementary definition: globaliza-

tion as the dominant element of the current security environment. Globalization can be seen as the defining aspect of the current post-Post Cold War international system, and therefore, an appropriate title for the system itself. The attributes of this contemporary international system—such coalition-building against global terrorism, or the cascading effects of regional economic crises in Asia or elsewhere—appear clearly entwined with the globalization phenomenon.

Globalization Effects on the Maritime World

These contemporary attributes are most evident in the direct and indirect effects of globalization on the maritime environment and on the military forces that operate in and from the maritime environment. Such changes become readily apparent due to the nature of the maritime world: through the historical evolution of international law, the oceans have effectively been *globalized* for over a century—that is, their use as what Alfred Thayer Mahan would call "the great common" has been open to all nations with the desire, access, and resources to master it. The maritime world can also be seen as a primary source—in recent parlance, a *root cause*—of globalization because it is the medium by which 90 percent of world trade (when measured by weight and volume) is transported. Without the method of oceanic trade, the barriers to global commerce would be insurmountable and the history of the world would have been vastly different. E-commerce and the internet may be the symbols of the most modern version of globalization, but historically the symbols have been the ever-increasing size and speed of ships and the shrinking cost of commercial transport. Ultimately, the open ocean is still the prime medium and symbol of globalization—for the *thoughts* transmitted along the internet must be translated into *products*, which must in turn be transported to far markets.

The nature of the maritime environment as *great common* also bears a striking similarity to the perceived nature of modern economic globalization—particularly as identified by globalization's discontents. The participants with the *access* and *resources* benefit

the most, even as all nations benefit to some degree. Developed economies appear to have benefitted more from globalization than the least developed economies—leading to questions of structural inequity. Likewise, those nations—sea power states—who have maintained the most powerful navies and/or most efficient shipping systems appear to have benefitted the most from the oceanic common, even as subsequent benefits can be identified in all nations, including the landlocked.

From this perspective, it can be said, *globalization begins at sea*.

Direct Effects on Naval Forces

Effects of Globalization on Maritime Power

1. **Increasing non-state and transnational threats to U.S. security**
2. **Increasing maritime traffic and trade.**
3. **Increasing American concerns about economic security.**
4. **Military (including naval/maritime) presence and intervention in locations not previously considered of vital interest.**
5. **New, unpredicted effects on alliances and coalition-formation and their maritime components.**
6. **Proliferation of information technology and high-technology sensors and systems.**
7. **Proliferation of advanced weapons systems and development of *anti-access* or *area denial* strategies by potential opponents.**

As explored in detail throughout *Globalization and Maritime Power*, there are at least seven categories of direct effects of globalization on the maritime environment and maritime/naval forces. These include:

1. A global security environment characterized by an increase in **non-state and transnational threats** to U.S. security. The most obvious of such non-state threats is global terrorism. However, other threats include global crime, drug trafficking, illegal arms transfers, illegal migrations, and international corruption. America's borders appear porous to certain of these threats. At the same time, all of these threats pose the potential for de-stabilization of the remote regions with which the U.S. economy is increasingly linked. Both vulnerabilities to and protections from these threats have maritime components. Some transnational threats, such as piracy, are almost exclusively maritime in nature.
2. Increasing **maritime traffic and trade**. Since tangible international trade is dependent on maritime transport, an increase in trade due to or as a means of globalization would naturally result in a corresponding increase in maritime traffic. Estimates of this increase vary; however, according to a U.S. Department of Transportation report issued in February 2000, global ocean-borne commerce is expected to grow 3 to 4 percent annually into the foreseeable future. Increased maritime traffic raises concerns about the safety of sea lanes of communications (SLOCs), and of transit through choke points—both from a safety of navigation and environmental protection perspective and from a national security perspective. In the light of the global terrorist threat, the security of the maritime transit lanes as well as the ports servicing international trade have become very serious concerns—concerns that were deemed almost inconsequential in the immediate post-Cold War years.[8] There are good reasons to see SLOCs and chokepoints as scarce resources requiring increased protection.
3. Increasing **American concerns about economic security**. These formerly submerged concerns have both specific and general elements. Specific concerns go hand-in-hand with the physical and indirect effects of increasing non-state and transnational threats. Can the U.S. economy weather successive terrorist shocks? The events of 9-11 have been

identified as deepening the chances of an extended recession. What would happen to the economy if there were severe attacks against economic infrastructure, such as the internet and global communication? Other concerns are related to the increase in maritime traffic and trade in light of threats posed by global terrorism. What about attacks on transportation hubs or utilities, particularly the few existing super-sized *hub* ports? Are the sea-lanes and straits through which passes international trade secure? General concerns include the question of whether the U.S. is gaining economic benefit from its current spending of defense, or whether such spending is a dangerous drag on an overburdened economy? Given that some increase in spending is needed for homeland security in the face of terrorist threats, is the rest of the defense budget—particular that for forward-deployed naval forces—being well spent? Are our defense industries being effected by globalization, and what are the effects on the economy as well as security? Is our environment—including the oceans—being imperiled by economic globalization? Whether or not these concerns are valid, they have obviously increased due to public perceptions of globalization.

4. Greater likelihood of U.S. **military presence and intervention in locations not previously considered of vital interest**, including regions in which maritime forces must provide the initial—and sometimes exclusive—means of applying joint military power. The interconnectedness of modern globalization, as noted by Baylis and Smith, is manifest in the cascading effects of regional conflicts. Intervention to prevent the globalization of such conflicts might take the form of peace-keeping, logistical support for local forces, or direct assault. As in Afghanistan—which, ironically enough, is completely land-locked—the significant portion of the initial forces are likely to be supported from a sea base composed of carrier battle groups (CVBGs) and amphibious ready groups (ARGs)—and supported by submarines in strike, special operations, intelligence and sea

control roles. The Bush Administration has expressed some skepticism on the effectiveness of peacekeeping and the need for U.S. involvement in several of the longer-term peacekeeping operations. However, the events of September 11 and the broad range of U.S. national interests suggest the assignment of even greater resources to the future contingencies in which the U.S. chooses to become involved.

5. New, unpredicted effects on **alliances and coalition-formation and their maritime components.** During the Cold War, alliance behavior was relatively predictable—there was an overshadowing threat that made close cooperation essential throughout NATO and its Pacific partners. Soviet control over the Warsaw Pact and what are now independent republics in Europe and Asia was repressive, but, again, predictable in ways that are not true of these regions today. With the overwhelming Soviet threat removed, old alliances take on new characters. Traditional allies, such as France—a nation whose 20th century survival twice hinged on U.S. involvement in world conflicts—suggest that U.S. *hyperpower* in the globalizing world has become disturbing. Unlikely allies, such as former Soviet republics have become supportive of U.S. military presence in their region. Coalition-building—such as the coalition supporting U.S. counter-terrorist actions—requires differing approaches and tools. One of these tools is naval cooperation, long a mainstay of NATO interoperability and the defense relationship with Japan. The use of naval cooperation and the peacetime engagement of U.S. maritime forces may need to take on new characteristics. In certain regions, such as the Western Pacific, naval operations may become the dominant, and in some cases, sole form of military-to-military cooperation with coalition partners. In a globalized world, U.S. naval forward presence—the peacetime posture of U.S. naval forces—may take on a revitalized role as an agent for political and economic stability. This naval component of U.S. overseas military presence has unique, and sometimes controversial, characteristics, which become even more

apparent under globalization.

6. A global security environment characterized by the **proliferation of information technology and high-technology sensors and systems**. This is an indisputable feature of military globalization and a premise of proponents of the concept of an ongoing *revolution in military affairs*. Information technology is obviously becoming more and more ubiquitous and much of it has military application—particularly in command and control and battle-management. The proliferation of commercial technology brings with it new forms of military-applicable sensors and intelligence, surveillance and reconnaissance (ISR) techniques. For example, satellite imagery has become commercialized. The global positioning system (GPS), originally designed for military navigation, is now the prime commercial global locating system, used to track shipments and direct transportation—both at sea and on land. The European Union has agreed to build a rival to GPS (Galileo) that may inadvertently make military-quality information available to rogue states.

The implications of the IT explosion goes far beyond the commercial effects which characterize economic globalization. IT and advanced sensors may not yet be able to *lift the fog of war*, but the use of commercial off the shelf (COTS) systems greatly enhances the military capabilities of many potential opponents—including global terrorists.

7. A global security environment characterized by the **proliferation of advanced weapons systems and development of *anti-access* or *area denial* strategies by potential opponents**, facilitated by the proliferation of high-technology information systems and sensors described above. The proliferation of advanced weapons systems, such as nuclear, chemical and biological systems as well as increasing numbers of ballistic missiles, has become a popular concern. Moving beyond the availability of these weapons, their integration with IT and advanced sensors to create advanced

anti-access or *area denial* systems may represent the true globalization of high-tech military power.

Obviously, it is possible to identify other effects of globalization that may impact the maritime world or categorize the effects described in a much different fashion. However, these seven effects seem an appropriate starting point for the examination of the implications of globalization for maritime power, and provide the underlying framework for the overall study.

Planning for the Future

Examining the effects of globalization is merely an academic exercise if it is divorced from real world planning. Up until now, the effects of globalization—as important as they have been on our economic prosperity—have not been identified in ways that they can be incorporated into defense planning. Globalization has been largely relegated to *buzzword* status. But in identifying and operationalizing the seven direct effects, the *Globalization and Maritime Power* attempts to provide guidelines for future decisions. For example, the increase in non-state and transnational effects (direct effect #1) would merit greater military readiness for counter-terrorism, counter-drug and counter-international crime operations. In the past, military involvement in such *non-military* missions was seen as diluting readiness from *real missions*. But, in a globalized environment, they are the *real missions*.

Likewise, an increase in maritime traffic and trade (effect #2) would seem to necessitate an increase in forces that protect that trade—both naval and coast guard. A robust fleet that provides for a visible, credible forward presence would appear a most useful tool for ameliorating economic security concerns (effect #3). Interventions in locations not previously considered of vital interest (effect #4)—such as happened in Afghanistan—would argue for a greater effort at sea-basing military assets in order to ensure that they are available even when land bases are too distant. Unpredicted effects on alliance and coalitions (effect #5) would seem to argue for more forward-deployed naval security cooperation efforts than less. At the same time, proliferation of high-technology sensors

and systems (effect #6), and especially, development of *anti-access* or *area denial* strategies by potential opponents (effect #7) argue for counter-measures and configuration changes in the future fleet.

Globalization and Maritime Power is intended to initiate the incorporation of globalization effects into such decision-making. But it is also intended to make scholars and non-military analysts of globalization recognize the importance that sea power, among other maritime elements, has in the globalization process.[9] Although none of the book chapters claim to be complete, definitive examinations of their chosen topics, they collectively provide an effective baseline for the analytical and political debate that is American defense planning can begin—in dealing with an ever-more globalized world and the inevitable reaction from its discontents. We would welcome feedback from the readership of **THE SUBMARINE REVIEW**.■

ENDNOTES

1. Studies that do examine the national security implications include: Richard Kugler and Ellen L. Frost, eds., *The Global Century: Globalization and National Security*Washington, DC: National Defense University Press, 2001; Andrew J. Bacevich, "Policing Utopia" The Military Imperative of Globalization," *The National Interest*, Summer 1999, pp. 5-13; Thomas P.M. Barnett and Henry H. Gaffney, Jr., "Globalization Gets a Bodyguard," U.S. Naval Institute *Proceedings*, November 2001, pp. 50-53; Paul Bracken, "The Second Nuclear Age," *Foreign Affairs*, January/February 2000, pp. 146-157; Jean Marie Guehenno, "The Impact of Globalisation on Strategy," *Survival*, Winter 1998/1999, pp. 5-19; Thomas Keaney, "Globalization, National Security and the Role of the Military," *SAISphere* [electronic version], Winter 2000, www.sais-jhu.edu/pubs/saisphere/winter00/indexkk.html; Michael Renner, "Alternative Futures in War and Conflict," *Naval War College Review*, Autumn 2000, pp. 45-56; Kenneth N. Waltz, "Globalization and American Power," *The National Interest*,

spring 2000, pp. 46-56.
2. Thomas L. Friedman, *The Lexus and the Olive Tree*, revised ed., New York: Anchor Books, 2000, pp. 464-468.
3. One of the first to state this boldly was Edward N. Luttwak in Luttwak, "From Geopolitics to Geo-Economics," *The National Interest*, Summer 1990, p. 17-23.
4. Ellen L. Frost, "Globalization and National Security: A Strategic Agenda," in Richard Kugler and Ellen L. Frost, eds., *The Global Century*, p. 37.
5. John Baylis and Steven Smith, eds., *The Globalization of World Politics*, Oxford: Oxford University Press, 1997, p.7.
6. U.S. Office of the Secretary of Defense, Defense Science Board Task Force on Globalization and Security, *Report of the Task Force on Globalization and Security*, December 1999, p.1. Also cited in Frost.
7. Frost, p. 38.
8. See, for example, the views expressed in several sources cited in Chapter 8—particularly John H. Noer and David Gregory, *Chokepoints: Maritime Economic Concerns in Southeast Asia*, Washington: NDU Press, 1996—which imply that the closure of individual chokepoints, such as the Straits of Malacca, have but a marginal effect on overall world trade.
9. For a discussion of a modern, broad definition for sea power, see Sam J. Trangredi, "Sea Power—Theory and Practice," in John Baylis, James Wirtz, Eliot Cohen, and Colin S. Gray, eds., *Strategy in the Contemporary World*, New York: Oxford University Press, 2002, pp. 111-136.

WHITHER THOU GOEST?

by CAPT William L. Norris, USN(Ret.)

Captain Bill Norris is a retired submarine officer with long experience in the nuclear weapons field, both while on active duty and as a civilian.

It appears that the major strategic arms initiatives of the new Bush administration have played out for the near term. Perhaps it's time to step back and look at the brave new world in which we find ourselves and where it might be headed.

The combination of the second nuclear posture review and the new strategic nuclear weapons treaty with Russia should characterize the forces we will see in place in 2012. At that time, the oldest of the 14 remaining Tridents committed to strategic deterrence will be nearing 30 years of their projected 40-year life. That is a much easier statement to make than what will be the state of the world. Will Russia continue along its friendlier road and no longer be the monolithic enemy that has defined our strategic force requirements? Will China still be an old guard Communist country that is more our enemy than friend? Two things are probably certain as we begin to think about the next generation of SSBNs and they are that there will still be nuclear weapons in the world and the SSBN will still be the most survivable, credible deterrent platform.

But if we assume that it is more likely that Russia will be our friend and that China will not yet be a monolithic threat, then that deterrent's capabilities will be different. With Russia removed as a threat, and probably less capable, our strategic submarine forces should be more secure. Even in 2012, China will probably have less global capability than Russia did in 1989 as the Cold War ended. In this projected environment, it is likely that there will be a move to further reduce the numbers of our nuclear forces. At some point, these reductions will lead to the removal of one of the historic legs of the Triad. One would hope that the Submarine Force would be able to modernize and revise its SSBN capabilities such that it would become more *dual or multiple capable* . The

bombers already have that capability but the ICBMs probably can't and won't.

What do I mean by *dual or multiple capable* forces? Historically we have argued that SSBNs are multi-capable because they have torpedoes that can be used tactically before or after their strategic capabilities are needed. Historically, we have seen since 1989, the likelihood of a torpedo being needed from the SSBN has significantly decreased and our existing and future SSN forces should be adequate. I believe that multiple capable forces, in this case, will mean forces that are able to operate across the expected spectrum of nuclear weapon requirements, from being part of the future Single Integrated Operation Plan (SIOP) to being able to conduct a precision strike against a single deeply buried target.

Many will properly claim that the Trident can already perform this variety of missions. Their fire control flexibility allows onboard retargeting as required. While this is true, there are several problems with the use of a Trident missile against a single target. First the submarine must be positioned so that the first and second stages do not fall in areas that could cause unintended or undesired consequences. This might even preclude its use against some emergent targets. Second, there is more than one warhead mounted on each missile and therefore we are *wasting* capability. Third, a Trident might still cause anyone with launch warning systems to misinterpret this as a strategic launch. Fourth, this is a very expensive, albeit timely and high probability of arrival, system with which to attack a target.

So what capabilities might we consider designing into the next SSBN or back fitting into our existing Trident? First, we might work with the nuclear laboratories to modify the existing warheads to provide less yield. This would allow success against many potential targets while reducing potential collateral damage. While this is not trivial, there is strong resistance in Washington to *new* weapons. The stockpile we have is probably the one with which we will have to live. The U.S. nuclear weapons community has some experience in this, as previous nuclear test treaties required this type of modification for existing weapons to be tested and be under the upper limits of yield. With probable reduction of SIOP

requirements and patrol area restrictions, it is possible that several tubes could be loaded with reduced yield weapons without compromising the SSBN's principal mission.

Second, the nuclear Tomahawk role is presently a reconstitution capability for our SSNs.

I guess I'm one of those who believe that the further this moves from a real capability, the less likely its use and the more likely its use will fail. On the other hand, the nuclear Tomahawk provides a highly accurate, single warhead option. If we look at this brave new world ahead, it is also likely that if it were ever to be used, it would be in a fairly benign environment in which modifications to its guidance system could make it even more accurate. It is even probably possible to modify its structure and final flight profile to give it some capability against buried targets. Presently, we can fire it out of a torpedo tube or a vertical launcher and are working on adapting it to the Trident tube. Clearly then, modifications of existing Tridents would allow nuclear Tomahawk to be deployed on them in the near term and any of these three capabilities could be built into the next SSBN. Tomahawk also provides a respectably long-range capability with no concern for where stages might fall. Passing this capability to the SSBN would reduce the taskings for the SSNs.

Third, other weapon systems and their warhead capabilities might be modified so they can be used by the Trident or future SSBNs. I believe that some work has already been done on the Army's ATACM. I'm sure that the SSBN project office has looked at many future capabilities that the Trident missile might be given such as single warhead uses and ability to be used against deeply buried targets. One might even envision its use as an ABM platform. With its existing communications connectivity and forward deployment, it's probably more capable against many future threats than the planned land based sites. I'm sure that many of you forward-looking thinkers out there can think of many others.

The point of this article is that the Trident is already an extremely capable and flexible national asset that can be made even more so. The war on terror and the peacekeeping missions are

detracting attention from the importance of nuclear weapons and making them possible targets for money for other programs. The SSBN has potential that neither the ICBMs, for sure, nor even the bombers can match. The brave new world will be a different place and the first to be there with the most attractive capabilities can be the winners (and survivors).■

IN MEMORIAM

Mr. Floyd J. Cook
MMCM(SS) John Headden, USN(Ret.)
CAPT Franz Hoskins, USN(Ret.)
CAPT Thomas M. Jaskunas, USN(Ret.)
CAPT Stephen S. Mann, Jr., USN(Ret.)
CDR John S. Mitnik, USN(Ret.)
CAPT Tom B. Thamm, USN(Ret.)

SUBMARINE FORCE STRUCTURE: AN EXERCISE IN APPLIED RADCON MATH

by CDR Mark L. Gorenflo, USN

With the end of the Cold War and the demise of the Soviet Union, the nation declared a peace dividend for the decade of the 1990s. All of the Armed Services were reduced by about a third; investment in the procurement accounts declined even more drastically. With the end of the open ocean, blue water Soviet Navy submarine threat (the widely perceived *raison d'etre* of our Submarine Force), the United States Submarine Force became a bill payer of choice for strapped Navy programmers and Congressional staffers for the appropriations and authorization committees. This decision was codified in the notorious *back of the envelope* calculations behind the 1997 Quadrennial Defense Review, which pegged Submarine Force structure at 50 SSNs. Thus, as the Submarine Force approached a century of service to the Navy and the Nation, it faced the greatest downsizing since World War II:

	1990	2000
Total Submarine Force Personnel	60,000	20,000
Attack Submarines	100	54
Ballistic Missile Submarines	42	18
Submarine Tenders	12	2

During the latter half of the 1990s, it wasn't even clear to some observers inside or outside the Submarine Force that the 50 SSNs set down in the 1997 QDR represented a floor or a ceiling. Possibly the only reason it remained a floor in the near term was that we were decommissioning submarines about as fast as we could—we just couldn't get rid of them any faster without simply tying them up pierside, Soviet style, to await their demise in the public shipyards capable of breaking them up.

And yet, to Fleet submariners, their services seemed more "in

demand" than ever, at least when viewed in terms of sea time. As the value of submarine intelligence, surveillance and reconnaissance (ISR) became ever more apparent to the Unified Commanders at the front lines of an increasingly confusing, dynamic and unstable world scene, demand for their services rose beyond levels previously seen in the Cold War.[1]

Concurrently, a "counter reformation" in thinking about submarine force structure was launched, beginning the advocacy for more, rather than fewer attack submarines.[2] The double high water mark of this counter reformation was achieved in the Defense Science Board "Attack Submarine of the Future" study of 1998 and the Joint Staff Attack Submarine study of 1999. Drawing heavily on the requirements elaborated by the Unified Commanders, and in particular the ISR contributions provided by SSNs, the JCS SSN study provided a rational and analytically justifiable basis to argue *up* from the 1997 QDR 50 SSN force structure goal. In fact, it explicitly justified, on its own terms, a force structure of 68 to 76 SSNs and concluded that a force structure below 55 SSNs in 2015 and 62 in the 2025 timeframe would leave the Department of Defense with insufficient capability to respond to urgent crucial demands without gapping other requirements of high national interest.[3] With this new thinking about submarine force structure, which explicitly recognized ISR, strike contributions and peacetime presence as the principal drivers for force structure, rather than war plan execution, the stage was set to recapture Submarine Force assets—deemed "a crown jewel in America's arsenal" by the

[1]ADM Frank Bowman, USN, "Submarines in the New World Order", *Undersea Warfare* (Spring 1999), www.chinfo.navy.mil/navpalib/cno/n87/usw/issue_3/contents.htm.

[2]CDR Mark Gorenflo and CDR Michel Poirier, USN, "The Case for More Submarines," *Undersea Warfare* (Winter 1999), www.chinfo.navy.mil/navpalib/cno/n87/usw/issue_6/contents.html.

[3]An unclassified summary of the classified 1999 CJCS Attack Submarine Study can be found at www.chinfo.navy.mil/navpalib/cno/n87/themes/forcester.html.

influential Defense Science Board.[4] Inactivations were converted into refueling overhauls, ballistic missile submarines deemed surplus to strategic requirements were slated to convert to Strike/Special Operating Forces (SOF) SSGNs—or guided missile submarines, and the goal of building 2 Virginia class SSNs per year became a focus of Submarine Force programming efforts. This build rate is about what the Submarine Force needs over the long term to maintain a steady state force structure of about 60 SSNs [steady state force structure = (build rate) X (design hull life). In this case: (2 Virginia class/year) X (30 years/hull) = 60 SSN steady state force structure].

It is at this point that unpleasant fiscal realities intrude. Desirable as more attack submarines may be to our warfighting Unified Commanders, they don't have to deal with the challenges of resourcing them. In fact, they don't deal in a responsible sense in resource issues at all, that being the Title X "provide, equip, train and maintain" responsibility of the Service Chiefs. The dysfunctionality of this division of labor is a topic for another time. Suffice it to say that the Unified Commanders want *more* of *everything*, *now*. They are never faced with the challenge of balancing one program versus another or of balancing current risks versus future risks; their timelines rarely extend beyond the fiscal year, let alone the Future Years Defense Plan. By stated Unified Commander requirements, we should have 15 carrier battle groups and 14 or 15 (depending on whether you believe the Navy or the Marine Corps analysis) Amphibious Ready Groups, as well as 68 to 76 attack submarines. Clearly, we don't have these assets very simply because we cannot afford them. So, relying on *Unified Commander requirements* as a *trump card* in resourcing decisions is a non-starter.

Here's where some RADCON math, applied to the Navy program, shows us the magnitude of the problem the Submarine

[4]Report of the Defense Science Board Task Force on Submarine of the Future, July 1998, Office of the Undersecretary of Defense for Acquisition and Technology, www.fas.org/man/dod101/sys/ship/docs/soft.htm.

Force faces:

- In general terms, the Navy gets about $100 billion per year in its Total Obligation Authority or TOA. While there is some prospect for this number to grow in real terms over the Future Years Defense Plan (FYDP)[5], let's assume that Navy TOA will remain constant in real terms over time.
- Of this $100 billion, about 10% ($10 billion) goes to the Ship Construction and Conversion accounts (known in programming parlance as SCN). Now the small proportion of Navy TOA that goes for this key investment is controversial (some would say shocking) in and of itself. [6] But that's what the numbers say today.

  Let's assume, for convenience of calculation, a Fleet size of 300 combatant ships, with *about* 50 SSNs.
- Let's assume that the per ship cost of a new construction Virginia class submarine is about $2 billion dollars.
- Finally, let's assume that, over the long haul, the Submarine Force proportion of SCN funding will roughly track the proportion of submarines in the combatant fleet.

  Now, any of these assumptions could be challenged, but they represent a good "order of magnitude" reflection of fiscal reality, at least good enough to pass muster in a RADCON seminar.

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[5] The FY2003 President's Budget submission for the Navy budgets $108.3 billion in FY03, growing to $134.1 billion in FY07. Details can be seen http://navweb.secnav.navy.mil/pubbud/03pres/highbook/03Highlights.htm.

[6] See for example "Navy Shipbuilding Cutbacks Challenged," Associated Press, quoted in *The Herald* of Everett, Washington (February 7, 2002), http://www.heraldnet.com/Stories/02/2/7/15121278.cfm. Sample quote: "'The trend in shipbuilding worsens in this budget,' Rep. Ike Skelton, top Democrat on the House Armed Services Committee, told Defense Secretary Donald Rumsfeld at a hearing Wednesday. 'The request for five new ships again falls well below replacement rates and continues the dangerous trend that will soon bring the United States to a 200-ship Navy—a level totally inadequate for the protection of sea lanes and other American interests,' said Skelton, D-Mo."

Given these assumptions, the long-term force structure challenge facing the Submarine Force become absolutely stark:

- Right now submarines comprise about one sixth of the combatant fleet (50 SSNs divided by 300 total combatants).
- Based on our SCN assumptions above, over the long haul, the Submarine Force should rate one sixth of the SCN TOA = 16 percent of $10 billion = $1.6 billion per year in new construction funds.

$1.6 billion per year won't even pay for 1 Virginia class SSN. And no CNO would dedicate 40% of his SCN account to buy 2 Virginia class SSNs per year to recapitalize 16 percent of the Fleet. These numbers are bad and no amount of quoting *requirements* will change them. We need a different strategy if we expect the Submarine Force to maintain itself in the Navy of tomorrow in anything like the same proportion as today.

As with many problems, solutions come in bite sizes (billion dollar bite sizes to be sure) rather than one big chunk or one silver bullet. Here are some things that need to be done:

- **Grow over all Navy TOA.** With a Global War on Terrorism, the identification of an axis of evil states pursuing interests inimical to our own using horrifying weapons of mass destruction and the longer term challenges posed by regional hegemons or near peer competitors, the case for this argument has never been better. The case for more resources for our Navy, the Shield of the Republic[7], both in absolute terms and relative to our sister services, is an easy one to make and Navy leaders of all stripes should be making it, in every available forum, all the time.
- **Grow the SCN account within the Navy's TOA.** This is a clear priority of the Secretary of the Navy and the Chief of Naval Operations. They both committed in their Congressional

[7] I borrow this epithet from Michael T. Isenberg's history of the Navy from 1945 to 1962, *Shield of the Republic*, St. Martin's Press, New York, 1993.

budget testimony this year to find more resources for shipbuilding.[8] This will require some hard decisions by Navy leaders, including Submarine Force leaders. Ruthless vertical cuts in certain programs will be needed to find the resources in the near term. In the longer term, the Navy will absolutely need to reduce personnel end-strength, which threatens to consume ever larger proportions of the Navy's TOA. While submarines are inherently efficiently manned, we will need to do more to help keep this cost under control.

- **Stop the bleeding in the Virginia program.** Costs continue to rise in this program, jeopardizing the long term viability of the program. For various reasons—none of them having to do with new requirements imposed by the Navy—so called *prior year* construction costs are presented to the Navy as additional bills for the Virginia class program (VIRGINIA is not unique in this respect—so-called prior year shipbuilding costs imposed a $700 million dollar bill on the Navy in FY 02 with another $645 million bill budgeted in FY 03).[9] This simply has to stop or we will never get to 2 Virginia class per year, ever. This is a problem for the entire defense industry. While Sailors have been asked to do more with less for the last decade, the defense industry has produced less for more, at a huge expense to the Nation in direct costs per weapons system as well as in huge tax subsidies to defense companies during the downsizing of the defense industry in the 1990s. It's time for the *businessmen* in the defense industry to do some of that *business thing* and deliver a product on time and within budget.
- **Deliver JIMMY CARTER on time and on budget.** If we can't deliver SSN 23 and 1 Virginia class SSN from the

[8] See, for example, ADM Clark's testimony on the Defense Authorization Request for FY 2003 before the Senate Armed Service Committee on 7 March 2002, at http://www.chinfo.navy.mil/navpalib/cno/testimony/clark-sasc020307full.txt.

[9] See the testimony of John Young, Assistant Secretary of the Navy for Research, Development and Acquisition before the House Armed Services Subcommittees on the FY 2003 Navy/Marine Corps Acquisition Programs, 6 March 2002, www.chinfo.navy.mil/navpalib/people/assistsecnav/asn_asnrda/young020306.txt.

industrial base we have now on time and on budget, no one will believe we can deliver 2 Virginia class per year. This will be our first test. We need to get it right.

- **Deliver our 4 SSGNs on time and on budget.** Enough said on timely delivery within a budget.
- **Lobby hard to accept the proposed A12 Settlement.** This unsuspected windfall promises to save substantial funds in key procurement programs for the Navy, including the Virginia class.[10] It's rare that submariners can benefit from the programmatic misfortune of aviators. Let's jump on this chance now, before funding the Flying Hour program consumes further billions in Navy TOA or before the Treasury and Justice Departments claim the windfall for their accountants and lawyers.
- **Start building the argument now for 4 more SSGNs.** With the recent treaty signed between the United States and Russia committing to substantial reductions in strategic nuclear weapons[11], the handwriting is on the wall for a 10 boat SSBN force. This will free 4 SSBNs for conversion. The Navy should convert every one of them to SSGNs. Let's start making the case now. With a lot of the preliminary research and design work done, those sunk costs can be amortized over 8 hulls versus 4. Furthermore, with 4 more conversions, we should be able to benefit from shipyard *learning curve* efficiencies on the second squadron of SSGNs. Besides affordably funding 2 Virginia class per year, this is the best chance we have over the mid term to grow the non-strategic submarine portion of the Submarine Force.
- **Assign our best Sailors to the SCN Campaign** . We abso-

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[10] Robert Hamilton, "Virginia Subs May Get Boost", *New London Day* , May 2002..

[11] Dana Milbank and Sharon LaFreniere, "U.S., Russia Agree to Arms Pact," *Washington Post* (14 May 2002), Page A-01, http://www.washingtonpost.com/wp-dyn/articles/A11512-2002May13.html

lutely need to succeed in this construction and conversion campaign. Many submarine organizations will need to contribute to this success:

- NAVSEA 08
- NAVSEA's Team Submarine acquisition community
- The local Naval Reactors Representatives
- The local Supervisors of Shipbuilding
- The Commanding Officers and Prospective Commanding Officers of both new construction submarines and submarines in conversion.

All of these entities must work *together* to succeed. They need the best talent available. Furthermore, we need to ensure our best leaders are rewarded for success in these jobs. Currently, there are no submarine Flag Officers who served as first tour new construction PCOs. This clearly transmits the message that these jobs aren't as important to the Submarine Force as others. I would submit that they are now *critical* to the long term health of the Submarine Force, so we better detail and promote accordingly.

As in any RADCON math exercise, some of the arguments are crude and some of the figures could be sharpened up. But the general outline of the force structure challenge facing the Submarine Force is clear. Reciting a mantra of Unified Commanders' requirements as if it were the Six Factor Formula will avail us little in programming battles where it's all about the money. Let's find ways to grow the available pot of money even as we impose the kind of discipline on procurement for which submariners are renowned in engineering and operations.

Beyond this, we need to build the case for submarines *within the Navy*. The Submarine Force captured the imagination of the Defense Science Board in its look to the attack submarine of the future. The Submarine Force presented a compelling case for the value of submarine based ISR to Unified Commanders and the Joint Staff during the CJCS Attack Submarine Study. The Submarine Force was extremely successful in selling the SSGN concept to Congress, defense think tanks and the Office of Secretary of Defense. That campaign resulted in saving the

wonderful Ohio class platforms for future innovative service as SSGNs. And yet none of these efforts have gained real traction with our professional peers in the Navy. It is a common perception among OPNAV action officers that, with more Tomahawk launcher cells in the Fleet now than Tomahawk missiles in our inventory, the last thing we need is the 600 plus more empty launcher cells provided by 4 SSGNs. The SSGN is viewed as a systemic threat to the strike-fighter aviation Navy (due to its strike role) and a fiscal threat to the surface Navy (due to the portion of SCN devoted to the SSGN conversion). The fact that the SSGN *unwarned strike* concept of operations complements other Navy strike assets is either unknown or not believed by a Navy which views all *anti-access* threats as an Air Force QDR 2001 ploy. The concept of a SOF campaign from an SSGN is frankly scoffed at. And the truly transformational work that the Submarine Force is engaged in to use the SSGN as a platform for experimentation in submarine payloads is a compelling story that has yet to see the light of day. As a result, we will get 4 SSGNs because OSD will force them on the Navy—but they will come at a price for the Submarine Force, a price levied by our Navy peers who think the SSGN robs them of resources (which is untrue—the money for their conversion came from the submarine resource sponsor aided by a Navy topline plus up from an OSD leadership which believes in the project).

Similarly, many in the Navy have no appreciation for submarine ISR, because few have ever seen the results of such efforts due to security compartmentalization. Quite frankly, such widespread compartmentalization of submarine ISR results has to end soon. In a Navy premised on *network-centric operations*, where data from all sources is shared widely with those who need it, the kinds of intelligence compartments that grew up in the Cold War environment need radical revision. The good news here for the Submarine Force is that this is not just our problem—it applies to the entire intelligence infrastructure. Indeed, it's a central conceptual challenge of network-centric warfare. Without submarines as the stealth arm of the Naval battle network, the

Navy loses out tactically and the Nation loses out strategically. We should take the lead in fixing the compartmentalization and data latency problems and work to share the results of our ISR efforts with our service peers. The more exposure aviators and surface warriors get to the data provided by their submarine brethren, the better for the long term health of the Submarine Force. All of us in the submarine business know the value of what we do. Without the ability to share that knowledge, however, we not only raise questions about our tactical utility, we sow the seeds of our long-term decline.

Finally, as part of any campaign within our Navy, we should position the Submarine Force as the community of choice for dealing with any threat under the surface of the water, as well as for delivering the unwarned strike the Nation will need in the future, whether that results in a Tomahawk strike or a SOF campaign. We should actively campaign to take on the mine warfare mission. With a submariner in command of Mine Warfare Command, we are in a unique position to do so. Surely no one could claim that the Surface Navy has made sense of this problem. And despite the continuing *angst* over the threats posed by adversary submarines, no other community is doing anything to take on that challenge. The aviators will neck down to P-3s as their only credible ASW asset, and that asset will spend most of its time doing some kind of non-ASW ISR. And the Surface Navy has no credibility in ASW, either operationally or programmatically (though they promise that the Littoral Combat Ship will tackle the littoral ASW threat, I'll believe it when I see it.). By contrast, with ARCI and TB-29 sonar assets today and the Virginia class for the future, the Submarine Force has both the operational chops and the programmatic substance to take on ASW. Let's take on the challenge of defeating all undersea threats for the Navy and apply our intellectual capital to defeating them.

To conclude, the Submarine Force has made tremendous strides in transforming itself from the exigencies of defeating a Soviet blue water submarine threat to tackling the more complex challenges of littoral warfare. One analyst has publicly lauded our imagination

and focus in these efforts.[12] And yet, these efforts are either unknown, ignored or not believed by our Navy peers. As a result, we will find ourselves on a resourcing downslope unless we can make a compelling case for the submarine contribution to our Nation's defense *among our own peers*. Working with them, we also need to grow resources for the Navy at large, find more money for the Navy's procurement accounts *and* find a way for the defense industry to deliver a product on time and within budget. Otherwise, we will only build one submarine per year forever, as we are tantalized with the promise of more resources in the outyears of the FYDP. Unless we want a Navy of 30 SSNs, we have some work to do.■

[12] COL Robert O. Work, USMC (Ret.) "*The Challenge of Maritime Transformation: Is Bigger Better* ", (Washington , D.C.: Center for Strategic and Budgetary Assessments, 2002) p. 74.

NEW DIRECTIONS IN SUBMARINE TECHNOLOGY

by RADM John D. Butler, USN
Navy League Breakfast
May 28, 2002

As I stand before you, I feel like the author of a new book at the first stop on his promotion tour. Just last month, in the Naval Submarine League's April issue of THE SUBMARINE REVIEW, I began a discussion on *Transformation*.

Today, while I continue this discussion, I want you to think about the popular television series Star Trek. Every episode opened with the challenging mission statement for the Starship ENTERPRISE to "boldly go where no man has gone before."

Now, sit back, get comfortable, and buckle up, while I tell you about my mission to develop new directions in submarine technology so tomorrow's submarines "can boldly go where no submarine has gone before."

In my article *Coming of Age: The SSGN Concept*, I used the word "Transformational" to describe the impact of the SSGN program on the submarine's evolution from yesterday, to today, and into tomorrow. In that article, I defined "Transformational" as the opportunity to "reinvent the wheel" without having to build a new one.

To show how we have done this successfully in the past, I gave the example of how the Navy converted USS TUNNY to carry the Regulus Missile. This conversion changed the ship's mission from an open ocean attack submarine to one of strike warfare. Adapting TUNNY, and later BARBERO, to carry the Regulus missile was an evolutionary concept in both construction and tactics. It is certainly a good example of a bold step moving the submarine in a direction "where no submarine had gone before."

Later, the Navy experienced another bold step for submarines by developing the Polaris missile system that allowed the submarine to assume a strategic deterrence mission. The Polaris intercontinental ballistic missile carried by the then new fleet ballistic missile submarines eventually became the mainstay of the nation's strategic deterrence force. Today, different from any

submarine that existed before, the SSBN with its Trident missile system is now the linchpin of our nation's strategic deterrence.

Over the past decade, the Cold War missions of the nation's submarine fleet have been substantially altered. In response, submarine technology is taking on a new focus. How the Navy will transform today's capable submarine platforms to meet tomorrow's new warfare challenges is an emerging vision we understand, as we remain flexible to change with changing times.

Change or not, we of the Undersea Technology Directorate know that tomorrow's warfare will take us into waters to perform missions which no submarine has done before. Today, fertile imaginations are working hard to make the next bold step. Today, we have begun the transformation of our existing undersea warfare assets to meet new missions. Today, the role of the submarine in strike warfare is growing. Tomorrow, it will combine with new technologies in intelligence collection, surveillance, and reconnaissance to provide the full spectrum of capabilities from information and special warfare to tactical response all from a single platform that can go places where others cannot, always remaining covert—and never denied access.

As I said in my article, "Transformational" is the right word to describe the enormous advances we need in undersea warfare. In that article, I mentioned that the Secretary of Defense's effort to transform America's Armed Forces includes a reexamination of how we use the resources we currently have available; developing new ways of thinking, and new ways of fighting, using our existing assets in previously unimaginable ways. This is particularly valuable to our taxpayers when it comes to hard, high value assets—weapons, systems, and platforms such as our Ohio class SSBNs. From that perspective, the SSGN conversion concept fits Secretary Rumsfeld's definition of Transformation to a "T"! This is because the SSGN conversion program takes an existing platform with existing weapons and recreates the entire package into something completely new and different. It remolds the SSBN to perform an entirely new SSGN mission—one never envisioned by its designers. And, we are doing it for a fraction of the cost of

developing a comparable platform from scratch.

It does not take much imagination to realize that the one thing a Trident SSBN has is SPACE. The payoff to the Navy by transforming the SSBN into an SSGN platform is PAYLOAD. This payload and sensor space offers us the opportunity to provide a very capable, and highly adaptable platform for conventional strike warfare and for the conduct of special warfare operations. As such, the SSGN concept easily emerges as a way for the Navy to use our Ohio class submarines for many years to come, simply by converting them from the Trident system to other weapon and sensor systems to accommodate new missions and tactics.

Conversion of four ballistic missile submarines into SSGNs starts with USS OHIO and USS FLORIDA. These first two conversions will get underway with these submarines' scheduled engineered refueling overhauls.

It is important to remember that the SSGN payload concept is being developed to take advantage of technologies and hardware that already exist—conforming to the essential concept of transformation as defined by the Secretary of Defense. For initial delivery, we are not seeking to create new weapons for the SSGN. The beauty of it is that we don't have to. But be aware, we are not going to limit the SSGN just to the Tomahawk. If we do, we will under-exploit a major opportunity.

We are already working to demonstrate adaptability of other existing weapons systems to the SSGN. Weapon payload options are being designed as modular units that provide a flexible interface between the sea and the ship. A real near-term benefit to the Navy, the SSGN conversion program provides us with opportunities for the early demonstration of flexible modules. This SSBN to SSGN transformation gives us the chance to prove our concepts and field new technologies ahead of anticipated schedules. An accelerated schedule where the SSGN is our transformational platform for demonstrating new payloads for future incorporation into the Virginia class submarines.

For example, our upcoming January SSGN payload demonstration,... also known as *the Bowman Challenge*, will deploy an existing unmanned undersea vehicle from a D-5 missile tube. This

UUV will carry various existing intelligence, surveillance and reconnaissance packages. Down the road, we also plan for the launching of a UAV from a submerged submarine in an expendable capsule. These two efforts will be a major step toward the future.

When these demonstrations complete, the submarine will be able to extend its reach into waters, air, and land areas where the submarine has never reached before. We will have made our first giant step toward providing battlefield surveillance, special operations force support, and decoys covering the entire battlefield. This is just the beginning of our transforming submarine platforms to support new missions.

The submarine, with its ability to remain on-station for months at a time, offers joint expeditionary force commanders the possibility of something we've never been able to adequately do before. It provides a vastly increased capability in preparing the battlespace.

Let me give you some examples of expanded battlespace preparation. Advanced underwater mapping and mine reconnaissance using semi-autonomous, hydrographic, reconnaissance vehicles, expands submarine surveillance via deployable autonomous distributed sensors, and gives the submarine the ability to gather intelligence over land and sea via high endurance UAVs and UUVs.

The holy grail of battlespace preparation in the far term is the deployment of a fully netted, high-speed, communications grid with underwater fiber-optic networks. Ever since Admiral Lord Howe of the British Royal Navy invented a secret system of numbered signal flags to coordinate his battle fleet over 200 years ago; covert, secure, high-speed data and video communications between all the players of a joint expeditionary force is something that every battlespace commander has dreamed of having at their disposal. Transformational technology will allow the submarine to deploy and maintain an undersea communications net that encompasses the entire battlespace. These technologies will go a long way toward making that dream a reality.

Several other submarine mission transformation efforts are underway. One is an Advanced Concept Technology Demonstration. This demonstration mates a Navy Penetrator warhead to an Army land attack missile. Another effort is the demonstration of a buoyant capsule that is used to launch existing weapons, such as the Army TACM missile, from a submerged SSGN. This transformed delivery system will give the SSGN the capability of time-critical strike at hard and deeply buried targets as well as other mobile targets. Again, the vehicle and the payloads already exist. We are just proving new methods of delivering this package to its intended targets.

As Admiral Bowman said recently: "Get real!" And, we are. The common thread in the development of these concepts is apparent. We are taking advantage of proven technologies developed for other services or other applications and putting them to work in a way that's never been done before. This is the definition of creative innovation and transformational concepts in their purest form. It is this transformation that defines the entire philosophy behind the SSGN.

Next, I want to transition your attention from my discussion on transformation as it applies to the SSGN—which I want you to think of as "near-term Transformation"—to a discussion of transformation that takes us into the distant future which I want to define for you as "far-term Transformation". To focus your thoughts, I want you to bring your minds back to the Starship ENTERPRISE.

I also want to bring into your consciousness another futuristic vision first presented over one-hundred and thirty years ago. This antique, but futuristic vision, was conceived by Jules Verne in his book *20,000 Leagues Under the Sea*. In his book, published in 1870, Jules Verne envisioned a submarine with extraordinary capabilities manned by a crew equipped with previously unimaginable undersea weapons and technologies that gave the crew out-of-hull capabilities.

Now, think of Jules Verne's NAUTILUS as the before and Gene Roddenberry's Starship ENTERPRISE as the after and place the Undersea Technology Directorate and the SUBTECH process

in between as the roadmap developing new transformational directions in submarine technology moving submarines from yesterday, to tomorrow, and into the future. Think of these two futuristic visions as you begin to understand a new, expanded definition of "Transformation." Transformation as an action that transitions us from the nineteenth century vision that became real twentieth century submarine capabilities to the twentieth century vision that can become our future twenty-first century submarine.

To achieve this transformation, President Bush has made his wishes pretty clear. He has endorsed the need for smart investment and innovation in creating the force structure we need for the 21st century. The President has asked Congress for a substantial increase in defense R&D between 2002 and 2006, describing this initiative in research and development as a search for new technologies to support the transformation of U.S. military capabilities. President Bush calls this budget a *Blueprint for New Beginnings*.

Today, SUBTECH's *Blueprint for New Beginnings* contains nearly 200 technology development initiatives to build toward already identified future Navy capability requirements. Some of these pages in our blueprint folder are funded. Many of these are candidates for the near-term transformation of the SSGN and the 688 class of submarines. Some of these pages contain developing blueprint drawings that are only partially funded. These are planned for insertion on the new Virginia class and for retrofit on existing submarines. And others are just sketchy lines on our blueprint paper, soon to become full pages in SUBTECH's *Blueprint for New Beginnings*. These long-term transformational technology candidates may be just dreams today. They may be just in the beginning phases of investigation. But, they may become the next set of transformational technologies that take us far down the road toward the futuristic Starship ENTERPRISE as we head down the technology path where no submarine has gone before.

Here are some of the sketches in our book of blueprints. Some of these are moving forward moving us beyond our existing SSGN

transformational technologies. Others may never be funded and will remain in our quiver of fertile ideas. But, we will look at them all. Evaluating their potential for becoming real capability, when needed, and at a reasonable investment cost.

- The next generation of submarine self-protection countermeasures will have communication links to a group of deployed assets. These links will enable the submarine to activate systems to engage or neutralize threatening torpedoes. These units will operate in full duplex mode and have an acoustic link for passing tactical information between units. This will allow the off-hull systems to change their mode of operation in response to changing tactical conditions. This new countermeasure will have built into it an advanced tactical processor and a threat torpedo classifier. Another self-protection system, the submarine defensive anti-air warfare and anti-surface warfare missile system will provide weapon system solutions providing the submarine with the capability of engaging rotary and fixed wing aircraft as well as small, high-speed surface vessels.
- Next, our environmental intelligence efforts will provide *in situ* data to optimize sensor performance, prediction, and navigation. Networking will provide a common environmental picture and, tactical aids combining information from onboard and offboard sensors. Another example is multi-line towed array technologies. These technologies, along with advanced information processing, will provide the 2020 submarine with enhanced search, localization, and acoustic communication capabilities needed for littoral anti-surface warfare and theater anti-submarine warfare.
- Other networking and command and control programs include the Stealth Torpedo Enhancement Program and our Mobile Communications Network Vehicles. The Stealth Torpedo Enhancement Program will provide guidance and control upgrades that permit advances in torpedo tactics. Our Mobile Communication Network Vehicles will allow network nodes to swim into an area clandestinely and set in place wide communication and sensor networks. Because these communication

vehicles are mobile, they will be flexible in responding to changes in the tactical environment moving network capabilities to where they are needed, when they are needed.

- Another effort is the Common Broadband Advanced Sonar System. The Common Broadband Advanced Sonar System will provide Navy torpedoes with an advanced signal processing capability and littoral-warfare-focused improved detection algorithms. The mission reconfigurable unmanned undersea vehicle will be capable of transporting many different payloads into contested areas. Many of those payloads will require advanced networking technologies so that they can perform as force multipliers.

The SUBTECH *Blueprint for New Beginnings* also expands the submarine's horizon by extending its capabilities through the use of out-of-hull technologies. Yes, we all know there still need to be great advances in ship architecture, propulsion, and onboard sensor capabilities but the **TRULY QUANTUM LEAPS** that will significantly transform today's submarine from Captain Nemo's NAUTILUS to Captain Kirk's ENTERPRISE will be the technology advancements we find that connect the submarine with the entire battlespace an environment that includes air and land warfare as well as undersea warfare.

In the late 1960s, the popular TV series *Journey to the Bottom of the Sea* introduced the futuristic research submarine SSRV SEAVIEW and the Flying Sub. In every episode, the Flying Sub was the lead character used by Admiral Nelson to solve that week's battle against evil. The Flying Sub was always the lead character in this program because it extended the SEAVIEW's eyes and ears to accomplish that week's mission.

Like SEAVIEW's fictional Admiral Nelson, I am here to tell you, I am also very interested in UAVs and UUVs. I would LOVE to have a Flying Sub!!! Someday, the Navy might, but in the meantime, I will settle for more conventional UAVs and UUVs to transform our submarines.

I believe off-hull capabilities are absolutely essential for

submarines to network fully, to achieve comprehensive communications connectivity with at-sea and land battle forces and connectivity with the National Command Authority. Off-hull capabilities are absolutely essential for submarines to extend their reach and expand their current surveillance, intelligence, reconnaissance, and targeting missions.

In our SUBTECH *Blueprint for New Beginnings*, the SUBTECH vision for the *Road Ahead* sees off-hull capabilities as absolutely essential for meeting the mission requirements of the future submarines of 2020.

To complete today's discussion on transformation, I want to leave you with some thoughts and challenges that I hope will inspire you to become participants in my mission to move submarine technology in new directions.

Many innovative technologies that existed prior to 9/11 had never been brought to our attention prior to that terrible event, possibly because. some of these technologies were not developed for the Defense community. I say today, "It is time to look elsewhere as well."

The Submarine Force, like most other communities within the Department of Defense, has focused its search for technology within the Defense industry and within the government R&D and S&T communities. Since 9/11, we are becoming exposed to technologies developed for other communities that have some true promise for contributing to our submarine transformation.

All of you here today are interested in submarines and submarine technology. Some of you may have moved out of the Defense industry community or know of others who have moved on. Connecting me and my SUBTECH organization with these new, fertile fields... can be a great help in harvesting new technologies. I WANT to hear about them and I want my people to hear about them. The medical research community is one example.

When thinking of medical research, I am reminded of the Dennis Quaid movie *Inner-Space*. Those of you who have seen this movie remember Dennis maneuvering his micro-miniature submarine through the blood vessels and inner anatomy of a person's body. When you saw this movie, you may have thought

of this as an impossible feat—Great fiction! But did you know today, in Richmond, at least one hospital has a device that is swallowed by the patient that does just what Dennis Quaid did in that movie?

Of course, Dennis is not inside that capsule, but, this medical device does move through a patient's stomach, lower intestine, and colon collecting data, taking pictures as it moves along—a fantastic voyage!

This revolutionary medical device has transformed an invasive procedure called a colonoscopy into a non-invasive procedure where a patient merely swallows a big pill. I wonder if the miniaturization technology, or the sensor technology, or the data recording and processing technology of that medical device can have a role in advancing our submarine technology transformational timeline.

Another thought to ponder. At the March National Defense Industrial Association conference, I spoke of the many research efforts taking place at Federally Funded Research and Development Centers, the DoD laboratories, universities, and other public and private research institutes. I mentioned during that presentation that those S&T and R&D efforts should not be duplicated simply because we were unaware of the advances being made. I challenged the audience then, and I challenge you now, to help me better understand what is being done elsewhere that has the potential for continuing our development of submarine and undersea warfare capabilities.

A third challenge—one I also presented at the NDIA conference. It was a call for attendees to look within their own companies for dual use technologies; dual use technologies that can be candidates for multiple agency sponsorship. You may know of other divisions within your company that are working with the Homeland Security folks, the Office of National Drug Control Policy, or other government agencies to develop new scientific advancements. Those technologies and advancements may be useful to the Navy or help us develop related, but new submarine technologies. Wouldn't it be great for us at SUBTECH to leverage

with those technology development efforts? I challenge you now. Look inside your companies. Bring me new opportunities.

And one final thought for today. Transformation takes place because someone has the imagination to create a new vision and the ability to envision completely innovative approaches different from traditional thinking. Nuclear propulsion transformed the submarine. The Aegis weapons system transformed anti-air warfare. The Tomahawk missile revolutionized strike warfare from the air. Modular design changed ship architecture concepts accelerating both ship construction and new weapon system insertion. Commercial Off-The-Shelf acquisition helps us stay abreast of the latest technology breakthroughs. And, Direct Vendor Delivery and Third Party Logistics have reduced the need for expensive supply inventories and reduced the requirement for multiple layered maintenance programs.

I am asking you to let your imagination wander into the unknown. Step back and take a fresh look. The Navy is seeking innovative approaches and solutions so that our transformation of submarines will enable it, like the Starship ENTERPRISE, "to boldly go where no man has gone before." I believe the more minds producing creative thoughts the more likely we will achieve innovative solutions.

In conclusion, let me remind you of some words spoken by Senator Robert F. Kennedy:

"Some men see things as they are and say why.
I dream of things that never were and say why not."

I want to inspire my people and our Navy to chase this same dream, and I am asking you to do the same. Let's move forward together as a team... discovering new directions... in undersea technology.

Thank you.■

Flow Pros.

Al Page and Jen Brown-Panosky, Hydrodynamacists
Two of 2,000 engineers at Electric Boat

Because of the work Al Page does, submarines look like they do today. Because of work Jen Panosky is doing, they could look very different in coming years.

They understand what happens when water flows over a submarine, affecting its speed, maneuverability, acoustic signature — and also its size, shape and weight. Working with predictions of the velocities and pressures at up to 10 million points on a 377-foot-long, 7,700-ton submarine and the ocean around it, they keep the desired characteristics in balance as they design the perfect submarine shape. When Al first started, analog computers were used. Then Crays, which took 50 to 100 hours to make a single run. Today, EB is one of the highest users of the nation's most advanced supercomputers.

Their work is always challenging because needs are always changing. Right now, Al Page may be figuring out how to increase payload tenfold. Jen Panosky may be figuring out how to make a submarine swim — literally — like a fish.

No one knows more about hydrodynamics — past, present, or future.

There is no substitute

GENERAL DYNAMICS
Electric Boat

ARTICLES

A HERITAGE OF EXCELLENCE AND NEW CHALLENGES TO MEET

Strategic Systems Programs State of the Program 2002

by RADM Denny M. Dwyer, USN

14 May 2002

I am proud to report that the State of the Strategic Systems Programs (SSP) is excellent. Last year, I outlined a Plan for the Future that we were pursuing to provide a steady baseline for our leg of the Strategic Triad. We had a very good year. The events and programs that we have accomplished will ensure the Nation will continue to have a flexible, adaptable and survivable deterrent, and it proves that our heritage of excellence continues.

Early in his administration, President Bush directed the Defense Department to transform America's military and prepare it for the new, unpredictable world in which we are living. The result was the Quadrennial Defense Review (QDR) that established the foundation for America's post-Cold War defense strategy. As part of the QDR, Congress directed the Defense Department to conduct a comprehensive Nuclear Posture Review (NPR) to layout the direction for American nuclear forces over the next five to ten years.

This transformational document provides direction for a New Triad designed to provide the Nation the necessary offensive and defensive systems to ensure our security in the post-Cold War era. Our Trident system will play a major role in our Nation's security for the next 40 years.

The New Triad is composed of 3 legs, the first being offensive strike systems both nuclear and non-nuclear. Strategic Systems Programs is participating in both aspects of this offensive leg of the New Triad. The second leg is Missile Defense. We have been active with the newly formed Missile Defense Agency in sharing technology and management information. The third leg, very important to the SP Family, is a revitalized defense infrastructure

that will provide new capabilities in a timely fashion to meet emerging threats.

On September 11, our world changed. We entered a new era with new challenges to meet. Deterrence is much more complex with multiple non-traditional threats. Offensive deterrence weapon systems like Trident must be more flexible, and as we develop new adaptable conventional weapon options; SP's heritage of solid systems engineering and program management will come to the forefront.

The Nuclear Posture Review validated the Trident submarine launched ballistic missile system as the backbone of the offensive nuclear strike forces. The force will consist of 14 Ohio class SSBN's all with D5 weapons systems, in two oceans. To accomplish this we are extending the life of the entire Trident II D5 System.

We have started the backfit of four SSBNs from Trident I to Trident II. As part of this backfit, we migrated our shipboard systems to commercial-based open-system architecture. The first backfit D5, USS ALASKA has completed her conversion at Puget Sound Naval Shipyard, **ahead of schedule and under cost.** This is extraordinary for a first-of-type conversion and is a tribute to the heritage of excellence of the entire SSP Family. The Demonstration and Shakedown Operation (DASO) of USS ALASKA culminated in the first successful Trident D5 launch using our new commercial based systems.

Early in May, I certified USS ALASKA for Strategic Service. After completing her strategic outload at our Strategic Weapons Facility, Atlantic (SWFLANT) in Kings Bay, Georgia, USS Alaska will return to her homeport at Strategic Weapons Facility, Pacific (SWFPAC) in Bangor, Washington this summer as the first West Coast D5 SSBN.

The second D5 backfit, USS NEVADA is ahead of schedule. All new systems are installed, and integrated testing is in progress. USS NEVADA will complete her conversion this summer and start her DASO period in the fall. As part of the backfit we are installing the Strategic Retargeting System (SRS). This commercial-based, open-architecture fire control upgrade will

provide the increased flexibility and capability required by the Nuclear Posture Review for our offensive strike platforms. We are also installing the new D5 Navigation system. This is also commercial-based and applies open-architecture to provide unprecedented navigation capability for the SSBNs.

Support equipment like the Data Recording Systems has also been upgraded to a commercial base and it is in this way that we intend to keep our strategic shipboard systems current for the next 4 decades. We have also started to install these new commercial systems in the current D5 SSBNs, and so far have installed five new Fire Control systems and one new Navigation system in the Atlantic Fleet.

Our goal is to continue to migrate towards a consolidated Strategic Weapon System with common workstations, common hardware and software building blocks, integrated documentation, and integrated on-board training. The flexibility and adaptability that will be required of SSBNs in the future will require considerably more situational awareness by the crew. We owe them the tools to succeed.

This past year was dominated by obtaining approval for our plan to extend the service life of the D5 flight hardware. The Secretary of Defense personally approved and funded our program to continue production of critical D5 missile components to ensure enough cost-effective missiles to support our flight-testing for the next 37 years. A companion program was also approved and funded to develop modifications to our missile electronics and strategic guidance systems. Support for the D5 system was strong across the board, from Congress to the Department of Defense.

Nobody can argue against our performance record. Trident is the most reliable delivery system in the President's arsenal and this again is a tribute to our heritage of excellence.

The nuclear warhead is probably the most complex part of our system. Refurbishment of our W76 warhead is also a part of life extension. This is the most numerous warhead in the Nation's stockpile. In a joint program with the Department of Energy (DOE), we have set out to extend the life of this critical asset to an

unprecedented 60 years. We must ensure its reliability and safety, and our initial analysis and development has already begun. Once again we are on the cutting edge—faced with the task of ensuring this warhead is certified—**without** the benefit of Underground Testing.

I mentioned that we were also participating in the development of the offensive conventional strike weapons for the New Triad. The SSGN Program will convert four Ohio class Tridents to a conventional role. SSP was chosen to develop the Attack Weapons Systems for this transformational program. The FY02 Defense Appropriations Bill, signed into law this past January, provided funding and authorization for the four-ship SSGN program. Each SSGN will have the capability to carry 154 Tomahawk cruise missiles for covert, conventional strike and a very robust capability to support Special Operations Forces.

Our Launcher Branch and industrial partners were out in front of this fast running program. They defined the concept of a Multiple All-up-Round Canister (MAC) to be placed in the Trident tubes to support Tomahawk. Then our Fire Control Branch and industrial partners developed a design to utilize the existing Tactical Tomahawk Weapons Control system married with our commercial based Trident backfit Fire Control System to provide the SSGN an unprecedented targeting, planning and launch capability.

Sometimes it is pure pleasure to watch our fine SSP Team operate. We widened our mission for this transformation. It will not be easy. The schedule for the SSGN is challenging... this program is reminiscent of Admiral Red Raborn and Polaris.

But if we can't do it, who can? We were hired for our discipline, for our systems engineering and program management expertise, and most of all, we were hired because we deliver systems that work... PERIOD.

Back in 1956, SSP was tasked with integrating the Army Jupiter missile into a surface ship and submarine. History relates how this effort in Huntsville, Alabama came to an end with the advent of the solid rocket initiative that became Polaris.

Well... 46 years later, we find ourselves back in Huntsville... hired by the Army to develop, test and deploy a Penetrating

Warhead for the Army standard Tactical Missile System (TACMS). This high-priority project will use an existing Trident re-entry aeroshell to house this robust warhead to destroy hard and deeply buried targets. Initial flight tests at White Sands Missile Range are scheduled for early 2003. This is another project on a hot track.

Remember our Mission: "The SSP team is dedicated to serving our Nation by providing credible and affordable sea-based deterrent missile systems." Deterrence is now composed of nuclear and conventional weapons systems... and we are a major player.

Support of the Fleet is our most important mission. The Trident Fleet successfully completed twenty-two (22) C4 and thirty-four (34) D5 patrols. The reliability of all our systems on these patrols remains well above goal, and we continually validate this through strong engineering, surveillance and by testing under near tactical conditions.

Since last year's State of the Program, C4 Follow-On CINC Evaluation Tests (FCETs) 52 and 53 took place on 9 and 18 December. Our Naval Ordnance Test Unit (NOTU) completed 8 in-tube-conversions on USS OHIO at SWFLANT in Kings Bay. This was the last flight test for the venerable warrior, the Trident I—one tough little missile. We were successful for 7 of the 8 tests. This is remarkably close to our success rate experience over the 23-year life of this *temporary* missile. No strategic missile has served as long as the C4 without a major refurbishment. We will retire this great system in 2005.

Also since last year we have conducted three (3) D5 FCETs, with seven (7) successful launches. FCET 24 was conducted in May 2001 by USS KENTUCKY. USS LOUISIANA conducted FCET 25 in June 2001, as well as FCETs 26 and 27 recently held in April. FCET 27 saw our first D5 launch failure. Well, this isn't magic—it's ordnance, and ordnance is a tough master. As our Technical Director said after that flight—sometimes our system reminds us who really is in charge.

Together we celebrate our successes and learn from our failures.

Our British partners have had a busy year as well. HMS VANGUARD (SSBN UKO5) was successfully offloaded at SWFLANT Kings Bay in preparation for her first re-fueling at Devenport Shipyard in Plymouth, England. We will start the major updates to the Navigation and Fire Control systems to the Royal Navy late this summer. Our unique Joint Program is as strong, and as vibrant as ever.

Our conversion to an all D5 Fleet is in full stride with the upcoming D5 Activation at SWFPAC in Bangor, Washington. SWFPAC is certified to handle and store D5 missiles and to process Mk4 and Mk5 warheads. Last summer, Captain Keith Lyles assumed command of SWFPAC. He has the facility ready to support USS ALASKA when she returns to Bangor in July. SWFPAC is also the recipient of SSP's Golden Anchor Award—as the top SSP command in Sailor retention.

Commanded for almost four years now by Captain John Friend, SWFLANT in Kings Bay, Georgia remains our Factory in the Field and performed superbly this past year. SWFLANT achieved a number of firsts. They completed the first British Strategic offload when HMS VANGUARD dropped off her missiles prior to returning to Devenport for her first re-fueling. This summer, SWFLANT will outload the first Pacific D5 boat, USS ALASKA.

Captain Bill Borger assumed command of the Naval Ordnance Test Unit (NOTU) on 26 September 2001. As SSP on-site test director, NOTU had a very active year with the last C4 FCET on USS OHIO (8-missile), D5 FCETS for USS LOUISIANA and USS KENTUCKY, and USS ALASKA's D5 DASO. NOTU is defining the operational concepts to be used at our Pacific Missile Range scheduled for initial operation in 2005.

Our Program Management Office in Sunnyvale (SPL), under the command of Commander Doug White had another banner year as our missile, launcher and re-entry representative on the plant floor. Achievements include design of our follow-on Test Missile Kit, re-engineered for affordability; and engineering support for the life extension of the MK4 Re-entry Body. SPL also received the inaugural Raborn award for "demonstrating an outstanding level of technical knowledge, professionalism and dedication to the team effort"—the very philosophy inspired by our Founder,

Admiral *Red* Raborn over four decades ago.

The Assistant Secretary of the Navy (ASN) (RD&A) has designated me as the Executive Agent for all Department of the Navy (DON) Arms Control Treaty Implementation and compliance. I administer this responsibility through our Naval Treaty Implementation Program (NTIP), led by Captain Mike Maxfield.

From October 2000 to November 2001, Benelux, Hungry, Germany, Poland, Romania, Sweden, Finland and the Ukraine conducted flights over the U.S., using the provisions of the Treaty on Open Skies as a guideline. Formal Entry into force is scheduled for 31 December 2003,

We also participated in a mock challenge inspection at the Naval Surface Warfare Center (NSWC), Indian Head to prepare for the upcoming Chemical Weapons Convention. The intent was to demonstrate DOD's preparations for such an inspection, exercise the established guidance, and demonstrate decision-making procedures in an interagency and international context.

Some say we are the "best run program in Department of Defense", we continue to validate this by receiving recognition for our efforts both individually and as an organization.

So WHAT IS OUR FUTURE?

Our Research and Development Programs are starting to pay off.

Our Guidance Applications Program is giving us the launch pad for the technologies that will form the Next Generation Guidance Systems.

Our Re-Entry Applications program is playing a key role in the development of the Mk4A and the TACMS-Penetrator Weapon.

Our Enhanced-Effectiveness (E2) Reentry Body is a candidate for future deployment on the TRIDENT Weapon Platform. This exciting concept brings GPS-like accuracy to a strategic weapon that can be launched and delivered to a target very quickly after a decision to strike by National Command Authority (NCA). The enhanced accuracy and quick delivery expands the potential targets that are threatened by Trident. With improved accuracy, a range of warhead options is being considered, from nuclear to conventional. The reentry branch has been developing the E2 technolo-

gies in the Reentry Applications Program (RSAP), and leveraging off existing Extended Navy Test Bed (ENTB) instrumentation. We are very close to a flight demonstration.

We are developing the technology for fiber optic gyro navigation systems that meet SSBN navigation requirements.

We are initiating a development program for a Buoyant Capsule that will protect a missile designed for use on the surface during its ascent from launch depth. Our first task is to launch an Army TACMS missile from the SSGN—truly making the SSGN the transformational submarine where we can test concepts for the future multi-mission, high volume strike submarine of the future.

This has been an exciting year in which everything came together. The Strategic Launched Ballistic Missile (SLBM) mission was validated and widened by the Nuclear Posture Review. Life extension of the SWS sub-systems is proceeding well. D5 missile flight hardware was approved for continued production and development. D5 backfit is underway. New applications of SSP's talents have been extremely successful—Navy treaty compliance and SSGN are just two examples. Yes, it has been a very good year.

But the congratulations go to all of you. You are the Team that made this success happen. From Capitol Hill to the halls of the Pentagon, from the shipyard to the plant floor or the missile processing buildings of the SWFs. It's the people, you, our Family that makes it happen. Nowhere else in the Department of Defense does such a high performing integrated military, civilian, government, industry team exist. Without the team, the whole team, there is no Trident system. Our Sailors depend on us, our Navy depends on us and our Nation depends on us.

Two years ago, I told you that I intended to expand SSP to be the premier Weapons Systems Engineering outfit in the Department of Defense. The excellent performance of our Team this year validates that we have reached that goal. Everyone wants to be like SSP.

It is an honor and a privilege to serve the SSP team as your Director. I could not be any prouder of **your** accomplishments. Well done to each and every one of you, and GOD BLESS AMERICA.■

COMMENTS FROM THE FLEET

by CDR Chuck Merkle, USN
CO USS KEY WEST (SSN 722)
NSL Annual Symposium

Good afternoon Ladies and Gentlemen. Thank you for the opportunity to talk to you today. KEY WEST deployed as a member of the CARL VINSON battle group from July through December of last year. This deployment took us to the front lines of our nation's global war on terrorism. KEY WEST was the first warship on the scene following the attacks against our country and participated in the first seventy-five days of Operation ENDURING FREEDOM.

I know that none of us will ever forget where we were or what we were doing when we first learned of the attacks against our country. September 11th had been a busy day on board KEY WEST. We were transiting in the Indian Ocean and had completed a full day of drills in preparation for our planned operations in the shallow water of the Arabian Gulf. We were scheduled for a port visit in Bahrain later in the week. Our sister ship PROVIDENCE had recently departed the Arabian Gulf and was en route to the Red Sea and home. The remainder of the CARL VINSON battle group was following us into Fifth fleet to relieve the ENTERPRISE battle group, which had recently departed. After our evening meal we went to periscope depth for routine communications and learned that our world had changed. Forever...

The initial messages that reported the attacks were vague—airplanes had been crashed into the World Trade Center and at the time it was reported that there had been an explosion at the Pentagon. But where we needed to go was clear. We were directed to make best speed to the North Arabian Sea. As we proceeded deep and came up to flank speed I briefed my crew on what little I knew of the day's shocking events. As you would expect, my entire crew had difficulty even beginning to imagine what had happened to our country. But I told them that we were headed where our nation needed us to be and that I knew that to

the man we were ready to do whatever might be required. I had four men who were immediately concerned about family members in New York City, including one Sailor whose father was a fireman and brother a policeman. Through a combination of e-mail and messages we learned that all of my crew's family members were OK in just a few days. Initially, it was hard not to feel like the crew of ARGONAUT that was patrolling off Midway Island nearly sixty years ago.

Fortunately, we received pictures like these via the SIPRNET a few days later that helped us to visualize what had happened. However, it was not until three weeks later when we received a video of CNN, recorded during the attacks that I put it all together. We had arrived at periscope depth that evening shortly after the first tower of the World Trade Center had collapsed.

KEY WEST arrived on station in less than a day. PROVIDENCE joined us a few days later. While we both stealthily commenced our patrols, the CARL VINSON and ENTERPRISE battle groups formed up well to the south.

Our top tasking priority was to maintain Tomahawk strike readiness, which included participation in numerous exercises and frequent updates to our tomahawk mission data library. Both submarines proved that they were ready for the real thing. As a true testament to our training, when the time came for actual combat operations, both of us performed flawlessly. Additionally, we were tasked to provide continuous Intelligence, Surveillance and Reconnaissance reporting to the battle group. Of particular concern was foreign submarine and warship activity. While I cannot go into details here, both KEY WEST and PROVIDENCE provided myriad reports to the battle group covering the full spectrum of maritime activity in the North Arabian Sea. KEY WEST maintained nearly continuous communications on multiple circuits for over two months in carrying out our tasking. We were typically up on two voice circuits, UHF and EHF and shifted between a multitude of data circuits as required.

KEY WEST worked directly for the CARL VINSON battle group for the duration of our operations in FIFTH Fleet. The key to our seamless integration into the battle group was access to the

SIPRNET. SIPRNET enables instant information exchange at multiple levels. Intelligence and operations web sites were updated more frequently than message traffic. Secure e-mail could be exchanged at any time. I kept my battle group commander, Submarine Group SEVEN and my Commodore at home updated using e-mail. Information was continuously exchanged at the watch stander level in several chat rooms. Chat allowed me instant access to the Destroyer Squadron commander, the senior submariner on the battle group staff and other ship captains. On numerous occasions we were able to share information and immediately resolve issues via chat that would have taken hours via message traffic. While we still copied the broadcast for record traffic, we typically received information by way of the SIPRNET hours before it was received via the broadcast.

The reliability of today's communications systems provides exceptional flexibility and I wanted to show a typical rapid plan and shoot STRIKE execution timeline. Around midnight local we received verbal notification of pending STRIKE tasking. An hour later we received message traffic directing missile preparation. While the missiles were made ready we copied a mission data update. Missions were verbally assigned and then executed. I was extremely proud of my crew in flawlessly executing all assigned STRIKE tasking. They were vigilant, patient and ready when it was our turn to step up to the plate.

KEY WEST performed three open ocean small boat transfers in the North Arabian Sea. These transfers with USS SACRAMENTO and USS DETROIT enabled us to transfer personnel and receive food and repair parts. On Thanksgiving morning I performed a humanitarian transfer for one of my chief petty officers with USS INGRAHAM. This chief made it home to his family in Kentucky in less than two days. My crew approached each of these transfers as infrequent, high-risk evolutions and was totally prepared. We were fortunate to have good weather each time and were able to safely perform these transfers.

A brief stop in Bahrain before Thanksgiving enabled my crew to stretch their legs and make calls to their families before we

started the long voyage home.

From the beginning I was concerned with the morale of my crew and their families. Despite the high OPTEMPO our crew's attitude remained positive throughout the deployment. I personally felt that this was the most important thing that I had ever done for my country and therefore spent a great deal of time talking with the crew to ensure that they knew how important what we were doing was. I mailed letters out to the crew's families and encouraged them to write home as well at every opportunity. The first letter— sent off during our first small boat transfer in late September was not delivered until mid-November, but the response was amazing. I received e-mail and letters from many of the families and many of my men thanked me personally. I also kept family e-mail open for my Sailors. Every message was reviewed by two Chief Petty Officers. All told we processed over 11,000 e-mails—quite a change from the days of family grams. It took a great deal of work to keep this line of communication open, but it was well worth it. Although our routine ten-day transit turned into a 10-week war patrol, I received only two messages from the Red Cross from mothers asking about their sons—these families did not have e-mail.

KEY WEST's deployment OPTEMPO was ninety percent. Of particular note, we steamed continuously for almost four months and had no maintenance days during our deployment. Thirty men qualified in submarines. Twenty four men re-enlisted and received over nine hundred thousand dollars in tax-free bonuses.

I will close with this picture that was taken as KEY WEST returned to a hero's welcome at Pearl Harbor just before Christmas. It was an honor and privilege to lead this fine crew during this very challenging deployment. I was extremely proud of their exceptional performance at the tip of the spear.■

COMMENTS FROM THE FLEET

by CDR David Hendricks, USN
CO USS ALEXANDRIA (SSN 757)
NSL Annual Symposium

Good Morning. It is a pleasure to be here with you today. This is the first Naval Submarine League Symposium I have attended and it is an honor to be among so many distinguished submariners, industry leaders, and submarine proponents. I have been in command of USS ALEXANDRIA a little over two years. In May of last year my crew and I completed a six-month Arabian Gulf and Mediterranean deployment with the USS HARRY S. TRUMAN battlegroup. During deployment ALEXANDRIA spent almost five months in the Arabian Gulf conducting a variety of battlegroup operations and exercises in addition to some independent operations.

Following deployment ALEXANDRIA conducted various local operations and in September saw homeport force protection watchstander and weapons requirements mirror those we had become used to while operating out of Bahrain. This January, ALEXANDRIA executed a homeport change to Portsmouth Naval Shipyard to commence a Depot Modernization Period.

My perspective of today's Submarine Force encompasses my nineteen years in submarines, but it is now focused and bounded by these two years in command.

Submarines today are just as important in our war against terrorism as they were in my junior officer days during the Cold War. Our mission may be different, but we still bring stealth to the table. Our ability to conduct sustained independent and undetected military operations in high risk areas is still unique within our military.

Submarine capability in multiple mission areas provides the operational commander with a variety of tools and options to achieve his aim. I saw this first hand on deployment where ALEXANDRIA's operations and exercises included coordinated battlegroup strike, surveillance and warning, battle space prepara-

tion, anti-submarine, and anti-surface warfare. It was not uncommon to receive short notice tasking to shift our primary mission focus.

In fact, simultaneous readiness in multiple mission areas is one of the biggest challenges facing the Submarine Force today. No longer can we focus on one or two primary mission areas as we did in the Cold War. Now we must train across the spectrum of operations and maintain competency in each, with the ability to conduct each on short notice. Over the last few years we have made great strides in both onboard and school training to help meet this challenge. Computer based training is now available in almost all mission areas.

A key element in multiple mission capability and readiness is technology. In the last two years I have seen technology advances onboard that far surpassed the advances I saw in the seventeen preceding years. ALEXANDRIA's last deployment was conducted with an electronic control room. No paper plots were used, electronic flat panel plots took their place. Automatic inputs and plotting enabled our operators to concentrate on analyzing the data, vice just trying to get it recorded. This enhanced our ability to operate safely in the shallow, high contact density areas of the Arabian Gulf. Required data packages became essentially a computer disk, instead of a box of plots and logs with an endless inventory.

Navigation is no longer only paper charts and pencils. Electronic charts now provide a clear navigation picture in real time. While operating our primary radar we now have the ability to show radar contacts superimposed on the electronic charts providing clarity to the contact situation and integration of the navigation picture. Set and drift are continuously calculated electronically. On deployment these tools enhanced our ability to operate in unfamiliar, littoral areas where the tactical picture was driven almost as much by the navigation picture, as it was by the contact picture.

Submarine communications have also undergone a leap in capability. Gone are the days of struggling to copy required traffic at sea via a single reception path. During our last deployment it

was not uncommon to be up on multiple voice and data circuits with the battlegroup, in addition to being up on one or two secure internet type chat rooms with them while copying our submarine broadcast. We now have multiple ways to receive and transmit information at vastly larger bandwidths. This capability is crucial in our ability to integrate with other sea, air, and land forces while conducting real time operations.

Probably the biggest technology advances have been made in our sonar systems. Hardware and software upgrades associated with Acoustic Rapid Commercial Off the Shelf Insertion, commonly referred to as ARCI, have significantly improved our ability to process data and ultimately our ability to detect, track, and classify submarine and surface contacts. We have regained much of the acoustic advantage we held over the rest of the world in the seventies and early eighties. This capability is crucial in today's mission where we are more likely to encounter a diesel in shallow, congested waters vice a nuclear submarine in deep, open ocean waters.

A major challenge associated with infusing new technology into our submarines is the large number of depot level availabilities scheduled over the next five years. Downsizing of our force has left us on the edge of meeting national and theater requirements. The large number of submarines requiring depot level maintenance increases this challenge. Current force and shipyard initiatives to shorten Depot Modernization Periods to eleven months and refueling overhauls to twenty months are key to meeting our commitments during this period. Additionally, it is imperative that we seek to maximize modernization during these availabilities, as opposed to other lengthy out-of-service periods alongside in homeport.

A major victory for ALEXANDRIA occurred when a significant alteration, the Tactical Integrated Digital System (TIDS Phase II), was rolled back into the availability just two months prior to its start. It caused some integration and scheduling challenges for the shipyard, but eliminates a three to four month alongside period after the availability. This was a victory for ALEXANDRIA and

for the Submarine Force. Each boat entering a major availability should have the same consideration.

While it is clear technology advances improve our multiple mission capability and are important to our planners and operational commanders, they also play a major role in keeping our operators rejuvenated and challenged. Our sonarmen are excited with their new tools. It improves their job satisfaction and enhances their desire to let no contact go undetected. Our radiomen are challenged every minute we are at communications depth. They know multiple circuits up quickly is the requirement and you can see pride in their eyes as they achieve it day to day. Technology advances have done as much for job satisfaction and retention as they have for mission capability.

While new technology invigorates our Sailors, it also places a higher premium on retaining them. Operational and maintenance skills of recent technologies are very marketable outside the Navy. Our ability to conduct sustained independent and undetected military operations in high risk areas depends on having the right operators and technicians to see it through. From my vantage point, our money programs over the last few years have been on the mark. Time and time again I have seen our best Sailors re-enlist. Job satisfaction keeps the door open to re-enlist, however the pay and the re-enlistment bonus normally close the deal. During ALEXANDRIA's last deployment we re-enlisted over thirty Sailors in a combat zone for tax-free Selective Re-enlistment Bonuses totaling over 1.3 million dollars. I encourage each of you that have any part in our *Stay Navy* program to keep putting the money in the right places. Our Submarine Force capability is dependent upon retaining the right people at the right time.

Now, as it's always been, people are the heart of our Submarine Force. They are well trained, motivated and professional. I feel that ALEXANDRIA's Sailors are similar to other crews on the waterfront. Let me tell you what they accomplished in a year.

On Christmas Day 2000 they arrived in the Northern Suez anchorage and transited the Suez Canal a day later. On New Year's Day they transited the Strait of Hormuz and operated in the Arabian Gulf area in support of the HARRY S. TRUMAN

battlegroup and FIFTH FLEET until transiting the Suez Canal Northbound on the 2nd of May. Returning to Groton, Connecticut on the 24th of May, they excelled on all post-deployment examinations and inspections. Following a well-deserved post-deployment stand down they conducted an aggressive upkeep to catch up after six months of deployment with no formal upkeep period.

Throughout the summer and early fall they maintained an active at-sea schedule including submarine versus submarine training and a torpedo proficiency firing inspection. They were at sea 11 September and they were mad. Upon returning to port several days later, they worked around the clock and were fully ready to deploy in five days, an enormous task. During this period they also maintained an aggressive pre-overhaul testing program in order to be ready for the shipyard in January if not surge deployed.

While maintaining this fully ready to deploy status, they conducted three weeks of Prospective Commanding Officer underway training operations, probably the most taxing local operations a submarine can conduct and they excelled. Upon returning to Groton they worked long hours to finish pre-overhaul testing and final preparations for changing homeport. In January they transited to Portsmouth, New Hampshire and by the end of February had transitioned to the shipyard environment, a significant change in the way things are done. They set several time records in starting the availability and are on track to complete the availability in the shortest amount of time ever. Throughout this challenging year retention on board continually improved.

If you talk to other Commanding Officers, their crew stories will be similar. Wherever you look, you will find crews adapting and overcoming. We place a large burden on our crews and they deliver. They are versatile and skilled at getting the job done. They are multi-mission capable and able to shift gears quickly. My experience is that they go above and beyond the requirements. Our job is to keep them paid, motivated, and trained. They are the future of our Submarine Force and in their hands I feel the future is bright. Thank you.■

U.S. NAVAL POWER AND THE PURSUIT OF PEACE IN AN ERA OF INTERNATIONAL TERRORISM AND WEAPONS OF MASS DESTRUCTION

by Dr. Anthony R. Wells

Dr. Wells is a partner with TKC International LLC, Middleburg, Virginia.

The United Nations has been the fulcrum for international peace since World War Two. Despite the United Nations' inherent weaknesses, the procrastinations, machinations, and individual agenda of member states it has, unlike the League of Nations, survived. Its strengths and weaknesses are well known and well analyzed. The Security Council and General Assembly, and its other main body, the International Court of Justice, can only do so much, constrained by the inherent limitations that were imposed by the founding members, the Great Powers. The world has to live with these limitations unless we see a genuine shift in world attitudes to the conduct of international relations. While the driving force of the latter is likely to remain the national self-interest of key members, there is little likelihood of a shift in both philosophy and the working relations and mechanisms of the United Nations.

The United Nations came into being on October 24, 1945. The Korean War was the first major test of the United Nations. The Korean conflict bound the United States, as the real leader, with those nations whom politically, philosophically, and ethically were drawn, inevitably, to stand with the United States to ensure that the principles of the United Nations Charter survived. Fifty-seven years later the United Nations now faces one of its greatest challenges. This challenge places the United States, and specifically the United States Navy, at the forefront of world leadership and action. This challenge is the threat posed to world peace by international terrorism, and those who possess weapons of mass destruction (WMD) and may seek to use them outside the classical concepts of super power deterrence. The players are international terrorist organizations, various rogue state players, and those state

players who sponsor such terrorist organizations by some combination of overt and or covert support. In addition there are those persons and organizations who support and fund such activities and who may be resident in such rogue states or may indeed be resident in states friendly to the United States.

The United States faces a major dilemma in the execution of its foreign policy in the domain of WMD, terrorism, and the rogue nations. It wants to be a positive member of the United Nations, it wants to act with its loyal allies, and it wants to pursue the U.S. legitimate national self-interest of protecting U.S. citizens, interests, property, and American ideals and values. The latter are also inevitably tied to the key interests of its major allies, particularly with those whose relations with the U.S. go back to the Second World War. However the U.S. is at one level constrained by the politics of the United Nations, and indeed at times the policies of some states whom the U.S. seeks to either protect or with whom it is allied. Built into this set of complex relations, the legal framework of the United Nations Charter, and the ambivalent policies of some members states, are a series of constraints that make U.S. policy implementation hazardous and, at times, very dangerous for U.S. self interests.

What is required is a new and practical framework that will permit the U.S. to fulfill its policy goals while maintaining a solid alliance within the United Nations and with its key, enduring allies. The United States will never be able to please all of the member nations all of the time. It may be able to please a few of the key members and its loyal allies most of the time. The United States Navy can be the key instrument for using U.S. power in the pursuit of peace. Let us examine the basis for this doctrine and its practical implementation.

The United States and the principal nuclear powers have survived the Cold War unscathed by a nuclear exchange. Despite the rhetoric and occasional brinkmanship of the Cold War, neither the United States nor the former Soviet Union ever intended to put their ideological and military differences to a nuclear test. The inherent logic of mutual assured destruction kept sane judgement

consistently on the right track. Owning weapons of mass destruction is not against international law per se, unless agreed to as a signatory to a non-proliferation agreement. The critical difference between the legitimate WMD state players, such as the United States, and the other categories, is intent. It is intent that defines their policies, organization, and actions. Just as in the criminal code of most common law nations, the notion of actus reus mens rea is the abiding principle for defining criminal behavior (where the criminal act and criminal intent must be in tandem), so in the domain of international criminal behavior does the principle apply. A player who builds a small nuclear device with the intent of using it against a third party outside the established bounds of international law, the rules of war and precedent in international state behavior, is just as guilty of criminal action and intent as if they were a common criminal by any standard defined in the common law of the civilized world. By the same argument those who would support and harbor such players, irrespective of the categories described above, are guilty of being accessories. For example, the production of a small nuclear or radiological device requires technical expertise (personnel, literature, access to information), materials, infrastructure (assembly, manufacture), finance, support (transport of people and materials), political cover and security (covert and clandestine operations). All those who participate in the above process are accessories.

There is not an international police force for patrolling the domain described above, and it is unlikely that there ever will be. The United Nations can only do what it has done to date. There can be international intelligence cooperation, the wiser use of INTERPOL, extradition, breaking international WMD financing operations and so on, but at the end of the day, this will not be enough. Organizations such as the Moussad may be good at what they do for the short-term interests of their masters. However, they are, simply, not quite good enough when dealing with the scale and scope of the problem, and are inherently skewed when viewed from the wider perspective of international relations and their involvement could be disastrous for peace and stability. The United States simply cannot afford to be tagged by association in

ways that will forever blemish its world standing. In the very fragile world of the Middle East today the United States must more than ever be the honest broker for peace, and not be damned by association.

What then is the way ahead for a new doctrine? The law of nations and the laws, rules and precepts governing for example the conduct of war and the law of the sea are set in precedents. There is a body of precedent developed over several centuries, some of which is codified in both international agreements and in the accepted practices of most nations. At the extreme of international behavior has been the issue of war criminals and crimes against humanity. The International Court of Criminal Justice that sat at Nuremberg to try the major war criminals at the end of World War Two and the International Court of Justice created by the United Nations evidence the intent of the civilized world to cooperate to try and punish transgressors. The United States has been the key leader. There is no exact precedent per se for dealing with the new situation since September 11, 2001, except for the actions taken by the General Assembly of the United Nations and the independent actions of the United States and its allies and associated friendly nations. However, the general body of international precedent, the principles of the Charter of the United Nations, and specifically the Law of the Sea, provide a basis for a new doctrine and for actions by the United States Navy. The President of the United States has made it abundantly clear that the U.S. will not stand by and be attacked again by international terrorists, least of all by those employing WMD. No one could disagree with his position. In addition, the United States has taken a leadership stance. This stance is cause for concern with even some of the United States' allies because of its implied intent to use overt action against the perceived threat beyond the actions taken in Afghanistan. What may be called a new Doctrine for the U.S. Navy in the containment of international terrorism and the use of WMD may now be articulated.

Hostile intent has always been a defining principle for Rules of Engagement (ROE). In the world of international terrorism and

WMD one cannot afford to wait for hostile action to follow. Counteraction may be too little and too late. The key to hostile intent is information, a combination of classical U.S. intelligence and multi-level information sources, some of which may be accessed by modern computer networks. Unequivocal intelligence is the key. There can be no more mistaken embassy bombings. Collateral damage, consequence management, and political perception management are as important as putting the right weapon on the right target at the right time. The chain of command must also be seamless and in unison, and act in timelines consistent with the actions of the threat. There can be no after action analysis that shows that the threat succeeded because of a breakdown in the U.S. command and control system. Hostile intent is, therefore, the defining event. Possession of the means to perpetrate an international criminal act may be an indication of future intent, but it will not stand alone as the casus belli. However, once hostile intent is clear, the rules change.

The Law of the Sea and the freedom of the seas permit the United States Navy to exercise its rights of presence, innocent passage, and board and search, and to enforce both the body of international law and those aspects based in precedent and tradition. The new Doctrine calls for actions similar to the basis and means by which the Royal Navy stamped out the slave trade in the nineteenth century. The latter was a clear crime against humanity encapsulated in the laws of nations and enforced as an act of international law. Those who continued to engage in the slave trade did so at their peril, and the Royal Navy was thorough and effective in its enforcement. International terrorist and WMD activities are an equal threat to civilization, the laws of nations, and constitute crimes against humanity totally similar to the evils of the slave trade. There are multiple other compelling precedents in the long tradition of the Law of the Sea.

The U.S. Navy is forward deployed around the clock, anywhere, anytime. It is the nation's front line force. Its carrier, surface, subsurface, Special Forces, and Marine elements constitute a prodigious capability. The key to their implementation success is accurate, timely information, acted upon without break

in command and control. Technological change, ergo WMD, has always been a basis for a shift in precedent in both international law and the Law of the Sea. France came under enormous pressure via the Law of the Sea and international law for its nuclear testing programs in the South Pacific in the 1970s. As historical illustrations the Battle of the River Platte in World War Two, Operation Sea Dragon and Operation Market Time, the blockage of Haiphong, all during the Vietnam War, used international law and the Law of the Sea as their fundamental basis for operations. The new Doctrine calls for the Navy to be able to legally attack those threats that meet the criteria of hostile intent founded in precedent and tradition, based on the experience of war. The corollary for the rogue nation or terrorist organization is that they must do absolutely nothing that indicates the hostile intent in order to avoid being attacked. Hostile intent may be widely defined. For example, the movement of nuclear materials by sea to a known terrorist organization defines hostile intent since terrorist organizations are defined by precedent to be inherently hostile. Organizing the means to execute international terrorist acts is hostile intent. The Doctrine calls for the appropriate military response at the appropriate level to meet the threat. Similarly, the movement of individuals and funding connected to the provision of and support for terrorist and criminal WMD related acts constitute acts of criminal intent. Such acts are conspiracies to perpetrate international criminal acts.

An article in the March 9, 2002 edition of *The Economist* stated, "America spends a staggering 40 percent of all the money the world spends on defense. The Pentagon's budget is over ten times that of the next biggest spender in NATO (Britain). This gap in resources translates into a technology gap, as Europeans would have found in Afghanistan". These facts polarize the issue of the amount of overseas support that the U.S. Navy can expect in implementing the new Doctrine. For the myriad political reasons discussed earlier the likelihood of widespread support is limited. The UK has been one of the U.S.' best allies, but even the UK is limited by its military capability.

Her Tomahawk firing submarines, SAS, RAF in-flight refueling, the Royal Marines and other support activities ashore and afloat have been invaluable, but until the UK acquires her new carriers and JSF variant, even she is severely limited in what she can do to support the U.S. Hopefully the UK will convert some of her SSBNs to a Tactical Tomahawk firing role and get into the air-launched precision weapons business. The good thing about the British is that they have no qualms over recognizing where their military capabilities can play while lending major political and diplomatic support, especially in the Middle East. The key point is that the best of the U.S. allies can only do so much. When NATO invoked Article 5 on September 12 (an attack on one member is an attack on all) there was indeed a hollow ring to the invocation. The U.S. is it, and the U.S. Navy represents the civilized world's best hope for implementing the Doctrine and maintaining an enduring peace. Pax Britannica was a viable and surviving modus vivendi in the nineteenth century. In the twenty-first century, Pax Americana may be the world's main chance for keeping our planet a safe place. It is a fragile world, and it is a great responsibility.

Finally, there is the issue of doctrinal implementation. Hostile intent must be answered before the threat can execute its designs. There can be no holding back, and the U.S. will be able to show quite unequivocally why she took such measures. The targeting of terrorist and WMD threats will take special training and expertise. The Navy that has inherited the traditions of Nimitz, Halsey, Spruance and Burke is well up to the job. The Submarine Force that Admiral Lockwood led in the Pacific in World War Two demonstrated extraordinary capability. That tradition will live on in this new era.■

THE FUTURE OF SUBMARINE ESCAPE AND RESCUE LIAISON OFFICE SMERLO

by CDR Jonathan (Jonty) Powis, RN

Commander Powis joined the Royal Naval College Britannia in 1974 and served in a number of surface ships before specialising in submarines in 1978. He saw action in the South Atlantic as the Navigating Officer of HMS CONQUEROR. After passing the Perisher Command Course in 1986 he commanded three submarines, the SSK HMS UNSEEN and the SSBNs HM Ships RESOLUTION and VICTORIOUS. He is currently serving as the Senior Operations Officer to COMSUBEASTLANT in Northwood England.

Since the KURSK tragedy there has been a sea change in the way that Submarine Escape and Rescue (SMER) is conducted. Once a strictly national or bipartisan affair it has rapidly become a shared discipline with NATO becoming the de facto lead and centre of excellence in the world. For a number of years NATO has run an annual SMER Working Group (SMERWG), chaired by a serving UK submariner and aimed at the standardisation of NATO member nations' equipment and procedures. In recent years SMERWG has been expanded considerably by the inclusion of invited non-NATO nations with observer status. Consequently SMERWG represents the only truly international forum for SMER. The next step is to form within NATO a dedicated SMER Liaison Office (SMERLO): this is about to become a reality.

The SMERLO will consist of a small staff led by a senior submariner. Perhaps 5 or 6 personnel in total whose tasks will be as follows:

- Monitoring the availability of Submarine Rescue Systems (SRS) of those Submarine Operating Nations (SON) that possess them.
- Provide a first point of contact in case of SUBSUNK.
- Maintain an up to date list of SMER personnel and facilities of

potential SMER utility throughout the world. This list will include the following:

- Suitable vessels to act as Mother Ships (MOSHIPS).
- Suitable ports of embarkation.
- Suitable airfields to be used by large cargo aeroplanes.
- Diving decompression and related medical facilities.

- In case of SUBSUNK advise on availability of rescue assets.
- Produce and distribute relevant publications.
- Work with and within the SMERWG in standardising procedures and specifications.
- Provide advice and if necessary training and inspection teams on all matters concerning SMER.
- Coordinate and advise upon SMER training and participation in exercises.
- Provide a first point of contact for SMER related press inquiries.

Participation in SMERLO will be voluntary. SON will be invited to contribute details of their SMER systems. Technical details of hatches, seats and internal submarine escape arrangements should not compromise national security and once provided will be incorporated into the relevant publications. SMERLO will establish a secure, read-only website. Access to the website will be limited to subscribers but all Internet users will be able to reach the initial page or pages which will contain contact details as well as general SMER information. In view of the supra-NATO international nature of SMERLO, all business will be conducted in English, although NATO usually works in both French and English.

The final physical location of the SMERLO is not yet decided. There are a number of options. It will either sit within an existing Submarine Operating Authority (SOA) at Northwood England or Norfolk Virginia, or within the NATO HQ at Brussels Belgium. The preferred option is Norfolk Virginia. However, as SMERLO has no command and control function and is purely an advisory service and custodian of the SMER database it does not need to be located within an existing HQ. In the interest of permitting access by non-NATO states it may be necessary to choose a site that has

few security implications.

Publications concerning SMER are already largely declassified. Some states may have difficulty in coming to terms with the declassification of certain information about their submarines. Nevertheless, it is envisaged that all SMER related publications would be made available either in hard copy or on the Internet to subscribers.

Membership of SMERLO will be open to all states that operate submarines. Should a country decline the invitation to participate, that is their own affair. However, they would still have limited access to the website and a call for assistance in case of SUBSUNK would not be ignored.

The establishment of SMERLO will not happen overnight. Wherever it should be located it is unlikely to be ready to undertake its responsibilities before 2006. Therefore on 1 July 2002 COMSUBEASTLANT (CSEL) with the agreement of COMSUBACLANT and COMSUBSOUTH stood up an Interim SMERLO (ISMERLO) with three personnel drawn from his extant submarine staff at Northwood England. Contact details are listed at the end of this article and ISMERLO is already represented at the SMERWG.

ISMERLO will not undertake all of the responsibilities of the full organisation. Until the full establishment, publications will remain with the designated custodians and visits for liaison and training will not be made except under national arrangements. The initial database will be developed from the extant UK database. A read-only ISMERLO website will be created giving contact details and the proposed Concept of Operations. In due course it will be expanded to include much of the information currently held in MTP 57. It is envisaged that this website will become the principal medium for obtaining contact details and basic SMER information. The website address is www.eastlant.nato/smerlo.

It is of interest to note that the nascent SMERLO and ISMERLO are similar to a concept briefed by the Indian Navy delegate (Commander Deep Mathur) at the 2001 Asia Pacific Submarine Conference. Commander Mathur named his idea the

Multilateral Submarine Rescue Arrangement (MSRA). MSRA called for legally binding agreements between states concerning SMER and the establishment of designated regional coordinators. Having met with Cdr Mathur during the recent SMER exercise *Sorbet Royal 02* we took advantage of the opportunity to compare notes and explore the similarities of the two methods. In essential purpose and ideas the two proposals are identical. However, it is considered within NATO that the difficulties of arranging binding international agreements would detract from the essentially voluntary and humanitarian nature of international SMER. Nevertheless it is pleasing to note that the concept of a central exchange for SMER information has already achieved wide acceptance. I hope that, in the dreadful event of a future submarine disaster; ISMERLO and SMERLO will make some contribution to saving lives.■

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THE NEW AKULA CLASS RUSSIAN SUBMARINE GEPARD

Commissioned in Severodvinsk

by Dr. George Sviatov
Captain 1st Rank, Russian Navy(Ret.)

The official act of finishing and delivering of the Russian Navy's first nuclear powered submarine of the 21st century, GEPARD (Project 971 Bars or Akula class), was signed at the Sevmashpredpriate industrial plant at Severodvinsk in the Archangelsk region of northern Russia on December 3, 2001. Navy Commander in Chief, Fleet Admiral Vladimir Kuroedov, Deputy Commander in Chief for Shipbuilding, Vice Admiral Michail Barskov, and Sevmash's General Director, David Pashaev, completed formalities there.[1]

On December 4, 2001, President of the Russian Federation Vladimir Putin participated in the commission ceremony at the *Sevmash* shipyard of GEPARD (cheetah in English). The weather in Severodvinsk that day was not cold (minus 8 degrees in Celsius). On the moorings near GEPARD stood about 100 workers. The yard did not work because of the ceremony. Near the pier was moored the aircraft carrier ADMIRAL GORSHKOV, which was in process of pre-sale preparation and modernization for the Indian Navy. Part of GEPARD's crew, with her Commanding Officer Captain 1 Rank Dmitry Kosolapov, was on the mooring pier.

President Putin had arrived silently without special cars' signals and sirens. He took the flag of the submarine and delivered it to GEPARD's Commanding Officer. Acting Commander of the Northern Fleet, Vice Admiral Dobroskotchenko had read the order for commissioning the submarine into the Northern Fleet. The Navy's traditional Russian Andreevsky flag had been raised.

Then the President went down inside GEPARD and inspected her interior. After finishing that mission, he visited some shops of the shipbuilding enterprise and talked with their workers.[2]

President Putin delivered his speech:

"Respected Severodvintsi, dear Sailors Severomortsi!

Today all of us became the participants of the event of special state importance. The guard cruiser nuclear submarine GEPARD was commissioned. The Russian Navy got the ship, which represents the pride of both the Fleet of Russia and the creators of that sub. The submarines of this class provide the basis of the Russian Federation's general purpose nuclear submarine force. And first of all, I like to congratulate the designers and builders of that project, all severodvintsi with this achievement.

During the three hundred years history of the Russian Fleet the raising of a Navy flag on every new major vessel was marked as an event of national importance. We must cherish that tradition of our ancestors, which gains the glory of a sea power for our country.

The common task of shipbuilders and sailors—our common task—is the creation of new, reliable, survivable ships, and formation of effective search and rescue services. Development of more exact standards of architecture and exploitation of ships is another aim. But as in all times, sea power of the contemporary Russia means not only ships, military bases, and unique shipbuilding technologies. First of all, it is people. It is their love of sea, devotion to the fleet and to the Motherland.

But today to be on a proper level of contemporary tasks for our Armed Forces is not sufficient. It is necessary to have the highest level of professionalism, a sense of responsibility and discipline. The sea does not forgive a neglecting attitude to it and punishes severely for mistakes.

In contemporary conditions our Navy provides not only security of our frontiers and sea resources. The destiny of the fleet, including the submarine force, and its qualitative renewal is very important for the state. We see today the strategic future of the Navy in technological, scientific and industrial perfection. Now we are shifting to creation of truly multipurpose submarines. The relevant subs were laid down in the assembly shops of your Northern Machinbuild-

ing Enterprise.

And I must also say about one important moment. Now, for the first time in Russia, we put a beginning to the formation of a national naval policy. Its foundations were determined in naval doctrine, in which naval activity has the highest state priorities.

Dear friends! Today we are presenting high state awards of Russia to the creators of GEPARD. I think that the country must know your names. The choice of the Sevmashpredpiratie for building of new submarines is based on the high trademark of your shipyard, which has built 127 submarines. Many of them personify Russian sea power. GEPARD is the 128th child of the Severodvinsk's shipbuilders. We'll hope that with each new submarine your wage will be growing. In any way, it is necessary to do all that is possible in that direction.

The shipbuilders combined in that sub an alloy of the most distinguished scientific achievements. And that is a credit to the adjuster of the shipyard, B.S. Chramtsov. This sub is number 34 in his records. The birth of this unique ship was possible because of efforts of many scientific-production and military electives. And not in the last place, it is to the credit of the St. Petersburg's Sea Bureau of Machinebuilding Malachite. Its Head and General Designer, V.N. Paylov, and Chief Designer of that sub's modification Yu.I. Farafontov. The successful sea trials of GEPARD were accomplished by her crew under command of Captain 1st Rank D.D. Kosolapov. The General Director of Sevmashpredpriatie, D.G. Pashaev, is not among those awarded today, but we know very well that doesn't mean his merits to the Motherland become less. We thank him very much.

Dear friends! You were able to preserve not only unique complex of nuclear submarines' creation but also the best native shipbuilding traditions, which always represented the highest levels of technologies and production skill.

I like to thank you for your labor from my heart. For your fidelity to Russia. For your faith to it.

Thank you."[3]

In this connection it is reasonable to put a couple of questions.

What kind of submarine is GEPARD? What is the place of that class of submarines among other nuclear submarines of the Soviet Union and the Russian Federation?

In the 1984-2001 period the Soviet and Russian shipbuilding industry built 14 Bars (in American terminology Akula) class Project 971 nuclear attack submarines. They were built in Komsomolsk-on-Amur and Severodvinsk shipyards and were commissioned to the Pacific and Northern Fleets. These submarines and four Project 945 titanium attack submarines (In NATO designation Sierra class) are the most advanced Russian SSNs and they are comparable to the U.S. Improved-688 class attack nuclear submarines and even with the Seawolf class subs.

The Project 971 submarine is earmarked, first of all, for sweeping, detection, and shadowing of an adversary's ballistic missile nuclear submarines and aircraft carriers and destroying them at the beginning of war actions. She also can destroy other submarines, surface ships and transports by her torpedoes, missiles and mines. The second very important mission, which was really first implemented on these SSNs, is her ability to strike land, and in principle, sea targets at ranges up to 3000 kilomters by her 533mm caliber Granat subsonic cruise missiles similar to U.S. Tomahawks.

The design of Project 971 began in 1977 in the Malachite Design Bureau which designed the first Soviet attack nuclear submarines of the November class (Project 627A), and later the serial production of the Victor classes (Projects 671, 671RT, and 671RTM) attack submarines. The Chief Designer of Victor and Acula classes was Georgy Tchernishov; the Chief Navy Supervisor of Projects 945 and 971 class was Captain 1st Rank Igor Bogatchenko.[4]

The submarine has six compartments plus bow and stern parts, 17 main ballast tanks, a superstructure and a sail. For unsinkabili-

ty, the first compartment is divided into two parts by the horizontal 10 atmospheres watertight deck. In the bow part there are torpedo and decoy tubes and the main hydroacoustic array. The I compartment has torpedoes and missiles, hydroacoustic equipment and storage batteries; II compartment—control room, living accommodations, air conditioning systems and electronic equipment; III compartment—radio, radar, navigational, some electrical equipment and diesel generator; IV compartment—reactor and its equipment; V compartment—main turbine, turbo generators and their components; VI compartment—thrust bearing, rudders and planes machinery. In the stern part—propeller, stabilizers, planes and rudders. The surfacing escape chamber, bridge, retractable masts and towed radio antenna are in the superstructure and sail.

GEPARD has the following tactical-technological characteristics:[5,6]

Surfaced displacement (tons)	8,470
Submerged displacement (tons)	13,800
Length, beam, draft (meters)	113.0x12.8x9.6
Bow torpedo tubes	4-533mm (upper row), 6 outside 400mm tubes with decoys.
Weapons	28-533mm and 12-650mm torpedoes and missiles or more than 40 mines; missiles Granat, Vodopad, Veter, 8 hand-launched antiaircraft missiles Igla-1.
Sonar	Scat-3 with bow cylindrical array (height about 5m and diameter more than 7m), fixed side and stern towing antennas
Test depth (meters)	600 (AK-32 steel with yield 100 kg/sq mm
Damage control	surface unsinkability with

	any one flooded compartment, 26 percent reserve buoyancy, bulkheads of II compartment calculated on 20 kg/cm², other bulkheads—on 10kg/cm², escape surfacing chamber in II compartment calculated to take all the submarine's crew
Speed, submerged, knots	33
Reactor	1 OK-650, 190 mgwt
Turbine	1x50,000 shp
Complement	73

In comparison with the Project 945 (Sierra) submarine, the increasing volume displacement of the Project 971 submarine reduced her speed by two knots but allowed the implementation of the newest weapons and electronics that broadened the spectrum of submarine mission. The most important of them was the installation of new cruise missiles Granat to strike land targets from the 533mm torpedo tubes at ranges up to 3000 km and a new hydroacoustic complex with digital processing.[7]

But because the main task of GEPARD is to fight with SSBNs, SSNs and aircraft carriers, her principal weapons are torpedoes and missiles with less ranges.

First of all, it should be mentioned the anti-aircraft carriers 650mm caliber torpedo type 65-76 with kerosene fuel and hydrogen peroxide oxidizer which entered service in the 1980s. It has a speed of 50 knots with a range of 50 km or 30 knots with a range of 100 km. The warhead weight is 900 kg and it has wake homing guidance. It is a torpedo equivalent of the Project 941 (Oscar) anti-aircraft carrier supersonic cruise missile Granat with a range of 550 km with a 1000 kg conventional warhead.[8]

The second category of torpedoes is a number of 533mm antisubmarine and anti-surface ship torpedoes. The contemporary USET-80 universal 533mm homing torpedo has a range of 20 km and a speed of 50 knots; a silver-zinc electric battery, a diving

depth of more than 400m with a 300 kg conventional warhead. To that category belongs also torpedo TEST-71 wire controlled with a range up to 20 km, also with a silver-zinc electric battery, speed up to 40 knots, diving depth 400m and more than a 200 kg warhead.[9]

The third exotic category of universal torpedoes is VA-111 torpedo Shkval developed in 1977 with a speed up to 200 knots and a range of 11-15 km with a ballistic missile type engine. It seems that this torpedo, in spite of its fantastic speed, cannot be a really practical weapon because of its limited range and dubious direction stability and accuracy.[10]

As to torpedo size cruise missiles, there are two contemporary types: the 533mm Vodopad (RPK-6) with a weight of 2,445 kg, a length of 8.2m and a payload of 742 kg with the UMGT-1 400mm antisubmarine torpedo with a range up to 35 km. The 650mm veter (RPK-7) is 11m long with the same payload and a range up to 100 km. These missiles were designed by Novator Bureau, Sverdlovsk (now Ekaterinburg) in the 1980s.[11]

But the main achievement in designing and building of that class submarines is in providing for their minimal self-noise. It was done by reduction of their mechanisms' noise levels and arranging all of that in the submarine on intermediate rafts, which are fixed to the pressure hull and bulkheads on pneumatic shock absorbers. It is the second cascade of noise insulation. The first one is on rubber struts and mechanisms foundations. Thick anti-echoing coating (64mm) on the outer hull and thin anti-noise coating on the pressure hull also play their roles. As a result, this new submarine is the quietest in the Russian Navy. As was said by Vladimir Pyalov, General Designer and Head of the Malachite Bureau, in his interview to the Russian *Izvestia* newspaper, "the noise level of GEPARD is 3.5 times less in comparison with the first submarine of that project."[12]

The new Russian SSN GEPART (K 335) arrived at the North Fleet submarine base in Gadjievo on December 21, 2001. The new Commander of the North Fleet, Vice Admmiral Gennady Sutchkov, and his staff met the submarine on the pier.[13] ■

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SUBMARINE BELLS TO SONAR & RADAR
SUBMARINE SIGNAL COMPANY
(1901-1946)
Part I

by John Merrill

Preface

Methods using sound in the sea as a tool for underwater detection as a navigational aid and enemy submarine finder expanded considerably throughout the 20th Century. History shows the Boston based Submarine Signal Company as a pioneer equipment developer manufacturer and implementer of what later became to be known by 1943 as **sonar**. It should not be overlooked that Submarine Signal during the 1930s and '40s also had involvement in the developing field of radar and during WW II with the manufacture of thousands of marine radar sets and radar fire control apparatus as well as continuing extensive sonar development and manufacturing. In 1946, Raytheon purchased the Company. As a division of Raytheon, today it is now known as the Naval and Maritime Integrated Systems. In its second century, this part of Raytheon continues to design, develop and build sonar equipment for surface ships, submarines and ASW equipment for helicopters. This essay recalls some of the first half century of the story.

A New Century

As the first days of the 20th Century unfolded, two ongoing important maritime pursuits were moving along separate paths that merged into one by 1920. Toward the end of the 1800s, an interest began in developing commercial undersea sound devices to enhance the safety of merchant shipping by alerting ships to the presence of rocky coasts. With the draft of steel ships increasing, warning of natural hazards and the presence of shipwrecks along coasts became important. Knowledge of the ocean bottom related to laying underwater cables, telegraph, telephone, and power, was

an additional need. Because of the vagaries of sound in air, sirens and foghorns as warning devices for shipping were limited. Ocean depth determination methods at that time were ponderous and time consuming. Interest in sound as a way to determine depth also began to receive new attention.

The other maritime interest that became predominant came from the April 1900, United States Navy purchase of John P. Holland's HOLLAND VI, the first practical submarine. By 1914 there were 400 submarines in the world's navies; by 1982, 1000. The innovative submarine required a way to navigate underwater and to find its targets; its opponents wanted to find the submarine and destroy it. This essay is an abridged version of how the Submarine Signal Company contributed to solving navigation and detection requirements during the first part of the 20 th century. The Company's engineers' commitment to continued progress during the remainder of the century is another essay.

For several years starting in 1898, Arthur J. Mundy, Elisha Gray (telephone inventor and one of the founders of the Western Electric Company), and Joshua B. Millet conducted experiments concerned with the use of a sea buoy with an underwater bell and a receiving microphone located on a ship to warn of hazards. Mundy's home on Cape Ann, Massachusetts, on the north shore was the site of the initial work. The project benefitted from Gray's technique for waterproofing telephone transmitters in developing the underwater equipment. Gray called the underwater microphone a "hydrophone." It consisted of a metal case with a thick metal diaphragm, which was attached to a carbon button microphone.[1] Prior to Gray's microphone and telephone headsets, a stethoscope-like receiver was used.

Submarine Signal Company Begins

In 1901, Mundy, Gray, Millet, E. C. Wood and others established the Submarine Signal Company to pursue the development, sale and installation of underwater bell systems. Working with these systems added new knowledge of the behavior of sound in the sea and how to have equipment meet the demands of that

environment. It was observed that microphones on the ship's hull picked up the ships own noise and prevented good reception. In the years 1898-1902, it has been estimated that about $80,000 was invested to come up with a way to dispense with a microphone on the outside of the ship's hull for reception of the underwater bell signals.

Aiding at-sea navigation, ocean depth determination and underwater cable laying led to using sound underwater in new ways to achieve these goals. As in the development of most technologies, there was no straight-line path from need to implementation.

Underwater Bells

Lightships were the first to be instrumented with underwater bells. Some bells were operated with steam others with compressed air. In 1903, the first of the Submarine Signal Company's bells was installed in Boston Harbor on Lightship 54. On sea buoys, wave action coupled with a spring mechanism activated some underwater bells later. Ranges were typically about eight to ten miles. Electrical bell operation with cables from the shore provided further location flexibility where it was not feasible to locate a lightship or a buoy. In some instances, the signal from the bell was coded for identification.

By the end of 1903, four lightships were equipped with underwater bells. The bells automatically struck the code number (dots) to identify the lightship to the ship equipped with Company's receiving apparatus. Several years later, the United States and British Admiralty were cognizant of the reliability of the pneumatic submarine bell. The British Submarine Signal Company covered the European equipment sales and service. Underwater receivers were not sold to commercial shipping. They were leased, and the Submarine Signal Company provided servicing and modernization of the equipment.[2]

In April 1905 at a meeting of the Institute of Naval Architects, J. B. Millet of the Submarine Signal Company presented a paper

that discussed the successful operation and wide use of submarine bells. At the meeting, Captain Reginald Bacon RN, first Inspecting Captain of Submarines and head of the embryonic British Submarine Service, spoke of the possibility of detecting submarines by the noise of their engines and observed that with electrical propulsion underwater, the noise was very slight.[3]

Progress

As mentioned above, experimental work indicated that microphones located on the hulls of ships picked up the ship's machinery noise as well as the signal from the bell. In the case of weak signals, this was unacceptable. It was learned that this could be avoided by streaming the microphone away from the ship's noise on a towed platform. Although workable, this method was awkward for commercial use, and other methods were pursued.

Submarine Signal Company founders Joshua B. Millet and Arthur J. Mundy developed a practical method for eliminating the ships self noise. Most of the ship's noises were reduced by hanging a waterproofed microphone in each of two tanks filled with a chemical solution denser than water. The tanks were about 16 inches square and 18 inches deep. With the tank secured against the side of the ship in the port and starboard fore peak, it was not necessary to cut a hole in the side of the ship.[4] The tanks were bolted to the ship's framework and sealed firmly to the ship's side by rubber facing. Signals coming from outside the hull passed through to the microphones while the own ship's noise also coupled to the microphone was reduced. The submerged warning bells were designed to resonate at 1215 Hz submerged.

Outputs from the microphones were fed to a pair of telephone receivers mounted on the bridge. A switch allowed the listener to use either the port or starboard microphone. A complete second set of receiving equipment was installed to provide reliability. A bearing of the sound waves from the bell could be found by balancing the level of the signals picked up by the port and starboard microphones through adjusting the ship's course.

4

SUBMARINE SIGNALING TO WARN LINERS IN FOG

Three Big German Ships Fitted with New Apparatus.

TESTS PLEASE THE OFFICERS

Man on the Big Kaiser's Bridge Heard Tinkling of Bells Through Water for Miles.

New York Times June 5, 1905

On June 5, 1905, the *New York Times* reported about submarine signaling with generous praise. The systems advantages were extolled by the officers of the North German Lloyd liner WILHELM DE GROSSE, recently arrived from Germany in New York. In addition, other German Lloyd Ocean liners KAISER WILHELM II and KRONPRINZ WILHELM were similarly equipped.

When under the conditions of fog and mist and approaching land, the liner's watch officers placed high value on the system. With each underwater bell having an identifying numerical code, accurate information about location in addition to providing a warning was provided to a ship proceeding under conditions of poor visibility. En route to New York from Germany, as the liner WILHELM DE GROSSE neared the coast a signal of six rings

followed by an additional six identified the presence of the NANTUCKET lightship. In a like manner, other lightships along the coast were identified: FIRE ISLAND with 6-8 bells and SANDY HOOK with 5-1. On departure from Germany, four miles from the mouth of the River Weser the local lightship provided a signal.

The Times also pointed out "Great Britain, Germany, and Italy have taken up the system, which they are installing along their coasts, while in Canada the St. Lawrence is guarded with the bells from the Atlantic to Quebec."

In 1906, Submarine Signal Company bells received United States Lighthouse Service approval and steam-operated bells were placed aboard several lightships in Massachusetts's waters. Circa 1918, 52 United States lightships and 9 buoys were equipped with the bells. After improvements, ranges of the order of 10 miles were typical. A quote by George R. Putnam, Commissioner of US Lighthouse Service (1910-1935) is of interest: "Sound from submarine bells is transmitted through the water more uniformly and effectively than it is through the air from aerial signal."[3]

Acceptance of Submarine Signal's systems using underwater bells was initially difficult but was fully established by 1912 in America and Europe. At that time, worldwide 135 of the alerting system bells were installed. More than 900 ships were equipped with the receiving equipment. Further encouragement came from the U.S. Shipping Board directive that all steel ships constructed by the Board be equipped with Submarine Signal Receiving Apparatus. It should be noted that strides made in radio transmission and reception (radio direction finding) pointed to other methods warning vessels of danger which competed with the underwater bell systems.

Submarine Signal Company
Submarine Bell Systems World Wide 1912

Australia	Argentina	Belgium	Brazil	Canada
Chile	China	Denmark	France	Germany
Great Britain	Greece	Holland	Italy	Japan
New Zealand	Norway	Portugal	Romania	Russia
Spain	Sweden	United States		

Industrial interest in the evolving technology should not be overlooked as a factor in seeking and improving detection of sounds in the sea. In parallel, the vested interest of the world's navies to seek solutions to enemy submarine detection provided a developing and long-term partnership with industry in this pursuit. In addition, the sea itself, an obstinate medium, became the source of a myriad of related questions and problems demanding answers.*

With the arrival, rapid growth, and improvement of practical submarines during the 20th century, sound in the sea gradually became entwined with the world's navies of surface ships and submarines. The April 12,1912 *Titanic* iceberg disaster stimulated renewed strong interest in underwater sound techniques for obstacle avoidance. Growing naval interest in submarine detection and commercial shipping concerns about improving safety at sea by the use of underwater sound shared a common goal. During World War I (1914-1918), there was little progress in increasing the number of submarine signal stations. After the Armistice in 1918, the demand from shipping for more submarine signal stations increased, with international support from the lighthouse services worldwide.[6]

Successful use of underwater sound by surface ships hunting submarines became an elusive goal. It was not until the extensive and well-timed use by Germany's U-boats of a *cours de guerre* tactic starting in 1914 and continuing throughout World War I that increased attention was paid to the importance of underwater acoustics as a tool for antisubmarine warfare (ASW). At the same time, sound detection developed as a pro-submarine tool when submarines were submerged and operating blind in the opaque ocean.

Although the emphasis for the development of these systems was heavily practical, overall knowledge of the sea and the

*A broad comprehensive and scholarly treatment of the history of research in underwater acoustics is found in Seek and Strike: Anti-Submarine Warfare and the Royal Navy 1914-1954, Willem Hackmann, 1984.

transmission of sound grew. In 1919, more than 150 bells were in operation. The 1920 count of Submarine Signal Company installations included 2,161 merchant ships and 1,026 naval vessels. Besides merchant ships and navies, fast passenger ferries operating from England to the coast of Europe used the submarine bells to check the boat's positions and as late as 1930 found the navigation method in daily use.

Origins of Echo Ranging

In the new century, echo ranging with rudimentary detection and distance finding features for underwater detection of objects using sound waves began with the research of two men, one working in England and the other in the United States.

Lewis F. Richardson

Five days after the tragic sinking of TITANIC, British physicist and meteorologist Lewis F. Richardson filed a patent for echo ranging with airborne sound. "An ingenious feature of his scheme was suggestion for discriminating between the transmitted signal and the echo by using a frequency-selective receiver detuned from the transmitting frequency by just the amount required to compensate for the Doppler shift arising from motion of the echo-ranging vessel."[7] He followed a month later with a second British patent application for the underwater equivalent, "...detecting the presence of large objectives underwater by means of the echo of compressional waves..." He specified the frequency of the source should be about 5000 Hz or higher.

Reginald A. Fessenden

From 1910 to 1921, Fessenden a well-known engineer, inventor and successful radio pioneer with a lifetime accumulation of 300 patents, was a consultant to the Submarine Signal Company. Fessenden's objective at Submarine Signal was to develop a more efficient underwater sound source that could be modulated into the

dots and dashes of the Morse Code.[8] This further refinement of underwater signaling would broaden the Submarine Signal Company's product line. As a young researcher, he worked with Thomas Edison. The widely-used amplitude modulation used in radiotelephony and broadcasting was one of Fessenden's accomplishments. He is probably best remembered for his 1906 radio voice broadcasts.

During his first year with the Company, Fessenden developed an oscillator that created high-energy sound waves in the water at 540 Hz. The oscillator, in addition to sending sound waves, was capable of receiving and could be used in place of a microphone to change the received sound waves into electrical impulses. The oscillator could be keyed with a telegraph key, and Morse code could be sent at increased speed and at five times the distance of the equivalent underwater bell system.

Fessenden filed for a United States patent in 1913 related to the detection of underwater objects using echo ranging. This included a moving-coil transducer operating at low frequencies and planned for signaling and echo ranging. In some instances it was used as transmitter in conjunction with a hydrophone receiver. Other features of the oscillator were noted "Later analysis showed this device to be very efficient-that is, between forty and fifty percent—with a power in the water of about two kilowatts."[9] The electroacoustic device, capable of transmitting and receiving acoustic energy in the water was referred to as the Fessenden Oscillator and sometimes identified as the first true underwater transducer. The patent was granted in 1916.

When testing the oscillator for transmitting and receiving code, it was observed that reflected waves (echoes) interfered with signal reception. Initially, it was not initially recognized that echoes horizontal (from the target) and vertical (from the ocean bottom) could be used for ranging. Fessenden's patent aimed at the distance between the oscillator and the reflecting surface.[10]

The concepts conveyed in his patents and the at-sea successful demonstration at sea of detection by echo ranging by Fessenden on April 27, 1914, provided stimulus for this detection method. Both

Fessenden and Richardson were interested in underwater obstacle avoidance.

Fessenden's first sound oscillator was an air-backed electro-dynamic driven clamped-edge circular plate a half inch thick. Weighing about 1200 pounds with a 30" diameter 1/2" thick diaphragm it was designed to operate at 540 Hz ($\lambda = 8.9$ feet). The motor generator delivered 4-1/2 kilowatts at 180 volts. The one way range was typically 4-5 miles, with maximum ranges of 30 miles reported. These oscillators found use in World War I. "By June 1927, all U.S. submarines had 540-Hz oscillators..."[11] Modified versions of the oscillators continued as research low frequency (500, 1000 Hz) sound projectors until the mid-20th century.

A test of the oscillator was made in January 1914 aboard two ocean going tugs. Tug SUSIE D with the oscillator aboard anchored at the Boston lightship and lowered the oscillator into the sea. Fessenden and Submarine Signal engineers aboard the tug NEPONSET received the signals out to a distance of 31 miles in the vicinity of Cape Race at the tip of Cape Cod. Inclement weather in the form of a snowstorm terminated the demonstration. In another January test in the Boston Harbor, underwater communication was first shown by using a Morse code carrier to modulate the oscillator, thus demonstrating a means of ship-submarine acoustic communication.

Royal Navy and Fessenden's Oscillators

As a result of the success of the sea tests of Fessenden's apparatus, built by Submarine Signal Company described above, the Consul in Boston advised the Admiralty of the results. Later, trials of the equipment were successfully held in England in Portsmouth Harbor. Next, equipment was procured for installation on ten *H* class submarines and 24 others under construction. Shore installations were made at Dover and Horse Sands Fort, Portsmouth to control the submarines in the area. The oscillator output was modulated with a Morse key. On the British submarines it was noted that the steel deck would vibrate when transmitting and

produce a tickling sensation in the feet. The normal range achieved for passing signals between submerged submarines was about 3 miles, this was sometimes exceeded (93 miles was once recorded off the North China Coast).[12]

The article referenced in footnote 12 describes how the distance between two submarines could be determined. "The distance between two submerged submarines could be measured by stop watch, the originator transmitting F and starting the watch on the last dot, the receiving boat then transmitting when it heard the last dot, and originator making a final F on the last dot of the other boat's transmission. Each could then work out the distance apart from a ready reckoner equating time with distance. The result either pleased the officer of the watch, or frightened him to death!!"

Echoes from an Iceberg

For a further demonstration, in March 1914 at Halifax, Nova Scotia, Fessenden's equipment was installed on board the United States Revenue Cutter MIAMI. At that time, the Cutter was assigned to the first International Iceberg Patrol. In 1912 following the loss of the liner TITANIC after it collided with an iceberg, there was considerable interest in determining the presence of icebergs in or near the steamer lanes. The equipment consisted of Fessenden's oscillator suspended in the water from the side of the 190-foot MIAMI. The oscillator was capable of performing as both a sending and receiving device. Reception was also supported by a Submarine Signal Company hydrophone.

An iceberg 450 foot long and 130 foot high was sighted on April 27, 1914 on the Grand Banks, off Newfoundland, Canada. Fessenden's oscillator was directed at the iceberg and for 3 hours horizontal echoes were received from the iceberg at ranges of 1/2 mile, 1 mile out to 2-1/2 miles. The distance traveled was determined by sending oscillator signals and timing their return by means of a stopwatch. Some echoes came from other icebergs. Additional echoes arriving at constant intervals were found to be

from the ocean bottom and provided depth readings.

After the test, a radio telegram was sent to the Submarine Signal Company's Boston Office:

> "First test today, bottom one mile. Berg two miles. Results good. Heard in wardroom also. Test stopped by bad weather."[13]

In 1915, the oscillator was even tested at 100 kHz. The Fessenden oscillator models (ca. 500, 1000, and 3000 Hz) were so successful that they were even used until, and during, World War II for sonar and mine detection purposes. Despite these landmark achievements, at present no oscillators are known to exist, and no modern acoustic measurements have ever been made to establish the acoustical performance.[14]

Time for the signal to reach the target and return was measured on a stopwatch and the distance to the iceberg determined. Echoes were received out to a distance of two miles. Direction of the underwater object could not be determined with the equipment. It was also noted that with the icebergs salinity equal to that of the seawater, a portion of the sound directed at the berg was absorbed. The same year the *Marine Journal* reported that it is possible with Fessenden's device to use the Morse code in telegraphy and also to telephone through the water. At the beginning of 1915, *International Marine Engineering* reported that the oscillator had been heard at a distance of 30 miles.

Using the oscillator and the echo, Fessenden also made ocean depth determinations. He referred to his sound system as Iceberg Detector and Echo Depth Sounder. In April 1914, Fessenden applied for a related patent called "Method for measuring distance" granted in February 1917. It appears that by 1922, Fessenden while at Submarine Signal progressed to using the cathode ray tube and developed submarine detection devices based on pulsed acoustic waves.

Bells and the Submarine

Submarine Signal Company bells were installed on both United States and British submarines. A comment in the Naval Institute in 1915 stated that many submarines were fitted with both submarine bells and receiving microphone.

> *"In the case of submarine boats, however, owing to the fact that the bell is hung in the perforated superstructure, and its sound is transmitted directly to the open sea, it is entirely practical to signal from one to the other."*

Journal of American Society of Naval Engineers, Vol. XXI, No. 2, May 1909, "Submarine Signaling", p. 453-457.

> *"Before ascent is made, it is practice to listen in on the submarine bell receivers for the noises made by the propellers of passing vessels."*

> *"GRAYLING directed maneuvering of NARWHAL, communicating by means of submarine bell apparatus."*

Scientific American, "The Modern Submarine", LT D.C. Bingham, Dec. 9, 1911.

> *"All modern submarines are fitted with devices which enable the commanders of submarines to communicate with each other when running under water. One of these outfits consists of a signal bell and a powerful receiver with which sounds may be transmitted and heard."*

Simon Lake, *The Submarine in War and Peace* , Philadelphia, Lippincott, 118, pg. 27.

In the following years, Fessenden's submarine oscillators found wide applications in both the military and commercial area. Data on a Fessenden submarine oscillator placed in operation on the Nantucket Lightship in 1923 produced the data in the following table.

Analysis of Ship's Reports of Distance Observations of Submarine Signals from Nantucket Lightship October 1923-January 1, 1929 (846 reports)

Signals Heard Least Distance (miles)	Number of Reports	% of Total Reports
5	765	89.4
10	488	57.0
15	285	33.3
20	178	20.8
25	107	12.5

Under adverse conditions, average distance for foghorn reception is about 4 miles and under favorable conditions 8 miles.

Later in the 1920s, a Fathometer based on Fessenden's investigations became a Submarine Signal Company product. In 1929, practically all U.S. Hydrographic Office ships engaged in deep-sea soundings used sound depth apparatus of the Fessenden type, developed by the Submarine Signal Corporation.[13] Scientific American's Gold Medal for 1929 was awarded to Fessenden for the fathometer, which could determine the depth of water under a ship's hull.

An Observation and a Need

A July/August 1915 Naval Institute *Proceedings* commentary "Submarine Signaling" points out the dilemma of the submarine captain. Fog confounds the surface ship captain. The submarine captain, submerged and with limited opportunity to use the periscope, operates in an environment equivalent to perpetual dense fog. Further discussion relates the pros and cons of

underwater bell signaling. A comment is made that proper exploitation of the Fessenden underwater oscillator could offer solutions to underwater navigation.

World War I Technology

In the United States, almost two years before it entered the War, the sinking of LUSITANIA by a submarine torpedo in 1915 stimulated members of the scientific community to offer their services in the pursuit of antisubmarine warfare methods and techniques. This coming together of the scientific community and the military for joint war effort did not stop at the end of World War I. Civilian scientists and military personnel working together occasionally presented difficult situations. As the war went on, in addition to Fessenden's oscillator, other approaches for detecting acoustic waves came almost directly from the laboratory to sea test.

U.S. Navy forces, submarines and destroyers, operating off Pensacola, Florida, during January, February, and March 1917 conducted tests and investigations of all prewar-available listening devices, which were those of the Submarine Signalling Company. The object of the tests was to determine the detection range of these devices under different service conditions. Submerged submarines listened to surface vessels of different types as well as to other submarines. Tests included the detection of submarines by surface craft. Results of the operations pointed out that the submarine was a better listening platform than the surface craft and that with the existing equipment, the probability of successfully detecting submerged submarines was remote. Specifying the location of the submarine was an additional problem.[16]

Great Britain started submarine detection efforts in 1915. At that time, initial British investigations included equipping surface ships with prewar Submarine Signal Company hull mounted port and starboard hydrophones.[19] By April 1917, Nobel Laureate Sir Ernest Rutherford, and others had two years of research and developing submarine detection devices using sound and meeting

with some success. Eventually in Great Britain there were 31 British anti-submarine research centers, with 27 of the centers dedicated to some aspect of developing and implementing equipment to detect submarines using acoustics. Development of equipment that could pick up propeller noises and detect and locate enemy submarines and surface craft was of the highest priority in England.

Soon after the United States declared war against Germany, Rutherford came to United States with a contingent of ASW scientists and engineers from England and France. Meetings and technical exchanges were held in eastern cities and at university and industrial laboratories during the period from May 19 to July 9, 1917. In May a one-week conference was held in Washington, DC with 50 scientists.

Information exchanged included the British detection devices. Discussions also involved the results of the distinguished French scientist Paul Langevin's successful investigations of the piezoelectric properties of quartz as an ultrasonic (150 kHz) transducer. At the ten primary United States ASW research centers established in 1917 and 1918 during WW I, investigations focused on piezoelectricity (quartz, Rochelle salt) and ultrasonics at seven of the centers. In the Post WWI period and beyond, piezoelectric transducers predominated. By the late 1950s, barium titanate, a synthetic material with piezoelectric properties replaced natural materials in many designs.

The vacuum tube amplifier invented in 1907 gradually became an important tool in acoustics. Previous to the war, all vacuum tubes were strictly a laboratory proposition impossible to produce in quantity and of an almost prohibitive cost. By 1917, with a vigorous wartime effort, vacuum tubes became available and at a more reasonable cost. However, immediate solutions through the war years frequently made use of the human ear augmented with horns and tubes able to compete successfully with the available mechanical devices for detecting sounds such as the recording galvanometer.

Submarine Signal Company at Nahant, Massachusetts

As relations with Germany deteriorated, the Naval Consulting Board (NCB) established in 1915 held a meeting to discuss defense measures on February 10, 1917 at the Engineering Societies Building in New York. At this meeting the NCB, headed by Thomas Alva Edison, created a Special Problems Committee with a Subcommittee on Submarine Detection by Sound. The following day the *New York Times* reported an offer to the NCB made by meeting attendee H. J. W. Fay, Second Vice President of the Submarine Signal Company: "...Company is ready to place its laboratories and all of its facilities at the command of the board in the event they are needed." At this time, the U.S. Navy had no equipment to even detect the presence of an enemy submarine, let alone its location.

A week later, the NCB invited H. J. W. Fay to discuss submarine signaling and detection. This was followed later in Boston by a demonstration of the Company's sound detection equipment. By letter on February 28, Fay requested authorization from the Chairman of NCB to obtain land to build a test station for submarine detection investigations near Boston. The NCB endorsed Fay's letter, and Secretary of the Navy Daniels acknowledged Fay's request. A site was found at Nahant, Massachusetts, on private land at East Point bordering on the Atlantic. Submarine Signal Company, General Electric Company and Western Electric Company pooled their resources and at their own expense constructed the test station. At the time, General Electric was already engaged in some research for the Navy in communications and submarine detection. Presently, engineers from the American Telephone and Telegraph Company were also at Nahant.[18] Submarine Signal Company furnished the buildings, the power plant and the oscillators.[19] The Nahant Experimental Station on April 6, the day before the declaration of war against Germany, conducted underwater sound experiments. The Station remained in operation for 20 months, disbanding in the beginning of 1919.

Nahant, a few miles north and east of Boston, is on a narrow

peninsula consisting of several causeways jutting out into the Atlantic. The test station at the most eastern point provided an efficient location for researching and conducting experiments in the offshore waters. At Nahant, the first problem planned by the Western Electric Company was to determine the nature of the sounds produced by vessels and the distances at which they could be heard. Available apparatus for this work included using the Fessenden Oscillator for sending and receiving sound signals. Incorporating a pilotron tube (an early vacuum tube amplifier) recently invented by General Electric scientist Irving Langmuir, it was possible for the first time to detect movements of ships at distances of many miles. Langmuir became a Nobel Laureate in 1932.

Nahant Experimental Station Submarine Detectors

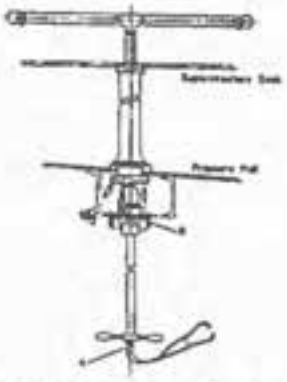
With the scientific and technological talents of the companies plus manufacturing capability, a series of detection devices were created, tested, installed and used during the twenty months of test station operation. Early investigations included consideration of Fessenden's system for submarine detection. This concept did not meet with acceptance and was dropped. Research moved in the direction of passive detection and some of the various best effort detectors continued in use until the 1930s.

C-Tube

By the fall of 1917, the Nahant group developed the listening device known as the C-tube. Earlier on 21 August, in less than four months from the start of the investigations, an experimental system was ready for test. An accounting of this test demonstrates the early success as well as a practical approach to a complex requirement, "...a very interesting practical demonstration of the use of the C-tube was given in Boston Harbor. The test was arranged to duplicate as nearly as possible an actual offensive attack upon an enemy submarine: with three (submarine) chasers equipped with C-tubes and various signaling apparatus to intercom-

municate the bearings obtained on the submarine. Miniature depth bombs, consisting of electric light bulbs designed to explode 50 feet below the surface, were dropped near the submarine to indicate that it had been located and could actually have been destroyed."[20]

The initial low frequency acoustic sound detector consisted of an inverted T shaped arrangement for surface ships. The sensor at the bottom of the T was a hollow pipe with a 3" diameter and 5 foot long and fitted with rubber spheres at each end. The spacing of the sensors accommodated a frequency of 500 Hz. Frequencies in the acoustic range of 500-1500 Hz were typical. Rubber spheres transmitted the changes in pressure through the vertical pipe to a stethoscope. On surface craft, the tube hung over the side or from the keel. On submarines, it was mounted upright on the deck. The vertical shaft fitted with a wheel could be rotated until the sound was equal in both ears. At this relative bearing, the target was located on a line at right angles to the rubber spheres. This detector was the first use of a binaural method of direction finding. Improved performance was achieved in later models by increasing the number of rubber spheres to 12 and equidistant spacing along the 5 foot section of pipe. Variants of the C-tube concept found application on seaplanes. By June 1918, General Electric Submarine Signal Company delivered 900 C-tubes out of an order of 1000 sets.



World War I SC Tube Submarine Installation

Submarine Signal Log, p. 22 Raytheon Co. 1963

Flying Boat MB-tube Navy Experimental Station WWI South Cove Fort Trumbull New London, Connecticut

C-tube operators achieved ranges of 1000-8000 yards based on 90-second listening and target bearings within 5 degrees.[21] According to Friedman, "By June 1927 all U.S. Submarines had 540 Hz oscillators (Fessenden) and SC tubes."[22] The forty-five S-class submarines included C-tube installations from 1917 through the 1930s.

By 1927, all U.S. submarines were equipped with C-tube systems. With new detection equipment introduced in 1934-35, the C-tube that persisted as an instrument of choice on many submarines saw its last removal in 1936.

Some limitations of this new detection equipment were noted. A U.S. Navy officer's remembrance of hunting submarines aboard

a submarine chaser in the English Channel in 1918 concluded that in listening there were 36 good hours for every 100 spent.[23] As a rule, in order to listen a United States small combatant was required to be silenced, stop engines and heave to. If the boat rolled, the hydrophone performance was impaired. Submarine chasers stopped every ten minutes. Operation of the detector required the submarine searching ship to be quiet, slow moving, or stationary to detect as the rubber spheres responded to the locally generated noise.

In the Royal Navy's history of sonar a comment about Nahant's C-tube is notable. "...the American listening apparatus was of great benefit to the British war effort both tactically and technically. The C or SC-tube was particularly popular, and more than 500 were in use by the end of the war...the K-tube influenced British hydrophone design during the last years of the war. The binaural compensator, too, was largely an American development."[24]

K-Tube Drifter Sets

C-tube detectors mounted on the observing platform were hampered by local noise. Further, the limited sensitivity of the rubber spheres led to the development of the K-tube, an off-hull (over the side) drifter detector system using microphones as sensors. In 1917, General Electric and Submarine Signal Company designed an improved small, sensitive, non-resonant, non-directional microphone mounted in a watertight rubber enclosure.[25] This off-hull drifter detector system could be towed behind the ship or attached to buoys and set to a depth of 40 feet.

The K-tube design consisted of three microphones rigidly mounted at the vertices of an equilateral triangle made of wood. The microphone sensors connected to the receiving platform by cable at distances of 100 feet or more. Aboard ship the output from two of the microphones connected to two telephone receivers and to the operator via flexible air tubes. Detection and bearing determinations were made using a calibrated compensation device.

In some instances, bearings were resolved using the third microphone. K-tube systems were widely used during WWI and required the ship to be at rest and all machinery shut down during reception. K-tube torpedo detection with the test ship dead in the water was made at 1000-1500 yards. K-tube detectors located enemy submarines but did not lend themselves to hunting. The detector achieved acoustic ranges of more than 30 miles.

K-tube Under Combat Conditions

In late November 1917, a group of scientists with ties to Nahant sailed to England on USS DELAWARE under the leadership of a U.S. Navy captain to test sample sets of the all of the latest apparatus on British vessels and American destroyers abroad. The equipment to be tested under combat conditions included several K-tubes and the New London Experimental Station's MF-tubes.[26] As a result of the demonstration of the newly-developed detectors, "The Admiralty was so impressed that by January of 1918 it had organized history's first sub-hunting expedition."[27]

Three ten-knot British fishing trawlers were equipped with sound detectors and radiotelephones. On the second day of the New Year on a test in the English Channel aided by an airship U-boat sighting, detection was made from a trawler. An accompanying destroyer depth charge pattern resulted in a large amount of oil and debris rising to the surface.[28] "As a result of these demonstrations, a large number of K-tubes and MF-tubes were requested by the British Admiralty and supplied by this country; and later other forms of detection devices, including tripod listening equipments, were supplied to it."[29]

K-tube Towed Detectors

Three towed configurations were developed to provide towing at high speed, constant depth, and maintaining its relative base line with the towing vessel or platform. All three configurations used compensation to determination direction. Submarine Signal Company engineered a detector (OV) meeting these requirements.

For use with dirigibles, the Nahant engineers devised a system (OK) with the microphones encased in a long rubber tube that could be lowered and towed underwater. During June 1918, towing tests for the (OK) took place by towing from the masthead of the test vessel to simulate dirigible performance.

In April 1918, a towed detector (OS) made with the three microphones mounted on a four foot equilateral triangle and the submarine chaser's engine shut down could detect a submarine moving at 4 or 5 knots in ranges of 1 to 5 nautical miles. Surface ships detected at 8-15 nautical miles. The direction accuracy was generally better than 10°. In total, 210 detectors were manufactured.[20]

K-tube on Board Detectors

The K-tube mounted on a streamlined frame on the deck or keel of a submarine was called a Y-tube. Deck mountings for submerged listening were well forward of the sail or fin and the keel installation for surface operations. Initial tests took place in March 1918, and approval followed the next month. General Electric in Lynn, Massachusetts manufactured 80 complete sets for keel installation and 25 for deck.[21] Detectors attached beneath a lightship were identified as X-tube. Those mounted within a tank inside a ship's skin were identified as Delta-tube. One hundred were produced for destroyers.

Destroyer System

A destroyer submarine detection system using Fessenden's oscillators was developed in the fall of 1917. The oscillators were constructed at the Boston factory of the Submarine Signal Company. The system allowed the observing vessel to follow the movements of a submarine. Four oscillators were located in the forward water tank and shielded from each other by sound screens. The object was detection and pursuit with the destroyer at high speed. With adjacent oscillators connected to a pair of telephone

receivers, direction was determined by sound level and compensators provided the angle to the target.

For purposes of conducting tests, Navy permission was obtained to install the detection system on board USS ALYWIN at Submarine Signal's own expense. On November 14 and 15, intricate testing with a submarine target was successful. With the Fessenden equipment partially dismantled, ALYWIN was ordered to the war zone in Europe. Admiralty tests aboard ALYWIN were successful with the destroyer operating at speeds of up to15 knots. Due to damage to a C-tube installation, ALYWIN was placed in dry dock. At this juncture, presumably the destroyer USS CALDWELL was outfitted with the Fessenden gear again at Submarine Signal expense. After the Armistice, on board CALDWELL a competitive test was held between the Fessenden equipment and the latest equipment developed by the Submarine Board. The pre-war Fessenden designed equipment prevailed.[32] A comment about Fessenden's contribution to submarine detection appeared in The History of Engineering During the World War. "The original research and experimental work conducted by Professor Fessenden in connection with the methods and apparatus which he proposed resulted in making available to other investigators knowledge and data the value of which should be fully recognized in the history of submarine detection."[33]

In the post-war period, the Nahant SC and Y tube passive detectors were broadly installed aboard U.S. submarines. The Bureau of Engineering focusing on the need for an improved trainable device worked on "supersonics" and "In January 1925 CinC U.S. Fleet drew up a standard sound outfit."[34]

Research Centers

In November 1918, there were ten main American ASW research centers, including Nahant. Sound, heat, light, and electricity were all given consideration as detection techniques. Most centers were in operation by mid-1917. Seven were supported by The National Academy of Sciences' arm The National Research Council (NRC) and were located at universities,

industrial laboratories, and the Navy Yard in Key West, Florida. One of the largest centers was the Navy Experimental Station located at Fort Trumbull in New London, Connecticut.

Primary U.S. ASW Research Centers During World War I[35]

Sponsorship	Location	Research
NCB*	Nahant, MA	hydrophones preliminary sea trials
NRC**	Ft. Trumbull New London, CT	hydrophones ultrasonics preliminary sea trials
NRC	Columbia University New York, NY	ultrasonics amplifiers
NRC	San Pedro Submarine Committee	quarts Rochelle salt magnetostriction
NRC (assistance)	General Electric Co. Schenectady, NY	Rochelle salt high-freq. oscillators Pliotron (vac. tubes)
NRC	Wesleyan University Middletown, CT	Rochelle salt
NRC	Pasadena, CA Palo Alto, CA (Part of San Pedro Committee)	power measuring instruments, cements echo-ranging
NRC	Western Electric Co. New York, NY	telephonic use of piezoelectricity
USN	Navy Yard Key West, FL	sea trials
U.S. Government	Bureau of Standards Washington, DC	quartz inspection and cutting

* Navy Consulting Board ** National Research Council

With the end of the War, all the research centers were closed. A small wartime group of the personnel at the Fort Trumbull Naval Experimental Station under the leadership of Physicist Harvey C. Hayes moved to the Naval Engineering Station at Annapolis, Maryland. Audio sound problems initiated at New London were continued there as well as further investigation of binaural listening to improve submarine detection by aural means.

Armistice

By the end of 1918, 3000 vessels were equipped with detection systems and the human ear was the primary instrument for detection and classification. The United States' 18-month extensive effort to develop and enhance underwater detection of submarines essentially stopped with the end of hostilities. However, WWI brought a number of transitions in the fighting of wars that continued throughout the rest of the 20th century. One was that government, military, industry, and academic relationships were essential to the development of new technologies to balance the measure versus countermeasure needs of wars. For the first time, WWI saw United States Army and Navy projects on over 40 campuses.[37] The mix of civilian and military personnel to address the problems related to sound in the sea brought two somewhat different approaches to the search for solutions. In some instances the military looked for using available devices for quick answers while the civilian scientists looked for answers from more basic and theoretical research. Later during WWII, some remembered this disparity of viewpoint.

WWI underwater detection efforts in the United States, Great Britain and France provided the basis for a number of detection devices in the years following the War. In the closing days of the War, the United States Scientific Attaches at Rome and Paris witnessed (August 1918), documented, and commented on an ultrasonic echo-ranging experiment. This was Langevin's successful sea test near Toulon involving the detection of a submarine with an ultrasonic echo-ranging system using piezo-electric transducers. In retrospect, this sea test and the four day

four power conference (Italy, U.S., Great Britain, and France) held from October 19-22, 1918 [38] discussing underwater echo ranging, ultrasonics, and Langevin's piezoelectric results provided a starting point for research and developments in the 1920s and beyond.

Beam tilting[39] or steering likewise provided impetus resulting from the wartime effort. Quartz, Rochelle salt, and the magnetostrictive properties of ferrous materials all investigated during the war were available for consideration in transducer use in post war systems. Fessenden's oscillator, as mentioned previously, found applications until the 1950s. Awareness of science as a tool to fight wars was highlighted by the successful detection devices developed by the team of industrial scientists at Nahant. The United States Navy faced sorting out the various detection devices and making decisions regarding the appropriate detection and other ASW equipment for surface craft and submarines.

In the years immediately following the Armistice, many of the various detecting equipments developed during the war years saw continued and broadened use for the next decade. Devices included the previously discussed SC-tubes, Y-tubes, Fessenden 510 Hz oscillators, and the MV-tube. The MV was one of the better multiple carbon button type microphone receiver listening devices developed at the New London Experimental Station. Proposed by Max Mason 3 July 1917, this set permitted the reception of sound waves from a distant source and essentially eliminated the need of using towed devices. By 1929, detectors with improved performance developed by the Sound Division of the Navy Research Laboratory were replacing the SC-tubes with improved performance.■

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NAVINT NEWS

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From the 1st June 2002 issue

New Royal Navy SSNs' Sonar Selected

Thales Underwater Systems UK (TUS) has received a contract from BAE Systems' Astute class Ltd. to supply Sonar 2076 for the UK Royal Navy's (RN) first three Astute class nuclear attack submarines (SSNs), ASTUTE, AMBUSH, and ARTFUL. In addition four 2076 ship-sets are already on order for a capability upgrade of four Trafalgar class SSNs.

The decision to use a proven sonar suite for the Astute class makes sense as it avoids the risk of a totally new system, and reduces the procurement and through-life cost of the £2 billion programme.

Particulars

(These figures may change as the design evolves)

Displacement:	7200 t (presumed to be surfaced)
Dimensions:	97m (oa)x10.7mx10m (surface draught)
Propulsion:	1 Rolls-Royce PWR 2 nuclear reactor; c27,000hp; 2 Alstom geared steam turbines; 2 Alstom turbo-generators; 2 Alstom emergency diesel-electric units; pumpjet propulsor; 1 retractable auxiliary propeller
Speed:	C30kn (submerged)
Armament:	6 53mm launch-tubes; mix of 38 weapons, including Spearfish torpedoes, TLAM Tomahawk cruise missiles, or mines (in lieu of torpedoes)
Complement:	98

Originally ordered from Ferranti-Thomson (now TUS), 2076

is the RN's first integrated sonar suite combining large flank arrays with three passive ranging spots on either flank with bow, towed, obstacle-avoidance and intercept arrays. A three year competition between Ferranti-Thomson and GEC-Marconi ended with a contract for five to seven years of full development and production. The prototype for shore trials and integration was delivered late in 1995.

Details of the system are sparse. Sonar 2079 may be the bow element. The system uses INMOS T9000 transputers, as in the AWS-950 FLASH dipping sonar. Its interfaces with the RN's standard SMCS command system have been updated with Phase 6 and Phase 7 software to support functionality. Other elements of the upgrade included a new fibre-optic Tactical Weapon System Data Highway and the Telumia Submarine Acoustic Warfare System (SAWS), a knowledge-based tactical aid to provide course-recommendations and manage the deployment of decoys.

Although originally intended only for the Trafalgar class, 2076 has since been retrofitted to the five surviving Swiftsure class.

From the 1st July 2002 issue

News in Brief

Three of the Hellenic Navy's Type 209 submarines are to have an air-independent propulsion (AIP) system installed by Hellenic Shipyards (Skaramanga). Like the Type 214 submarines currently under construction, these will use fuel cells with polymer electrolyte membrane (PEM) modules installed in new mid-sections that will be inserted into the existing hulls.

From the 15th August issue

The Royal Swedish Navy's Heavyweight Torpedoes

The Royal Swedish Navy is in the process of re-equipping its submarines and surface ships with a new generation of 533mm (21

inch) heavyweight torpedoes. Since 1960, when Sweden acquired not only the results of the enquiry into the loss of HMS SIDON but the entire design and development background of the UK Royal Navy's Mk12 *Fancy* thermal-fueled torpedo, Swedish heavyweights have been driven by high-test peroxide (HTP), with no accidents. The then state owned company FFV was given the task of producing the first of a series designated Tp 61, and variants were numbered:

- Tp 611, a wire-guided anti-ship and anti submarine weapon
- Tp 612, a swimout variant of Tp 611
- Tp 613, the standard Royal Swedish Navy variant with wire-guidance, a two-way data-link and dual speed
- Tp 617, the export variant of Tp 613, sold to Denmark, Norway, and Yugoslavia.

Other variants, Tp 614, Tp 615, and Tp 616, may have been experimental models not put into production. Tp 613 is to be replaced by Tp 62, and Tp 617 is to be upgraded.

Development of a new generation heavyweight, designated, Tp 62, began in the mid 1980s by the Navy's defence procurement agency, the Forsmaterielvarets (FMV), and the successor to FFV, Bofors Underwater Systems (now Saab Bofors Underwsater Systems). A contract worth an estimated SKR200 million was awarded by FMV in April 1991, to complete development. It was hoped to get the weapon into service around 1995, and sea trials began at Motala in 1992, but the SKR568m production contract was not signed until 17 December 1997. Deliveries started in the summer of last year, about 18 months later than planned. A *tropicalized* export variant, T96, was redesignated Tp 2000. The Swedish order was to be 600 torpedoes, while 300 were to be made for Denmark and Norway.

The major advance over Tp 613 is the adoption of an axial swashplate twin sinusoidal cam piston engine with seven cylinders. A shrouded pumpjet similar to that in the British Spearfish is made by BAE Systems' Underwater Weapons Division. The new engine maintains the 60kn capability of the Tp 61 series, with extended range. Precise figures are classified, but relaiable sources quote a range of more than 21.5mm (40km) at 40kn, falling to about

33mm at top speed. Exhaust gases are vented outboard and dissolve in seawater, so Tp 2000 leaves no wake.

Tp 2000 is 30 percent lighter and smaller than its predecessor, and has a comparatively light 240kg warhead, presumably using a shaped charge to enhance lethality. It is actuated by impact and proximity fuzes, using active, passive or combined active/passive homing to track several targets simultaneously. If the two-way wire link is severed or damaged, the torpedo's on-board microprocessor takes over full command, calculates the target's anticipated position and guides itself to the predicted point of impact. This involves the initiation of one of several pre-programmed search patterns. In the standard configuration 80 different types of data can be transmitted in both directions, and a fibre-optic link allows the transmission of even more data.

Particulars

Length:	5.99m
Diameter:	533mm
Weight:	1450kg
Warhead:	240kg
Speed:	60kn
Range:	40km+
Running depth:	500m+

The Tp 61 series played an important part in convincing the RN to return to thermal fuel for its Spearfish programme. The high speed at maximum depth required for the Cold War could not be achieved by traditional *steam* torpedo engines or batteries, so the misgivings had to be overcome. The design team at Motala have a simple explanation for the safety record of HTP in the Tp 61 series and its successors. When the British Mk12 *Fancy* was examined in detail the Swedish engineers criticized the decision to adapt a standard Brotherhood engine, then driving the successful Nk 8, by simply converting the fuel supply to HTP. This brought the sensitive fuel into contact with incompatible materials, and created a high risk of a fuel fire. The Tp 61 team redesigned the

fuel supply completely, avoiding the use of any material likely to raise the temperature of the fuel. This factor, combined with a thorough wash-through after each run, has given the Royal Swedish Navy safety and reliability as well as outstanding performance.

Typhoon SSBN Returns to Service

A Project 941 Typhoon class nuclear powered strategic missile submarine (SSBN) has returned to service after a 10 year conversion to a missile trials boat. The former TK-208 has been renamed DIMITRI DONSKOI, a traditional Russian name, and was relaunched at the Sevmashpredprivatiye shipyard at Severodvinsk on 26 June.

TK-208 was one of six Project 941 SSBNs designed by the Rubin Bureau, and at 26,500t submerged displacement they were the largest submarines in the world. They joined the Northern Fleet between December 1981 (TK-208) and 1989. The triple hulled design (two cylindrical pressure hulls surmounted by a smaller cylinder) was intended to lie on the bottom in time of crisis, awaiting instructions to launch their 24 RSM 52 (SS-N-20 Sturgeon) ballistic missiles. To boost morale during the long wait on the seabed they were given such luxuries as a sauna.

It had been hoped to re-arm the class with the new RSM 52V (SS-N-28 Bark) missile, and TK-208 returned to her builders at Severodvinsk in 1992 to start the modernization programme. The RSM 52V missile failed in early test-firings, however, and development was terminated in 1998. The missile system was also intended for the new project 955 Borey class, of which YURI DOLGORUKI is the lead boat. The decision was made to re-orient the modernization of TK-208 to allow her to be the trials boat for the submarine-launched version of the land-based TOPOL-M (SSN-27 Bulava). She was subsequently given the name DIMITRI DONSKOI, reflecting the Russian Navy's wish to revive famous traditional names.

Admiral Gennady Suchkov, commanding the Northern Fleet, has confirmed that only two Project 941 SSBNs remain in service,

TK-17 and SEVERTSTAL (TK-20). They have recently undergone maintenance refits at the Sevmashpredprivatiye yard. TK-202 has been defueled at the Zvezdochka facility in Severodvinsk under the Cooperative Threat Reduction Programme, and TK-12 and TK-13 are laid up awaiting scrapping.

News in Brief

- The Russian built Project 877EKM submarine INS SINDHUGOSH is to be modified to launch 3M-54E Klub-S anti-ship cruise missiles. She is the fifth Indian Kilo type diesel-electric submarine to be modified: SINDHUVIR, SINDHURATNA, SINDHURAJ and SINDHUKESARI have already received the upgrade at Severodvinsk and the New Admiralty yard in St. Petersburg. SINDHUGOSH is to start her refit this month and will be recommissioned in 2004. The 3M-14E land-attack variant may be acquired later.■

SUBMARINE COMMUNITY

THE IMPACT OF VOLUNTEER SUPPORT

by Sheila McNeill

Sheila McNeill is a member of the Naval Submarine League, was nominated for the 2002 Civilian Distinguished Award, is National Vice President for Legislative Affairs of the Navy League of the United States, Chairman of Friends of Kings Bay, and a member of the Georgia Governor's Military Affairs Coordinating Committee. She has also served on defense committees for both Republican and Democratic Senators.

I'm a volunteer. Most of my adult life I've been involved in organizations that support the military. I've also had many mentors. I'd like to share with you some of the ways a civilian can get involved and at the same time tell you of the impact this involvement brings. In my early years in the world of military committees, some of the most impressive and forward thinking military officers who were encouraging to me were: Admirals Chiles, Bowman, Boorda, Ellis, Giambastiani, Fages, Beers, and Konetzni. Vice Admiral Ed Giambastiani who, with his staff, gave the best briefing at a DACOWITS conference that we'd ever had. Admiral Kelso, who very recently gave me the encouragement I needed to continue with my work. Rear Admiral Jerry Ellis, who insisted that I had the *right stuff* to be recommended by the Navy for DACOWITS and encouraged me to work for that goal. And even today at Kings Bay, Rear Admiral Gerry Talbot who keeps me in the loop on issues where the community involvement is important.

Just a few years back, Generals Burba and Reimer (sorry folks these are Army types-former CINC Forces Command and Chief of Staff for the Army) and now Admirals Jim Loy and Vern Clark gave me the encouragement and inspiration to continue making those trips, (40 to Washington in the past 24 months) and working the sea services legislative issues.

One of the ways that I am most involved is with our educa-

tion/lobbying Congress. I was fortunate to have Captain Randy Zeller, then Commanding Officer of the Trident Refit Facility who briefed me on issues and stressed the way those briefs had to be given—concise and well prepared with a handout with explanatory notes. At the same time Rear Admiral Chuck Beers who, with great vision, established Friends of Kings Bay, gave me more knowledge of the operations of the Navy and encouraged me to stay involved, endured my first DACOWITS visit with great wisdom, and now serves as my National Chairman of Legislative Affairs for the Navy League.

Let me share with you a study conducted several years ago by Worthland Worldwide for the American Society of Association Executives concerning grassroots influence on Capitol Hill. This particular study was done only for the House of Representatives—not the Senate. The study showed that a congressional member who is opposed to a particular position would change his position to neutral if he/she receives as many as 80 letters from constituents who are in favor. And for those issues where the congressman is neutral, only 20 letters from constitutes who are in favor will, 9 of 10 times change to support.

And I've found that the letter doesn't have to be in a complex, technical language. In fact, some of my most effective correspondence has been the most simple.

I've heard too many say that Congress will not listen—not so—not if you are vigilant, persistent, know your subject and do your homework. The first time I spoke to our Congressman, Jack Kingston, on the SSGN was about 5 years ago when he came off the house floor for a few minutes to listen to this *great new concept*. He was as excited as I was when he heard of the concept. The same was true for Senator Cleland. If fact, Senator Cleland spoke at the 20th anniversary of Kings Bay and his subject included the necessity for the nation to convert the four Tridents from nuclear to conventional warfare with a platform for special operations forces. He continued to work toward this end.

Congressman Jack Kingston traveled with President Bush and several other congressmen shortly after President Bush was elected

when he visited Ft. Stewart in Georgia. He really didn't expect face time with the President but on the return flight they asked the congressional members if they would like to join the President in the wardroom (or the equivalent on Air Force One!) Jack said he thought to himself, what would I talk about in the five minutes allowed? What ideas do I want to put forward? How can I make the best use of this time? Then he thought of the civilians in Camden County, lobbying for the SSGN and he made the decision. After Congressman Kingston gave the same brief he heard several years prior, the President liked the concept turned to his staff and asked that he get a complete brief upon his return. We all remember his speech at the Naval Academy a few months later.

Do I think that the SSGN was approved because a group of citizens made several trips to Washington? Do I think it was approved because of all those chocolate SSGN submarines and position papers that we delivered to every member of Congress? No, I don't. But it didn't hurt!! I believe it was approved because it is an awesome use of 80+ years of submarine life that would be lost had not some very smart individuals many years ago come up with this concept. I've heard rumors but I am never sure exactly who to thank for this!

While I'm talking about community support let me tell you about the Kings Bay memorial for the 100th anniversary of the Submarine Force. Rear Admiral Chuck Beers saved the sail from USS GEORGE BANCROFT when he was Group Ten Commander at Kings Bay with the idea of one day building an exhibit. In 2000 our community and our military did this in record time. This project, much like the museum was a project with a true joint effort. My co-chairman was MMCM(SS) John Crouse, retired, the manager and curator of the St. Marys Submarine Museum—I'll talk about the museum later. Built in less than a year with everything paid for and completed by the projected date (yes, even the last minute grass sodding) gave us the opportunity for a glorious celebration of the 100th anniversary of our Submarine Force. It was a beautiful Georgia day with bright blue skies against that new fresh green grass and the stark reality of the submarine—built like a submarine rising from the sea. (There was

even a call to the base reporting a sighting of someone trying to *bury a submarine* in front of the base!) There were about 3,000 in attendance at the dedication of the 100th anniversary memorial and the exhibit has been used for many retirements, changes of commands, reenlistments, and commissioning. The entire community is proud of this large exhibit, one of the largest military static exhibits in the World.

And while I speak of retirement and changes of commands, two of the most rewarding events in my life were being asked to speak at the retirement of CMC (SS) Royal Weaver, command master chief of SWFLANT and the change of command of Captain Frank Stagl, Commanding Officer of Kings Bay Naval Submarine Base and Captain Walt Yourstone. They didn't see anything so unusual about a civilian woman speaking at these events—well maybe they did, but they did it anyway!!

I had the honor of serving as commissioning president of the committee to build the St. Marys Submarine Museum that was built with a minimum of funds. The community just pitched in and made it happen. One day, during construction, I walked around with a video camera interviewing the workers. Their reasons for their contribution had one theme. They appreciated the Navy and Marine Corps in Camden County, they were proud of the submarine service and they wanted to honor both the veterans of past wars and the present day warriors who give so much so we can be free. From electricians to painters to carpenters, they all came and they all donated their time. It was worth it all when our first WWII subvets came through. **THE SUBMARINE REVIEW** printed an article on the museum when it was first built back in 1995. At that time I said, "I have told those who have volunteered their time and energy for the submarine museum that we will have reason to be very proud of what we are doing. Those who have come and gone from Camden County always try to put their finger on just what it is about this community that makes the difference. I believe it is the esprit de corps, which is evident in many of Camden's events. This spirit is once again seen in the commitment to make a submarine museum a reality."

This year we welcomed our 76,500th visitor and, yes, John Crouse is still with us. Our museum continues to receive artifacts from our WWII subvets and other past and present submariners who want to make sure that their memories are preserved and shared with the next generation. John continues to receive requests from well-known news sources, publications, and organizations for information on the Submarine Force. Our active duty force has used the museum for commissionings, reenlistments, and retirements. Some of the Trident submarine commanding officers have used the opportunity the museum affords to educate their new, young sailors on their heritage. This has been a wonderful place also to let our general public become engaged by offering the most modern American periscope on public display. It most likely is the only wheelchair handicap accessible periscope. Presently the museum is installing major shipboard components from USS JAMES K. POLK (SSBN 645). Just recently John was called to come pick up a torpedo breech door from a WWII SubVet. The door will go on display at the George Bancroft 100th Anniversary memorial soon.

We are pleased to work with Ben Bastura, curator of one of the most complete personal submarine libraries/museums in the world. He, like John at the museum, continues to receive requests for information on the Submarine Force. Several years ago, Shirley Fages (formerly on the Submarine League staff and now in Brussels) drove me to Mr. Bastura's home/museum in Middletown, Conn. At that time he made the commitment to leave his extensive library and artifacts to the St. Marys Submarine Museum. We hope this is many years in coming and that Mr. Bastura continues to expand his collection. We realize what an honor he has given to us at the St. Marys Submarine Museum as we try to honor our submariners past and present.

Our numbers of WWII veterans are decreasing. We lose significant numbers of veterans each day. Where will we find the support for our military support organizations when our *greatest generation* is no longer here? It gets harder and harder to attract younger people. Perhaps that's what every generation thinks—but eventually each generation comes through recognizing the

importance of a strong national defense to our nation's freedom. Vice Admiral Al Kontezni made a good case for the younger generation at the Navy League's national convention in New York. He most emphatically said the young people in the military are as fine a group as we've ever had in the military. I agree. But these are the cream of the crop and those inclined toward public service. How do we attract this age to our support organizations—this is a challenge we have to meet in the Submarine League, in the Navy League, in many of the 13 organizations in the Military Coalition.

With the United States at war there is no better time to refocus our vision and to involve our citizens in this support for a strong national defense. As President Theodore Roosevelt said in November 1902: "Every man owes a part of his time and money to the business or industry in which he is engaged. No man has a moral right to withhold his support from an organization that is striving to improve conditions within his sphere."

Since the events of September 11th we have seen both retention and recruiting improve. It is heartwarming to hear of stories of those active duty members who had discharge or retirement papers in the system and asked that their papers be withdrawn. Our military continue to be stretched but, under the excellent leadership of Admiral Vern Clark they continue to perform amazingly well.

I'm also amazed at the amount of time our military spends on volunteering their time. They are deployed for weeks and months, away from families yet, when they are home—many hours are given back to the community. Just think, if all military volunteers stopped for a week—what a negative impact it would have on our communities, schools, organizations and churches. Who knows, some day it might be absolutely necessary to curtail some of this volunteer time of sailors and other military. In this time of increased optempo/itempo, demands on sailor's times are greatly increased and just how much can we continue to expect from our military? As a businesswoman and community worker, I think we should tell our military much more about how we appreciate how they affect our community by their hard work and sacrifice both in the service and in their community.

At the recommendation of Rear Admiral Jerry Ellis, (then Group Ten Commander at Kings Bay) and endorsement by others mentioned in this article, I was nominated for and served for three years on the Defense Advisory Committee on Women in the Services. I served as Vice Chair and installation visit coordinator after my first year. In the three years I served I visited 45 installations worldwide listening to the concerns of over 3,000 military men and women in every branch of the service. I was responsible for reading and compiling the results of issues from official DACOWITS visits for the SECDEF. The main issues we saw in the last two years I was on the committee were not gender issues. The military wanted the resources to do their jobs and they wanted their families taken care of. The least we civilians can to do is to support that.

I am but one volunteer—supported in my work by many. To belong to an organization is one thing. To be active in support of the organization's mission is another! I would urge all Submarine League Members to consider the positive impact they can make individually by becoming more active members.■

DOLPHIN SCHOLARSHIP FOUNDATION
THEN AND NOW
A Continuing Series

by Kathy Grossenbacher
DSF President

When my husband became COMSUBLANT, I was thrown into a job and a role that was a bit mysterious. DSF and I go way back—behind the scenes volunteer, cookbook and calendar salesperson, boat representative, even an auction chairman. However, being the President of DSF is a completely different challenge. I feel a huge responsibility as the President. Many of the former Presidents were my mentors—Sara Long, Mickie Kauderer, Betty Cooper, Joan Bacon, Katy Chiles and Pat Emery. I have great respect for the many, many dedicated people associated with this tremendously wonderful foundation past and present. Our Navy is so fortunate that the DSF is able to provide scholarships to 132 children of the Submarine Force. Today, there are hundreds *behind-the-scenes* people who do so much for DSF. I thank you. Keep up the hard work.

All of us at the Foundation office, our Board of Directors and our Distinguished Advisors, continue to strive for excellence in the decisions we make regarding DSF. In this article, I would like to highlight five people who work *behind-the-scenes* everyday to ensure the Foundation runs smoothly. They are bright, articulate, talented, hard working and completely devoted to DSF.

<u>DSF Office Staff</u>

Dianne Moore - Director of Finances and Operations/Assistant Treasurer to the Board of Directors

Dianne has worked for DSF since February 1994. She previously worked for USPA/IRA. She graduated from the University of Connecticut with a Bachelor of Arts degree in Economics and a minor in Business. Dianne is married to Lieutenant Commander Tom Moore, USN, stationed on USS ALBANY.

She manages the office, has day-to-day contact with our directors, legal counsel and financial advisors when necessary. She works under the guidance of the Foundation Treasurer and oversees all financial and business operations of the DSF. She is also my trusted assistant. I rely on Dianne's good advice, knowledge and expertise every day.

Tomi Roeske - Scholarship Administrator

Tomi graduated from the University of Georgia with a BA in Spanish. Tomi has worked for DSF since March 1991. She and Dianne are my *walking encyclopedias* regarding the history and workings of the Foundation. Tomi's husband, Captain Jackson Roeske, is a submariner. Tomi was an active duty naval officer for fourteen years and in February 2000 retired as a Captain from the Naval Reserve. She directs all activities related to the existing scholars. This includes the selection process for new awardees, the preparations, processing, updating and dissemination of all applications. Tomi maintains all student files, the database and all correspondence relating to the administration of DSF scholarships.

Ann Maliniak - Projects Administrator/Assistant Secretary to the Board of Directors

Ann is a graduate of Catholic University with a BS in Nursing. She is married to Captain Michael Maliniak, a submariner. Ann joined the DSF staff in early 2000. She produces and distributes the annual Cartoon Calendar, markets our cookbook, designs and creates all our display boards and produces our newsletter. She handles public relations and advertisements, prepares all materials related to our quarterly Board of Directors meetings, as well as boat rep, calendar chairman, Navy Relief chairman, Dolphin Store Chairman, and Vice President.

Barbara van der Biezen - Financial Administrator/Assistant to Director of Finance

Barbara has worked for DSF since late 2001. She is married to Lieutenant Commander Michael van der Biezen, Navigator on USS NEWPORT NEWS. Barbara graduated with a Bachelor of

Business Administration degree in Business Management and Economics from Kent State University. She most recently worked at Pfizer Central Research in Groton, Connecticut as assistant webmaster in Information Resources, where she developed and maintained the Pfizer Research Intranet. From 1995 to present, Barbara has volunteered in many SOWC areas including: auctions in Connecticut and Hawaii, Hawaii ISWAS newsletter editor, Dolphin Store Co-Chairman and most recently helped plan the Navywide Junior Officers' Spouse workshop-Norfolk. Barbara manages the day-to-day banking, processing all incoming money, preparing payroll checks and taxation forms.

Mary Beth Charlton - Philanthropic Development

Beth joined the staff in October 2001 to develop and implement foundation and corporation fundraising strategies. Beth moved here from the DC area where she worked in the area of grant writing and fundraising for a non-profit organization. She is a graduate of Radford University with a BS in Anthropology.

Marlene Beyrodt - Financial Administrator/Assistant to Director of Finance

Marlene is our newest employee. She started working at DSF this summer. She is married to Captain Dave Beyrodt, Commanding Officer of the Submarine Training Facility. Marlene is a graduate of West Chester State College in Pennsylvania with a degree in Chemistry/Biology. At DSF Marlene manages the day-to-day banking, processing all incoming money, preparing payroll checks and taxation forms. She has held many volunteer positions with PTA, including president, fundraising chairman, and volunteer coordinator.

We at DSF are always looking for good ideas, suggestions and advice. Again, thank you all for your hard work and dedication to the DSF.■

REFLECTIONS

TRIBUTES TO ADMIRAL R.L.J. LONG

A number of messages have been received by the Naval Submarine League paying tribute to Admiral Bob Long. The following are representative of the statements of respect and honor in which he was held by all who knew him.

From RADM Al Kelln, USN(Ret.)

Admiral Bob Long has a special place in the annals of the Naval Submarine League. He relieved Admiral Al Whittle as Chairman about our third year or so of existence. Admiral Whittle had done much on getting our organization documented and standards set. Bob Long gave us credibility within the submarine community when there were still issues of whether or not the Naval Submarine League could serve a useful purpose. It was his intent to make the League visible at the highest levels of DoD. His personality and gentle manner got the NSL Corporate Benefactors Day off to a solid start, and with his steady hand at the helm, Admiral Rickover went along with never an outspoken word.

Bob Long's relationships with members of Congress were strong and it was his idea to become proactive and give the members and their senior staffers courtesy copies of **THE SUBMARINE REVIEW**. We soon got feed back that the **REVIEW** was received as an honest look within the Submarine Force. Our submarine stock rose as we were seen to be big enough to be our own critic as well as telling what we felt the Submarine Force needs were, even if that differed from the Navy's budget.

One of his dreams was to have the Submarine League with its own analysis capability so we could document all of the suggestions NSL members hear at the Annual Symposium and the Tech Symposium and read in the **REVIEW**, then evaluate them in White Papers to support new directions of effort. One such example he cited was Jerry Cann's strong push to get into the AUV (Autonomous Undersea Vehicle) word without delay. Admiral Long wanted to have an independent look at what the

payoff could give us in the near and far term. In all, his imprint, though not obviously labeled as such, is in every fiber of the Naval Submarine League. I was extremely proud to be his associate in those formative years. *Al*

From CDR Neil, R. Wollam, USN(Ret.)

Admirals have to authorize lots of medals. As an old submariner who turned into an LDO in the submarine repair business, I was fortunate to earn two consecutive Meritorious Service Medals covering a six year period 1984-90 thanks to the hard word work of folks in the Repair Departments of USS McKEE (AS 41) and Trident Refit Facility Bangor. Admiral Long authorized both and I treasure them because I knew he was a submariner plus he took the time to send a note also. Little personal touches mean a lot.

Neil

From CAPT David Tuma, USN(Ret.)

Bob and Sara were two of the most wonderful people I have known. As a Lieutenant Commander and Ops on a boat in Norfolk, I had been considering getting out of the Navy and had been job hunting. Admiral Long, who was SUBLANT at the time, called me and asked me to come up to see him to talk about it. I went up and we talked—no pressure at all. He told me that if I changed my mind, he'd like me to come work for him up in Washington—he was headed up to be OP-02. I ended up doing that back in 1975. I had the opportunity to watch how he worked the Pentagon and Washington—he was the best I have ever seen.

On a personal note, I had the opportunity to play squash with him on a few occasions. When first asked, I thought I would be going up to just help him get some exercise. He came on the squash court in an old *holy* T-shirt, old shorts, and black high-top gym shoes laced part-way up. He quickly let me know we weren't there for exercise. He was one of the most competitive people I have met on the court. We ended up tied the first day and quit "before there would only be one of us leaving. Bob was also Godfather to my youngest son who was born during my tour in

Washington.

I have never met a finer, more principled, and accomplished naval officer. *Dave*

And, as a final word, we have from the Chief of Naval Operations, Admiral Vern Clark, at the start of his address to the NSL Symposium in June of 2001:

> "I have some credentials and connections with the Submarine Force even though I'm a Surface Warfare Officer. I had just left an assignment working for a person named Bob Long. He was the Vice Chief and I was the Assistant Executive Assistant. He was a man of tremendous wisdom and great character and integrity.
>
> I left working for him and we to (command) USS McCLOY, and it turns out he helped me with a follow-on connection in the Mediterranean. COMSUBMED was a man named Bobbie Bell and I had the SUR-15. I felt that instead of chasing carriers, I could do a lot better working with them. ...I did end up working for him and it was truly one of the richest experiences of my life."

A THANK YOU TO THE LEAGUE

August 23, 2002

Dolphin Scholarship Foundation would like to express our appreciation for the opportunity to participate in the 2002 Naval Submarine League Symposium held June 12-13. This event provided us a forum to share information about our foundation and our scholars with NSL's many supporters.

Again we thank you for the invitation to attend the symposium and look forward to continuing our relationship with the Naval Submarine League.

Sincerely yours,
Kathy Grossenbacher
President
Dolphin Scholarship Foundation

The role of the SSNs has changed, reflecting challenges of the post-Cold War world. So, we are aggressively incorporating new technologies into the *VIRGINIA* Class. Optimized for the littoral, near-shore environment, these submarines will be the *first in* and *last out* to prepare battlespace, launch land attack missiles, deploy Special Forces and more.

We are teamed to build the *VIRGINIA* Class. And we're proud to serve the Navy as it charts a new course *Forward from Under the Sea*.

NORTHROP GRUMMAN
Newport News

www.northropgrumman.com

OPERATION HARDTACK AS A SUBMERGED TARGET

Life Aboard a Diesel Submarine in the 1950s

by CAPT Ned Kellogg, USN (Ret.)
Santa Barbara Maritime Museum
14 March 2002

Captain Kellogg is a retired submarine officer who served as Reactor Officer in USS ENTERPRISE (CVAN 65) and commanded USS NARWHAL (SSN 671) and USS FULTON (AS 11). On retirement he entered the seminary and was later ordained as an Episcopal priest. He went on to serve several parishes in Southern California and today lives in his second retirement in San Diego.

As I was preparing my talk for this evening, I realized that I could not just tell you about one submarine's participation in Operation Hardtack, the atomic bomb tests in the Spring of 1958. I really had to tell you something about the submarine itself and the people who gave her life, the crew. I also had to tell you something about what it was like to be on board a diesel submarine in the 1950s. Yes, I will talk about Hardtack because that operation became the crown on the otherwise tarnished reputation of a submarine that existed for less than seven years. There are also some lessons to be learned from all this which I will try to pass on to you at the end.

First, a little background on the submarine itself. USS BONITA (SSK 3) was built at Mare Island Naval Shipyard in California. It was designed after World War II to be a small, inexpensive hunter killer platform, that is a submarine designed to sink enemy submarines. The keel was laid in March 1950, BONITA was launched in June 1951 and commissioned in February 1952. BONITA was one of three submarines of its class. When it was commissioned and for the first few years of its life it was known as USS K-3 (SSK 3), but when I first went aboard in early July 1956, it was BONITA, its name having been changed in December 1955. The other two submarines in the class were BARRACUDA (SSK 1) and BASS (SSK 2). BARRACUDA was

home ported at the Submarine Base New London, BASS and BONITA at Submarine Base Pearl Harbor. BONITA had a rather bulbous bow which is really above the waterline except when trying to make any way through the sea. This bow contained the old passive BQR-4 Sonar which was highly effective at slow speeds, but its bearing accuracy was poor. The class was designed for a second passive sonar with higher bearing accuracy, the newer BQR-2, on a chin mount under the bow. But, as a cost savings, that sonar was never installed. Instead the World War II JT sonar, a *T* shaped device on the forward deck, was added to give bearing accuracy, but it had very limited range. Atop the bow was a piece of active *searchlight* sonar. It was used for taking a single ping range just before firing a torpedo. Its range was also very limited.

I went to BONITA right out of Submarine School. It was my first choice. One of our instructors at Sub School had been on the commissioning crew and had recommended it to me. Although I could have gone to most any submarine on the list because of my class standing, Margaret was pregnant at the time and I wanted to be around for the birth of our second child. The projected schedule of BONITA would assure me of that. Also we both wanted to go back to Pearl where we had been for my first tour on a destroyer. Although BONITA would be different from the fleet submarines and Guppies (for Greater Underwater Propulsion) we had studied in Sub School, I felt it still wouldn't be too hard to qualify on, and I was really looking forward to the duty. Let me digress for a moment to tell you a little more about the submarine itself. I think it will help you understand why it was picked to be a target for an atomic device.

Some of the good features of the class were its simplicity in several areas. It had a dry snorkel mast, no main induction valve, half a fleet boat battery split forward and aft, no conning tower and therefore no safety tank, no low pressure blower for the ballast tanks, instead a diesel exhaust gas blow system similar to what the German submarine force had used during World War II, a simple remotely operated electrical control panel which kept the battery always available for propulsion, the newest fire control system, four torpedo tubes forward but none aft, all AC power rather than split between AC and DC.

Some of the bad features of the class were the propulsion diesels, the seawater to fresh water distilling plants, and the DC to AC motor generators. First the diesels: They were known as *dinkies*. World War II Fleet Boats each had one of them. Made by the Cleveland Diesel Division of General Motors or Fairbanks Morse, they were designed to keep a zero float on the battery while you were going *full on four* on the main propulsion diesels. Most submarines kept in commission after the war had them taken off because they were hard to maintain, fairly inaccessible, and only marginally reliable. On the K class they were a pain to maintain, and using their exhaust to blow ballast tanks instead of a low pressure blower was especially hard on them. They leaked cooling water and lube oil like they were going out of style; rarely were all three in commission. On one occasion at sea we were down to zero in commission; our enginemen swore at them but could usually get them back running again in a few hours of back breaking work.

Next, the distilling plants were not only unreliable but even when on the line did not make enough water to keep a crew happy. When BASS was being transferred from Pearl to San Diego, the Submarine Force Commander in the Pacific, commonly referred to as COMSUBPAC, had to scramble a Submarine Rescue Vessel, an ASR, to go out and provide water to her lest she begin to drift for lack of water to her diesels much less no water for the crew who were down to drinking and brushing their teeth with canned orange juice. Finally, the DC to AC motor generators, affectionately known as 75 KVAs, were also unreliable and nearly impossible to parallel. We had two, we were supposed to shift them daily, but usually ran one until it tripped off the line, and then started the other one. This was almost every day anyway. But actually the biggest drawback of the class in the minds of those who ran the Submarine Force at the time was that it was just too slow.

You have to realize that the senior submariners then had all served on Fleet Boats in World War II. A Fleet Boat could make 21 knots on the surface, could end around most convoys, and could get to station in a hurry. Although *Jane's Fighting Ships* said BONITA and the rest of its class could make 13 knots on the

surface, that was pie in the sky. Unless you were in a flat calm for hours on end, the best SOA we could count on was about 6 knots, maybe 6.5, but in rough seas much less. In fact, whenever we made a transit any distance which required a movement report, not unlike an aircraft flight plan which gave our position within a few miles at specific times, the entire class would almost always have to make several movement report changes in transit due to the sea state or engine repairs. Now 6 knots plus or minus a little doesn't sound so bad for a sail boat, but COMSUBPAC, then Rear Admiral *Jumpin' Joe* Grenfell, a fiery, multiple Navy Cross winner from World War II, felt this was completely unsatisfactory.

Admiral Grenfell decided the class needed to put up or shut up. He therefore sent first BASS and then BONITA on an extended arctic patrol. I'm not sure what problems BASS had, but I can tell you a little about ours. We had to stop off at Adak both going and coming back to take on both fresh water and lube oil, despite carrying multiple 5 gallon cans of lube oil in the sail. We filled our forward escape trunk with fresh water and that was our supply for showers and washing until we returned. On station it was extremely cold and our snorkel mast would ice up while snorkeling, drawing a vacuum in the boat and periodically shutting down even the one engine on the line, due to the high vacuum cutout. But the worst problem was one we generated ourselves.

We had a submerged collision with a massive iceberg which wiped off our radar antenna, damaged one periscope, and took away our VLF and HF antennas. We were left with only the long wire to communicate. This happened when our conning officer saw what he thought were the lights of ships on the horizon, which by Captain's orders he was to close, only to discover suddenly that what he had seen was the moonlight reflecting off ice. When we returned to Pearl, proud to make it home in one piece, more or less, with no one hurt, COMSUBPAC was livid. Just as soon as the Submarine Base and Pearl Harbor Naval Shipyard could effect repairs, he wanted us out of his sight. He was transferring both BASS and BONITA to San Diego.

So you can see, when nine months later a submarine target was requested for Operation Hardtack, the1958 atomic bomb tests at Eniwetok and Bikini, Admiral Grenfell had already decided to

decommission both submarines; so why not volunteer us. He did. But before I tell you about the tests, let me again digress and talk about the crew. You see, it is the crew that makes a Navy ship, certainly it makes a submarine, not the hardware. Overall the Wardroom Officers were a tight knit group. When the chips were down we supported each other to the hilt. All submarine wardrooms are that way. We had a good crew too. Hard working, dedicated chief petty officers and below who got along despite the close quarters and the many hours at sea. We had one *plank owner* still on board, that is a member of the commissioning crew. He was a second class engineman named Gignac. Gignac was in the auxiliary gang and knew the boat cold. He was a great help to everyone trying to qualify in submarines. One of my priest friends remarked to me recently that he thought submarine crews must be something like monastic communities when at sea. In many ways he's right. Certainly, a submarine crew at sea is very considerate of one another. You would never leave a wash basin or shower after using it without wiping it clean, leaving it in as good a condition as you found it. But submarine crews also engaged in pranks against one another like stealing the door to the Captain's Stateroom or hiding the seats to all the commodes. They may be like a monastic community in some ways, but they're sure not very saintly.

When we left for Eniwetok I was the officer who had been on board BONITA the longest, less than two years. Dan Marangiello, Naval Academy class of 1951, came aboard six months after I did. He was a bachelor. We were delighted when we heard he was coming, for we thought whenever there would be a wardroom family type get together, Dan would stand duty for one of us, since the rest of us were married. We were wrong. Dan was more of a party animal than any of us. If something was planned when he had the duty, Dan would try to get one of us to stand by for him. He was fresh out of Submarine School, but had a different background from the rest of us. After qualifying as an Officer of the Deck Underway on a destroyer, he had gone to MIT for post graduate training in engineering. He was on track to become a Submarine Engineering Duty Officer. All he needed was to earn

his Dolphins first. He served BONITA as Engineer Officer. He's probably the finest engineer I've ever known, although he could be rather frank with some of his superiors, which some probably took the wrong way. We're still good friends. He finally married several years ago, lives in Annapolis, and Margaret and I had dinner with him when we were back there for my 45th Class Reunion in 1999. He graciously provided me with his personal remembrances of Operation Hardtack.

Our Operations and Weapons Officer was Bill Green, NROTC from USC, Class of '52. Another great guy, we became the best of friends. He and his wife Marge became Godparents to Carolyn, our third child. He also passed on to me his reminiscences from Hardtack. What you will hear in a few minutes will be a combination of Dan's and his and mine. Bill also was a superb officer, coming to us kicking and screaming from USS SEA FOX where he had qualified. He was a real people person as well as a super competent officer. When BONITA was finally put in mothballs after Hardtack, Bill went off to Navy Intelligence School, while I headed to Nuclear Power School. But our paths crossed many times after that, and each time was a wonderful family get together. Bill had an outstanding career with many great assignments including command of the submarine TUNNY during Vietnam, a diesel boat based in the Philippines that Navy Seals used to infiltrate the Vietnamese coast. Much later he did a super job as Defense Attache in Rome during the Cold War. He retired just a year before I did from the deck of NAUTILUS, now lives in Coronado, and we still get together every few months or so. One of the greatest things about a Navy Career is that you make friends for life. I can think of no better friends than Bill and Marge Green.

The last two officers making up our unholy five were the skipper and the exec. Of the Exec, or XO, there's not much to tell. He was the last one to come aboard shortly before we left San Diego for Eniwetok. His name I will leave out. He was competent enough but never did hit it off with the skipper, which was his undoing. On the way out to Eniwetok, as our Navigator, he failed to get up to call our turn into the long mine swept entrance lane. We overshot, causing us to have to go through waters that had not

yet been swept for mines. The skipper never forgave him for this. The skipper was Bob Newbern, a dynamic, hard charging officer. When I qualified in submarines, he gave me his dolphins, which I still have. Captain Newbern had been one of my instructors in Submarine School. He was in the Weapons Department there. We called him *Tubes Newbs* for he really knew his stuff. He could also be a bit crude, rarely dismissing a class without remarking, "Time to go home and play with the baby's mama." After BONITA he went on to a great command, the submarine SALMON, where he distinguished himself winning more than one Battle Efficiency E. I'm truly sorry to say that he died this past year. Otherwise, I would have been delighted to have him share some of his reminiscences also. They would have added much to this talk. Far and above anyone else Captain Newbern was the reason we were able to bring BONITA back in one piece, rather than leave her on the bottom thousands of miles from home.

Before we could leave for Eniwetok, BONITA had to be configured for the tests. While we were being configured, our sister submarine BASS was decommissioned at Mare Island Naval Shipyard on 20 December 1957. For us however, this meant a three month availability at the old Hunter's Point Naval Shipyard, very close to where Candlestick Park is today on the south side of San Francisco Bay. First, four huge pad eyes were welded directly to the pressure hull protruding through the ballast tanks and seal welded to prevent escape of air from the tanks. These were to moor BONITA for the two blasts. Next, a means for venting and blowing ballast tanks from outside the pressure hull had to be devised. This was accomplished by adding piping to the vent risers of two ballast tanks leading to two valves topside, and adding high pressure piping with a shut off valve from the topside high pressure air charging connection and the internal ballast tank blow piping. This latter valve was marked with bright white paint so that divers could see it. Finally strain gages were installed throughout the boat and two 1,000 frames per second movie cameras were installed to get a feel for exactly what happens when the shock waves hit. An elaborate timing device was set up through a radio receiver to actuate the cameras at the exact time of

the explosions. Since the atomic bomb tests meant that BONITA was less than likely to return from Eniwetok in serviceable condition, the boat was decommissioned at this time and placed in a new category called *In Service Special*. There was some debate whether we were still a *United States Ship*, but it was decided that it wasn't worth making that change. During this time our crew was also pared down to just those we'd really need for the transit out and to maintain all the equipment on board.

During a battery charge the last night before we left the shipyard, one of our *dinkies* blower mechanism froze causing a brief fire. This in turn caused the engine to go hard down which required a blower replacement. Since the blower was bigger than our 25 inch hatches, this meant a pressure hull cut to remove the old blower and install the new one. Most skippers I'm familiar with would have stayed in the shipyard to get this done, but not Captain Newbern. He said, "We're leaving as scheduled. We'll get it fixed in San Diego." And we did.

Also in San Diego Dan, our gifted Engineer Officer, made a couple of modifications to BONITA which were to prove very effective going out to Eniwetok and coming back. First he converted one of our auxiliary tanks to a fresh water tank. All submarines have four tanks inside the pressure hull to trim the boat, that is make it neutrally buoyant when submerged, and not only just neutrally buoyant over all but stable both forward and aft. These four tanks are Forward Trim, near the bow; After Trim, near the stern; and two Auxiliary Tanks, as close to the center of buoyancy as possible. At Sub School young officers must learn how to dive a submarine and *trim it*. That means getting it neutrally buoyant after a dive. There are diving trainers to teach this that can be programmed to make the boat heavy or light, forward or aft. The diving officer has to figure this out in his head by the way the boat responds and pump or flood as necessary to get the ship into perfect trim. The diving officer has speed control of the boat until he makes his report: "Trim satisfactory, Sir." Only then does the conning officer take speed control. A favorite trick of conning officers is to order all stop after receiving a "trim satisfactory" report, particularly if his own evaluation of the trim indicates his diving officer was premature in reporting trim

satisfactory. A submarine's Engineer Officer normally computes the trim before the first dive after any time in port taking into consideration all weight changes since the last trim dive, such as torpedoes, stores, fuel, etc. Anyway, since auxiliary tanks are quite large, this gave us an ample supply of fresh water for the trip even if our distilling plants became even less reliable.

The second thing Dan did was to convert a hydraulic oil tank to a lube oil tank. This solved our lube oil problem, but unfortunately created hydraulic oil problems. On the way to Pearl we developed a number of hydraulic leaks that caused great concern. We were down to using only the hydraulically operated rudder which was vital to steer the boat. All other hydraulic equipment was isolated from the system. Captain Newbern even ordered Dan to research what else we could use on board for hydraulic fluid. Dan did this and reported that Wesson Oil was the best substitute available. From then on the cooks didn't use any Wesson Oil until we got to Pearl. Dan recently wrote me, "Ned, I cannot tell you how many prayers I said in my bunk every night." After Pearl we carried fifty 5 gallon cans of hydraulic oil secured by white line everywhere in sail and superstructure.

At Pearl Harbor we replenished all our supplies, including oil. There Captain Newbern made a courtesy call on COMSUBPAC who told him in no uncertain terms not to bring BONITA back, that he didn't want to spend any more money on a piece of junk.

Arriving in Eniwetok was also quite an experience for a submarine used to operating solo. We realized that we were truly a very small cog in a very large wheel. There were 44 ships involved one way or another in the series of blasts. At first it was hard to find the right people to talk to. As someone said, there were 10,000 men in Bermuda Shorts on a very small island, and no one seemed to be in charge. When we finally looked at the plans for the first test we were involved with, a deep explosion in very deep water with BONITA at a range of about 4,000 yards, heavy and suspended from large floats, we concluded that the chances of the boat surviving and not going to the bottom were minimal. "Why don't we do the shallow water test first?" we asked. "That's not what the schedule calls for," was the reply.

"Well, can the schedule be changed?" "No chance." Characteristically, Captain Newbern would not accept this answer. We had a wardroom meeting, and after much discussion he decided the only way for the boat to survive the first test was for us to man her. He then volunteered all of us except the XO, who was to remain in charge of crew members who stayed on our support ship USS HOOPER ISLAND. Captain Newbern ordered Dan, Bill, and me to get one strong section of volunteers to be on board for the test. He then went to see the Chief of Staff to the Admiral in charge of the tests. When the skipper proposed that we man BONITA for the deep water test, he was told, "No, do it as planned." "Well, then," he replied, "I'd like to send this message." He pulled a typed message out of a folder addressed to the chain of command, including the Chief of Naval Operations, requesting that he be absolved of the loss of BONITA before the shallow water test could be conducted. The Chief of Staff blinked, told him to hold the message, and said he'd see what he could do.

Two days later the word came back that we could man the boat. Since the range to the blast of 4,000 yards was too risky, we would move out to 6,000 yards for an extra safety factor. There would also be another submarine there, USS STERLET another 1,000 yards farther out. As both Supply Officer and Communications Officer, I had already started off loading all consumables and classified publications to HOOPER ISLAND; so I had to get them all back on board. Captain Newbern didn't want any volunteers on board for the test to think there was any chance we wouldn't survive it. He was right. Most of us were more than a little apprehensive.

We then devised our own plan as to how to rig the boat for survival. First off, we would rig BONITA for depth charge which meant all watertight doors were dogged shut and bulkhead flappers in the boat's ventilation system were closed. We also decide to secure all sea water lines into the boat during the countdown so that the over pressure would not cause any internal ruptures. This included all depth gage stops. This caused some amusement just before the test when Captain Newbern noticed that we were getting shallower and shallower (the depth gages were drifting after the stops were secured). He shouted at Dan who was on the dive with

some colorful profanity I will leave out. Dan reported very quietly that the stops were shut, at which the skipper apologized. In addition we added a simple tape recorder of our own to monitor what went on in the Control Room and Conning Station. This was great fun listening to later, hearing the voices rise in octave levels the closer the countdown came to the blast. When the blast occurred, a brief roar was heard on the tape, then nothing. The first of three shock waves had blown the power cord out of its socket.

On the day of the first test, code named WAHOO, we got underway early, waving good by to the XO and about half of our enlisted crew on the support ship. They kidded us a little, but there was concern on their faces. We made our trim dive in deep water and took our station at periscope depth and slow speed on a 6,000 yard radius circle from the blast point. We kept the blast point on our beam and slowly circled. STERLET did the same 1,000 yards farther out. The nuclear device was suspended from an anchored barge at a deep depth. On the barge were antennas to receive the signal to detonate the device. The long countdown came over the radio to all in the area. There were at least three old destroyers and possibly other ships, unmanned, that had been towed out to Eniwetok also in the circle at shorter ranges than we were from the barge. My station was all the way aft at the normally unmanned, except for battle stations and maneuvering watch, manual propulsion control panel. With me was an Engineman who will remain unnamed, very competent, but very nervous. I was manning a sound powered telephone headset on the line with other manned stations. The countdown was being relayed to all of us from the Control Room over the General Announcing System.

At 1330 on 16 May 1958 WAHOO blew. When the blast went off, it sounded to me like a freight train was running over us. The boat shook violently, light bulbs broke, dust and debris flew everywhere, and all the lights went out as our 75 KVA tripped off the line. The Engineman with me soiled himself, but then ran as fast as he could to get it back on the line, which he did, while I made my damage report to Control. What I called a freight train, Dan and Bill described as three separate shock waves. The first

one was the direct wave; the second, a bit milder, the bottom reflection; and the third, milder still, the surface reflection. Dan pointed out to me recently that if the direct shock wave and bottom reflection had arrived much closer together, there would have been serious trouble. After we surfaced to return to HOOPER ISLAND we noticed that both of our escape trunks had water in them. This phenomenon we didn't understand until after the second test.

We learned from one of my classmates on STERLET that they had their problems also, including a loss of power and a number of minor leaks. A few days later they let us see the movies from our 1,000 frames per second cameras. These showed us a ripple effect as the shock waves hit, wrenching both BONITA and all the mounted equipment in the Control Room. I vividly remember seeing the ripple go through the Fire Control System, which we could never get to work again, by the way.

Before I describe the second test, I feel I need to tell you a little about what Eniwetok was like in the Spring of 1958. When we arrived, the place was not really geared for submarine crews. There was only one place an enlisted man could go for some liberty, a very small island called Elmer with a very small beach with a shark net. On it there was an open air pavilion at which beverages were sold. Beer and any kind of a high ball went for 10 cents each, soft drinks were 15 cents each. There may have been some snack food too, but not much. When we arrived, the liberty policy for enlisted men was 10 percent of each crew due to the lack of recreation areas. The good Captain Newbern quickly got that changed for our crew, and we basically could send up to half of ours to Elmer. The only way to get to the island was by Mike Boat which picked up liberty parties about noon and returned them in the early evening. There was also Shore Patrol assigned to this so called *recreation island* as I recall, three or four petty officers and one officer. You can imagine what would happen in the hot afternoon sun with alcohol cheaper than soft drinks. People on liberty got very drunk. On one occasion they overpowered the Shore Patrol, who were not allowed to drink when on duty, stripped them buck naked, and sent them back with no clothes at all. After that, when I was assigned as Shore Patrol Officer, I made sure I had big strong non-drinking petty officers along with

me. A few in our crew got in trouble after drinking too much, but for the most part we were model citizens. We had one Second Class Engineman named Ashley, formerly a First Class Engineman, whom the skipper had to order not to drink at all, and he actually obeyed. Our boat's saving grace was a volleyball tournament in which we entered a team and won, against several larger commands. This really perked up crew morale and kept us going for the next test.

We got underway for the second shallow water test, code named UMBRELLA, early in the morning on the day before the test. This was the test the Submarine Force was most interested in, since a nuclear tipped torpedo was in the design stage. The Submarine force needed to know how far the stand off range had to be so that the submarine that fired the torpedo didn't sink along with the target. As I recall, most of us were on board, and all consumables and classified publications had been offloaded to secure stowage on HOOPER ISLAND. We arrived in position, bow on to the device at a range of 1,000 yards. Chains with heavy weights attached were secured to our four pad eyes. Dan trimmed the boat some 10,000 pounds light. The outer door to one torpedo tube was opened to simulate the firing of a wire guided torpedo. We all left BONITA and got onto a Fleet Tug. Dan and Captain Newbern were the last ones off. They opened the vent valves topside, and it took BONITA 23 minutes to submerge. This was a rehearsal run, and the divers in scuba gear went down and opened the painted white blow valve topside. The boat surfaced nicely, though with a slight down angle, with the diver riding up on deck and securing the blow and vent valves. Now we were ready for the actual test. We went back on board to recheck everything and spent the night in the moor.

The next day it was for real. This time Dan had the escape trunk hatches wired shut so that no sea water would get in, he thought. We repeated the previous day's sequence and waited out the test on the Fleet Tug. At 1115 on 9 June 1958 UMBRELLA went as scheduled. This time we watched the test from about 10,000 yards away. It was quite a show. We stayed there until after BONITA was surfaced by the diver, and I heaved a sigh of

relief when I saw her pop to the surface. We waited as BONITA was checked for radiation, and when the all clear signal was given, our Fleet Tug took us along side. Dan went over to the boat first, unwired the escape trunk hatches, and proceeded below with a CO2 sniffer to check each compartment. Again he found water had entered the boat through both escape trunks. We later learned that for both blasts after the initial high pressure shock wave there is also a very low pressure that follows. This low pressure lifted the hatches off their seats thus bringing in sea water. When Dan reported the air in boat was okay, we got back on board and got the boat ready to return to HOOPER ISLAND as soon as the chains with the weights could be removed from the pad eyes topside. When we finally got alongside and secured, I was exhausted, and although we had been told to wash thoroughly, I fell asleep on the wardroom transom.

The next day we were confronted with a new problem. HOOPER ISLAND had taken radiation readings on us and determined that none of us could come on board without first being frisked with a radiation detector and walking through a shoe washing solution. Again Captain Newbern got into the act and solved this dilemma rather quickly. We had to get everything locked aboard HOOPER ISLAND back on board before we could head for home. This we did while Bill got his sailors to wash us down topside and throughout our superstructure with fire hoses from HOOPER ISLAND to eliminate areas of higher than allowed radiation levels. A few days later after conducting one final trim dive, the last one for BONITA, with permission from the Operation Hardtack Commander, we were underway for Pearl. Just before we left, the crew painted a new insignia on each side of the sail. It pictured an atomic bomb blast with two hash marks underneath it, symbolizing what we had survived.

When we arrived in Pearl and later in San Diego, it was a different story than before. We were hailed as conquering heros even by COMSUBPAC. In our formal report of the two tests Captain Newbern recommended that never again should a submarine or, for that matter, a surface ship have to serve as a target for such tests. He had learned from some of the scientists on Eniwetok that you could get the same kind of information from shaped

charges at varying distances which could be correlated to an atomic blast of any magnitude. Although I don't know whether this was ever adopted by surface ships, I do know that it was adopted by the Submarine Force, and no submarine ever went though any atomic tests after BONITA. As a footnote, the last atmospheric test at Eniwetok was conducted in 1962, Operation Dominic. After that all United States tests went underground on our own turf.

BONITA finally returned to San Diego, and stayed there for about a week so the crew could get together with their families, and then departed for her place of birth, Mare Island Naval Shipyard. Most of us took our families up there with us. Captain Newbern was relieved just before we left to take over SALMON. One last postscript, while at Mare Island we continued to look for ways to keep the crew's morale up. We entered a team in the flag football league there, and we won the afloat championship. All of our officers played on the team, keeping the great spirit of camaraderie with the crew we had developed on Eniwetok. On the morning of 7 November 1958, I and what was left of the crew departed BONITA for the last time.

Before I close and open up for any questions you may have, let me pass on one more lesson learned from the short life of BONITA. That is, "You just can't build an inexpensive submarine that is worth much at all, unless you man her with a crew of courage and heart."

Thank you.■

PRACTICE MAKES PERFECT

by CAPT John F. O'Connell, USN(Ret.)

During 1957 I served in USS CAIMAN (SS 323) with Lieutenant Commander Jack Hawkins as CO. Jack was a wonderful man to work for if you didn't mind being held to very high professional standards. We had a very good boat, and as I recall we won the *E* that year. However, Jack became concerned about the fire control party's lack of precision at the firing point. So we retired to the conning tower one afternoon during the final week of upkeep before a week of type training and we practiced and practiced and practiced. We responded to a dummy target introduced from sonar, solved for target motion and honed our skills at the firing point procedures. "Set, Shoot, Fire!" rang out time after time as we simulated firing torpedoes. This seemed to go on for hours. Jack never yelled at us but he was adept at Chinese water torture methods and he never let up for a minute. 'Set, Shoot, Fire!" again and again, ad nauseam. Finally we quit, having honed ourselves to a very fine edge, with Jack confident that he had the best firing point fire control team in the Pacific Submarine Force.

On Monday we went to sea and started an approach on the target. I was fire control coordinator and Ray Heimbach, our XO, was assistant approach officer. John Shilling manned the TDC and Joe Smith was ATDC officer. We did a nice job of target motion analysis as I recall and were getting close to the point where we could fire a Mk 14-5 steam torpedo with a high hit probability. Ray checked on all the details: torpedo ready, tube flooded, and muzzle door open, as the range closed.

Then he made a fatal mistake. He turned to John Shilling at the TDC and asked John "Are you set?" Immediately Joe Smith, having heard the magic word "Set" and having already computed the spread, yelled "Shoot", the fire controlman on the firing key hit the button and yelled "Fire" and away went the exercise torpedo with poor Ray yelling "Noooooo" and trying to pull it back into tube with body English.

I can still remember Jack Hawkins' look of disgust at his highly trained and finely tuned fire control party as the torpedo went out and missed the target.■

THE SUBMARINE REVIEW

THE SUBMARINE REVIEW is a quarterly publication of the Naval Submarine League. It is a forum for discussion of submarine matters. Not only are the ideas of its members to be reflected in the **REVIEW**, but those of others as well, who are interested in submarines and submarining.

Articles for this publication will be accepted on any subject closely related to submarine matters. Their length should be a maximum of about 2500 words. The League prepares **REVIEW** copy for publication using Word Perfect. If possible to do so, accompaning a submission with a 3.5" diskette is of significant assistance in that process. The content of articles is of first importance in their selection for the **REVIEW**. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the **REVIEW.**

A stipend of up to $200.00 will be paid for each major article published. Annually, three articles are selected for special recognition and an honorarium of up to $400.00 will be awarded to the authors. **Articles accepted for publication in the REVIEW become the property of the Naval Submarine League.** The views expressed by the authors are their own and are not to be construed to be those of the Naval Submarine League. In those instances where the NSL has taken and published an official position or view, specific reference to that fact will accompany the article.

Comments on articles and brief discussion items are welcomed to make **THE SUBMARINE REVIEW** a dynamic reflection of the League's interest in submarines. The success of this magazine is up to those persons who have such a dedicated interest in submarines that they want to keep alive the submarine past, help with present submarine problems and be influential in guiding the future of submarines in the U.S. Navy.

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NAVAL SUBMARINE LEAGUE
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BOOK REVIEW

TERRORS AND MARVELS
by Tom Shactman
ISBN 0-380-97876-8 $26.95

Reviewed by Tom Pelick

This is an excellent documentary about the role of science and technology in WWII. The interaction between the scientific community and the military is closely examined for both the Axis and the Allies prior to and during the War. The author examines closely the relationship between the military, scientific community, and the money source: the political leadership.

In the book, there are many names to remember, however, these are to provide accuracy and tell the story about how science and technology supported the war effort on both sides of the conflict. The author indicates that the Axis, particularly Germany, focused on development of war materials based on current technologies instead of investigating newer technological concepts. When Germany began their war on two fronts, even scientists were drafted into the military. Sometimes, scientists and engineers had trouble convincing the political leaders that their concepts were worth pursuing. Again monetary priorities were given to proven techniques which would directly aid the war effort.

In Chapter 8, *Seagoing Science* the author indicates that the German allocation of funds to ground forces hindered Germany's submarine force by denying the development of the snorkel until late in the war. Admiral Doenitz remarked that the extreme loss of German submarines in 1943 was related to the Allied development of microwave radar which located the submarines traveling on the surface. The Allied Mk 18 electric torpedo and the homing torpedo, the Mk 24 known as FIDO, were based on concepts obtained from captured German torpedoes, such as the T-34 torpedo with its homing system.

Radar was also helpful in detecting incoming German planes and helping the British fighter pilots to double their efficiency by scrambling earlier. When Germany developed the jet plane, Hitler

insisted that it be applied to bombers only and not fighter planes as his advisors suggested. Communication systems including Ultra and the German's short compressed bursts of information from submarines are discussed in detail. Some of the guidance systems for bombs were aided by proximity fuses with radar homing systems. Near the end of the war, crude televison homing systems were used in bombs called *Robin* and *Azon*.

Prior to WWII, several scientists were purged from Germany for political reasons. Other scientists, such as Albert Einstein, fled Germany to avoid persecution. The author spends a bit of time talking about some of the reasons that the U.S. was able to develop the atomic bomb first. There were several factors, including bombing German controlled heavy water sites, refining uranium, and industrial might. Prior to WWII, the concepts of an atomic bomb, were known to many scientists in both Axis and Allied communities.

It is noteworthy that both the Axis and Allies developed large poison gas stockpiles during the war. Fortunately, based on the lessons learned from WWI, both sides refrained from using these poison gasses. However, the author reports one accidental leakage which occurred late in WII, a German bomber bombed a U.S. ship carrying a cargo of poison gas near a Southern Italian harbor. The ship sank and some of the gasses were released causing some injuries in terms of blisters and burns.

The author talks about the limited concept of sharing technologies between the Allied partners. Initially, no one wanted to provide Russia with all the newer technologies. In the early part of WWII, Churchill was reluctant to share full atomic research concepts with the U.S. since he felt the English were more advanced than the U.S. in its development. Of course this changed, as the U.S. with its resources and scientists made rapid advancements and after Einstein wrote a letter to President Roosevelt about the feasibility of building an atomic bomb.

After World War II, the U.S. Navy decided to maintain its technological edge developed during the war, by funding several University research laboratories, such as Johns Hopkins, Applied

Research Laboratory/ Penn State, the Applied Research Laboratories, University of Texas, and the Applied Physics Laboratory. Admiral Hal Bowen (now deceased) was the director of the newly created Office of Naval Research which helped to further develop technologies after WWII for Navy applications. Facilities at MIT and Caltech supported technical innovations for the Army.

This is an excellent book about the role of technology in World War II. I highly recommend it for your reading. It is contains so many technological marvels that it is difficult to select which ones to use for this book report. The author details the relationships between the political, military, and scientific communities and how the interactions affected the war on both sides of the conflict.■

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