THE SUBMARINE REVIEW
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FEATURES **PAGE**

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EDITOR'S COMMENTS

With this issue **THE SUBMARINE REVIEW** salutes the start of the Submarine Centennial Year and offers two Features of particular and timely notice. The lead Feature is a speech given by Admiral Skip Bowman, the Director of Naval Nuclear Propulsion, at MIT in mid-December in which he states the case for a larger Submarine Force than the current objective. He gives both the reasons for current taskings and the logic for future needs. In his President's column VADM Dan Cooper cites this speech, offers some specific force numbers which are emerging from current studies, and recommends it for all. There is a lot in Admiral Bowman's words which can be used to great effect by all of us in our conversations, presentations and debates throughout the coming year as the focus on submarines, and submariners, becomes more intense.

The second Feature appropriate to the Centennial Year is the update on the events and special activities being planned. The complete schedule is kept on the Navy's Home Page and directions to that part of the world-wide-web are found within the article. Please note there is an offer to purchase one of the Submarine Centennial jacks to be flown from all U.S. submarines while not underway. This offer is definitely time-limited so check out the update right away.

The other two Features are really calls for the attention of the submarine community from two widely different arenas of the undersea warfare world. RADM Suggs, Deputy CinC of the U.S. Special Operations Command, speaks of the submarine's place in a needed "forward-deployed credible conventional deterrence" and specifically cites the advantages to be gained from the proposed conversion of several Trident SSBNs to an SSGN force. From the *heavier* end of the deterrence spectrum, Captain Bill Norris, now with Sandia Labs, outlines a scenario for the not too distant future in which a probable National Missile Defense System might significantly alter the cost/benefit equation of ICBMs vs SLBMs. This look into that future alerts the submarine community and warns against any complacency in regard to the prospects for any next-generation Strategic Submarine Force.

In the more general-interest Articles section there are several items which may be of more specific interest to certain discrete sections of the submarine community. First, there is Dr. Lee Willett's survey of Britain's submarine status and future. While that subject is, of course, of general interest to all of us, those seeking to make the most effective political-military arguments for credible and viable submarine forces should note the logic Dr. Willett deduces for the specific RN force levels set by their government's Strategic Defense Review. For the historians and the World War II group there is a piece describing CDR John Alden's effort in updating the post-WWII JANAC report of sinkings by submarines, using declassified information and a deeper look at Japanese records. For those into the naval architecture of submarines (and who among us has not tried his hand at putting favorite ship characteristics and warfighting attributes into a hull form), Mr. Mark Henry gives us a story of the problems involved. It is a great rundown of an early NavSea effort to accommodate an external weapons carriage scheme to an acceptable submarine hull design.

For those with a desire to learn all there is to know about the history of torpedoes (and we know what happens when the generalists leave the weapons problem exclusively to the ordnance experts) we have another review of a particular sector of that history from Fred Milford. The other articles all rate specific mention, but let it suffice to recommend reading all of them.

Jim Hay

FROM THE PRESIDENT

As we enter the year 2000 (which may not be the beginning of the next millennium since we usually start sequences with the number *1*) the Naval Submarine League continues its primary missions of supporting the Force and educating its members and the public. The Submarine Centennial has been and will continue to be our primary focus this year—thus addressing both missions.

By now many of you may have seen the submarine representation in the Rose Bowl Parade. There have been or will be many events throughout the country from the Smithsonian Exhibit opening in April, to the Submarine Museum addition in New London, the Cold War Memorial with a ceremony in Charleston in November, and many others from Pearl Harbor to the East Coast.

Various members and units of the Submarine Force, the Submarine Veterans of WWII, Submarine Veterans Inc., and the Naval Submarine League will sponsor each of these activities.

I strongly solicit your support for all these and **your attendance at the NSL Annual Symposium in June**—at which we will honor the WWII Submarine COs and the several active duty awardees who are now serving our country and submarines.

As to *education*, there are several interesting articles in this edition, but none is more germane and timely than Admiral Bowman's speech to the MIT security Studies Program. [Jim Hay, literally, got permission to print it as the Admiral was delivering it in December.] In the speed he addresses the Force past, present and future. With that as a basis for your information, you should know the long-awaited JCS submarine study will conclude that the level of 68 submarines (Admiral Bowman states "around 72") is absolutely necessary to carry out the missions required, strongly supported and determined by the fleet commanders to be critical. [In other words, the study report will validate the requirements which the Submarine Force has advocated for the last several years.] There is a second number, 55, mentioned. The report reputedly states: that number is the one below which "we" can not fall without seriously degrading national defense.

Finally, you should be advised the CNO, Admiral Johnson, has unequivocally recently stated in several high fora that women will not be assigned to submarines for as long as he can envision. And, of course, we should all support the CNO. [Although not yet accepted, we have good reason to believe that both the CNO and the SECNAV will speak at the symposium.]

Although this is written prior to the Holiday season, you will receive it after, so I hope all of you had a good holiday.

Dan Cooper

NEW E-MAIL ADDRESS FOR NSL

NSL is changing its E-mail address to improve its communications support to members and chapters. The new address is **subleague@starpower.net**. This address will be effective on 1 January 2000 and will run in parallel with the current address for two months. It will be the **ONLY ADDRESS** on 1 March 2000.

MOBILE TARGETS FROM UNDER THE SEA: NEW MISSIONS IN A NEW SECURITY ENVIRONMENT

by ADM F.L. Bowman, USN
MIT Security Studies Program Conference
13 December 1999

As we stand on the brink of a new millennium, I think it's fitting that we stop and candidly share some thoughts regarding our nation's preparations to maintain our superpower status in the challenging environment of the next century. What I'd like to do this evening is to contribute to the **specific theme** for this conference, to be sure: *submarine roles in prosecuting mobile targets ashore*. However, there are a lot of real experts here in the **details** of that business.

So, what I'll do is share with you some thoughts this evening about how submarines stand to fit **preeminently** in our **overall** 21st century national security—certainly with precision strike, but with more—much more. And in the process, I'll address this focused, and very important, sub-topic of **mobile land target prosecution** as a significant component of our submarines' unique contribution to national security and the military game plan.

My discussion regarding how submarines stand to figure so prominently in the future revolves, of course, around a central proposition—that **the submarine fills a critical role of *irreplaceable value*, and will continue to be a *necessary*, although not *sufficient*, element of our nation's military force structure.** Yesterday, today and far into the future. So what I'll do is develop and discuss this central proposition, undergirded by five supporting arguments:

- **The Historical Need** for Submarines and the Submarine Force's **Legacy of Adaptation** (the yesterday);
- **The Current Operational Relevance** (the today);
- **Future Challenges** (the tomorrow);
- The Enduring, **Inherent Characteristics** Submarines Possess (the always);
- And, how we're racing forward **Technically**, to develop the tools for tomorrow (the revolutionary).

Then, having all agreed on that central proposition of the submarine's continuing **necessity**, I'll conclude by discussing a strategic plan being developed, to map the *way ahead*, to ensure our submarines and submariners continue to meet the need for this *crown jewel* in our nation's arsenal.

So, let me begin with **yesterday** and my

First Supporting Argument, The Historical Need and Legacy of Adaption

We're observing the U.S. Submarine Force's Centennial Celebration in the coming year—**100 years of continuing service to the nation**. It's remarkable in a rapidly evolving century like this one has been, for any war-fighting platform to be as vitally relevant as the submarine has been throughout this century.

And there's **no end** in sight to the collective demands of our national, regional and battlegroup customers—we've seen in fact, a continual **increase** in the missions requiring these large multi-mission nuclear submarines and their **special capabilities**.

Let's review this first 100 years, and recognize the U.S. Submarine Force **legacy of adaptation** through technological, strategic and tactical innovation.

- We came into this century with a limited submarine and a limited vision—of short-range submarines as *harbor protection* and *picket ships*.
- Learning from our own first, limited wartime employment of submarines in WWI, we adapted them to become longer range, offensively oriented—to capitalize on their stealth to gain access, and to take the fight to an enemy. We gave them new, more reliable, lightweight diesel engines, more fuel, more volume—making them stealthy, self-sustaining instruments of war. Those new, long-range *fleet boats* appeared in the late '30s.
- In the nick of time to step up to a WWII ASUW mission that surpassed anything anyone expected—when our heroic submarines held the line—in Fleet Admiral Nimitz's words, "...the *only* units of the fleet that *could come to grips* with the Japanese for months...". Submariners represented less than two percent of Navy personnel during WWII, but accounted for more than 55 percent of our enemy's maritime losses.

- Our submariners were also employed effectively in that war as **tactical sensors**, as our periscopes, our radars, and our endurance improved.
- The boats that took the war to the enemy sustained a terrific pounding by the Japanese. Many ships survived because of the innovation of the crew and the fact that those responsible for the design and construction of those submarines recognized that to survive under the seas, even in peace, submarines must be superior to the threats they face.
- After WWII, we added the snorkel and then, nuclear propulsion—finally evolving from submersible ships to true submarines—which allowed the unfettered execution of a broad spectrum of missions.
- In this aftermath of WWII, the Cold War presented us with yet another new mission—*Blind Man's Bluff* ASW mission—locked-in with their SSBNs. On the outcome of which, once again, our submarines were *the only units that could come to grips with* (and yes, threaten) the adversary.
- And the *tactical sensor* collateral duty of WWII evolved into the early warning mission of the Cold War...the so-called *Indications and Warning* mission that became so crucial to our response posture. Success here then spawned the blood and guts *Intelligence, Surveillance, Reconnaissance* mission.
- Another radical adaption—the submarine launched ballistic missiles of our SSBN force—provided the nation's only truly *survivable deterrence*, playing a key role in *coming to grips* with that grave threat to our national security.
- To a significant degree, the Cold War was won under the seas. Submarine superiority and innovation were key elements in that victory.
- In the Cold War, the superior quality of our engineering, our tactics, our people, and yes, our **submarine culture**, overwhelmed the Soviets' simple calculus of numerical superiority.

So, over this first century of existence, time and time again our nation has relied on our Submarine Force's technological foresight, along with our continuing ability and **willingness to adapt** to new mission requirements. From yesterday's harbor protection to picket ship, to plane guard, to ASUW, to ASW to I&W to ISR to

Strategic Deterrence,...to tomorrow.

In retrospect, it is this ability, this willingness, indeed this enthusiasm, to embrace change—to evolve and leverage the submarine's *inherent* strengths with new technology to meet rising new challenges—which has emerged as one of the Submarine Force's strongest suits over our first century—and we're ready to do it again.

This legacy leads to today and my

Second Supporting Argument: The Current Operational Relevance

What are we doing today? Well, we've been called once again to *come to grips* with an unexpected adversary. This time, it's harder to even identify the adversary, because the *monolithic enemy* days are over—it's not one guy, one place, one threat. Instead, they're the **multiple** threats in an increasingly dynamic global security environment.

The Submarine Force **has adapted**, out of necessity once again, to respond to the nation's need—this time, to cope with the stress and strain of increasing demands on a shrinking U.S. Navy fleet.

It has adapted to accommodate a volume of nationally tasked **worldwide** Intelligence/Surveillance/Reconnaissance (ISR) missions that have **doubled**, over the same decade in which our SSN **numbers** have dwindled by almost half. And **in that same decade**,

- We've added **precision land attack** to our repertoire—and more importantly, to the repertoire of the Theater Commander.
- **We've added operations under direct Battle Group and Joint Task Force Tactical Command (TACOM)** to our longstanding proficiency in independent operations—re-honing the WWI scout mission.
- We've enhanced the multi-mission flexibility of today's submarines and submariners to the point that they're often engaged in **multiple** missions and taskings simultaneously...both to execute submarine-unique tasking and to plug gaps left by our other forces, who are similarly over-burdened—or in some cases haven't adapted to the new world. Witness in this category, the abject failure of

overhead assets to detect the nuclear happenings in India and Pakistan.

Our Navy's fleet commanders have consistently called for around 72 SSNs to execute their post Cold War requirements. Recent operational experience and studies have revalidated this number.

So much for the *arm-chair* pundits who continue, somehow, to state submarines don't currently have a mission!...which leads to the future and the

Third Supporting Argument: Challenges of the Next Millennium

All that I've said notwithstanding, about the historic and current need for submarines; it doesn't necessarily argue for their continuing necessity. So let's look at the best predictions of this future millennium.

A growing chorus advises us to prepare for a very different set of national security challenges than we've seen throughout this century—much less about massing firepower and focusing strength at the Fulda Gap than about countering challenges that are, frankly, tough to perceive, much less to engage.

Examples of this *future thinking* include:

- Last year's Defense Science Board Study on Submarines of the Future which looked at the predicted set of future threats and validated the virtues of this "Crown Jewel of America's Arsenal"—the nuclear submarine. They also enumerated its present limitations, in the context of that future environment, and challenged the Navy and DARPA to do better "with the front end of the ship"—specifically with payload and sensors.
- Another good example is George and Meredith Friedman's book *The Future of War*. They correctly rail against "senile" weapons systems and the coming preeminence of the synergy between space, precision-guided munitions and information technology—and they encourage stealth, mobility, self sufficiency.
- And there's also Rick Newman's factual U.S. News and World Report article last month, *The New Space Race*—about the increasing access to space-based surveillance

capability.

- Secretary of the Navy Richard Danzig in a 24 November Jane's Defense interview reiterated his view of a future Navy force structure with greater reliance on the (attack) submarine—noting the relative invulnerability of submarines to satellite detection and land-launched missiles.

Such *future thinkers* talk about:

- **Multi-polar conflicts**...of enemies within, across, and without borders. And even the eventual emergence of a peer competitor.
- **Multidimensional demands**...across the entire spectrum of engagement, from peace through wartime missions.
- **Global interdependencies**
- **Proliferations**...of WMD and means of disruption, in an age of ready and affordable access. And,
- **Asymmetry**...in an age where weapons systems which are stealthy, fast, numerous, smart, cheap and networked...will become the bane of those which are detectable, slow, few, dumb, expensive, and stand-alone—solitary...

In response to this projected future, and moving from theory to practice, CNO Admiral Jay Johnson, delivered in Newport last month, the Navy's strategy for the 21st century—he called it a "naval century".

- He resolved that the next century's U.S. Navy would truly be able to **directly and decisively influence events inland**.
- Our capabilities to do so, he said, are to be significantly enhanced by our purposeful leverage of Information Technology,
  - both to rapidly obtain and disseminate information and knowledge,
  - and, in turn, to coordinate forces and "create rapid, overwhelming victory."
- He articulated the **concept of operations** for this 21st century vision as a "capstone concept" called **Network-Centric Operations**. It's supported by **four pillars** he defined, all of which describe an environment in which submarines will

be even more critical to our Navy's success.

- **1st Pillar, information and knowledge superiority**—CNO's "Information and Knowledge Superiority" goes beyond *trading e-mails*—he includes the ability to maneuver a network of smart sensors at the tactical level, interrogate those sensors, then distribute the product. Parenthetically, I note that submarines are doing this—albeit in a rudimentary fashion—**today**.
- **2nd Pillar, assured access**—from over the horizon to the beach and beyond. Especially in a future environment that is likely to include broad **area denial** capabilities, nuclear submarines can bring **assured access**—first-in, sustained and last-out. Imagine any of our favorite littoral areas defended by a combination of mines, diesel submarines, chem/bio, and space-based surveillance/targeting/delivery systems... Who's going to get in?
- **3rd Pillar, what Jay called the speed of effects**—responding to threats and indications of threats, rapidly and decisively, from a forward posture, in such a manner as to alter an enemy's strategy—limit his available options—stop something before it starts—by knocking down key nodes, including mobile nodes. We will have to work, not merely to manage consequences, but to **prevent** them—deployed submarines will be key players in satisfying this objective.
- **4th Pillar, sea basing**—the U.S. Navy, operating from our ship's borderless domain in our sovereign interest, without having to ask permission. We're talking about total war-fighting capability based at sea: the ability to sense targets and activities from the sea, coupled with the ability then, to decisively influence those events and activities ashore (and even inland). That's on the mark—and it's what nuclear submarines **do**.

These pillars of Network-Centric Operations for sure must include submarines—in fact, referring to my central proposition again, I'd say submarines are a necessary (although not sufficient) part of each pillar.

I'm tempted to thank Jay Johnson for introducing my discussion tonight.

Now, the always, and the

Fourth Support Argument: The U.S. Nuclear Submarine's Inherent Characteristics

Our large nuclear submarines possess a unique blend of warfighting characteristics that will enable them to be lethal, asymmetric weapons well into the future. They include:

- **Stealth and Self-Sufficient Survivability**
  - Submarines just don't require a defensive protection force.
  - Self sufficiency accrues to the true stealth that is the submarine, along with a combination of other factors: including our edge in propulsion plant technology and the acoustic health superiority that comes with that edge, coupled with the continuing advantages realized from our evolving sensors and weapons and relative immunity to chem/bio threats.
  - Stealth is expensive—and worth every dollar. To be superior under the sea, you must be better than the adversary—parity is not enough.
- **Our People**
  - While I know it may not conform to a strict definition of *inherence*, I have to include another U.S. nuclear submarine inherent characteristic here—our top-notch people—our culture really. What we've learned in 100 years of operating submarines can't just be put in place overnight (or in a decade, or even in a generation) by a would-be competitor. It's arguably one of the greatest *inherent* advantages possessed by the United States Submarine Force.
- Then there's **Endurance and Mobility**...again, inherent characteristics in our nuclear submarines.
  - What other fighting machine carries a life-of-the-platform gas tank (along with its own atmosphere, supply train and chow hall), which allows it to go where and when our country needs it?
  - Requiring no negotiations with finicky allies or neutral parties for forward basing...it all goes with us.
  - Borrowing a slogan from one of our key shipyards,

There's No Substitute for Nuclear Power in the Power Projection Business.

- And our **Multi-Mission Flexibility**...(the yesterday and today we've already discussed)
  - ...Will be especially important to a Navy with reduced fleet numbers.
  - And along with that thought, this attribute of multi-mission flexibility and self-sufficiency will continue to be important to a Navy with thinly stretched logistics trains, which are themselves becoming increasingly vulnerable to the proliferating tools of the space, information and missile age.

<u>Fifth Supporting Argument</u>

My last supporting argument for the submarine into the future—is how we're moving out...not resting on laurels...embracing the culture of adapting to the new environment, by **exploiting technical opportunities...**

We recognize that since there's a new world beyond...and since that new world will bring new demands, then just like our earlier transitions...from picket ships to ASUW, to ASW, strategic deterrence, I&W, to today...some key investments must be made, to even more fully exploit the submarine's inherent characteristics I talked about.

And this time, we're doing it even smarter than in the past—rather than waiting until 2020 and harvesting what technology might be available, we're purposefully **planting** the technology we'll need.

So we're off to get connected, get payload, get electric, get modular...

- **Get (better) connected**
  - Getting connected is about many things—but they're all in synch with that 21st century Navy network-centric vision CNO talks about.
  - Getting connected is about access, relevance, timeliness, utility, man-machine interfaces and potential vulnerabilities.
  - But in the end, getting connected is about the power of knowledge...

- And when industry delivers the capabilities we need...-our submarines will fill two niches:
    - First, to fulfill the CNO's requirement for "tactical control of sensors", submarines will be prominent—as uniquely capable, fully interoperable teammates. In fact, they'll be the first-in/last-out teammate—in tomorrow's capstone concept of **network-centric operations**...
    - But also, when needed, by employing our unique capabilities to conduct extended, covert, self-sufficient operations the old-fashioned way—by ourselves.

- We're also off to **Get (more and varied) payload**
  - To more fully realize the potential of submarine platform capabilities...this group is working to eliminate the tyranny of the 21 inch torpedo tube and bring aboard the ocean interface.
  - Too often, we find ourselves with a seat at the table, because of the access our stealth and our endurance bring—then find we have little to say, because we don't bring enough, or the right, payload to make a difference.
  - And of course, payload here means more than just things that go *boom*...it's also sensors, and transmitters, and decoys, onboard processing power...
    - which can in turn, employ and/or deploy **other** payloads...payloads that don't just see—but hear, taste, and smell too...even attack...
  - Anyone who doubts our commitment to improving submarine payload need only look as far as:
    - USS JIMMY CARTER
    - The SSGN concept
    - Our serious work in UUVs and UAVs
    - And your presence here today.
  - We must think much farther outside the box:
    - About such concepts as **effectively** achieving *increased payload* through covert pre-positioning of caches of weapons and sensors, which can be remotely activated after the host submarine is long gone.
    - Or about achieving effective *increases* in payload through miniaturization, or by elimination of stored

propellant.

- ▫ About covertly deploying and tactically controlling (as the CNO said in Newport) networks of small, smart sensors blanketing urban or rural terrain, which emulate biological systems in form, function, and efficiency.
  - – For example, Frank Fernandez at DARPA is working hard on developing the robotic analogs of small *geckos*—devices that can scale walls and ceilings; *lobsters and crabs* that can negotiate tough littoral surf zones; and *moths* that can sense and localize trace quantities of highly specific chemicals in turbulent air.
  - – Some of that sounds a little far-fetched today, but the expected merging of *nanoscale* biological and information systems in the 21st century is likely to thrust such fanciful concepts out of the realm of science fiction and into the realm of engineering fact.
  - – It probably would have seemed far-fetched not long ago, to suggest launching a precision missile attack into a terrorist's training camp, situated far inland in a land-locked country—from undetectable submarines in distant waters. We must seize the relevant opportunities presented here.

- We must Get (totally) electric
  - ▫ Who said if you want a new idea, read an old book?
  - ▫ I guess Jules Verne had it about right in his prophecy of an all-electric submarine some 130 years ago.
  - ▫ Pick your *all-electric* raison d'etre from:
    - ▫ Power distribution which allows the commanding officer to, in situ, apportion all usable rector power to propulsion or payload.
    - ▫ Increased and more efficient use of space for payload volume and architectural flexibility.
    - ▫ Reduced logistics requirements.
    - ▫ Technology growth potential—greater electric power margins for new, power-intensive developments.
    - ▫ Opportunities for dramatic new weapons such as rail guns (to greatly increase firepower and *payload*) or

directed energy weapons.

- And last, but certainly not least...achieving the next level of **acoustic stealth**, in an era when technologies which sense and analyze noise on the front end (and off ship) are likely to mature (and proliferate) at rates which far exceed the rates of those technologies which produce and mitigate noise on the back end.

- **Next, Get (truly) modular**
  - We have a good start, in the form of VIRGINIA's modular design features, modular construction technologies and modular testing.
  - However, we have to take this to its logical conclusion...analogous to the mission module approach taken by the Space Shuttle—or by the Air Force's B-52, for those of you familiar with how that venerable platform has been modified for varied applications. We need to develop the **option** to configure our submarines with specific mission capability like we configure the Space Shuttle...vice the Noah's Ark approach we currently use—with a couple of everything onboard.
  - If we do it right, this concept offers the best prospect of achieving rapid re-configurability, for tailoring our submarines to optimize their application to operational fleet commanders' requirements.

Well now, I've stated the case for my central proposition about the submarine's **continuing necessity**.

So, given that we've all signed the agreement that submarines are necessary for our future: Where do we go from here? Where's the *roadmap*? And how are we making sure we fit best into that Network-Centric Concept?

The Submarine Force's Future Studies Group has reviewed our Unified Commander's projected strategic plans, missions and tasks and where the submarine fits. They have derived **four principal strategic objectives** from those plans, which coldly define the path ahead.

- **Gaining and Sustaining Access...in militarily contested and (yes) otherwise politically *denied areas*.**
  - Being there and staying there (in the restricted geography

of the littoral) is already hard, and it's going to get harder fast, based on the emerging technologies I've already discussed.

  - Even getting there (via open ocean and regional choke points) isn't going to get any easier...yet this capability is assumed today...
  - The submarine can do this.

- **Developing Dominant Knowledge...*for* our own real-time use *and* for sharing with other joint, combined, NCA and Battle Group customers.**
  - Collecting, developing and rapidly disseminating knowledge...for use by all of our forces and our national authorities.
  - The very essence of the CNO's words about "information and knowledge superiority".
  - Time and knowledge are the critical commodities in the Information Age...it's not simply about massing stuff and bludgeoning your enemy to death.
    - Not everything can be seen from satellites or gleaned from HUMINT, etc. There's nothing like camping out **unseen**, *for weeks*, in his front yard.
    - Getting into the heart, mind, and conscience of the enemy is key to his undoing and to causing the paralysis we desire...
    - More than the *battle-space awareness* people like to talk about—it's **battle-space understanding**. Not just the who, what, where, when, how,...but the why.
  - Dominant knowledge enabled by information superiority can provide the leverage to **control** the pace of negotiations and engagements. It can allow us to maneuver, engage and protect our forces in a manner that keeps the would-be aggressor on the defensive.

- **Projecting Power...when surprise, suddenness and survivability are paramount.**
  - And when other assets can't be there!
  - You are here today and tomorrow to examine this role.
    - Our presence can and will cause a disproportionate measure of agony on the part of an adversary who's getting smacked from a platform he can't locate, track or anticipate.

    - And even if we're not there at the time, he can never be sure...
    - I'm not going to claim that we *can or should do it all*. But, often we'll be the only ones who can execute..

- **Deterring and Countering Weapons of Mass Destruction...when an asymmetric offensive approach is necessary.**
    - Most of what we see and hear today on this topic is the angst over how to deal with the aftermath of a WMD or information warfare strike against the U.S. homeland. There's am implicit resignation to the inevitability of such an attack.
    - **Nuts!** I say we must make them petrified that we can find them and kill them first, no matter where their offices, factories, storage facilities and launching platforms are located.
    - And the ultra stealthy, well-connected, SOF-carrying, sensor deploying, organic targeting, missile shooting, nuclear powered submarine is a key element in our arsenal—for disclosing, rotting out and terrorizing the would-be terrorists. **This is all about the "speed of effects"** the CNO talked about in Newport.

I'll stop. But, please pass forward for me the signed charter that screams **the submarine...the superior submarine...is, and will continue to be, a *necessary*, although not *sufficient*, element of our nation's military force structure.**

I applaud your efforts. Your innovative ideas are important to our national security. I hope I've been able to add something useful to the discussion this evening.■

CENTENNIAL UPDATE!

by CAPT Dave Cooper, USN(Ret.) and
CDR Rick Dau, USN(Ret.)

Submarine Centennial
100 Years - *From the Depths* - SEAPOWER!

Events: The following are the six *Flagship* events plus several highlighted ones. For a complete list of Centennial events see the centennial web site at www.navy.mil. Click the large *Submarine Centennial* button on the top left portion of the page.

1. Submarine Stamp First Day Issuance. On 13 October 1999 the U.S. Postal Service (USPS) announced that a series of five submarine stamps would be issued to commemorate our Submarine Force. In a philatelic first, USPS also announced that a free *prestige* booklet detailing the history of U.S. submarines would accompany the stamps. The Navy is finalizing first day issuance plans, but expects the major issuance to be in Groton in April with additional issuance events planned at later dates at other submarine bases and in Washington, DC.
2. Washington Submarine Force Centennial Birthday Ball. The major Submarine Ball will occur on Saturday 1 April 2000 at the Gateway Marriott. This will be a night to remember. Other Submarine Birthday Balls will be conducted throughout the country. For a listing, consult the detailed Schedule of Events on the Centennial web page.
3. Smithsonian Exhibit Opening. *Fast Attacks and Boomers: Submarines in the Cold War* exhibit will open 12 April 2000 at the Smithsonian's National Museum of American History. The exhibit will contain portions of the control room, sonar room and maneuvering room taken from two SSNs and an SSBN as well as a great number of other artifacts. The display will also include a large amount of material devoted to Cold War history with emphasis on how various types of submarine missions aided U.S. military preparedness. The exhibit will explain the value of submarine intelligence, surveillance and reconnaissance by showing some video, still

photography and acoustic recordings taken during Cold War missions.

4. SUBLANT International Submarine Visit. Planning is underway. A number of nations will be invited to participate in festivities planned for Norfolk in mid-June.
5. SUBPAC International Submarine Visit. Tied into the traditional RIMPAC exercises, a number of submarines from allied nations are expected to participate in festivities planned from May-July 2000.
6. San Diego Fleet Week. Will run from Friday, 13 October to Sunday, 22 October. Planning has started with expected highlights including a new exhibit at the San Diego Maritime Museum, a SUBRON 11 reception, and visits by SSNs, USS DOLPHIN and DSRVs.
7. Vallejo Naval and Historical Museum. A new exhibit will commemorate the 100th anniversary of the Submarine Force. *U.S. Navy Submarines: Century Beneath the Sea* will examine the contributions of the submarine service in time of peace and war and will focus on the important role played by the Mare Island Naval Shipyard in this story. Mare Island closed in 1996 after 92 years of service to the Submarine Force including construction of 43 submarines and five submarine tenders. The Museum exhibit will feature models, rare photographs, documents, and other artifacts relating to submarine history. The exhibit is scheduled to open on January 22 and continue through September 2, 2000. The Vallejo Naval and Historical Museum is located at 734 Main Street, Vallejo, CA. Call (707) 643-0077 for additional information.
8. Deterrent Park. A new permanent memorial is taking shape in Bangor, Washington. The memorial, located adjacent to COMSUBGRU 9 Headquarters, commemorates the *41 for Freedom* submarines that helped win the Cold War. The centerpiece of the park will be a full-length replica of a Lafayette class submarine, including the actual sail and rudder of the ex-USS WOODROW WILSON. The missile deck will be fabricated of gray bricks and donors can put a personal brick in the site. More info on this project can be found at http://pnwsha.hypermart.net/d_park/-dp_main.html.

9. Wisconsin Maritime Museum. Many activities planned for the Submarine Centennial in 2000. The museum features USS COBIA (SS 245). In April a 2000 sq.ft. special interactive exhibit on the history of submarines will open. In April-July the crew quarters of COBIA will be restored and in May a memorial stone will be dedicated by submariners in thanks to the people who built 28 submarines in Manitowoc during WWII. August is scheduled to feature a COBIA crew reunion and tentative plans include starting the #1 engine after 45 years! Additional information may be obtained at (920) 684-0218 or by e-mail at maritime@lakefield.net. The museum is located at 75 Maritime Drive in Manitowoc, WI.
10. Submarine Force Library and Museum. The expansion of the library and museum continues. The grand opening of the expanded facility will be on 28 April. This coincides with the date of the Groton area Submarine Birthday Ball.
11. USS COD (SS 224). In Cleveland the historic submarine will mark the Centennial of the U.S. Navy Submarine Service with the unveiling of a memorial tablet on the dock next to COD on Lake Erie in downtown Cleveland. A flag illumination program will also be featured. The 18x22 inch bronze tablet officially dedicates COD to the more than 3900 men who gave their lives in defense of our freedom while serving in the Silent Service. The tablet will be mounted below a 2800 pound fleet submarine propeller and the unveiling ceremony is scheduled for April 11, 2000. A COD crew reunion will also be held and crewmen are invited to contact the boat at (216) 931-9392 or at the web site http://www.usscod.org.
12. Albacore Park. Located in Portsmouth, New Hampshire, the park includes the landborne USS ALBACORE (AGSS 569), a memorial garden dedicated to all naval and civilian personnel who have perished while serving aboard United States submarines and a small museum. A larger museum is under construction. Albacore Park will host an event focusing on the presentation of the ASME award of *Historical Mechanical Engineering Landmarks* to ALBACORE and a special Memorial Day ceremony. The first event will occur on Saturday 13 May 2000 and will feature presenta-

tions by Captain Harry Jackson, USN(Ret.) and Vice Admiral John Boyes, USN(Ret.). The Memorial Day ceremony will be held on Monday, 29 May 2000 and will be jointly conducted by the Park, the SQUALUS Chapter of U.S. Submarine Veterans of WWII, the THRESHER Base of U.S. Submarine Veterans, Inc., the Veterans of Foreign Wars, and the American Legion.

13. Cold War Submarine Memorial. Charleston, South Carolina will dedicate the memorial on 15 November 2000 as part of our Centennial celebration. The memorial will be in the form of a full size SSBN using the sail, fairwater planes and rudder of USS LEWIS AND CLARK (SSBN 644). The submarine will be oriented to appear to be headed to sea from Charleston Harbor and will be in a landscaped park setting. The day of dedication marks the 40th anniversary of USS GEORGE WASHINGTON's first patrol from Charleston. More information may be obtained at http://www.cwsmf.org.

All Submarine League members are strongly encouraged to get out and visit and support these Centennial activities.

Centennial Jacks have been procured and distributed to all submarine units to be flown throughout the Centennial year. Private citizens, companies, and Navy personnel can order personal copies of the jack. Orders must be submitted by 1 February 2000 with delivery expected in mid-April

The jacks come in three sizes and prices include packaging and postage:

Small (22-9/16"x31-15/16")	$55 US
Med. (32-1/3"x45-3/8")	$72 US
Large (126"x180")	$339 US

Checks should be payable to **MWR Hong Kong Office** and submitted to:

Ms. Tracy Tsang, MWR Coordinator
Ship Support Office, Hong Kong
PSC 464, Box 20
FPO AP 96522-2200

E-mail: tracyt@pacific.net.hk; phone (852) 2802-9379; fax (852) 2511-3106. Hong Kong is 12 hours ahead of the East Coast.

In addition to the Centennial events, a bronze memorial statue by Paul Wegner of an SSN breaching the surface during an emergency blow will be placed at the U.S. Naval Academy during the early fall of the Centennial year.

A stained glass bronze memorial window rendering by the sculptor Leo Irerra will be installed at the Navy Memorial in Washington. It will honor the submarines and men who have given their lives in defense of their country.

A Submarine Centennial trifold with handouts, bumper stickers and other memorabilia items is under production and will be provided to all submarine-related commands. Additional sets will be procured by the National Commemorative Committee and given to requesting groups and activities.

How You Can Help

Active Duty. Many regional and local events will need volunteer assistance. Contact the organization listed as POC on the Centennial website for more information.

Reserves. Reserve officers and enlisted personnel desiring to conduct AT in support of Centennial planning and execution (including maintenance of Navy equipment at the Smithsonian) contact CDR Jim Anderson at n87reserve@hq.navy.mil or your TYCOM PAOs.

Interested Civilians/Retirees. The National Commemorative Committee is composed of members of the Naval Submarine League, the Submarine Veterans of World War II and Submarine Veterans, Inc. They are charged with fundraising and running a number of major centennial projects and events including the Smithsonian exhibit and the Submarine Memorial in Annapolis. For information on how you can assist financially or with your time, contact CAPT Dave Cooper, USN(Ret.) at subcentnel@aol.com.

Namesake Cities and States. Both active duty and those living in namesake cities/states can help here. Many submarines have a special relationship built with their namesake cities and states. We recommend that submariners deepen or renew these ties during the Centennial year. Civilians interested in getting involved can contact NSL at subcentnel@aol.com to be put in touch with community namesake POCs.■

REMARKS PREPARED FOR SUBMARINE CONFERENCE

*by RADM Ralph E. Suggs, USN**
Deputy Commander-in-Chief
U.S. Special Operations Command

Editor's Note: These remarks were to be presented at the annual Clambake in September but Admiral Suggs was grounded in Tampa due to the hurricane.

As we look forward to the political and military challenges of the next century, there is a need for a forward-deployed credible conventional deterrence. Control of the world's littoral regions and projection of power ashore is a cornerstone of joint strategy and will be essential to success in any conflict. Our potential adversaries are aided by the inexorable spread of advanced technology that can pose significant threats to U.S. Joint Forces operating near their shores. Access to new information technologies and sensors, such as commercial satellite imaging, coupled with the availability of advanced weapons, including sea skimming cruise missiles, can allow remote targeting of our surface fleet. In effect, hostile nations can establish a *denied area* creating a significant threat to our littoral forces. Real time intelligence, warning, reconnaissance, and battle space mapping ashore, above and below the sea would be deficient in an area where our forces could not operate safely. The potential losses resulting from establishing control of the littoral seas, the realities of hostile modern diesel submarines equipped with anti-ship cruise missiles, mine threats in coastal waters, and other significant impediments to our future ability to project power ashore must be considered.

A more sobering reality concerns the vulnerability of our littoral surface and air forces to proliferating weapons of mass destruction. As the umbrella of danger reaches further out from hostile shores, the need for stealth, flexibility, endurance, battle space preparation and early nodal-centered firepower projected ashore increases asymmetrically. A self-contained and self-protecting platform, the SSGN can operate independently for prolonged periods without the

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*The views presented are those of the author and do not necessarily represent the views of the Department of Defense or its components.

need for outside support. The ability to operate clandestinely complements the covert operations associated with Special Operations Force (SOF) direct action. The SSGN can effectively undertake national intelligence, surveillance and reconnaissance missions. The ability to maintain station undetected in hostile locations that are denied to other less stealthy platforms with no forward infrastructure or logistic requirements enables the SSGN to launch missiles, conduct SOF operations, and gather intelligence from locations where other platforms cannot or would not prudently operate.

The development of a SSGN presents enormous capabilities not available in current systems. In many cases, targets are protected with a pre-conceived idea of a threat axis or trajectory. The ability to locate the strike platform off of the predisposed threat axis opens the enemy to new vulnerabilities. The major advantage of a subsurface strike platform is covertness. In the crucial opening moments of conflict the ability to strike from an unpredictable location and direction and then relocate to fire securely again provides an enormous element of surprise which may prove decisive. The existence of the platform at sea may be sufficient to achieve deterrence or it may force the enemy to allocate critical resources to the elimination of the platform's potential threat. In addition, during a slowly building crisis the SSGN could preposition non-provocatively to continuously gather intelligence, direct battlefield preparation, and conduct preventive actions and then may either withdraw if diplomacy resolves the crisis or strike before the enemy has fully elevated its alert status. The addition of the ability to conduct long range SOF insertions through the use of the Advanced SEAL Delivery System (ASDS) tremendously enhances the precision strike capability of the SSGN. No other strike platform can act as covertly and swiftly as the SSGN.

The most controversial portion of the SSGN concept appears to be a large resistance to maintaining a SOF presence onboard for a full 90-day deployment. The ability to remain onboard for a full 90 days is not intended to imply an unused presence onboard but to illustrate the capability to conduct long-term campaigns from onboard the vessel. The SSGN will have the space for planning and the capability to do so onboard. In addition there will be sufficient exercise facilities to ensure fitness may be maintained. The ability to sustain SOF at sea for up to 90 days without having to change out personnel and/or equipment is a significant improvement over SSN host submarines.

The SSGN/ASDS system with SOF and cruise missile capability allows military planners to achieve a precisely measured effect at a specific vulnerability in the enemy's strategic plan or warfighting infrastructure. The SOF support and land attack missile capabilities, coupled with the submarine's stealth characteristics, provides the warfighting commander with operational capabilities not previously available in any platform. It is a platform that not only acts as a force multiplier, but also contributes to the Maritime Component Commander's ability to implement operational concepts of dominant maneuver, precision engagement, full-dimensional protection and focused logistics. The SSGN is the only platform that will allow the full utilization of the ASDS system.

The SSGN when coupled with the ASDS provides the most important strike, intelligence gathering, and special operations platform ever conceived. The potential overwhelming capacity of this platform will never be understood until the capability to synergistically exploit every attribute of the platform has been explored. The brief list of capabilities discussed provides an insignificant glimpse at the SSGN's potential.

The submarine and SOF is a logical progression. The two communities share:

- Battlespace preparation and shaping
- Peace time missions that reflect wartime efforts
- Desire for stealth
- Force provider to overall warplans
- Recruit/retain/promote top quality personnel

SOF operations need to be part of the base level of training for the Submarine Force. This will ensure the submarine is more than just a *bus* to deliver SOF. It is this shift in mindset that will allow the vast potential of the SOF/Submarine marriage to by realized.■

NATIONAL MISSILE DEFENSE AND STRATEGIC FORCES

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

Captain Bill Norris is a retired submariner who commanded USS MEMPHIS (SSN 691) and Submarine Squadron THREE. He is currently at the Sandia National Laboratories.

Indications in the latest budget submissions to Congress are that we will probably see, sometime late in the next decade, a National Missile Defense (NMD) System. One might expect this system to be capable eventually of detecting and engaging incoming ballistic missile strikes somewhere in the low tens of attackers. While this capability would offer some, if not significant, protection from countries possessing small arsenals of ballistic missiles, including any of the so-called rogue nations, it should also ignite a new debate on how NMD affects our strategic requirements, or in other words, what should be the offense/defense mix?

First, one should note that for the United States, the word offense is somewhat of a misnomer. For years our national strategic nuclear policy has been to have strategic nuclear forces only to respond to an attack on the United States or certain allies, such as NATO. Therefore, the offense in our equation is made up of those forces that would strike the attacker's soil (and possibly his allies) in response to such an attack. Today those forces are our SSBNs, ICBMs and B-52/B-2 bombers.

Nuclear strategic force levels are marching toward the Nuclear Posture Review recommendations of 14 SSBNs, 500 ICBMs, 66 B-52s (later revised to 72 by the USAF) and 20 B-2s (revised to 21 by the USAF). But those force levels were determined solely on the basis of response requirements, and did not consider an NMD. They were assumed to be able to counter the most likely major threats, and thus by default, any emerging minor threat. Those force levels were sized to be adequate regardless of whether the attack was a total surprise and the response was made after some forces had been lost in the attack or if all forces were available.

In the present construct of these forces, each has its niche. The SSBNs play in any part of the equation since they are survivable assets. (I must add that many of those who delve into the subject of nuclear deterrence cannot believe that the oceans will not one day become transparent, relegating the SSBN to the same status as an ICBM. In fact some of them believe it probably already has occurred and it's being protected by classification.) With bombers no longer on alert, SSBNs are the only forces considered to be survivable. The size of the SSBN response is determined by the readiness state of the forces (i.e., the number at sea). After the launch of their missiles, the SSBNs could serve as additional attack submarines, which, with today's dwindling SSN fleet, may become even more important.

The B-52s and B-2s fulfill several roles. First, if they are generated they are considered survivable. Therefore they either significantly increase the number of weapons available to the National Command Authority (NCA) or serve as a backup to the other survivable leg, the SSBNs. Second, they are dual purpose platforms, justified by the nuclear mission, but available for conventional conflict as we have just seen in the Balkans. Les Aspin's Bottom-Up Review in 1993 called for 100 heavy bombers for a Major Regional Conflict. One should also note that had it not been for the development of the cruise missile, it is doubtful that a B-52 airframe, designed in the '50s and with the last of those presently in service built in 1961, would still be a viable war-fighting machine.

The ICBMs nominally serve but one purpose since they are not considered survivable. They have traditionally provided a significant portion of the prompt response to a detected, incoming nuclear attack. It is doubtful that they would ever be offered to the NCA as an option in a limited response to an attack by other than Russia because their Polar flight path might not be discernible by Moscow as mere overflight.

From time to time, some strategists have advertised the reason for ICBMs as providing a large number of targets within CONUS to force the potential enemy to use sufficient warheads to allow our early warning systems to recognize a preemptive first strike. Otherwise, an aggressor might need significantly less than 100 warheads to eliminate all bombers and inport SSBNs as well as critical nuclear command and control infrastructure. This *small* strike might not be recognized as a decapitating attack. In fact, some quarters have offered this as the prime reason for ICBMs. These theorists further envision most scenarios as those wherein the NCA would not launch on warning, and thus the ICBMs be lost, vice those in which the NCA would launch on warning, especially if the incoming attack was viewed as less than an all out effort.

One should also note that it is this ready ICBM force that many improperly identify as being under *hair-trigger* readiness, and thus the major threat to stability. While it is true that the ICBMs might be considered a *use-it or lose-it* part of the strategic triad, and they are maintained under high readiness, most of us recognize that the ICBMs use many of the same stringent procedures for launch control that are used by our high readiness SSBNs, and some controls beyond those presently in our SSBNs. This makes the unauthorized or accidental launch of an ICBM a virtual impossibility.

It should not be anticipated that any of the above precepts would change in the near term. NMD deployment is probably still at least a decade away. Our strategic forces will not need to be modernized (beyond present budgeted plans for conversion of four Trident Is to Trident IIs and the remotoring and guidance upgrades for the ICBMs) for more than two decades. START II is still to be ratified by the Russians and so its entry into force is probably a decade away. The markedly reduced force levels promised in the still to be negotiated START III, therefore, are even further in the future. Even if the current administration initiative to begin to formally negotiate START III before START II is ratified occurs, and were it even to supersede START II, the proposed increased reductions will ensure it happens no sooner than the present, and now questionably achievable, 2007 date for START II.

However, the creation of a NMD would seem to markedly alter the future requirements for ICBMs. Since the very purpose of NMD is to ward off small attacks, it must have sufficient discrimination to accurately detect and classify small attacks shortly after their launch. The NMD would also allow us to counter, or intercept, this *minimum* type preemptive attack, described above, and thus preserve more of our forces. Therefore, ICBMs no longer need to serve as target *sinks* to allow proper characterization of an attack but can, and must, stand on their merit. This leads to a possible conclusion that the future (2020), smaller ICBM forces (that must be envisioned for START III and beyond) under the aegis of NMD might have the same survivability as SLBMs and, for sure, would no longer be characterized as *hair trigger* or *use them or lose them*.

The nexus of all these issues will be defined by how coincidental in time they become. Should we see a confluence in the 2020 time frame of reduced (mandated by treaty) requirements for strategic nuclear forces, required force modernization and the realization of an NMD, there could be a real and heated debate and redefinition of strategic nuclear requirements. The *holy* triad theories would be easier to discredit, and we could easily be marched toward a dyad or even, a monad.

So, submariners, start developing the arguments for the maintenance of your vital contribution to strategic deterrence away from the previously safe and overfocused argument of survivability. What do you face? ICBMs have claimed for years that they are more cost effective per warhead (diminished or reversed when they de-MIRV but increased as everyone goes to smaller forces and submarines reduce their warhead loading). Congress will listen. Putting a new missile in an existing silo will be much cheaper than putting a new missile in a new submarine. This will become a major issue in the 2020 time frame when it is time to design the replacements for both the SLBM and ICBM forces.

A late start by either the SLBM or ICBM advocates might even lead to all strategic nuclear forces being bombers, which is a desired end result of many of the minimum strategic deterrence theorists. These theorists believe that, since bombers take a long time to generate and reach their targets, there is no chance of a surprise attack. Further, in this regime, they believe that a nation's preparations for nuclear employment have become transparent. There is also believed to be total bomber recall capability and thus time to resolve the crisis short of actual nuclear weapon employment. Bombers are dual-purpose forces that have been employed in the most recent conflicts. Isn't Air Power alone being credited by many for *winning* the *war* for Kosovo?

From the deserts of New Mexico, today's contributions of the Submarine Force truly represent the *Silent Service*. While submarines have been cited as contributing to the missile launches (Tomahawks) in recent actions, it appears that it was more the demonstration of capability than necessary contribution. Without a strategic mission and with an apparent waning role in the general purpose forces, one can envision that the nuclear submarine Navy will shrink from an all time high of more than 150 crews in the 1980s to just a handful of SSNs (and maybe even no SSBNs) on each coast 50 years later. Was Billy Mitchell just ahead of his time?■

'THE MOST IMPORTANT TYPE OF WARSHIP IN THE WORLD'*: The Royal Navy Submarine Service and Britain's Strategic Defence Review

by Dr. Lee Willett
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'70% of the earth's surface is covered by submarines.'
Admiral Hank Chiles, USN (Ret.)[†]

Despite the post-Cold War draw-down in Britain's Submarine Force the words of Admiral Chiles highlight the primary utility of a submarine force, as threats to the security of Western powers take on a more global nature. Today, in the face of the strategic challenges of the modern world, the British and American submarine communities have an opportunity to maintain their primacy at the leading technological and strategic edge of the maritime battlespace.

Before the deployment of Britain's first submarine, HOLLAND I, at the turn of this century, British interest in submersible technologies was in question. Some analysts argued that the British Admiralty treated American developments in this field "with a mixture of scepticism and disdain."[1] It was argued that this new dimension to the naval service would prove to have little military value and threatened the strategic primacy of other major programmes.

Yet such debates were more the result of intra-service rivalry than hard technical issues. Contrary to popular opinion, below the surface the Admiralty's interest was tangible. Public declarations hid the attention being paid to the potential of submarines as effective instruments of war:

Accurate plans of submarine-boats employed by the Confederate Navy during the American Civil War, for example, can be found

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*- Beach, Capt. E.L., USN (Ret.). (1982). *The United States Navy: A 200-Year History*. Boston: Houghton Mifflin Co..
† Author's interview, 28 August 1998.

in British naval archives. The Victorian Navy, in other words, generally kept itself well informed about submarine development.[2]

Certainly, submarines were a key component of Admiral Jackie Fisher's strategic revolution. In the move away from an emphasis on traditional battlefleet units, the placing of submarines at the centre of British naval planning highlighted the strategic shift towards a sea denial fleet. Fisher argued that "I don't think it is even faintly realised – the immense impending revolution which the submarines will effect as offensive weapons of war."[3]

As the next century approaches the Royal Navy (RN) Submarine Service has evolved into an almost unsurpassed sub-surface warfighting force. The passing of the Cold War provided a natural break in the history of the submarine which had made astounding technological and strategic progress.[4] In the Cold War, submarine forces increasingly came to dominate maritime operations, their primary role evolving from targeting surface warships and sea lines of communication to an emphasis on Anti-Submarine Warfare (ASW) in defence of Britain's strategic deterrent, the ultimate guarantor of national security. Notably, the advent of nuclear propulsion turned the submarine into "the ultimate weapon of the strongest powers in the nuclear age."[5]

However, the perceived decline in post-Cold War requirements for open-ocean sea control has thrown up a new set of unique challenges for the British, and American, submarine communities. Today, submarine forces which had adapted so well to meet the rigours of the Cold War must maintain such presence and influence while at the same time returning to more traditional naval tasks.

<u>The Strategic Defence Review and Britain's Maritime Forces</u>

The role of the RN is to support Government foreign and security policy in joint and combined expeditionary contexts. In the debates surrounding the British Government's 1998 Strategic Defence Review (SDR), Defence Secretary George Robertson highlighted Britain's return to a traditional national maritime military strategy to underwrite government policy.[6]

The shift of emphasis towards expeditionary warfare reflects the prevailing grand strategic mood of promoting the broad utility of forces based *at* sea as a mechanism for exerting force *from* the sea.[7] The evolution in U.S. strategy is shown in the development of the concept of *...From the Sea.*[8] The RN has tuned its capabilities to reflect these evolving strategic realities by developing a new operational concept, the Maritime Contribution to Joint Operations (MCJO). SDR and the MCJO, in providing a fresh blueprint for Britain's post-Cold War military posture, are primary expressions of an armed force re-moulding itself into a more cost-effective, stronger and usable tool of defence policy.

SDR, The MCJO and The Submarine Service

A principal aim of British defence policy is the maintenance of an independent, national nuclear deterrent underpinned by strong conventional forces capable of conducting operations across the range of modern military operations.[9] When operating with joint, multi-service assets maritime forces have relevance across this spectrum. **In particular they bring a flexibility unrivalled by any other service.** *[Emphasis added by Editor.]*

Submarines, especially, are more synonymous with such flexibility than any other naval asset. They provide:

- rapid deployment and long endurance;
- physical robustness;
- manoeuvrability and mobility;
- independence from host nation support;
- operational integration with or independence from other forces;
- invulnerability, stealth and tactical surprise;
- surveillance, reconnaissance and intelligence; connectivity;
- (covert or overt) reach, poise and presence;
- anti-surface, sub-surface, land attack and special forces warfare;
- sea denial, power projection and considerable, readily-available and co-ordinated high intensity firepower.

This combination of "stealth, endurance, agility, and firepower make [submarines] crucial assets in an unstable world, today and for the future."[10] Britain's current submarine force consists of four Vanguard-class Trident ballistic missile submarines (SSBNs) and twelve Trafalgar- and Swiftsure-class nuclear attack submarines (SSNs).

Given the residual threat of the Russian ballistic missile and nuclear submarine force, and of the global proliferation of weapons of mass destruction among rogue states, strategic deterrence retains a primary role for Britain. Thus a durable rationale for Britain's SSBN force is perhaps less in question today than that for an SSN force whose own primary strategic rationale is perceived as diluted with the post-Cold War decline in global challenges to the supremacy of the RN and United States Navy, in particular to the submarine fleets.

For Britain, the argument that the case for retaining an SSN force was much reduced was reflected in SDR's decision to cut Britain's SSN force from 12 to 10 hulls.[11] It is perceived that, despite these cuts, the continued importance of the SSN force is underscored by Britain's major investment in the more capable Astute-class SSNs and by SDR's commitment to fit all SSNs with Tomahawk land attack missiles.[12]

Yet the rationale for SSNs has not been lost. The need for platforms with the flexibility of an SSN is arguably greater today than at any time during the Cold War, as the military continually is asked to do more with less. SSNs remain vital to the global strategic success of a maritime power such as Britain, though the strategic spotlight has shifted from more traditional roles. Today, to meet the strategic requirements of littoral warfare—the concept around which expeditionary strategy is based—there is greater requirement for SSNs to deploy upon threat as part of joint and coalition forces, operating more on *transmit* than *receive* mode, to provide a range of military options including electronic and mine warfare, intelligence and special forces insertion, as well as land attack and ASW. Yet such tasks are also traditional, primary naval traits. Moreover, having conducted sustained operations as primary forward-deployed assets at perhaps the highest levels of force readiness throughout the Cold War, SSNs have considerable practise at littoral warfare.

In providing a multidimensional force package in one modular unit, submarines are a primary asset for providing a range of balanced, flexible and discretionary political and military choices across the spectrum of military operations from grand strategic to tactical levels of warfare to meet the diverse strategic challenges of the expeditionary era. As shown by HMS SPLENDID's very presence in Operation ALLIED FORCE, SSNs are a cornerstone of the MCJO and its strategic *triad* (completed by aircraft carriers and amphibious forces[13]). SPLENDID, and the other NATO submarines deployed to the region, provided sea control, power projection and presence (both covert and overt): in the view of former U.S. Chief of Naval Operations Admiral Elmo Zumwalt Jr. these three roles are the substance of broader naval duties.[14]

Sea Control

Sea control is defined as the "condition that exists when one has freedom of action to use an area of sea for one's own purposes for a period of time and, if necessary, deny its use to an opponent."[15] A submarine is the quintessential sea control platform.

The SDR noted that force reductions in areas needed primarily to confront Cold War threats mean Britain "will place somewhat less emphasis on open ocean anti-submarine warfare."[16] The concept of littoral warfare, around which British expeditionary strategy will be built, assumes that NATO forces and their allies retain open ocean sea control. Thus, today sea control (with ASW—both open ocean and littoral—as its fulcrum) remains a primary naval role, and for submarines in particular as the archetypal sea control platform. Despite the belief that ASW is less important, sea control will continue to be an area of key naval strength, particularly if NATO navies are to deter adversaries from attempting to exploit the misperception that sea control is no longer an area of interest. Moreover, the residual ability of the Russian Navy to threaten NATO interests—through improvements in Russian acoustic technologies and Moscow's political emphasis on power projection, not to mention its persisting domestic instability—still presents a significant challenge to Western navies[17]: this suggests that sea control will remain a contemporary and future, not just past, requirement as naval strategy moves back to sea.[18] Last, an effective ASW capability underpins sea control and power projection capabilities.

Power Projection

Power projection is "the use of seaborne military forces to influence events on land directly."[19] Throughout history the projection of naval power as a form of seaborne artillery to shape the battlespace has been a key tool of maritime engagement. Force projection is the key component of expeditionary warfare. A submarine force is indispensable to an effective, composite sea-based force package projecting power ashore. Historically, "the Royal Navy is without rival in the successful projection of power."[20] Today, coupled with the independent strategic deterrent, the RN's triad of carrier-borne air power, amphibious manoeuvre warfare from the sea and Tomahawk-capable submarines present a new and formidable ability to deliver both select political influence and raw combat power ashore.

Strategic Deterrence

When deployed aboard relatively invulnerable submarines, nuclear weapons—the ultimate guarantors of national security--provide Britain with an independent, covert, political and strategic reach. By threatening to exert the most catastrophic use of military force from the least vulnerable platform, SSBNs are the most effective form of deterrence to the point that they are deemed the most important element of the navy in the eyes of political leaders.[21]

According to current British maritime doctrine, "the maintenance of a secure strategic nuclear deterrent is the first Military Task of the Royal Navy."[22] The maintenance of a seamless at-sea deterrent has been perhaps the RN's major post-war achievement. Today the Trident D-5 Submarine-Launched Ballistic Missile (SLBM) system deployed onboard Britain's SSBNs is a cost-effective, credible central strategic force which shows its flexibility by carrying Britain's minimum strategic and sub-strategic nuclear deterrent.[23]

Yet Britain is observing closely American discussion of options for converting Trident missile tubes to carry conventional and special forces payloads. Such plans highlight the growing role of conventional force as a strategic deterrent, the unique utility of a submarine in maximising maritime political and military power projection ashore and, thus, the submarine's use in providing flexible strategic options for government. The debates about developing conventional and sub-strategic options for Trident reflect the fact that the proliferation of weapons of mass destruction means that deterrence may have more value today, the actors possessing such capabilities operate outside traditional Cold War nuclear deterrence frameworks: their perception of such weapons as tools for nuclear *coercion* emphasises the utility of a more flexible deterrent force as a useful hedge against the disorder of the modern world.

<u>Land Attack</u>

With its Tomahawk land attack capability the RN's Submarine Service provides the vanguard of Britain's conventional deterrent force. A land-attack capability is not a new development for navies. Under President Thomas Jefferson, U.S. Naval forces bombarded North African towns, and President James K. Polk's navy supported operations ashore during the Mexican War of 1846-48.[24] Historically, Britain has also understood the strategic, operational and tactical advantages of projecting stand-off conventional power ashore of force from the sea. For example, in a classic display of gunboat diplomacy the RN's bombardment of French positions at the Battle of Acre in 1840 prompted Prime Minister Lord Palmerston to state that "every country that has towns within cannon shot of deep water will remember the operations of the British Fleet ... in 1840 ... whenever such country has any differences with us."[25] Such precepts remain applicable today. Tomahawk enhances significantly the land-attack capability of the SSN, providing a sabre for a force often regarded as maritime *cavalry*."[26]

Four points are worth noting about Britain's procurement of Tomahawk. First, in the form of coercion, Tomahawk provides Britain with a balanced, discreet, proven and dramatic military capability to apply political pressure at distance.[27] The key to the MCJO is the ability and utility of forces based at sea to influence events ashore through presence and the threat and/or application of force. Forces are required to *go to* crises as there is now no longer a single adversary to confront across the Fulda Gap. Meeting these criteria through power projection, coercion and maritime fire support, the SSN/Tomahawk package provides a classic maritime asset at the core of the MCJO. Tomahawk also maintains the RN's reputation for responding to political changes through technical opportunities, enabling Britain to punch above its weight and increasing Britain's military and political global presence. Britain's strategic thesis for deploying Tomahawk onboard SSNs was borne out in ALLIED FORCE: the firing of two salvoes of missiles in a co-ordinated high intensity strike from a forward-deployed SSN exercising sea control and conducting covert force projection operations accentuated NATO's efforts to exercise strategic coercion in Kosovo.

Second, although the full impact of Tomahawk upon the SSN fleet alone is not yet fully evident, the growing calls from within the UK military, defence-industrial and academic establishments for a wider Tomahawk fit highlight the confidence in the system as a key club in Britain's strategic golf bag. Third, with Tomahawk Britain's Submarine Service provides government with a credible military means for operating alongside the U.S., underlining both Britain's global standing and its importance to Washington as an index of political support. Fourth, the sheer speed of Britain's Tomahawk procurement emphasised not only the strength of the Anglo-American special relationship but, more specifically, the pivotal role of the respective submarine communities in forging these enduring links.

Conclusion

To quote former British Navy Minister Sir Patrick Duffy, the "broad future shape of the Navy is already determined by major force determinants such as Trident and the introduction of the Tomahawk submarine-launched cruise missile."[28] With this package, the RN Submarine Service represents Britain's main strategic force, highlighting the role of the submarine as a key policy tool. Trident, as the "ultimate guarantee of our security[,] brings with it some essential ASW baggage".[29] Yet the development of Tomahawk as the first weapon of choice and the Submarine Force's return to more traditional warfighting roles of sea control (as shown in ALLIED FORCE) show that the rationale for an SSN force reaches far beyond the role of guardian of sovereign strategic deterrents. In the expeditionary era the value of submarines' wider, unique flexibility should not be underestimated nor underplayed.

As noted during Britain's SDR debates, the future of Britain's attack submarine is *assured* because of its utility over a wide range of operations.[30] Today, submarines are working "as hard or harder" than at any time during the Cold War.[31] Yet such is the utility of a submarine's flexibility and the overstretch continually placed on armed forces that many British and U.S. officials argue for greater, not lesser, numbers of submarines.[32] The challenges of the future will give greater prominence to the submarine's unparalleled and enduring qualities of stealth, endurance, agility, and firepower.[33] From Britain's viewpoint, "a submarine arm in a medium-sized navy provides, literally, another dimension of maritime power."[34]

Several issues of *Undersea Warfare* have provided an overview of current U.S. Navy submarine deployments. If a similar snapshot was taken of current Royal Navy submarine operations, with the deployment of boats in support of NATO operations in the North Atlantic and the Adriatic, in defence of British sovereign territory in the South Atlantic, in deploying to U.S. waters and in participating in operations other than war it is clear that the Royal Navy Submarine Service is succeeding in meeting the core of Military Tasks set out in SDR.[35] Given the emphasis on power projection operations, the evolution of British nuclear strategy and the strategic significance of British Tomahawks fired from SPLENDID during ALLIED FORCE, it is evident that the Royal Navy Submarine Service has made a rapid, robust and (within the British armed services) a possibly unique transition to meet the requirements of the SDR, the MCJO and the new world order.■

ENDNOTES

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[2] Lambert, N. Draft volume on the Royal Naval Submarine Service. Royal Navy: Naval Historical Branch. Forthcoming.
[3] Quoted in van der Vat, D. (1994). *Stealth at Sea: the History of the Submarine*. London: the Orion Publishing Group. p.34.
[4] van der Vat. *Stealth at Sea:*. p.1.
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[6] First Sea Lord Admiral Sir Michael Boyce RN KCB OBE ADC. *First Sea Lord's Message*. Available on-line: <http:// www.royal-navy.mod.uk/new/latest/news/080299.htm>: Evans, M. 'Treasury Grabs £1bn Defence Windfall', in *The Times*, 2 July 1998. p.1.
[7] *The Strategic Defence Review* (Presented to Parliament by the Secretary of State for Defence by Command of Her Majesty, July 1998. Command 3999. London: The Stationery Office): ' Message

from First Sea Lord.' Fact Sheets; Chapter 2, para 33 (p.10) & chapter 11, para 199 (p.53).

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[9] Naval Staff Directorate (NSD), RN. *Rolling Brief*. Autumn 1998. Brief 3.

[10] Bowman, Admiral F., USN. 'Submarines in the New World Order', in *Undersea Warfare*, vol.1, no.3. Spring 1999. Washington DC: Office of the Chief of Naval Operations. p.3.

[11] Following the decision to sell Britain's four *Upholder*-class conventional submarines, this further cut reduced significantly Britain's attack submarine force from a fleet requirement of 17 SSNs and 10 SSKs in the early 1990s. However there was a strong argument that the SSNs were traded in SDR to fund a new generation of aircraft carriers.

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[13] See: House of Commons Select Committee on Defence. 'Strategy and Force Structure: Naval Force.' *The Strategic Defence Review*. Eighth Report: Session 1997-98. Available on-line: <http://www. parliament.the-stationery-office.co.uk/pa/cm199798/cmselect/.../cmdfence.htm>. p.1 (*n630*).

[14] Cited in Rhodes, E. '"...From the Sea" and Back Again: Naval Power in the Second American Century', in *Naval War College Review*, vol.LII, no.2, sequence 366. Spring 1999. Newport, RI: U.S. Naval War College. p.27.

[15] *BR1806*. (Royal Navy Doctrine Manual) p.235.

[16] *Strategic Defence Review*. p.2.

[17] Department of the Navy. *1998 ASW Focus Statement*. p.3; Lacy, J. 'Attack Submarines: the Case for Negotiated Reductions', in

Arms Control Today, December 1990. p.10: 'Moscow Resumes Navy War Games', in *The Daily Telegraph*, 24 November 1997. p.11: Scott. 'Nuclear Attack Submarines Cast Off Cold War Mindset.' p.26. (ONI: JDW article)

[18] Rhodes. '"...From the Sea" and Back Again:' p.27.

[19] *BR1806*. p.223.

[20] Duffy, Sir Patrick Ph.D. (Parliamentary Under-Secretary of State for Defence, Navy, 1976-9). 'New Horizon', in *Defence Review*, vol.5, issue 1. Spring 1999. London: SMG Publications. p.38.

[21] See: Grove, E. (1990). *The Future of Sea Power*. Annapolis, MD: United States Naval Institute (USNI) Press. p.189; Miller & Jordan. *Modern Submarine Warfare*. p.188.

[22] *BR1806: The Fundamentals of British Maritime Doctrine*. Directorate of Naval Staff Duties, RN. D/DNSD 8/36. 1995. London: HMSO. p.83.

[23] Sub-strategic is a concept focusing on the use of nuclear force in contexts short of the ultimate threat of strategic nuclear use but where action is still required to deter or coerce an aggressor when supreme national interests are at stake.

[24] Palmer, M.A. *The Navy: The Continental Period 1775-1890*. Essay available on-line at the Naval Historical Center home-page: <http://www.history.navy.mil/history/history2.htm>.

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[26] Patton, Capt. J.H., USN (Ret.). 'New Roles on the Horizon for Triad's Last Leg?' In *International Defense Review*, September 1994. Coulsdon, Surrey: Jane's Information Group. p.41.

[27] *BR1806*. pp.70 & 170: Abbott, Admiral Sir Peter, KCB RN. (1996). 'The Maritime Component of British and Allied Military Strategy', in *RUSI Journal*, December 1996. p.9: Blackham, Vice-Admiral J.J., RN. *Speech to Oxford University Strategic Studies Group*, April 1998: Loughran, Rear Admiral T., RN. (1996). 'Projecting Power from the Sea: the RN Contribution to the Air Battle', in *RUSI Journal*, vol.141, no.5. October 1996. London: Royal United Services Institute (RUSI). p.28. Rifkind, RtHon M. (former Secretary of State for Defence). *Speech at King's College, London*. 15 February 1994; Portillo, RtHon M. (former Secretary of State for Defence). *Statement to House of Commons on Defence*

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[28] Duffy. `New Horizon.' p.38.

[29] Bathurst, Admiral of the Fleet Sir Benjamin, RN. `The Royal Navy – Taking Maritime Power into the New Millennium', in *RUSI Journal*, August 1995. p.12.

[30] *Strategic Defence Review*. `Fact Sheets: Attack Submarines.': House Select Defence Committee. *Strategy and Force Structure:*. p.2.

[31] Bowman. `Submarines in the New World Order.' p.2.

[32] Author's interviews: House of Commons Defence Committee. *Royal Navy Submarines*. Report, together with the Proceedings of the Committee relating to the Report, Minutes of Evidence and Memoranda. Sixth Report. Session 1990-91. 12 June 1991. HC369. London: HMSO. pp.v & xiv: Truver, S. `Tomorrow's Fleet', in *Proceedings*, vol.125/2/1,152. February 1999. Annapolis, MD: USNI. pp.65-6: Bowman. `Submarines in the New World Order.' p.3: DSB report.

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[34] Hill, Rear Admiral J.R., RN. (1985). `Strategy at Sea: Submarines Worldwide', in *Journal of Defense & Diplomacy*, July 1985. p.20.

[35] See: *Strategic Defence Review*. p.13; (NATO Strategic Concept)

JANAC SUBMARINE CREDITS REVISED

(The Submarine Review Staff)

The *official* tally of sinkings credited to each U.S. submarine in World War II appears in an appendix to Japanese Naval and Merchant Shipping Losses During World War II by All Causes published by The Joint Army-Navy Assessment Committee (JANAC) in February 1947. This list was repeated verbatim by Theodore Roscoe in his monumental and semi-official work United States Submarine Operations in World War II (Annapolis, MD: U.S. Naval Institute, 1949). Since then the JANAC assessments have been cited in most books and articles dealing with the submarine war.

Researchers have known for many years that the JANAC list was incomplete because of certain inherent limitations. It counted only regular Japanese warships and merchant ships of 500 or more gross tons, thus ignoring the smaller merchant-type ships that were taken into the Navy as converted gunboats, minesweepers, submarine chasers, picket boats, and various types of auxiliaries. It also excluded German and other non-Japanese ships that were sunk by our submarines. Then, as new information came to light after the war's end, errors began to be revealed. Nevertheless, the Navy has never seen fit to revise or reopen the JANAC assessments.

Ten years ago Commander John D. Alden, USN(Ret.) Produced an interim compendium of data on submarine attacks based on material from recognized sources available up to that time. (U.S. Submarine Attacks During World War II. Annapolis, MD: U.S. Naval Institute, 1989.) Since then a flood of new information has been released with the declassification of formerly top-secret intelligence material including the famous ULTRA radio messages intercepted and decrypted during the war. Also in recent years Japanese researchers have published a wealth of data from their own archival sources. Printed in the Japanese language, these books and articles have been inaccessible to most U.S. students of the submarine campaign. Thanks to a British researcher who provided material translated from many Japanese publications, hundreds of additional cases have been revised or amplified.

There are 143 U.S. submarines for which Commander Alden believes that the JANAC credits need to be revised or seriously questioned. About 130 ships should be added to, and about 60 subtracted from, those attributed to submarines by JANAC. There are over 80 other revisions to the credits; about 50 corrections of ship names, dates, etc.; and a few other questionable cases. (No attempt has been made to include ships that may have been sunk by mines laid by submarines, because such sinkings can seldom be verified. The JANAC report attributes a few ships to submarine-laid mines, but does not identify the submarines involved.)

Several kinds of cases deserve special mention. In its early months of operation, JANAC credited some submarines with "Unknown Marus". Although the committee soon abandoned this practice and required that sinkings be substantiated by other evidence, 26 of these early assessments remained unchanged in the final report. All but 11 cases can be resolved on the basis of postwar information, and it is improbable that any of the remaining attacks resulted in sinkings that would have qualified for inclusion on the JANAC list.

An interesting group of cases involves *wolf pack* attacks on convoys or other instances where two or more submarines were firing at the same targets. Most such cases have been resolved by correlating details in the patrol reports, the JANAC list, and Japanese convoy histories. The patrol reports give the times when torpedoes were fired, the Japanese record indicates when ships were hit, and the JANAC list gives the latitude and longitude for each assessed sinking, thus indicating which specific salvo fired was credited with sinking the target. Where the times fail to match, JANAC appears to have credited the wrong attack.

Among the small warships not counted by JANAC, 56 picket boats have been identified. These were mostly former fishing craft that were taken into the Navy, armed with a few guns, and classified as guard boats. Often stationed far offshore, their main function was to warn of approaching enemy ships or aircraft. They were a particular nuisance to U.S. submarines and usually put up a good fight when attacked. Although small in tonnage, they were bonafide warships and tough adversaries.

With regard to Japanese ship names, most of the changes result from different interpretations of the Japanese characters, which can often be read in several possible ways. Even Japanese sources do not always agree on which name is correct. In a few cases, JANAC simply identified the wrong ship.

The proposed changes to the JANAC credits are listed in a 40 page report titled "JANAC Revisited and Revised", which includes full explanations of the reasons for each change, data sources, and related information. Interested readers may obtain a copy from the author for $4.50 to cover the cost of duplication and mailing.

Commander Alden has also prepared a completely updated and expanded compilation of submarine attack data, United States and Allied Submarine Successes, Pacific and Far East, WWII, available as a 427 page, spiral bound, 14x8.5" publication. It includes a section on submarine-laid mines and an appendix summarizing the successful attacks made by each U.S., British, and Dutch submarine. Copies may be obtained for $58 per copy postpaid ($64 overseas) from Commander John D. Alden, USN(Ret.), 98 Sunnyside Avenue, Pleasantville, NY 10570-3136.■

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. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the **REVIEW**.

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Articles should be submitted to the Editor, SUBMARINE REVIEW, P.O. Box 1146, Annandale, VA 22003.

ASDS: ONE MINISUB, MANY ROLES

by Joseph J. Buff

*Editor's Note: Mr. Buff is a novelist currently working on a submarine-related project. Mr. Buff's previous articles in **THE SUBMARINE REVIEW** were Looking Forward—Submarines in 2050 in the July 1998 and October 1998 issues, Diesel-AIPs: Low Displacement as a Weakness in the January 1999 issue, and Hydrothermal Vent Plumes as Acoustic Lenses in the October 1999 issue.*

The Advanced SEAL Delivery System (ASDS) minisub enables a major step forward in Special Warfare mission tasking. This shirtsleeves-environment SEAL *taxi* is a shock-hardened autonomous combatant vessel deployable from a host nuclear submarine. The present article will explore additional possible roles and uses for this versatile new subcompact warship, on the premise that expanding the envelope of naval submarine capabilities enhances global peace maintenance (conventional deterrence), and improves low-casualty and low-collateral-damage peace restoration (warfighting). As discussed below, a) the dry hyperbaric lock-in/lock-out chamber of the ASDS amounts to an important and flexible undersea Ocean Interface, and b) the potential of the ASDS to carry materiel internally and/or in external harnesses makes the minisub itself a stealthy interface between a submerged SSN/SSBN/SSGN and a friendly, either a surface unit or a shore facility, or enemy target objective.

Summary of ASDS Specifications

Open-source information on the ASDS is available in references [1], [2], and [3]. [1] and [2] include an external artist's rendering; [3] includes a schematic of the internal layout.

It is manufactured by Northrop Grumman and subcontractors. The ASDS is 65 feet long, 8 feet wide, and displaces 55 tons surfaced—the vessel is road- and air-transportable. It is battery powered, with a single screw, and has a reported range of 125 nautical miles at 8 knots. The on board O_2 renewer and CO_2 scrubber give an underwater hotel endurance of several days. The ASDS is equipped with rudder and bow and stern planes, bow and stern anchors, retractable auxiliary side thrusters, and variable ballast tanks.

The ASDS has no sail, but is provided with a non-hull penetrating optical periscope, and a separate radio/ESM mast, which retract by folding back atop the hull. The vessel has forward-and side-looking sonars, and both GPS and inertial navigation gear.

The internal layout consists of a two-man control compartment forward, a central hyperbaric lock-in/lock-out sphere, and a rear transport compartment. The two-man crew and the SEAL passengers enter the ASDS from the host sub through a mating trunk leading to the bottom hatch for use while surfaced (freeboard is low) or for emergency escape. Once on station the SEAL swimmers depart the ASDS through the bottom hatch, after the hyperbaric chamber's atmospheric pressure has been equalized with that of the local seawater at the depth of the keel—the ASDS need not be shallow to perform this evolution, although air compressor capabilities, and diver physiological limits and decompression tables, would affect the mission profile. The crucial advantage of the ASDS is that the SEALs remain relaxed and dry, and avoid loss of body heat, until they drop into the water through the hatch. The capacity of the transport compartment is approximately eight men with their equipment.

While the operating depth and crush depth limits of the ASDS are classified, note that an Italian minisub intended for combat swimmer transport, the 3gst9, is reportedly capable of diving below 2000 feet [4].

The ASDS as Combat DSRV

Increased emphasis on littoral warfare heightens the chance that a disabled submarine might be forced to bottom on a continental shelf in hostile waters, or be rendered immobile above its crush depth in zone of enemy sea-surface denial or control. The damage to the submarine might result from enemy action, or from an operational casualty—situations might arise in which the emergency diesel is functional but snorkeling would invite immediate attack. Capture of the disabled submarine and/or its crew by the enemy would represent a major intelligence and propaganda coup for the aggressor regime. Rescue of the crew, removal or destruction of crypto gear and other sensitive materials, and retrieval or safe demolition of the submarine itself, would be extremely high priorities for American naval forces.

In this adverse scenario, the nearest deep submergence rescue vehicle (DSRV) may be several days away, and the two DSRVs extant at the time of this writing are not specifically designed for use in combat [2]. Deployment of a new modular rescue system, which stages from a (vulnerable) surface ship, may also be impossible in wartime [5]. In such an emergency an ASDS, possibly already in-theater mounted on a host fast attack or guided missile sub, could act as a field-expedient stealthy rescue vessel, shuttling between the disabled submarine and the mini's parent SSN/SSGN.

The ASDS would need to bring its mating trunk or an equivalent docking collar, to connect to the disabled submarine's own escape trunk(s), but the latching pylons (used by the host for ASDS transport) would not required. If current ASDS mating trunk design does not permit this evolution, perhaps an appropriate *rescue* docking collar might be developed, or adapted from those on existing DSRVs. The ability to mate with the escape trunk of a disabled submarine skewed to odd angles would be an important capability of the docking hardware.

Note that in relatively shallow water, the crew could make conventional escapes while wearing Steinke hoods or the new Mark 10 full-body survival suits, but rather than ascending all the way to the surface in hostile waters, they could pop right into the ASDS hyperbaric chamber. The batch of escapees could then be decompressed at a controlled rate while avoiding hypothermia. Furthermore, the hyperbaric chamber could be used to temporarily treat crewmen suffering from decompression sickness—the ASDS could bring medical corpsmen to the scene. Unlike a conventional hyperbaric chamber used for diver treatment, the ASDS lock-in/lock-out sphere does not possess an air lock. A host submarine's own escape trunk might, in an emergency, serve this purpose, allowing corpsmen and supplies to enter and exit the high pressure environment at will.

As with other rescue systems, a number of shuttle trips would be needed to evacuate the entire surviving crew, along with code books and/or other (small) sensitive items not readily destroyed with the disabled submarine. (The use of more than one ASDS, or of an ASDS to supplement an on-site DSRV, would quicken the operation.) The passenger capacity of the ASDS might be increased in an emergency, by overcrowding the transport compartment and cramming additional personnel into the hyperbaric sphere and even the control compartment, while adjusting buoyancy with the variable ballast tanks. Lifting capacity could be further increased by jettisoning the anchors.

If the disabled submarine were neutrally buoyant but had suffered a mobility kill, an underwater tow cable might be rigged by divers, or by the ASDS or an unmanned undersea vehicle (UUV) equipped with robotic grapnels. Conceivably, SEALs equipped with mixed-gas rebreathers might be tasked to protect the submarine from enemy salvage divers or combat boarders, by staging from an ASDS and operating from inside and/or outside the hull.

Note that the use of the ASDS allows the host submarine to lurk at a safe distance from the disabled submarine whose general position may be known to the enemy. The cruising endurance of the ASDS creates an uncertainty as to the location of the parent which exceeds the range of typical heavyweight ASW torpedoes, and even exceeds by roughly an order of magnitude the lethal radius of a one megaton underwater blast [6]. Especially if time constraints allow for relatively lengthy transits between the submarine and the host (with battery charges as needed), this helps protect the parent sub from barrage attacks both conventional and nuclear.

Undersea Replenishment, Undersea *Bos'n's Chair*

An ASDS could shuttle between two submerged submarines, neither of which is disabled. This would permit transfer of anything small enough and light enough to be accommodated within the minisub. Information, such as intelligence reports or software upgrades, can be transmitted by secure radio, laser, and/or acoustic links, but personnel, special gear, food, medical supplies, and spare parts, all must be physically transported. So long as at least one of the full-size submarines that make the rendezvous carries an ASDS, and docking collars are compatible, the task is fairly straightforward. The ability to carry some eight SEALs with equipment suggests the cargo carrying capacity of the ASDS is at least one ton.

When stealth must be maintained at all costs, during peace or war or quasi-war, and/or the receiving submarine's mission prevents it leaving station—perhaps due to one-of-a-kind equipment or uniquely qualified riders—such an evolution achieves clandestine undersea replenishment in the forward OPAREA. Alternatively, so that the special equipment/riders remain on station, they could be transferred to the arriving submarine in the ASDS, while the original submarine departs for *conventional* replenishment, satisfies crew quality-of-life considerations, and transports the ASDS for its next assignment.

Covert Ambulance, Cargo Lighter, or Liberty Boat

Instead of shuttling between two submerged submarines, an ASDS might travel back and forth between a submerged submarine and a surface unit or shore installation. (With a flotation cradle to reduce its depth-to-keel, the ASDS could operate from the well deck of Navy amphibious ships [2].) Situations might arise in which a) enemy surveillance and/or the threat of attack discourages a friendly submarine from surfacing, yet b) it is desirable for people or equipment to enter or leave the sub. As above, if personnel and/or cargo are transferred in the minisub as an intermediate step the enemy does not learn the submerged host's exact location, and cannot even tell what type of submarine (let alone what class) might be involved. The use of one or more ASDSs for ship-to-shore and shore-to-ship transfers can even disguise the number and the nationality (U.S. Navy, Royal Navy, etc.) of full-size submarines present. Such an evolution could in fact be used as a deception or diversion, to imply the presence of a parent sub when none were really there. (Conversely, a surfaced host with a conformal minisub hangar inside an ocean interface hull module—a latter day *bat cave*—could deny evidence of an ASDS presence.)

Stealth Landing Craft or Ship Takedown Platform

The discussion above regarding covert personnel and cargo transfer also applies to direct combat operations. By surfacing against a pier or seawall, or beaching in suitable terrain and surf conditions, an ASDS can deploy and/or retrieve through its top hatch a Marine infantry squad or other non-swimmer landing party—the minisub amounts to a submersible landing craft.

By deploying from an ASDS alongside a targeted oil rig or ship—perhaps one seized by terrorists or one involved in smuggling contraband—a SEAL takedown squad can achieve complete surprise while arriving in peak physical condition. The SEALs could dive out through the ASDS bottom hatch, or exit *dry* through the top hatch while a surfaced minisub hugs the objective. Again, the ASDS is more stealthy than its nuclear powered host sub, more shallow-capable, and in extremis, more *expendable*. The ASDS also has better speed and endurance than the Mark VIII SEAL Delivery Vehicle (SDV).

Especially for the dry-exit option, the target's speed and the local sea state would need to be within the ASDS operating envelope. Perhaps friendly surface units might create a diversion, or perform maneuvers, to force a targeted ship to slow sufficiently. Instead, the SEALs themselves might deploy from the ASDS bottom hatch special netting to tangle propellers, or lay a line of sea anchor *snares* that simulate an engineering casualty on the target.

The ASDS might be fitted with a waterproof skirt to be erected around the top hatch to prevent swamping, and might shelter in the lee of the objective, during foul weather—the vessel could also use a flotation collar to increase its limited freeboard, and to enter very shallow water. (Recall such skirts were used on battle tanks during World War Two amphibious operations.) In this manner released hostages, prisoners, and any wounded could be moved to the ASDS without the use of scuba or free diving, or even needing to swim. Evacuation would thus be accomplished without reliance on surface craft or helos—some tactical situations might necessitate such hasty covert egress.

Stealthy Platform for Advanced Deployable System (ADS)

The Advanced Deployable System (ADS) is a portable and expendable passive acoustic undersea surveillance system designed for littoral use [7, 8]. The ADS battery powered hydrophone lines can be emplaced from a towed deployment vehicle (TDV) streamed from a surface unit. A shore installation provides the equipment needed for operation, for communications, and for monitoring the sonar data. But shore installations are vulnerable to detection, and therefore to countermeasures or attack. Strategic situations might arise in which a clandestine ADS adds value. It is conceivable that versions of the ADS might be deployed and even monitored from an ASDS.

As one possible arrangement, the necessary operator consoles and power sources could be placed within the transport compartment, and reels of (thin) hydrophone line could be played out through the bottom hatch. In deep water a submerged buoy could bring waterproof ADS jacks and plugs up to a more convenient depth, for access by divers or by technicians simply reaching down into the water from the equalized lock-in/lock-out sphere. A special adapter for the hatch rim might be provided to permit opening and closing the hatch without breaking these connections. The ASDS could then anchor while submerged within the limits of its test depth, perhaps masked by topography or a wreck, allowing the ADS operators to perform their duties in a clandestine but shirtsleeves environment. Depending on the length and quality of the ADS hydrophone line(s), and on local sound propagation characteristics, detection capabilities might significantly exceed those of the ASDS's own sonar suite (which does not include a towed array). In this manner the host—while concealed by terrain or poor sonar conditions—could launch weapons at a hostile contact based solely on targeting data from the ADS and the mini. Alternatively, the host might be cued to get in trail of the target.

Portable batteries might supplement the amp-hours available from the ASDS ultra-high-power-density silver zinc battery bank. Such ADS power packs could be emplaced on the bottom rather than carried in the minisub. They might be borne in an external harness, similar to the mine laying harness of the German Type 212 diesel/fuel cell submarine [9]. *Renewable* power sources might instead derive energy from local wave action, currents, and tidal flow, or from water temperature differences at different depths [10]—the potential availability of this *free* energy is one advantage of operations in the littorals. For that matter, multiple reels of hydrophone line might also be carried externally, making the ADS/ASDS scheme somewhat less weight- and space-critical. Furthermore, an ASDS might be rigged to tow the TDV while submerged, so as to deploy a *conventional* ADS clandestinely.

Regardless of the specific hardware used, various ADS data-transfer amplifier/relay options exist, including sequential combinations of a) an automated transmitter or a non-radiating data recorder emplaced by an ASDS which then departs, b) relay onward of *live* information by ADS operators in an ASDS remaining on-site, and c) transmittal of data and/or a tactical assessment from the host nuclear submarine to a battle group commander and/or theater or higher command authorities. Information could be sent from the ASDS to its host in real time via undersea secure acoustic link, or by trailing a (lengthy) fiber optic wire between the parent and the mini. Radio or laser-burst contact could be established when it was safe for the ASDS and/or the host to raise a mast. The parent sub or the mini might deploy a delayed-action radio buoy well away from the ADS, for stealth.

For better transmission performance than achievable with a buoy, the ASDS itself could break EMCON (radio silence) at a distance from its deep-running host, to pass on (and/or receive) urgent data while masking the host's location. Note that this evolution could apply to messages other than ADS data, giving an ASDS-equipped host what amounts to a super-cable lower-observable all weather stand off transceiver vehicle.

Adjuvant Sensor Platform

With its optical periscope, ESM mast, and sonars, the manned ASDS can serve as a kind of brilliant Undersea Unmanned Vehicle (UUV), one with considerable range, endurance, and autonomy. This role could be performed while the ASDS transits on its primary mission, including the time it loiters pending recovery of its debarked Special Warfare passengers. With its mast up, at least intermittently, the ASDS could monitor high-baud-rate friendly message traffic for its deeply submerged host. The ASDS could also gather SIGINT (signal intelligence) from closer in shore than the host and/or from a different relative bearing to the enemy emitters. Alternatively, instead of SEAL passengers the ASDS transport compartment might carry a load of deployable sensors, or the space and weight capacity might be used to store enemy artifacts (defuzed mine arming packages?) retrieved by on board divers. In general, with its own capable sensor/connectivity suite, the ASDS could serve as an agile covert scouting craft for one or more parent submarines.

It is conceivable that the ASDS could be equipped to control a long-term mine reconnaissance system UUV via the LMRS's standard autonomous acoustic link, once the LMRS is launched from a large host sub. In this manner the reach into the littorals, and concomitant risk-taking, are delegated from parent to ASDS to LMRS in turn. Each platform might relay up-to-the-minute hydrographic and bathythermometric data, as well as minefield and other tactical data, to the next unit off shore, enabling the larger platforms to move in more safely and covertly.

As an extra node from which to detect and localize enemy targets, the ASDS can aid the parent sub to triangulate and smartly derive a useable firing solution. (Again, real time communications would be achieved by low-probability-of-intercept digital acoustic link, or perhaps by a fiber optic wire. ASDS positional data would be obtained from its inertial navigation system, initialized at the host and updated when feasible by GPS and/or HF sonar bottom terrain orienteering.) An ASDS's bearings-only passive sonar data could substitute for an additional TMA leg by the parent sub. Target range could be refined quickly using the different arrival times at the two friendly vessels of a single enemy acoustic transient. The ASDS instead of the parent might go active, or (as above, with the ADS) might be the sole source of hostile contact tracking for its host. This targeting augmentation allows the host sub to attack effectively first [11], and/or evade the enemy successfully, as the ROEs (rules of engagement) require.

If weapons were launched, precautions would be needed to protect the ASDS from both friendly and enemy fire. An ASDS crewman might drop standard 3 inch and 6 inch torpedo countermeasures through the bottom hatch of the pressurized hyperbaric sphere, assuming an ASDS were not fitted with regular signal ejectors. In extremis, the ASDS might mimic a full size SSN behaviorally and/or acoustically, to serve as a decoy to protect its parent ship, or to deceive or intimidate an enemy. (The flank speed of the ASDS might roughly equal the maximum practical speed of an SSN with external dorsal load—an ASDS, DSRV, or dry-deck shelter.)

Arming the ASDS

As designed, the ASDS is unarmed. It might be possible to equip it with offensive and defensive weapons in one or more of several ways. An external neutrally buoyant mine carrying harness might be fitted, like that of the German Type 212s mentioned above. An external weapons canister might be fitted to an ASDS, similar to the Magnum system discussed in [12]. These steps would bring the ASDS capabilities closer to that of the proposed off-board combatant UUV, Manta [13]. As a field expedient, small mines might simply be rolled out of the ASDS bottom hatch once pressure had been equalized.

Were the host also fitted with a Magnum or ocean interface, the parent might be able to reload some types of weapons from the mini while submerged, with the aid of divers using adjustable buoyancy bladders and tethers to shift the units. The ASDS equipped with a Magnum (or temporary external cradles) could thus become a submersible weapons carrier for its host, shuttling between the SSN/SSGN and a sub tender or milch cow or pier, enhancing undersea replenishment capabilities.

Arming the ASDS externally might increase its own (and the mated host sub's) flow noise, and impair speed and maneuverability, but it would allow the ASDS to defend itself when going in harm's way. It might become standard practice to release the ASDS when the host commences undersea combat, to be free of the added hydrodynamic drag created by the piggybacked minisub. Pre-battle separation could also be made if the ASDS were carried internally. An armed ASDS would then become an SSN's *escort fighting vessel* as well as adjuvant sensor platform, passing *flag signals* back and forth acoustically. (Imagine sending "Engage the enemy more closely" on covert digital HF sonar.) At a minimum, the provision in the mini's hyperbaric sphere of a few torpedo countermeasures, and (during wartime) small mines with brief time delays, would improve ASDS survivability.

Hiding in Plain Sight

During anti-submarine operations, biologics may be misclassified as possible enemy submarines (POSSUBs), and may draw fire [14]. In some circumstances, an ASDS exposed to detection by the enemy may seek to be misclassified as a *CERTWHALE*, a definite biologic, and thus hope to avoid drawing fire.

By virtue of its size and shape, the ASDS has the potential to mimic a cetacean. Given the minisub's quiet battery propulsion (i.e., minimal self-noise tonals), it has the option to emit whale sounds via active sonar or purpose-fitted hydrophones, enhancing its disguise as a large biologic. The crew might maneuver, as to course, speed, and depth variations, in a manner similar to the behavior of some whale species known to be endemic to the target area at the applicable time of year.

Conclusion

The introduction of inhabited and uninhabited adjuvant vehicles, deployed from an *SSN* or *SSBN* or *SSGN*, is changing the nature of undersea warfare, as is the concept of the USS JIMMY CARTER's ocean interface hull module. The NMRS and LMRS (as well as high-frequency low-probability-of-intercept active sonar) have brought the Silent Service a long way from the Hell's Bells mine detection gear of World War Two. Unmanned aerial vehicles (and high data rate antenna masts) are raising the *eye height* available in a submarine's control room from that of an optical periscope to that of an observation aircraft or reconnaissance satellite. Clearly, the potential versatility of the ASDS special Warfare minisub, and the ability of the basic platform to be *up-capabled*, make it a particularly cost effective force multiplier for the full size naval submarine fleet.■

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SUBMARINE EXTERNAL ROTARY RACK WEAPONS SYSTEM

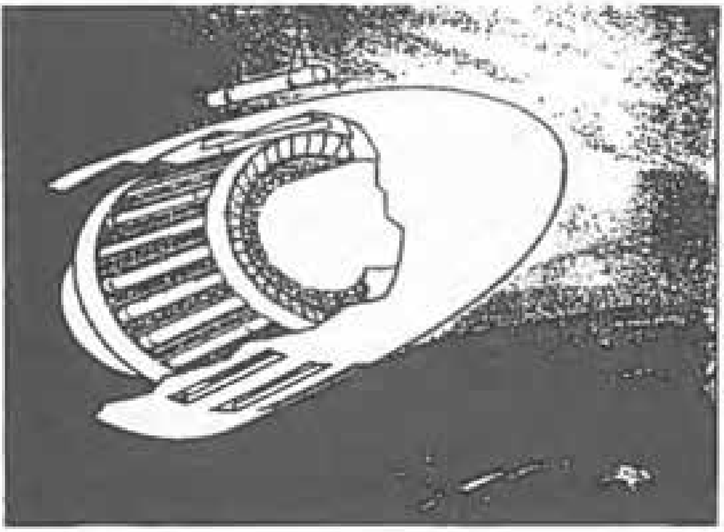
by Mark Henry

Mr. Henry is a League member and is Treasure of the Capital Chapter. He is a naval architect and retired from Naval Sea Systems Command in 1999 after 35 years of working in early-stage submarine design and research and development management. His last position was as Head of Submarine Preliminary Design and as Principal Naval Architect for the Virginia class.

A Submarine External Weapons Delivery System, hereinafter referred to as the *rotary rack system*, was developed in 1969-70 under the sponsorship of the U.S. Navy's SSN Continuing Concept Formulation (SSN CONFORM) Program. The basic concept of the rotary rack system is a movable carriage mounted on and revolving around the pressure hull in a double hull section of a submarine. Weapons are stored within the rotary rack structure and move with the rack to appropriate launch locations. [The "Magnum" revolving rack concept, described by Harold Armstrong in the January 1999 edition of **THE SUBMARINE REVIEW**, has many similarities to the rotary rack system.]

Concepts were developed for rotary rack installation in a submarine's bow or amidships, i.e., around *bottlenose* or *wasp waist* pressure hull sections, in an otherwise single hull ship configuration. The figure shows a notional bow installation. A bow system would replace the contemporary SSN torpedo room and its angled torpedo tubes. An amidships system is independent of the torpedo room, which could be retained or eliminated based on other criteria.

Torpedoes are stored wet and at ambient sea pressure. To prevent corrosion, each weapon is packaged in a flexible water-proof container (e.g., a plastic bag) containing a non-corrosive fluid. Torpedoes, which tend to be denser than water, are launched near the ship's keel using a trapeze-like mechanism to move the weapon from its stowed position between the hulls into the free stream and to impart an initial forward velocity, a requirement for some torpedoes. Torpedo launch is feasible from both bow and amidships launchers.



Cruise missiles are stored dry in buoyant capsules. Launch is accomplished by releasing the buoyant capsules at topside launch positions. The capsules float to the surface where the missile is ejected, similar to the later developed Encapsulated HARPOON system. Missile launch is feasible from bow and amidships launchers. However, there is risk that the sail may impact bow launched buoyant capsules and the amidships scheme is preferred.

Both missiles and torpedoes are loaded at a topside launch position. Shutter doors provide a smooth hull surface except during weapon launch.

[More recent submarine external weapons concepts typically place weapons in pressure proof canisters to maintain an appropriate environment for the weapon. To launch a weapon, canister pressure is equalized with the surrounding ocean, an end closure opens, and the weapon is impulsed into the free stream (e.g., by means of a gas generator or catapult). This approach was considered during the course of rotary rack development but was not included for two reasons. First, it replaced a submarine's weapon launchers (four torpedo tubes and two impulse devices) with a number equal to the number of weapons. Second, it requires firing the weapon forward or aft, either of which adversely impacts the geometric configuration of what otherwise were single-hull, body-of-revolution ships, causing ship size, drag and cost to increase.]

A number of alternative concepts were developed during the 1969-70 study. The principal differences between Electric Boat and Lockheed developed rotary rack concepts are summarized below, as applied to torpedo stowage and launch.

Feature	Electric Boat Concept	Lockheed Concept
Outer hull	Fixed	Fixed or rotating
Rack structure	Welded plate	Welded and bolted truss
Rack suspension system	Hull-mounted, flexible	Rack-mounted, solid
Rack drive	Geared	Wire rope/capstan
Power source	Hydraulic motors	Electric motors
Weapon stowage environment	Sealed plastic pod filled w/special fluid	Fresh water filled compartment in rack
Launch	Powered	Gravity

The primary areas of concern for rotary rack system weapons, loading, handling, stowage and launch were as follows.

- Environment: shock, corrosion, marine growth, cyclic fatigue on weapon pressure boundary components and seals, etc.
- Stowage: the rotating rack places weapons in non-upright positions (unless the system can independently rotate the weapons, keeping them upright, as the rack rotates - an undesirable added complexity), lack of accessibility for weapon maintenance, etc.
- Communication and power: existing methods for transferring data and power to the weapon could not be used.
- Launch: existing methods for external launch were very noisy, problems associated with launching most likely could not be corrected until the submarine returned to port, the location of launchways severely limits launch speeds, and the potential ship impact with a dud weapon needed to be

resolved. Buoyant missile capsules cannot be launched when the submarine is surfaced.

- Fabrication, operation and maintenance: external rack poses significant problems related to fabrication, operation throughout the submerged operating envelope, and maintenance over a ship's life cycle.
- Redundancy: none—a single casualty to the rotary rack would probably abort a mission.

In addition to system concept design efforts, the Submarine External Weapons Delivery System project sponsored selective technology development to validate the concept. The more notable tasks included:

- Model tests: conducted by the Naval Ship R&D Center in the high speed model basin at Carderock, demonstrated that denser than water weapons could be successfully launched near the keel at high submarine speeds.
- Model tests: conducted by Lockheed in the Lockheed Underwater Missile Facility (LUMF) at Sunnyvale, demonstrated that buoyant capsules could be successfully launched from topside.
- Compatibility studies: conducted by the Naval Underwater Weapons Research and Engineering Station, demonstrated the compatibility of the Mk 48 torpedo and the Mk 28 missile (SUBROC) with external stowage and launch.

The current torpedo room occupies valuable space inside the pressure hull and building and installing weapon stowage structure, torpedo tubes, the shipping system, etc., utilizing expensive materials and with many critical alignments, is very costly. However, this configuration provides a very dense weapon stowage scheme with heavy weights low in the submarine.

A rotary rack scheme, in lieu of a torpedo room, eliminates the torpedo room and weapon stowage structure, the torpedo tubes, the weapon shipping trunk and system (including the need for centerline cutouts on the platform decks), the weapon ejection system (ejection pumps, firing valves, impulse tank), many large pressure hull penetrations, and also reduces manning requirements. However, it has its own significant implications on total submarine design. Some of the more important torpedo room versus external rotary rack tradeoffs are discussed below.

- Double hull submarines tend to be larger, slower, and more expensive than single hull submarines. This also pertains to partial double hull submarines.
- The rotary rack and all of its associated component weights are higher in the submarine. In a stability limited design, this would require additional stability lead and, perhaps, cause the ship to increase in size.
- The external weapons space between the pressure hull and outer hull cannot be used as main ballast tankage due to the large topside openings for weapon shipping and missile launch. The volume of this free flooded space will be approximately the same as the torpedo room volume and the overall ship will be larger unless the torpedo room is removed.

Removing the torpedo room can be accomplished only if the submarine does not require the buoyancy provided by the torpedo room volume to achieve neutral buoyancy. While the weights associated with the torpedo room weapon stowage structure, torpedo tubes, weapon shipping trunk, and weapon ejection system are eliminated, the rotary rack system adds the weight of the rack, additional outer hull structure, large shutter doors, operating mechanisms, etc.

- A torpedo room provides space for alternative purposes, e.g., SEAL teams and UUVs. [This is particularly true in the Virginia class with its reconfigurable torpedo room.] Even if all weapons are external, some alternative uses require one or more torpedo tube-like features to transfer payloads from within the submarine to the water column and, perhaps, to also retrieve payloads.

While considerable engineering development efforts would have been required to field an operating rotary rack submarine external weapon delivery system, the design and advanced development efforts conducted in 1969-70 demonstrated the fundamental feasibility of such a system. However, the rotary rack system was not included as a candidate weapon delivery system in subsequent submarine design concepts due to what were *then* considered overwhelming system and total ship disadvantages. Perhaps today's innovative submarine designers, applying advanced technologies, will overcome the hurdles encountered during the past thirty years and create new and improved submarine weapon delivery systems.■

Most of the organizations involved in the 1969-70 Submarine External Weapons Delivery System development have changed name due to reorganizations and mergers. The sponsoring SSN Continuing Concept Formulation Program (no longer existing) was managed by PMS 393 (now PMS 392) in the Naval Ship Systems Command (NAVSHIPS, now part of NAVSEA). Development efforts were primarily performed by the Naval Ship Engineering Center (NAVSEC, now part of NAVSEA), the Naval Ordnance Systems Command (NAVORD, now part of NAVSEA), the Naval Ship Research and Development Center (NSRDC, now NSWCCD), the Naval Underwater Weapons Research and Engineering Station (NUWS or NUWRES, later NUSC, now NUWC), General Dynamics/Electric Boat Division (GD/EB) and Lockheed Missiles & Space Company (LMSC, now Lockheed Martin Missiles & Space).

IN MEMORIAM

CAPT Henry Bress, USN(Ret.)

Vice Admiral Eli Reich, USN(Ret.)

AIR INDEPENDENT PROPULSION FOR SSNs

LT Robert G. Hanna III, USN

Editor's Note: Lieutenant Hanna's paper won The Naval Submarine League Essay Contest for Submarine Officers' Advanced Class 99030. Lieutenant Hanna is currently the Executive Officer on NR-1.

You may be thinking that an SSN already has an air independent propulsion (AIP) system powered by its nuclear reactor; however, you would only be partially correct. While the reactor is the primary power source, a diesel engine with attached generator is the alternate means for *long-term* emergency power. This diesel engine is not an ideal alternative power source to the reactor and there is the better technology being developed.

The Problem

As a power source, the diesel has some major tactical deficiencies. As an air dependent system, the diesel is not available on-demand at any operating depth of the submarine. Instead, the submarine must have access to external air through either the snorkel mast or an open hatch for the diesel to run. In arctic areas, the requirement for external air could create serious consequences if ice-free water is not immediately available. In addition, the demand for snorkel air would create a very long and dangerous trip home, if the diesel becomes the sole means of recharging the batteries and providing propulsion. Because of the air dependency, the submarine must risk non-acoustic counter-detection by exposing a large radar cross-section in order to gain the air for the diesel. On some peacetime missions, a counter-detection could have serious political ramifications and during wartime, it may mean death for the submarine and her crew. Along with the non-acoustic counter-detection risk, the diesel is a serious acoustic counter-detection risk. The diesel operations are not as quiet as operating on the reactor and provide a significant acoustic source. In summary, the diesel provides the SSN three major problems during an emergency, 1) air dependent, 2) non-acoustic counter-detection risk, and 3) an acoustic counter-detection risk.

The Solution

There is a new technology that is on the near horizon (less than 5 years away) which can solve all the problems of the diesel and provide some additional benefits. The technology is air independent propulsion power provided by hydrogen-oxygen cells. This technology is under development by the Germans for incorporation into the Type 212 SSK in the year 2005. The cells work on a process similar to running an oxygen generator in reverse. Hydrogen and oxygen are mixed in a cell with a catalyst and recombine into water while directly producing electricity. There is no combustion and no motor or generator required. The cells are expected to be extremely safe (it is anticipated that Mercedes-Benz will even use these cells in consumer vehicles, i.e., cars and trucks). The AIP system will give the U-Boats an ability to operate for over 10 days submerged and could possibly provide an SSN with the same sort of ability as a substitute for the diesel generator.

Hydrogen-oxygen cells have many advantages. To begin with, they address all the concerns of the diesel generator. They would be an on-demand alternate power source able to provide long-term emergency power without the need for external air. They remove both the non-acoustic and acoustic detection opportunities associated with the current diesel.

AIP technology has the ability to provide more advantages than just fixing the diesel. A possible tactical advantage of AIP would be as a means to gain a few dB of acoustic advantage by shutting down the reactor and associated systems. Of course, the CO would have to weigh the acoustic advantage gained with his corresponding loss in maximum propulsion capability; however, with careful considerations a *quick-start* ability to shift back to nuclear propulsion and evade could be safely devised.

In addition to tactical advantages, hydrogen-oxygen cells have the prospect for some significant side benefits. Installation of AIP would necessitate the removal of the diesel and the associated equipment. If the AIP cells were an integral part of an SSN's design, then several hull penetrations and their associated subsafe systems currently required for the diesel could be removed. The removal of these hull penetrations could help allay some of the costs of installing AIP and, at the very least, increase hull integrity. Along with the removal of systems, the hydrogen-oxygen cells should contain significantly less moving parts when compared to the diesel. The reduction in moving parts likely would allow a reduction in the required PMS and associated long-term costs of operating the system. In addition to reducing systems and maintenance, the AIP system should reduce operators. At a minimum reduction, there will be no need for a sump watch and at a maximum reduction, the system might even be designed such that the Electrical Operator could push a button and have power. Of course, this would also entail removing the current test of manliness—priming the diesel. The last side benefit of hydrogen-oxygen cell technology is the possibility that it may help the Navy meet even tougher environmental regulations. For example, diesel lube oil and diesel fuel would be removed. In addition, water is the waste product of the AIP cell and could be used on board or pumped safely overboard. The last benefit of the cells may not be realistic; however, it should be examined. The SSN's oxygen generator could function as a means of recharging the hydrogen-oxygen cells; thereby creating almost a virtual hydrogen-oxygen battery able to be used during drills or actual events and recharged at will.

Conclusion

While there are bound to be some drawbacks with any new systems (such as a safe means to store the hydrogen and the oxygen), the hydrogen-oxygen cell provides a significantly better alternative power source for an SSN when compared with the diesel. Working with Germany, the United States should develop AIP technology for inclusion in latter Virginia class SSNs and the post-Virginia class SSN.■

<u>THE IMPACT OF MODERN RADAR TECHNOLOGY ON SUBMARINE TACTICAL EMPLOYMENT</u>

by LT Shawn T. Nisbett, USN

Editor's Note: Lieutenant Nisbett's paper won The Naval Submarine League Essay Contest for Submarine Officers' Advanced Class 99020. Lieutenant Nisbett is currently the Weapons Officer on USS OLYMPIA (SSN 717).

From June to December 1998, I had the opportunity to deploy with the Eisenhower Battle Group as the Submarine Operations Officer on the Destroyer Squadron Two staff. During the deployment, DESRON Two participated in six different multinational Undersea Warfare (USW) exercises in which a total of nine diesel submarines and five U.S. fast attack submarines participated. The Battle Group had Tactical Command (TACOM) of four SSNs simultaneously. I had the unique opportunity to participate in all the planning and execution of the USW exercises. As a submarine officer, my previous USW experience was limited to the single dimension of hunting below the surface of the ocean. I gained many valuable insights while on the staff as to the very complex three dimensional problem of USW which incorporates air, surface, and submerged assets to hunt for enemy submarines. One particular high tech, USW non-acoustic sensor captured my attention, and this article attempts to explain this USW sensor and its implications on future submarine employment and tactics. The article will also explore the impact of similar, high tech, commercial-off-the-shelf (COTS) technology in the Virginia class submarines, as well as technology that is being back-fitted on Los Angeles class submarines.

Those in the submarine profession fully understand the term of acoustic advantage, and they understand the significance of the declining acoustic advantage as Russia continues to produce highly capable and stealthy submarines. Acoustics aside, there is no such term that refers to the submarine's radar stealth advantage in approaching and attacking a surface ship, however, decreasing the radar stealth advantage of a submarine has implications equally serious to the decreasing acoustic advantage. The surface ship's ability to detect a submarine mast with its surface search radars has yet to pose a significant threat. A submarine can approach a surface ship using short mast exposure times and only reveal its presence when the submarine's torpedo explodes and the ship is on its way to the bottom of the ocean. It is a challenge to the submariner's way of thinking to imagine a world in which a surface search radar can detect a submarine's periscope and vector a helicopter to prosecute *before* the submarine can visually detect the surface ship.

Automatic Radar Periscope Detection and Discrimination

Such a radar system exists today, and it is known as Automatic Radar Periscope Detection and Discrimination (ARPDD). The incredible digital storage capacity and lightning fast processor speed of commercially available computer hardware enables the radar system to track all initial detections, including wave clutter (up to 100 detects/second), and track each detection to develop a course and speed. A complex three layer algorithm is performed on each detection which effectively analyzes the sea state to filter out the clutter returns, it analyzes the shape and the stability of the object in the water, and then automatically provides the operator with a valid periscope declaration. All this with only brief moments of mast exposure! The operator is spared the overwhelming returns from wave clutter and trash in the water and is only given the real periscope return. The operator then has the tools to further analyze the information for the aspect of human evaluation.

ARPDD utilizes the AN/APS-137 ISAR radar mounted on S-3 and some P-3C aircraft. The AN/APS-137 was originally designed as a periscope detection radar with two modes, search mode and searchlight mode. In search mode, the operator was presented with all radar returns, whether the returns were trash, sea state, or a periscope. The operator would then switch to searchlight mode in order to evaluate and discriminate the returns. Search lighting was immediately detected by the submarine's ESM system causing the submarine to lower its periscope or to proceed deep. Unless in an alerted condition, the APS-137 operator might miss the mast detection. ARPDD utilizes modern digital technology to replace the human operator functions of identification and discrimination of a short exposure periscope detection. The radar characteristics are unchanged, and the requirement to use the searchlight mode is available but no longer necessary. By installing the APS-137 on a surface warship, the warship is provided with a non-acoustic, USW sensor that will detect a submarine periscope beyond the visual range that the submarine can view the warship.

ARPDD offers promising benefits in the war against the diesel submarine. Passive sonar is generally ineffective against a diesel submarine. Active sonar produces better results, but it is highly unlikely that the environment will support the use of active sonar, and counter-detection is a great disadvantage of active sonar. Mountains of evidence have been collected that prove non-acoustic sensors provide the majority of detections against diesel submarines, the primary sensor being the human eye of a pilot in a helicopter or a fixed wing aircraft. By nature of their design, diesel submarines must spend a large portion of time at periscope depth in order to snorkel. The correlation is clear between the amount of time diesel submarines spend at periscope depth and the number of detections of diesel submarines by visual detection. Armed with ARPDD, ships have a force multiplier that is many times better than human vision. ARPDD provides the operator with automatic detections, requiring only brief periods of mast exposure, well beyond visual range of a lookout and with highly reliable, 24-hour coverage.

ARPDD was to be tested in the P-3C aircraft during 1999. The mobility added by the MPA aircraft will further its usefulness in locating diesel submarines. ARPDD also has great potential as a coastal defense radar. ARPDD could be affordably used to prevent submarines from collecting information off the coast or to prevent special operation forces from invading a beach head. The potential is very high, and the remarkable factor is it only takes a modern radar with the right operational attributes in bandwidth, range resolution and update rate (the ISAR radar) along with COTS computer hardware to create such a system.

In the Falklands War, hundreds of British USW weapons were employed against Argentine submarines without success. To prevent this large expenditure of weapons against false contact, the U.S. adopted a more conservative doctrine of weapon employment. Three types of submarine detections were defined: Possible Sub, Probable Sub, and Certified Sub. The only way to classify a submarine as a Certified Sub according to the doctrine is to visually identify the sub. The ARPDD system proved to be so reliable during its first deployment that a detection was definitely a submarine, but according to the doctrine it could only be reported as a Possible Sub or Probable Sub. The system was so much better than the traditional sonar detections, either by surface ship bow mounted or towed array sonar or aircraft dropped sonobuoys, that it did not fit in the USW doctrine. This is only the tip of the doctrine iceberg that must be evaluated and changed to incorporate the far reaching effects of computer technology.

Submarine SUW Tactics and Equipment—the Present and the Future

ARPDD is a highly capable radar system that surpasses any periscope detection radar available today, but it does not make the submarine obsolete. The capabilities and limitations of the ARPDD system makes clear that the nuclear submarines will remain the submarine of choice due to factors of speed, maneuverability, survivability, the ability to remain submerged, continued sustainability, communications, and rapid firepower of multiple weapons that only nuclear submarines can guarantee in any situation. However, the U.S. Submarine Force must always focus on the future to continually evaluate what systems may pose a threat and then invest the resources to counter that threat, whether it be with tactics or technology. The submarine community must be on the leading edge of research and development to maximize not only the acoustic advantage but every advantage that makes the submarine such a lethal, stealthy, and highly versatile platform.

The impact of such a radar system on submarine tactics is significant. ARPDD effectively removes the submarine's ability to identify and distinguish surface targets visually. The risk of counter-detection for the submarine increases dramatically. The extended range of ARPDD on a surface ship is about 20 kyds, which is limited by the horizon and the mast head height of the surface ship. The submarine's only defenses are Sonar and Electronic Support Measures (ESM). At 20 kyds, a warship could detect a submarine at periscope depth well beyond the submarine's sonar range. ESM is limited as well by the short mast exposure time. By the time the ESM operator reported a signal strength 2 or 3 threat contact and the OOD lowered the periscope, the necessary time for counter-detection by ARPDD would certainly have elapsed from the moment the periscope initially broke the water to the time it was subsequently under water. In that short amount of time, the submarine was counter-detected and in moments will be prosecuted by helicopters or fixed wing Maritime Patrol Aircraft (MPA).

How does the submarine participate in Surface Warfare (SUW) in an environment in which every surface combatant has an ARPDD radar? The scenarios of unrestricted submarine warfare practice during World War I and II offer the only legitimate case when submarines would have the freedom to sink surface vessels without discrimination. Such indiscrimination would be unthinkable in today's political environment. In fact, blue-on-blue engagements and blue-on-neutral engagements are key items of concern during inspections of deploying battle groups. By denying the submarine the ability to penetrate within visual range of a warship, the submarine is either forced into an Over the Horizon engagement or the submarine must be willing to sacrifice its stealth during the attack.

In order to conduct a surface attack using torpedoes, the submarine can easily penetrate the surface defenses to within weapon range while submerged using sonar. It is recognized that against a capable adversary, the submarine sacrifices its stealth once the torpedo is deployed. The submarine must recognize that it can no longer make a round of observations while approaching a surface ship equipped with ARPDD. It must make the approach submerged, the firing TMA solution must be obtained submerged with the firing tactics assigned, and the torpedo must be ready to fire with the tube flooded and the outer door opened. The captain, as the approach officer, can make one observation of the surface ship for identification purposes only to verify the contact is classified correctly and to ensure there are no interfering contacts. Odds are that the submarine will be counter-detected by ARPDD once the scope is raised, but against the capable adversary this equates to only a few seconds difference from when the torpedo is fired. The difference being that the surface ship now has an exact bearing and range to the submarine rather than only the bearing from which the torpedo originated. The submarine must then immediately evade after firing its torpedoes.

The Russians continue to effectively employ the Oscar II with its SUW missile ranges at 300 NM. The U.S. submarine community is void of any similar SUW OTH capability. U.S. submarines presently have no anti-surface ship weapons other than the torpedo. The Harpoon and the Tomahawk Anti-Ship Missile (T-ASM) are no longer carried on fast attack submarines. The absence of the missiles only tells half the story. The U.S. submarine community, despite its recent commitment to battle group operations, shows little interest in OTH capability. The surface ship community continues to invest money into OTH systems such as Link 11 and Link 16 and Cooperative Engagement Concept (CEC). The surface community is upgrading their Link 11 systems, while the submarine community has no intention of upgrading their own USQ-76 system which is incompatible with the new surface Link 11 system. Although submarines have experimented with Link 16, no submarine has carried the correct equipment to have its fire control system directly interface with Link 16. Link 16 data has to be entered manually by hand into fire control. Link 16 is merely a communication connection exercise. The remaining means of a submarine gaining OTH information from a battle group is via OTCIXS/JOTS, but JOTS data is not meant to provide targeting information--it is mostly used for planning and situational awareness.

This discussion illustrates the difficulty and shortcomings of the surface approach and attack problem using existing submarine equipment, sensors, and weapons. Future options would require equipment not yet developed. In order for the submarine to make an attack from over the horizon, one option is to develop a long range torpedo that could approach quietly with the ability to perform an identification maneuver in which the torpedo proceeded to *periscope depth* and remotely provided a picture of the target back to the submarine before impact. The torpedo itself could possibly gain targeting information from a satellite during this *periscope depth* maneuver. The submarine could also be provided real time targeting information from a satellite to employ long range OTH torpedoes or missiles. The submarine must have some form of equipment on board, in either case, to receive OTH targeting information from a battle group or a satellite.

Submarines have successfully employed and controlled Unmanned Aerial Vehicles (UAVs) within the last two years. What if the submarine could conduct *coordinated and simultaneous* operations with UAVs and the periscope depth capable torpedo? The UAV could provide the OTH picture and communicate with both the torpedo and the submarine. UAVs have a great potential for the Submarine Force and efforts should continue to develop and test UAVs for such applications.

Another option is to develop a low signature periscope. A departure from the traditional periscopes is required. Any scope-like object that sticks three feet in the air must have a minimum diameter to support the forces necessary for the submarine to make headway through the water, but any object of this size will be detected by ARPDD. A low signature periscope could be developed such as a flat mirror-like object that floats on the surface of the water which is able to communicate with satellites in order to paint a picture of the surrounding waters and contact situation.

Technology in the Virginia Class Submarines

Technology continues to influence new construction and how submarines will fight in the future. The application of modern computer technology to weapon systems and sensors, such as the computer technology used in conjunction with the AN/APS-137 radar to create the ARPDD system, raises key questions that should be addressed. What is the impact of using COTS technology in weapon systems? What functions are the computers performing? Are the computers merely being used to speed up the information flow process with the same old processes that were used by the Legacy system, or are the processes being revised to fully utilize the processing power of modern computers? Are the computers being used for more than just information flow? Can we use computers to filter information, discriminate and correlate information, and make decisions that humans once made with the Legacy system? The remaining discussion will focus on these questions.

Submariners are traditionally conservative and feel very uncomfortable about removing the human from the decision making process and replacing him with a computer. However, it is unreasonable for a human operator to sit in front of a radar screen for six hours at a time looking for a radar blip that lasts only ten seconds. It is unreasonable for a sonar operator to stare at a waterfall display for six hours and detect a faint DIMUS trace that might last for three minutes. Conversely, it is also unreasonable for a radar or sonar operator to distinguish, track, and classify upwards of 20 contacts. A sonar narrowband operator is faced with the same overwhelming situation. The correct answer is to let the computer perform this function.

Computers and local area networks offer information at our fingertips. Often, though, the availability of information is overwhelming the operator. The information can be displayed immediately on one computerized flat display in a fraction of a second. ESM bearings, sonar bearings, radar bearings and ranges, and visual bearings are all immediately displayed. Data base management can become impossible to handle when upwards of 100 contacts are displayed. It is information overload, and computers are typically blamed for this problem. The collection of information is only the first level of effectively employing computers in weapon systems. The key to the whole process is *knowing when to insert the human operator*. Computers are powerful but we must use them properly. Increasing raw information is great, but computers must be employed to provide a second and third level in which the computers correlate, filter, and discriminate.

The ARPDD system offers a prime example of how computing technology can be incorporated into weapon systems. The ARPDD developers recognized that gaining more raw information is not the answer. Radar technology that has been used for years, such as the AN/APS-137, can provide more information than any operator can distinguish. A radar operator has always been able to adjust the gain sensitivity and blank out the screen with radar information. In the ARPDD system, the computers provide a second layer. The computers correlate, discriminate, evaluate, and then deliver a small amount of information that the operator can understand and comprehend. By adding the new computer dimension, the benefit is not necessarily the availability of information but the processing of information.

The Virginia class submarine is the first class of submarines to use COTS computers and hardware for its fire control and sonar systems vice the shock resistant Legacy system. The COTS system is a factor of ten cheaper than the Legacy system (a price tag of $100 million vice $1 billion), but it is not shock tested or proven to survive a close aboard explosion. A change in thinking is required to give up the hardware military specifications (Milspecs) in order to use COTS hardware, but we must demand more of the software developers. How many times has Windows 95 frozen up for the average American, forcing a reboot? The cost savings in using COTS is great and the amount of money necessary for the Legacy system to meet Milspecs is no longer warranted, yet submariners cannot sacrifice survivability for saving dollars.

COTS hardware and software developers are in a highly competitive and fast changing business. The business must perform a financial analysis of how much time the company can afford to spend on creating a *bug free* product compared to how much profit the company can make if the product was on the shelf in stores. Simply put, the key word in COTS is *commercial*. The COTS hardware and software developers are not held to the same standard expected of military hardware and software which has the lives of sailors, soldiers, and airmen depending on its performance. The real issue with using COTS equipment in weapon systems and sensors is not about *shock tested* but rather *performance tested*.

It would be prudent to use a portion of the cost savings in buying COTS hardware to ensure a 99.9 percent absence of software bugs and to provide improved algorithms that will enable computers to provide the second and third layers of correlation and discrimination previously discussed. The amount of effort and money in the 1970s that went into developing Milspec hardware should correspond to the amount of effort and money to develop intelligent software that works 99.9 percent of the time. The software should enable the replacement of the human operator from mundane and tedious tasks; it should dramatically increase the information available to the operator; it should correlate and filter; and finally, it should present that information in a format that the operator can easily comprehend. The human must be a key consideration in the software design and engineering, and the human must be placed at the right place in the decision making.

Recommendations

Focusing on only one system such as ARPDD illustrates the dramatic impact that computer technology will have on sensor and weapon performance. Increased radar or sonar sensor performance will force submariners to change their tactics, equipment, and doctrine. Tactics and doctrine can change quickly, but the development of new equipment to counter the new threat requires forethought, vision, resources, time, and imagination. Aside from the potential threat that ARPDD presents to submarine SUW, the submarine community can draw some interesting parallels from ARPDD with respect to utilizing computers for not only gathering information but to also correlate, sort, make decisions, and reduce the information overload of the operator. Human decision making will always be critical to weapon system success. The challenge in implementing computer technology lies in adequately programming the computer to perform the mundane and highly complex tasks with the human operator intervening at the correct time in the decision making process.

In summary, the following are recommendations that I propose:

- Introduce the concept of ARPDD in the submarine officer training pipeline at the division officer, department head, executive officer, and commanding officer level. The ARPDD system is only in the development phase, but submarine officers should be introduced to the potential threat that ARPDD offers and how ARPDD affects the traditional surface approach and attack tactic.
- CNO N87 should invest research and development (R&D) resources to investigate the feasibility of a low radar signature periscope, a long range torpedo with a *periscope depth* maneuver capability to gain OTH information from satellites, and the development of UAVs that can provide OTH information to submarines.
- CNO N87 should invest in a modern OTH weapon and/or return the Harpoon and T-ASM to fast attack submarines.
- The submarine community must be completely integrated into the battle group Link 11, Link 16, and CEC picture. The submarine community must keep pace with the surface community's advancement in Link 11. Submarines deploying with battle groups should have the necessary equipment onboard for Link 16 to directly interface with its fire control system.
- CNO N86 and CNO N88 should fund the ARPDD system to be installed on all USW surface combatants and P-3C aircraft as force multipliers in the battle against the littoral diesel submarine.
- The design of the Virginia class submarine must employ computers in a manner that not only increase information flow through the sonar and fire control systems, but also provide the necessary software that is 99.9 percent fault-free with intelligent algorithms and decision making programs that present the increased information in a manner that is beneficial and useful to the operator.■

SUBMARINE INFORMATION TECHNOLOGY:
It Begins with the Backbone

by LT T.R. Buchanan, USN

Editor's Note: Lieutenant Buchanan's essay was written while attending SOAC Class 99030. He is currently Engineer on USS FLORIDA (SSBN 728) (Gold).

The explosion in information technology (IT) has engulfed the Navy. As we head into the 21st Century the United States Submarine Force will be left in the proverbial IT21 wake if we are not technologically innovative. We must act now to build the Virginia class attack submarine with the fundamental capabilities and train the right people to operate effectively in a network based environment. What must the Virginia have to be ready to assume its role as a leader in Information Technology? First, we have to create a new personnel program to adequately train our sailors and officers in network operations and maintenance. Second, we must build into the Virginia the proper infrastructure and network backbone to guarantee its success. Finally, we have to make sure we understand the potential for future development and build into Virginia systems that can be upgraded with hardware and software throughout the expected 35 to 40 year life of that submarine and the others of the Virginia class. It is a challenging task. It must be solved today. The United States Submarine Force cannot squander this opportunity to build a new class of submarines appropriately outfitted with the proper network infrastructure to make the submarine more operationally effective and the crew better able to do their day to day work in port and at sea.

We must understand the capabilities of information technology and be aware of its limitations. In the past, we have focused too much on the limitations rather than on what the capability can do to make our submarines more efficient and effective. There are certainly aspects of incorporating network technology that are a challenge. Challenges can be overcome if we apply the resources and the creative people to make it happen. IT will help us do things faster and more efficiently. IT is not simply doing things with a computer that you would have normally done manually or by hand, but it is an entirely new way of thinking and problem solving. It is important that a standardized Local Area Network

(LAN) package is developed that can be outfitted on any boat in the future. I will present an alternative; there are many others that may be varieties on my theme. The critical issue is that we must take the steps necessary to transition our submarines to be an essential part of the IT world. A most important aspect of any computer network alternative is that it takes into account the multi-layered security concerns and the management of each network configuration.

As we made our earliest attempts to backfit LANs aboard submarines, there was little training afforded the officers or crew. Many of the crew knew about the capabilities of computers and as a result there were many suggestions and unfortunately, just as many solutions. There was no help desk and it was an environment that lacked standards, possessed no configuration controls, no documentation and little training for those who needed it. If there was training it was normally provided to one person in the crew and that person became a one-person expert charged with the training of over one hundred other people. A very difficult task to say the least. LANs cannot be administered in this haphazard fashion. We have to accept the fact that this is a new way of life and we must commit the resources, change the way we are doing business and dedicate people on a full time basis to this responsibility. Personnel need training, they need to understand what they can and cannot do, and they have to recognize the security implications of doing certain things. Without this invaluable training security breaches occur, hardware and software problems arise, and inefficiency frustrates the crew and the leadership of the submarine.

The local area networks and their capabilities need to be treated like any other ship system. Likewise, every submarine system must be a part of the network. Networks must be tracked as active maintenance issues, they must be ready to go to sea to support the mission, and they must be relied upon as we face the world of the future. LANs should not keep commanding officers from getting their ship underway to conduct operations. Knowledgeable individuals trained in network operations correcting problems on the spot will give commanding officers the confidence that these systems and the personnel who maintain them can support the operational mission just as effectively as any other system.

The ability to stay on top of hardware performance is a challenge for any industry; it is even a more important challenge for the space limited submarine. We have to build systems that are space conscious and sufficiently flexible to meet the needs of the future warrior. The network must be robust enough so that it can be modified with the right hardware and software as required. The ship must be human engineered such that the computer workspace is considered the focal point rather than as an afterthought.

Understanding information technology and its potential is one of the greatest needs the Navy has today. On submarines the problem becomes even greater. As a submarine performs different operations, appropriately the submarine begins to involve many different security levels. Each of these levels has different criteria and requires separate procedures. To incorporate information technology to service each level of security remains a challenge for our Submarine Force. The ability to seamlessly manage these local area networks for each level of security remains the most effective way to bring computer networks into the submarine environment without risking a multi-level security violation.

A submarine requires four separate LANs, each performing a different function. (1) A TOPSECRET High LAN designed for planning, reviewing and reporting on any submarine intelligence collection or special mission operations. This LAN must have restricted access but must be effective in its support of operations. (2) A SECRET LAN dedicated to the ship's tactical operations and planning. (3) A CONFIDENTIAL LAN designed for equipment monitoring and diagnostics, supply support, maintenance management and to facilitate the ship's day to day internal operation. (4) An UNCLASSIFIED LAN available for logistical support at the unclassified level, administrative coordination and planning, as well as other functions useful in improving every aspect of the crew's at sea and in port quality of life.

The first LAN would deal specifically with the highest classification levels. The commanding officer, executive officer, other appropriate officers, radiomen, and other personnel as necessary could access this TOP SECRET High LAN. The information on this network would include highly classified message traffic along with planning documents for the mission. It would link control, the wardroom, and other appropriate locations for real time reporting, as well as the collaborative generation of mission reports.

The value of the wardroom for planning and operational discussions has run its course. It has neither the security barriers nor the capabilities to support the around-the-clock requirements necessary for continuous support to the battle group commander or the joint task force commander. The submarine has always had problems sharing and receiving real time data with the rest of its brethren—with a central knowledge dissemination facility the information can be readily provided. The submarine needs a space separate and distinct from control and the wardroom to conduct collaborative strike preparation, operational analysis and future operational planning.

This center, possibly called the Knowledge Acquisition and Analysis Center (KAAC), could double as a damage control central for combating complex casualties. The KAAC would be a computer/information center where appropriately cleared personnel can get away from the operations center to review past patrol reports, look at weather information, consider options and develop plans. It would also have the appropriate communications capability such that the commanding officer or command duty officer could talk to the appropriate forces while referencing directly tactical and strategic planning information while not interrupting the activities of the control room. This center would be the central nervous system for submarine information technology. It would contain COTS workstations along with electronic navigation charts, ship's control and damage control displays. This cannot and should not be done in the wardroom. It should not be viewed as a uniquely officer space but rather as a planning and control space with the appropriate computer support and display support hardware to prepare for an operation. DC Central functionality is not the topic of this paper, but the KAAC would far exceed the current limited capabilities of the CO's stateroom.

The TOP SECRET High network would be small, but would allow the CO/XO access to messages and reports about the intelligence gathered while in his stateroom or in the KAAC. A dedicated server in the KAAC (as the network operation center and planning cell) would provide adequate mission support and real time intelligence gathering—connections with radio could provide the ability to transmit SCI OPNOTES through the next generation EHF. Real time support for the battle group is critical and remains one of the hottest submarine missions. Preparing written mission reports is becoming folklore. They are historic and need extensive analysis. The submarine needs to focus on being part of the real time Navy for amphibious attack and other operations, including strike planning. To assist the TS LAN in its security measures the

KAAC could serve as a secure location for the hub that would be necessary to line all the access ports together. Sufficient ports would be available for simultaneous access to mission information. The ports could be controlled as will. Each wall plate could theoretically be secured under lock and key. This would allow only a select number of personnel accesses to the LAN at any given time. The navigator or security manager would provide access to the LAN through issuance of a key and a special laptop. The laptop would be for SCI use only. A LAN access password would be required and the domain of the network could be strictly controlled.

The second LAN that should be available is SECRET operation LAN. This LAN would be the tactical link between the fire control and sonar COTS. The server, again located in KAAC becomes the place where the operational data exists and can be accessed on a variety of workstations throughout the operational spaces of the ship. This would provide a unique way to share information between each of the stations while at battle stations, during normal underway steaming, and during casualties, but it could also provide the ability to access valuable planning information for strikes, navigation operations and the like. A remote monitor or flat panel screen should be built into the crew's mess to provide routine updates and training to the crew. This SECRET operation LAN would provide the valuable link to the battle group. OTCIXS and BGIXS could in the near term provide the communication path to other units.

It should be the goal of the Submarine Force to be linked via this LAN to the SECRET Internet Protocol Network (SIPRNET). Right now the only thing limiting our bandwidth is the ability to use a large antenna. The Virginia class must be ready to utilize the larger bandwidth once it is available with systems and people on board who can handle large amounts of data. At no time in the future of submarine design should we be outpaced by antenna technology. We need to be ready with the appropriately sized backbone to ensure we can manipulate and utilize as much data as is available within the submarine. Certainly data and more appropriately knowledge is only useful if it can get on and off the submarine. That is the challenge of improving antennas. We must be ready to send and receive useful and well-structured information and knowledge when the antennas are available.

The third LAN is a CONFIDENTIAL one. This LAN involves the whole ship and requires a dedicated server for mass data storage. The LAN could be the lifeblood for the nuclear propulsion plant with a connection to the KAAC. If inappropriate to work nuclear engineering issues in the KAAC then an equivalent space in the engineering spaces must be created. The ability to automatically log and catalog readings and conduct trend analysis would be exceptionally valuable. The real challenge here is determining how to route the appropriate fiber network and where to place the LAN connections throughout the ship. Bulkhead penetrations and cableways will be necessary to line the submarine's exoskeleton with the highest grade fiber network. Technical drawings and diagnostic systems will be embedded on the system for use. The logistical investigative process of SNAP III will be a breeze and ship's training will be the most interactive and educational available in the Navy today.

Once the determination has been made where to put the connections the question now becomes how will log taking be accomplished? There should be no need for trend analysis by reviewing logs. It is technologically feasible to develop an automatic recording system for the different equipment parameters. These parameters can then be displayed on the computer to determine performance characteristics. If a characteristic is out of specification then the supervisor can investigate for other indications of trouble—noises, etc. The computer should take the data, do a projection and point the operator to possible areas of concern. This will ultimately reduce the number of watch standers required in the engine room, which in turn will save the Navy money and space. There should be no need to search tech manuals for troubleshooting. It should be available by inserting the appropriate characteristics of the problem into the computer and the computer can help with diagnostics.

A space similar to the KAAC is needed separate from maneuvering to perform the same functions for the engineering plant that the KAAC does forward. Controlled by the engineering log room yeoman, the Engineering Maintenance and Analysis Center (EMAC) would be the hub of the engine room. Filled with CD-ROM technical documents, divisional workstations for additional training, administration and online monitoring of critical equipment, this configuration can allow the engineer to instantaneously monitor a problem area and research its solution. Everything from monitoring engine room component temperatures to reactor power could be available to him at a touch of a button. During refits this area could serve as the central planning facility as well.

A fourth LAN is required for the needs of the crew. Whereas the previous three LANs had specific end users and functionality, this LAN must be more general in construction. I call it the quality LAN. Like the confidential network, this LAN runs the length of the ship and is available to the whole crew. The unclassified and confidential ports are located adjacent to one another. This LAN has the most ports and workstations allotted to it and as such is the most difficult to maintain. The LAN can be used by the crew to print paperwork or route e-mail or post schedules. The main concern here is providing adequate access for everyone. The KAAC and EMAC will provide all the workstations each division will need. The unclassified LAN will be another resource for training and reference material. Qualification records can be tracked here. Additionally, qualification and continuing training exams can be given, scored, compiled and trends determined on the computer. These rather simple examples of *going paperless* are all possible if we spend the money and embrace the technology. This LAN is the ship's Internet and gateway to the outside world.

The quality of life portion of this LAN focuses on electronic mail functionality. E-mail is great and may be the greatest quality of life initiative to come to the Submarine Force in a long time. It has finally provided a method of conducting two-way communications with home. When the submarine is in port away from home, crew morale will be greatly enhanced by the ability to communicate with family. There are potential issues with the system, but those can be resolved with the right training, network monitoring and support by trained personnel. We should not prevent this tremendous quality of life initiative from being achieved because we are afraid to deal with the small percentage of the crew who may not utilize it appropriately.

In all the LANs that I discussed, the most important aspect of their configuration is the location of their ports. Ports inappropriately placed will cause more problems than solutions. It will also determine where full workstations (desktops) can be placed and where laptops are in order. On the Virginia class, there must be a bow to stern review of where space is available for these most important workstations. I recommend that we create three shore billets for junior officers and assign them as a team to Electric Boat/Newport News and PEO Submarines to conduct an evaluation of this LAN technology in an operationally effective way. These JOs should have undergraduate degrees in Electrical Engineering or Computer Science and should be provided an opportunity to attend graduate school in conjunction with their duty assignment. Submarine network technology and its implementation would be their primary focus. This subject could serve as a thesis or dissertation if presented properly to the schools. Schools like MIT or RPI could sponsor this effort and benefit appropriately from the linkage with this project. In the past, we have had similar arrangements with MIT Woods Hole. The JOs would benefit by enjoying a rewarding two years investigating the technology needs of the Submarine Force and more importantly, providing solutions that will have direct impact to future submarine designs.

By embracing IT the Submarine Force will benefit. As IT becomes more and more an issue the Submarine Force with its best and the brightest will be able to innovate. Give these young sailors the latest in technology and they will figure out good ways to turn information into knowledge.

Networks are complex systems. They rely heavily on software systems and embedded protocols. While one may be proficient at Word and Excel, one generally doesn't learn how to manipulate and monitor the network without good training. Network engineering is not intuitively obvious, therefore, young men and women need to be trained to operate these networks. Whether the task is setting up the server, backing up the tapes, or setting up the standalone network, network operations are difficult and often times extremely stressful. It is no surprise that Windows NT can be a nightmare if one is not properly trained.

LAN managers at shore installations are often government contractors hired to specifically administer the network and troubleshoot problems when they arise. The submarine does not have the space or the luxury to rely on outside help. If the above is given then the only solution to our problem of LAN management is to develop our own. We need someone specifically trained in this field to adequately service the network and provide the appropriate level of oversight.

My proposal is a small division of personnel working directly for the weapons officer. Since the network is going to support he largest weapons system (the ship) it could be an additional task for the weapons officer. The WEPS could be trained as an administrator and support the effort of his division called information division. In this division, resides a leading petty officer and three additional personnel--typically, two petty officers and a seaman designated striker (on the job training). Three people besides the LPO would be necessary so that they can support a three-section watch at sea and surge to port and starboard if needed. The watch bill in port will be a four-person rotation with additional folks from other divisions augmented and trained to stand in port LAN manager. All division members and those selected to stand duty will have been through a rigorous Microsoft-based network administrator course. Like any other division, they have other duties that they are assigned, but their primary focus is the maintenance of the equipment, monitoring LAN status, troubleshooting problems, and implementing upgrades.

As submariners we are by definition innovators. We have done so for 100 years. Now we face new challenges and must think outside the lifelines. We need to redesign how we think about the problem of information technology. The sharing of information between teammates and shipmates via the network will allow knowledge to flourish. Only then can we have innovation. Moreover, as a Submarine Force we have come a long way in the use of IT tools, but we have only scratched the surface on how to gain added productivity from the use of IT. We need to dedicate appropriate numbers of personnel, fiscal resources and the time of submarine designers to develop IT solutions for the future. The longer we wait the further behind we will be. Establishing spaces like the KAAC and the EMAC as well as improving personnel training and establishing junior officer fellowships to determine the right mix of technology needed in the future are some initial steps that can be taken to improve the transition to the networked 21st Century. We need to be aggressive and not delay in our quest to find more space onboard Virginia for IT components. Our productivity and connectivity depends on our ability to manage the IT backbone and its resources.■

TORPEDOES OF THE IMPERIAL JAPANESE NAVY
Part One: Through 1918

by Frederick J. Milford

Soon after the United States and Japan became involved in World War Two, the Allies learned through disastrous experience that the Imperial Japanese Navy was well prepared in many ways for a major naval war. One of the surprises was that torpedo warfare was a major strength and that strength encompassed doctrine, tactics and weapons. It was eventually learned that Imperial Japanese Navy torpedoes far outperformed anything the Allies had. The details of these weapons will be discussed in a subsequent article. As a preliminary, however, it is useful to explore how torpedoes evolved in the early years of the Imperial Japanese Navy.[1]

Robert Whitehead's first successful automobile torpedo was built in 1868, the same year that the Imperial Japanese Navy was born. The original torpedo consisted of a fusiform shell 14 inches in diameter and about 11 inches long which comprised the main structural member. Within the shell there was a) a warhead with a forty pound high explosive charge, b) a flask or tank containing compressed air that provided the propulsive energy, c) a small reciprocating engine driven by compressed air with a small propeller attached to its shaft to provide propulsive power, and d) a surprisingly sophisticated depth control system, which used hydrostatic depth error to control one set of movable elevator fins and pitch angle, measured by a pendulum, to control another set with the combination making a stabilized closed loop system. External features included vertical fins, running almost the full length of the torpedo, whose purpose was to stabilize motion in the horizontal plane and compensated for the torque of the propeller, the elevators fins and, of course, the propeller. The automobile torpedo was widely regarded as a great equalizer. Small navies

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[1]The history of the Imperial Japanese Navy up to 1941 is elegantly presented in David C. Evans and Mark R. Peattie *Kaigun*, Annapolis: U.S. Naval Institute Press, 1998. In addition, both of the authors have been extremely generous in answering questions and providing advice. The source for most of the data on Japanese torpedoes used in this article is Kaigun Suiraishi Kankokai, *Kaigun Suiraishi* (Abbreviated KS). Tokyo: Shinkosha. 1979.

saw it as a low cost means to naval power; large navies viewed it, with great trepidation, as a threat. At both ends of the naval power spectrum the torpedo was an essential weapon.

Torpedo technology developed rapidly and by the early 1880s the 14 inch torpedo had grown to about 14 feet in length. The single propeller had given way to a counter-rotating pair. The long vertical fins had disappeared. Engines and compressed air supply had been improved to yield faster, longer ranged weapons. Two firms, Whitehead in Fiume, Austria and Schwartzkopff in Berlin, with few restrictions sold torpedoes on the world market. About a dozen navies had purchased Whitehead torpedoes and manufacturing licenses. A few navies had purchased Schwartzkopff torpedoes and a few other had developed independent torpedo manufacturing operations usually based on Whitehead licenses. Torpedoes were thus well established in most navies. One exception, however, was the Imperial Japanese navy (another was the United States Navy). Little or nothing was done about torpedo warfare by the Imperial Japanese Navy until the early 1880s. At that time the Japanese Navy was still well behind other navies in this and other technologies and needed a strategy for catching up. This strategy had to take into account the need to develop an industrial base as well as understanding the technology. An examination of the history of the acquisition of torpedoes by the Imperial Japanese Navy shows that the strategy, whether formally stated or not, had four requirements that were satisfied by appropriate actions:

REQUIREMENT	ACTION	EXAMPLES
Acquire modern torpedoes (The best available)	Purchase standard torpedoes	14" Schwartzkopff Types 84 and 88. Many Whitehead models
Learn to manufacture torpedoes (Develop the industrial base)	Licensed manufacture	14" Whitehead Types 26 and 30
Improve existing torpedoes and learn to design torpedoes	Modify foreign designs	45 cm Whitehead Type 37
Develop and manufacture indigenous torpedo designs (Largest warheads, fastest, longest range)	Original design	45 cm Kure Type 38-1

This strategy was followed beginning with the purchase of standard Schwartzkopff torpedoes in 1884, the purchase and licensed manufacture of Whitehead torpedoes, modification of Whitehead designs and a series of original designs culminating in huge oxygen torpedoes with very large warheads, high speed and very long range.

This approach to achieving technological competence was practiced in other areas as well, and it was in many ways a national technology strategy. Given the circumstances, one must appreciate that as long as weapons could be purchased and technology licensed, the approach was very sound, efficient and effective. The technology acquisition strategy was accompanied, especially during the 1930s, by very strict naval security with the net result being unpleasant surprises, alluded to above, for the Allied Powers in WWII.

Japanese Torpedoes

In the course of its history the Imperial Japanese Navy acquired at least 30 distinct Types of torpedoes for service use. The type number was derived from some significant year in the torpedoes history, purchase, test firing, approval or service us, etc. Some of these Types had variants designated in various ways, an added letters and/or numbers or appended model and modification numbers, much as RN torpedo Marks carry asterisks and USN Marks carry Mods. In five cases there were torpedoes of different diameters with the same Type number. The full designation should be *45 cm Torpedo Type 43* or *21 inch Torpedo Type 43*, to given an example of the dual use of a Type number. The first Japanese Navy torpedo armament consisted of 14 inch torpedoes acquired from foreign sources. As soon as large 45 cm[2], torpedoes became available they became the preferred weapon. The 45 cm torpedoes were in turn displaced, first in surface vessels and later in submarines, by 21 inch torpedoes. After the First World War 24 inch torpedoes were developed for surface ships while 21 inch torpedoes remained standard for submarines. Eighteen inch torpedoes reappeared as air launched weapons beginning in 1931 and in the late '30s and early '40s as weapons for MTBs and midget submarines. A gross examination of torpedo acquisition reveals another aspect of Japanese naval materiel strategy, the focus on extremes, largest, fastest, longest range, largest warhead etc.

Japanese torpedoes which were acquired before the end of the First World War are listed in Table 2. The first group consists of seven varieties of 14 inch torpedoes. The Imperial Japanese navy negotiated with both Schwartzkopff, Berliner Machinenbau AG (BMAG), and Whitehead for the acquisition of their first torpedoes. Schwartzkopff was selected because of their use of corrosion resistant bronze compressed air cylinders and because of more favorable contract terms. Two types, designated Types 84 and 88, were purchased from BMAG. Later three types were purchased from Whitehead Fiume, the Austrian firm, and two from Whitehead Weymouth, the English firm.

All seven types of 14 inch torpedoes were *cold runners*, that is, they used only the energy stored in compressed air to drive engines which provided the propulsive power. The engines were all three

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[2]Forty-five centimeter torpedoes were commonly called 18 inch torpedoes in the RN and USN. The IJN used both designations. Torpedo weights, dimensions and performance are frustratingly given in both English and metric units, which are sometimes mixed. We have tried to use the dimensions given in our sources with conversion.

cylinder radial types based on the design developed by Peter Brotherhood and modified by Whitehead and Schwartzkopff. The propulsive performance of the Whitehead torpedoes was clearly better than that of the older Schwartzkopff design, but his was simply the general evolution of torpedo design, in particular the increased weight of compressed air. The performance of 14 inch Whitehead torpedoes did not improve much in the few remaining years during which they were procured. One interesting feature of the Japanese torpedoes is the inclusion of a low 11 or 12 knot, speed 2500 meter setting. The long range was made potentially useful by Whitehead's incorporation of the Obry device which use a gyroscope to keep the torpedo on a steady course. Twenty-five hundred yards was an extraordinarily long range for the time and probably represents one of the precursors to the "outranging the enemy" concept that later, between the world wars, played such an important role in Japanese naval thinking.[3]

The 14 inch torpedoes were all about 15 feet long and except for the first Schwartzkopffs carried a charge of 50 kilograms of wet guncotton. The Imperial Japanese Navy probably acquired somewhat over a thousand 14 inch torpedoes. These torpedoes were not substantially different from those of the same size acquired by other navies, but other navies were already acquiring larger torpedoes. The Royal Navy, the German navy and the U.S. Navy were all acquiring 45 cm torpedoes and such torpedoes could be purchased from Whitehead. At this point in time Japanese torpedo technology lagged—they had learned to build torpedoes in their own shops, but not yet mastered the design process. For a navy that started from scratch in 1868, that was, nevertheless, fantastic progress.

The next group of torpedoes in the table is best identified as *early 45 cm (18 inch) torpedoes*. This distinguishes them from a group of air launched and high performance 45 cm torpedoes which were developed between 1931 and 1944. The 10 early 45 cm torpedoes introduced between 1897 and 1911 were part of the evolutionary development of Japanese torpedo armament—larger torpedoes with larger warheads, higher speeds and longer ranges. The early 45 cm group is particularly interesting because within it

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[3]Evans and Peattie *Kaigun*, p. 250 ff.

one sees the first indigenous design for an Imperial Japanese Navy torpedo (Type 38-1), four cylinder radial engines (Type 38-2A), the transition from cold running torpedoes to dry heaters (Type 38-2B) and the final transition to wet heater, or steam, propulsion plants (Type 44-2). All of the 45 cm torpedoes as well as the last four 14 inch Types incorporated the Obry device for gyroscopic course control.

There were, however, some other interesting developments. The 1901 45 cm Type 34 (Whitehead) was 6.5 m long, as compared to a nominal 5.0 m for the others, and obtained two to two and a half times the range of the shorter torpedoes. Such a design would be again at least partially consistent with the *larger warhead, faster, longer range* objectives of the Imperial Japanese Navy. The speed was not increased probably because that would have required a new engine design or improved propulsive efficiency, but it is not clear why a larger warhead was not incorporated especially since one had already been developed for the 18 inch Type 30. The 6.5 meter length was not adopted for subsequent 45 cm torpedoes probably because it was not strong enough in the longitudinal bending mode to survive the inevitable rough handling to which torpedoes are subjected.

The 1904 Type 37 was not a strict copy of a Whitehead design. It was however, sufficiently closely based on the Whitehead 45 cm Type 32 and Type 34 designs that it should probably be classified as a modification rather than in independent design. This torpedo was produced mainly in Japanese Navy shops. The 1905 Type 38-1 was, however, designed and produced at Kure Naval Arsenal. It was not a copy of a Whitehead design and so we concur with *Kaigun Suiraishi* and classify it as an indigenous design (the first). We note, however, that this torpedo carried a substantial design heritage from long experience with Whitehead torpedoes.

TABLE 1: IMPERIAL JAPANESE NAVY TORPEDOES 1894-1918

IJN 14" TORPEDOES

Type	Year	Design/Mfg	Quantity	Length	Weight	Warhead	Propulsion	Range/Speed
84	1884	Schwartz	200	15'	594 lb	21 kg	3 cyl cold	400 m @ 22.0 kt
88	1888	Schwartz	307	15'	300 kg	56 kg	3 cyl cold	400 m @ 24.0 kt
26	1893	Weymouth/Kure	100	15'	740 lb	110 lb	3 cyl cold	800 yd @ 22.0 kt 600 yd @ 25.0 kt
30A	1897?	Fiume/Kure	125	15'	337 kg	50 kg	3 cyl cold	2500 m @ 11.0 kt 800 m @ 21.7 kt 600 m @ 25.4 kt
30B	1897?	Fiume	127	15'	337 kg	50 kg	3 cyl cold	2500 m @ 11.6 kt 800 m @ 22.0 kt 600 m @ 26.9 kt
32	1899	Weymouth	76	15'	338 kg	50 kg	3 cyl cold	2500 m @ 12.0 kt 800 m @ 23.0 kt 600 m @ 27.0 kt
34	1901	Fiume					3 cyl cold	

IJN 45 cm TORPEDOES								
Type	Year	Design/Mfg	Quantity	Length	Weight	Warhead	Propulsion	Range/Speed
30	1897?	Fiume		5.0 m	532 kg	100 kg	3 cyl cold	3000 m @ 14.2 kt 1000 m @ 23.6 kt 800 m @ 27.0 kt
32	1899	Weymouth	132	5.0 m	338 kg	100 kg	3 cyl cold	3000 m @ 14.6 kt 1000 m @ 25.5 kt 800 m @ 28.8 kt
34	1901	Fiume	163	6.5 m	895 kg	150 kg	3 cyl cold	3500 m @ 20.0 kt 2000 m @ 27.0 kt
37	1904	Fiume/IJN	50	5.0 m	551 kg	100 kg	3 cyl cold	2000 m @ 15.5 kt 1000 m @ 25.5 kt
38-1	1905	Kure		5.149 m	617 kg	100 kg	3 cyl cold	3000 m @ 20.0 kt 2000 m @ 24.0 kt 1000 m @ 27.0 kt
38-2A	1905	Fiume		5.088 m	640 kg	96 kg	4 cyl cold	3000 m @ 20.3 kt 2000 m @ 26.0 kt 1000 m @ 31.5 kt
38-2B	1905	Fiume?		5.150 m	660 kg	95 kg	4 cyl dry htr	3000 m @ 28.0 kt 2000 m @ 32.0 kt 1000 m @ 40.0 kt

Type	Year	Design/Mfg	Quantity	Length	Weight	Warhead	Propulsion	Range/Speed
42	1909			5.150 m	660 kg		4 cyl dry htr	3000 m @ 30.5 kt 2000 m @ 35.0 kt 1000 m @ 43.0 kt
43	1910	Fiume		5.188 m		95 kg	4 cyl dry htr	
44-2	1911	Kure	526	5.388 m	719 kg	110 kg	4 cyl steam	4000 m @ 36.0 kt
IJN 21" TORPEDOES (through 1918)								
43	1910	Fiume		6.394 m		130 kg		
44-1	1911	Kure		6.7 m	1290 kg	160 kg	4 cyl steam	10000 m @ 27 kt 7000 m @ 36 kt
06	1917	Kure/Mitsubishi	3537	6.84 m	1432 kg	200 kg	4 cyl steam	15000 m @ 26 kt 10000 m @ 32 kt 7000 m @ 36 kt

Notes: Schwartz = Schwartzkopff; Fiume & Weymouth indicate Whitehead plants in Austria and England respectively. Primary source of data "Kaigun Suiraishi".

The 1905 Whitehead Type 38-2A torpedo introduced a new four cylinder radial Brotherhood type engine. This engine was developed as part of the transition to heated air propulsion, but the Type 38-2A was a cold runner, the last of that type adopted by the Imperial Japanese Navy. The 1905 Type 38-2B torpedo was designed and produced by Whitehead and also produced at several Japanese Naval Arsenals. It, and the very similar 1909 Type 42 (also Whitehead[4]), both employed dry heater power plants. These plants heat the compressed air before it enters the engine and thus add thermal energy to that stored in the compressed air. The source of the thermal energy is the combustion of hydrocarbon fuel (or alcohol). A typical hydrocarbon fuel together with the air required for combustion stores in excess of ten times more energy per kilogram[5] than compressed air. Further, the higher engine inlet temperature enhances the thermodynamic efficiency of the engine. Collectively, the result is a torpedo with a longer range or a large warhead at the same total weight. If the engine can operate at higher pressure and temperature, the horsepower and consequently the maximum speed can also be increased. The Type 38-2B torpedo was rated at 3000 meters at 28 kts as compared to 3000 meters at 20.3 kts for the cold running Type 38-2A, which was, except for the heater, identical. There were three Japanese 45 cm dry heater torpedoes, Types 38-2B, 42 and 43, which were generally similar. They were a little over 5 meters (16 ft 5 inches) long, weighted about 650 lb, carried 95 kg warheads and used the four cylinder Brotherhood engines.

The introduction of dry heaters was a major development in torpedo technology, however, the process did not optimize the available energy for a given total weight of air and fuel and even at sub-optimal conditions the high temperatures eroded both

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[4]Effective control of Whitehead was obtained jointly by Vickers and Armstrong in 1906.

[5]For a variety of reasons, for example, the added weight of the heater, fuel tank etc., the full gain in energy storage per pound cannot be converted to propulsive energy. A Whitehead publication "La Storia del Siluro, 1860-1936" indicates that in strictly comparable torpedoes heated compressed air yielded 1.8 times the energy of cold compressed air and steam yielded 5.5 times the energy of cold air. The point is not the exact numbers, but the fact that the ratios are large.

durability and reliability of the power plant. Some consideration was given to reducing the engine inlet temperature by externally cooling the combustion chamber, but energy removed in cooling would be wasted. The solution was to inject water directly into the combustion chamber in the wet heater torpedo. The injected water flashed into steam, which together with the heated compressed air and combustion products provided the energy to drive the engine. Such torpedoes came to be known as *steam torpedoes* and that has persisted. The first Japanese steam torpedo was a Kure design designated 45 cm Type 44-2. Mitsubishi produced 526 of 4000 m at 36 k, a very substantial improvement over the Type 42. Simultaneously with the acquisition of the last 38 inch dry heater torpedo and the first 45 cm steam torpedo, corresponding 21 inch torpedoes were acquired. Attention quickly shifted to these larger torpedoes and not further 45 cm torpedoes were developed until 1937.

The first 21 inch Japanese torpedo appears to have been the 21 inch Type 43 manufactured by Whitehead and adopted by the Imperial Japanese Navy in 1910. Other than dimensions and the fact that it had a dry heater propulsion system, only sketchy information has been found about either this torpedo or, as noted earlier, its smaller sibling, the 45 cm Type 43. All of the other Imperial Japanese Navy 21 inch service torpedoes (six types) were designed and produced by the Naval Arsenals and Japanese commercial firms such as Mitsubishi. The first of these were the 21 inch Type 44-1 (1911) and the 21 inch Sixth Year Type (1917). In terms of specifications these two torpedoes were very similar, with the Sixth Year Type being about 6 inches longer than the Type 44-1, carrying a heavier explosive charge and using higher pressure air. Both torpedoes were conventional wet heater steam torpedoes using four cylinder radial engines. They achieved a maximum speed of 36 k and a range of 7000 m (7650 m Sixth Year Type) at that speed. This performance, as shown in Table 2, was comparable with that of the best 21 inch torpedoes developed at abut the same time by other navies.

TABLE 2: 21 INCH TORPEDO COMPARISON WORLD WAR ONE ERA

Type	Year	Design/Mfg	Length	Weight	Warhead	Propulsion	Range/Speed
Sixth Year Type	1917	Japanese Kure-/Mitsubishi	6.84 m	1432 kg	200 kg	4 cyl steam	15000 m @ 26 kt 10000 m @32 kt 7000 m @ 36 kt
RNTF Mk. IV (a)	1917	RN Torpedo Factory	6.90 m	1454 kg	234 kg	4 cyl steam	12350 m @ 25 kt 96000 m @ 29 kt 7300 m @ 35 kt
W250	1915-1918	Whitehead	7.18 m		250 kg	4 cyl seam	10000 m @ 29 kt 5000 m @ 36 kt
US Mk 8 (b)	1911	U.S. Navy	6.51 m	1179 kg	211 kg	turbine	14360 m @ 27 kt 7400 m @ 36 kt
1919D (c)	1919	St. Tropez French Navy	8.22 m	1909 kg	240 kg	4 cyl steam	14000 m @ 25 kt 6000 m @ 35 kt
G7 (d)	1914	German Navy	7.02 m	1365 kg	195 kg	4 cyl steam	9300 m @ 27 kt 4000 m @ 37 kt

Notes: (a) RV[1] at 35 kt seems high; (b) range at 36 kt is estimated; (c) 55 cm torpedo; (d) 50 cm torpedo.

The 21 inch Sixth Year Type was the last torpedo developed by the Imperial Japanese Navy before the end of the First World War. In the years between the wars and during WWII additional 21 inch torpedoes, huge 24 inch torpedoes and modern 18 inch torpedoes for aircraft, patrol boats and midget submarines were developed. A great technological step was taken in the development of operational torpedoes using pure oxygen rather than air in the combustion process. These, in some cases phenomenal, weapons and the technologies will be discussed in a subsequent article.

Combat Use of Torpedoes by the Imperial Japanese Navy Through 1918

The combat use of torpedoes requires not just the torpedoes, but also launching capability and trained personnel. The Imperial Japanese Navy worked as diligently at these requirements as they did at torpedo acquisition. The first Imperial Japanese Navy warship capable of launching torpedoes appears to have been FUSO which was completed in 1878. As completed she was equipped with towed torpedoes, but no launching gear for self propelled torpedoes. HIEI and KONGO also completed in 1878. All three were fitted with Schwartzkopff tubes for 14 inch torpedoes in 1885-86.[6] The first four Imperial Japanese Navy torpedo boats were completed in 1880. These four boats were originally equipped with spar torpedoes, but there were refitted first with "torpedo launching cases/boxes", about which no further information has been found, and later with torpedo tubes. The first 50 Schwartzkopff torpedoes were delivered in March of 1884. In January 1886 FUSO conducted experimental torpedo firings against

[6]We are indebted to Herr Hans Lengerer and his Japanese associates particularly Mr. Takasu for generously sharing information about torpedo tube installations on FUSO and the early torpedo boats. They have also supplied very useful information about the early firings of torpedoes by the Japanese Navy. The installation of torpedo tubes in FUSO, HIEI and KONGO is noted in KS p.409. It seems probable that between March 1884 and January 1886 some experimental launchings, probably from shore or barge based facilities, were made, but we have found nothing dealing with torpedo firing in that period.

a stationary target.[7] These tests were reported as successful, but it seems probable that the torpedoes were damaged on impact with the water. *Spoons*, essentially extensions of the upper half of the tube, were added to the torpedo tubes and fully successful launches were made in October 1886.[8] The same source indicates that FUSO fired torpedoes at moving targets in 1888, and that torpedo boats fired at moving targets in 1893. The first five Imperial Japanese Navy submarines, Holland boats, were completed in 1905. Each had one 45 cm torpedo tube and practice torpedoes were probably fired soon after the boats were commissioned.

Japanese naval forces were involved in two wars prior to WWI, the Sino-Japanese War (1894-95) and Russo-Japanese War (1904-05). Automobile torpedoes, as opposed to towed or spar types, were used by both sides in both of these conflicts. The results were mixed. In the Battle of the Yalu, 17 September 1894, Chinese vessels fired Schwartzkopff torpedoes at ships of the Japanese fleet without effect. The torpedoes were fired at long range and apparently had poor or poorly maintained depth gear. At least one torpedo was reportedly fired at short range (about 40 yards) and went under its target. In early February 1895 Japanese torpedo boats made night attacks on the remnants of the Chinese fleet in the harbor at Weihaiwei. At least two hits were scored on the battleship TING-YUAN and a cruiser was damaged by torpedo hits. These results were not spectacular, but the torpedo actions represent the use of torpedoes on a larger scale than had been seen earlier.

The Russo-Japanese War, 1904-05, saw further growth in the use, if not the effectiveness, of torpedoes. The first torpedo action of the war, which took place 8-9 February 1904, again before formal declaration of war, was a Japanese attack on the Russian Pacific Fleet at Port Arthur. During this attack ten destroyers fired a total of about 20 torpedoes. Four hits were scored seriously damaging two Russian Battleships and a cruiser. Torpedo attacks against ships at Port Arthur continued until it surrendered in

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[7]Presumably the period between the delivery of the first Schwartzkopff torpedoes and the first FUSO firings was occupied with test launchings from shore or barge facilities, but nothing definite has been found.

[8]KS p.482.

January 1905. In these attacks, the largest use of torpedoes against a single target was the remarkable expenditure of 85 in repeated attacks on the battleship SEVASTAPOL. Four hits were scored, but the ship was eventually sunk by scuttling. The Battle of the Yellow Sea also saw some notably ineffective use of torpedoes. Japanese vessels fired a total of 74 and scored no hits. The great fleet action of the Russo-Japanese War was the Battle of Tsushima. In this battle the Imperial Japanese Navy gained nearly absolute control of the seas surrounding Japan. Our interest is not, however, in the entire battle, but in the use of torpedoes. It appears that the torpedoes fired by the Imperial Japanese Navy at Tsushima totaled somewhere between 60 and 100[9] including 50 to 90 fired by destroyers and torpedo boats and a few fired by larger vessels. The results were not insignificant. Torpedo attacks were responsible for or played a significant role in sinking three battleships and two armored cruisers of the Tsarist navy. In the entire war the Japanese navy fired about 250 torpedoes which sank or seriously damaged perhaps ten Russian ships. This far exceeded any previous use of torpedoes both in number and in the damage inflicted by them. For a weapon from which the Imperial Japanese Navy had expected much, however, it was disappointing. Postwar analysis revealed that the confusion of battle, especially night battle, was large and required training that was not provided by stereotyped exercise. The Japanese navy adopted a *train as you fight* approach, which, while brutal, stood them in good stead in later years. It is worth noting that up to the beginning of the First World War, the Japanese navy had fired more torpedoes against enemy targets than all of the other navies of the world combined.

Japan declared war on Germany on 23 August 1914. The Imperial Japanese Navy chased German surface raiders, invaded German colonies int he Pacific and contributed to convoying in the Indian Ocean. In addition, they provided a cruiser, 12 destroyers and manning for two others in the Eastern Mediterranean where they were part of the escort and ASW forces. There is no indication that any torpedoes were fired by Japanese forces during

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[9]For some reason there is more uncertainty about the use of torpedoes at Tsushima than about any other Japanese naval ordnance consumption in the entire war. Usually reliable sources give numbers ranging from 60 to 100 and some simply say unknown.

the war.

Summary

The Imperial Japanese Navy came into existence in 1868 and quickly began developing a cadre of skilled officers and acquiring modern weapons. In many cases weapons were acquired following a sequence consisting of 1) importing foreign weapons, 2) developing the capability to manufacture these weapons and manufacturing them under license, 3) modifying the foreign designs to gain design experience, 4) developing and manufacturing indigenous designs. Torpedoes were a particularly clear example of the application of this strategy. Fourteen inch torpedoes were used as purchased and/or copied at Kure. Most 45 cm torpedoes were also foreign designs, but several Types were manufactured in Japan, one significant modification of a Whitehead design was made and two indigenous designs were developed. The cycle was further shortened for 21 inch torpedoes where only one foreign torpedo (the Whitehead 21 inch Type 43) was acquired for service use. The indigenously designed and manufactured 21 inch Sixth Year Type was comparable to the best of its contemporaries (of Table 2). By the end of WWI Japanese torpedo technology and manufacturing had clearly reached parity with that of the major navies of the world and was developing rapidly, though these facts may not have been recognized by the major navies. The Sino-Japanese and Russo-Japanese wars had provided combat experience in the use of torpedoes. While the effectiveness was less than had been expected, valuable lessons about the problems of torpedo attacks were learned. The Imperial Japanese Navy had fought and won the greatest battle between fleets of armored vessels that had taken place before WWI. Torpedoes had been used successfully against some major warships. While other navies had more torpedo boats, more submarines and more large vessels with torpedo tubes,, the Imperial Japanese Navy had excellent weapons and the edge in experience. Although the Imperial Japanese Navy apparently did not fire any torpedoes during WWI, Pearl Harbor and early battles at sea proved that by 1941 they had made enormous progress. That progress will be the subject of a subsequent article.■

SLIDE RULE STRATEGY BEGINS
World War II Operations Research

by John Merrill

In the fall of 1939, England was again fighting Germany, the same enemy as in World War I. However, advances in the tools of war during the twenty years of peace set the scene far distant from August 1914. Advances in aviation made antiaircraft defense a high priority. The short distance from mainland Europe to England presented a minimal challenge by that time for a military aircraft.

Similarly, a scarcity of appropriate antisubmarine weapons, resources and tactics provided further new formidable tasks in hunting an improved enemy submarine, always a complex target operating in an opaque environment. U-boats of 1939 were faster underwater, could operate at greater depths and maneuver more skillfully. They were quieter, with longer endurance and tougher hulls.

The severity of the U-boat problem led Vannevar Bush,* President Roosevelt's adviser and chief contact on all matters of military technology including the atomic bomb, to observe in his memoir Pieces of the Action, "The United States came very close–too close–to being defeated in each war by the submarine."[1] After the war, Winston Churchill wrote, "The only thing that ever really frightened me during the war was the U-boat peril".[2] Statistics on U-boat sinkings support the post-war reflections of Bush and Churchill.

U-Boat Sinkings	
September 1939-April 1943 (44 months)	*193*
May-June-July 1943	*100*

Credit for this remarkable shift in the antisubmarine war against the U-boats stems from a number of activities, efforts, and approaches, by many individuals. Success was not instantaneous. The progress beginning in May 1943 was hard earned. The introduction and evolution of operations research, the application of mathematics and the scientific method to military operations, was one of many contributions leading to the defeat of the U-boat.

World War I was fought with weapons available at its start. World War II, sometimes referred to as the physicists' and engineers' war, witnessed a continuing stream of new weapons, frequently complex, and raising difficult operational questions on occasion beyond the purview of the military.

England's late 1930s introduction of radar in conjunction with air defense epitomizes WWII high technology. New, untried, extremely complicated, costly and needed, it was highly effective when properly used. The military user required assistance from the scientists who conceived it and the engineers who manufactured it.

Operations research was not prescribed. It evolved, as participation by civilian physicists, engineers, mathematicians, astronomers, physiologists applied their scientific methods to equipment performance with the field military operators on land, air, and shipboard. Optimizing system performance and solving problems based on careful analysis of data collected from direct experience in real time operations in a wartime environment followed scientific methods, bringing the term *slide rule strategy* into use. Operations research improvements by factors of 3 or 10 were common. This level of contribution was out of proportion to the amount of effort spent. By 1942, acceptance of the methodology brought formal operations research groups to all three of Britain's military services.

Operations research techniques used by civilian scientists contributed to a first defeat for Hitler, with the UK winning the Battle of Britain (air warfare) in the summer of 1940. Increased mastery in sinking U-boats starting in May 1943 is attributed likewise in part to operations research. Because of this and other successful WW II applications of the method, today every branch of the military has its own operations research group involving both military and civilian personnel. Military operations research provided the logistic planning for Operation Desert Storm. The United States National Security Agency has its own Center for Operations Research.

Early Operations Research

During the 1800s, two inventors, one a mathematician and the other an engineer, contributed significantly to the formulation, expansion, and acceptance of operations research as a tool in the 20th century.

The mathematician and inventor Charles Babbage (1792-1871) contributed to the early formulation of this new field. His book Economy of Machines and Manufactures (1832) is said to have initiated the field of study known as operational research. It is notable that during this same period, Babbage developed plans for an analytical engine, the forerunner of the digital computer. His participation in establishing the modern English postal system and developing the first reliable actuarial tables reflects his analytical skills and early operational analysis.

In the United States, Frederick W. Taylor (1856-1915), an inventor and engineer known as the father of scientific management, provided additional quantitative methods addressing man-machine problems. Taylor applied scientific principles to mechanisms to make them more efficient, conducting scientific measurement of work and productivity in the work place with the workers and the machines. Taylor's work helped to make Henry Ford's precision automobile production line conveyor belt operation possible. Babbage and Taylor are representative of early contributors to operations research.

World War I Efforts

During World War I, F. W. Lanchester, a pioneer in the English motor car industry, made fundamental contributions by mathematically describing the outcome of military actions related to numerical and firepower superiority and concentration of forces. He also foresaw the importance of aeronautical efficiency in future great battles. His equations appear in current literature.

In 1915, Lord Tiverton completed a detailed study of strategic bombing anticipating the 1000 plane bombing raids of WW II. A. V. Hill of the experimental section of the Munitions Invention Department of the British Army studied antiaircraft gunnery and developed tactics and procedures to enhance the effectiveness of antiaircraft fire.

Thomas A. Edison, as a member of the Naval Consulting Board during WW I considering the antisubmarine problem, concluded that sinking German submarines was only one means of saving merchant ships. He directed his efforts to a study of the statistics of enemy submarine activities to evolve strategic plans for optimal merchant ship movements across the Atlantic Ocean. The impact of his findings is not clear. A 1953 paper in Operations Research commented "Nor did Edison's work seem to have had lasting effect on the U.S. Navy, judging by the need to rediscover his statistical procedures at the start of World War II."[3]

Lewis Richardson, a British ambulance driver in World War I who believed mathematical equations could quantify patterns of war, gathered data in his off-duty time. After the War, he compiled his statistical data and developed mathematical equations to predict wartime behavior. In World War II, the British armed forces found extensive use for his equations.

During the twenty years between the wars, while all the tools of war and communications moved forward there was no significant progress in operations research, tactics and countermeasures to combat improved weaponry.

World War II

Great Britain

The development of defense against enemy aircraft had an increasing national priority as early as 1935. Large numbers of capable and creative civilian scientific and technical talent began to be drawn together to address the development of new air defense oriented military equipment. The aim was to use scientific and technical knowledge to strengthen the current methods of defense against hostile aircraft. As the war began, the extreme national danger and risk to life and property by the weapons of the new war and the significant initial success of the enemy brought additional personnel to the problems.

By September 1939 at the onset of war, a large part of the anti-aircraft defense system, later known as (early warning) radar, was manned and operating along all of the east and southeast coasts of England. Some of the country's best academic researchers achieved this considerable development. Their scientific methodology involved techniques for analyzing system performance by measurement, collection of data, statistics, analysis and optimization of the man-machine interface relationships.

Battle of Britain July to September 1940

The first major battle fought entirely in the air was the consequence of Germany's mid-July initiative to prepare for an invasion of England by air bombardment. German Luftwaffe outnumbered the British Fighter Command. The British front line defense fighter planes numbered about 600. The Germans, with 1300 bombers and dive-bombers and 900 single-engined and 300 twin-engined fighters were formidable.

British fighter interceptors of Spitfires (unsurpassed in any other air force) and more squadrons of Hurricane fighters, plus a well planned and executed tactic, helped to make the smaller number of fighters effectively larger. Countering the German flights consisting of up to 1500 planes per day intent on bombing fighter airfields was a most crucial undertaking for a fighter force of 600 planes, with the fate of the country dependent upon its outcome.

Preparation for fighter interception began in late 1936; experiments were conducted for two years at the R.A.F. Fighter Command station at Biggin Hill to address problems in fighter direction and control led by civilian research engineer B.G. Dickins. During the two years before the availability of operational radar, the experiments used simulated radar data and input from the Observer Corp personnel. This planned effort provided a basis for the successful use of the fighters in the summer of 1940.

The radar chain was operational by 1939. In a report by the first radar station at Bawdsey, the term *operational research* originated. With a limited number of fighter planes, the tactic held the planes on the ground until the right moment. Then control directed the plane to a location within visual sighting of the enemy aircraft. Radar range capability at the time was 120 miles out to sea with 50 mile detection of low-flying aircraft. These experiments integrated the radar into the early warning systems, the Observer Corps, and the fighter direction and control.

With increased British plane production, radar, *operations research* methods, and extremely brave fighter pilots, the German plane losses by mid-September 1940 totaled 1700 and the British 900. With limited German plane production and his attention now focusing on Russia, Hitler put aside his plans to invade England.

P.M.S. Blackette

Blackette served in the Royal Navy at sea during World War I, seeing action in the Falkland Islands in 1914 and at the battle of Jutland in 1916. Following the war, he studied physics with Nobel Laureate Lord Ernest Rutherford. He came to be widely known for his research related to the Wilson cloud chamber. Later in 1948, unrelated to his war work, Blackette received the Nobel Prize for his work in nuclear physics and cosmic rays.

Starting in mid-January 1935, Blackette served on the Committee for the Scientific Survey of Air Defence. During the five years of the committee's existence, the development and implementation of radar stands out.[3] Commenting on the U-boat crisis in 1941-42 and Blackette's contributions, a paper[4] reported "Prof. P.M.S. Blackette, whose name will go down in the history of operational research as outstanding, came into the picture to see what could be done."

OR and Antiaircraft Gunnery

By August 1940, antiaircraft batteries around London included new gun-laying radar sets just out of the laboratory. Blackette, appointed science advisor to the headquarters of the Anti-Aircraft Command at Stanmore, addressed the radar implementation problem. Blackette's young scientists included physiologists, an astronomer, and a mathematician, as well as physicists. Problems addressed related to operational use of radar, guns and predictors at the gun sites and headquarters. The overall problem was the blitz bombing of London and other British cities. At this time, Penguin Books published the first book dealing with the development of operations research.

Blackette's team (referred to as Blackette's Circus) perfected a number of operational recommendations. The Circus worked with the Service operational staffs and against very short deadlines. Results included: best use of limited radar resources in gun deployment around London, improved data plotting techniques, design of simple plotting machines, and special schools for training personnel in data handling.

Blackette pointed out a notable change in antiaircraft gunnery effectiveness and its relationship to *operational research*. "At the start of the blitz, when control methods were poor, the 'rounds per bird,' as we called this number was about 20,000. As methods and instruments improved this gradually fell to some 4,000 the following summer."[5]

By May 1941, German bomber losses over Britain were more than seven percent. Improvements in the use of antiaircraft gunnery and the introduction of airborne radar contributed to the increased losses. The overlay of operational research was a strong contributor. In addition, increased attention to the Balkans and Russia by Germany also led to a diminishing of the overall bombing of Britain.

U-Boat Problem (Britain)

Upon entering the war with Germany in 1939, England's 1936 naval treaty with the Third Reich did not allow merchant ships to be armed. From the beginning of the war, the U-boat success rate in sinking naval and merchant ships was high. To counter the U-boats the Royal Navy hunted them with planes, ships and submarines. The Navy provided merchant convoys with escorts on some sea routes.

Hunting submarines required submarine detection. In 1935, British expectations of submarine detection performance were flawed. It was believed in some quarters that the enemy submarine was no longer a menace to national security. The Asdic surface ship performance in reality was an average range of the order of 1300 yards with the last 200 yards blind. Nighttime exercises with submarines were rare prewar. In retrospect, even if the performance was as anticipated, there were only limited numbers of vessels equipped with the detection equipment, as a further problem, the number of skilled operators was insufficient. Further, in 1939 the Royal Navy supply of mines for ASW was minimal.

Mahanian thinking with the capital ship at its focus still prevailed. Decreased naval budgets and the expense and long lead-time for capital ships did not allow for small ship construction for ASW, and convoy escort ships were not available in numbers as the war began.

As late as November 1938, a retired German Vice-Admiral noted in an article, "Nothing substantial has as yet been done in England (and equally in France) for the protection of oceanic convoys."

Blackette and the Anti-U-boat Campaign

In March 1941, Blackette moved from the Anti-Aircraft Command to the Coastal Command to advise on problems arising from the air-war against U-boats. The Coastal command's purview included antisubmarine operations, convoy protection and attacks on enemy shipping primarily an offensive role. Blackette established his new operations research team as part of the Command's senior staff.

In the next several months, Blackette's research revealed the small number of U-boat sinkings by aircraft dropping depth charges. Pursuing this, the OR team carefully studied in detail air attack reports and provided new insight regarding the estimate of the actual depth of the enemy submarine at the instant of attack. This study brought to light the unsuitability of the standard setting of 100 feet for depth charge detonation.

A depth charge dropped by aircraft near the alerted U-boat's submergence point with a lethal radius of 20 feet and a 100-foot explosion depth frequently led to a successful escape by the U-boat. Enemy submarines operating near or close to the surface escaped damage from the deep explosion depth of the charge. Operations research team analysis suggested a detonation of the order of 25 feet. U-boat sinking rate immediately improved. Related problems included aiming, depth charge size, and spacing between depth charges dropped from the aircraft. Collectively the findings and operational measures from these inquiries brought further improvement.

First usage of OR often brings outstanding results. As systems are refined improvement is sometimes less spectacular. By late spring 1943, mastery of the U-boat problem was at hand due to the coming together of a variety of efforts. OR's role was not in creating the weapons but in providing guidance and influence in their judicious use and successfully assessing the enemy's tactics.

Operations Research Countering the U-boat 1941-1943
Recommending an optimum depth for air dropped depth charges Securing additional Liberator night bombers for convoy cover Painting bombers sky color to reduce U-boat sighting Expediting the night use of Leigh Lights on ASW aircraft Discerning the use of radar listening devices by U-boats Promoting the use of large convoys (1944 186-ship convoy) Implementing High Frequency Direction Finding (HF/DF)

U-Boat Problem (United States)

The U-boat crisis was one of the many defense areas Bush faced when President Roosevelt appointed him chairman of the newly created National Defense Research Committee (NDRC) on 15 June 1940, the day after Paris fell to the Germans. Within a year, Bush recruited six thousand of the country's leading physicists, chemists, engineers and doctors. By the end of the war, they numbered thirty thousand. From within this vast number of scientists the personnel of operations research talent emerged.

The United States U-boat problem was twofold in December 1941. One was how to efficiently hunt and find U-boats. The other how to defend merchant ships from U-boats. The merchant ship problem needed escorts, better depth charges and air cover. Navy convoy escort vessels were in short supply and no central ASW group or unit existed.

As late as early 1942, some U.S. Navy personnel were initially not enthusiasts for convoying merchant ships. A quotation in Morison "when the U-boats hit our coast in January 1942, we were caught with our pants down through lack of anti-submarine vessels"[8] is concise and apt. In February, Britain gave United States 24 trawlers and 10 corvettes. These additional escorts allowed small East Coast convoys during the day and putting into harbor at night. Soviet Admiral Gorshkov observed in 1976 that the "American Navy came into the War (II) totally unprepared to protect merchant vessels from submarine strikes."

U.S. Antisubmarine Warfare Operations Group (ASWORG)

The U.S. Navy was aware of British success with ASW due in part to their civilian scientists' OR efforts. After the first few months of the war, it became apparent that the navy needed detailed ASW data analysis for tactical decisions. The requisite analytical skills including statistics and probability were not in the purview of the military. In March 1942 the Navy requested Bush's NDRC to provide civilian scientific support in the U-boat campaign to the Boston ASW unit. The NDRC appointed MIT acoustic research physicist Philip M. Morse then at the Harvard Underwater Sound Laboratory to form the group.

Morse directed the U.S. Navy Operations Research Group from 1942 to 1946 starting in Boston, Massachusetts with a team of seven at the beginning of May 1942 it grew to seventy-three as the war ended. The members were primarily chosen for their general scientific training and included physicists, mathematicians, chemists, biologists, geologists, actuaries (from the six largest US insurance companies), and a champion chess player.

Beginning efforts analyzed the results of U.S. attacks on U-boats by ships and planes and examined the tactics of finding U-boats. U-boat search studies quickly provided fresh guidance to the Navy. The studies revealed potential search rates in square miles per hour of 75 for radar equipped destroyer, 1000 for meter radar equipped aircraft, and 3000 for an aircraft with microwave radar.

A previously established Navy Mine Warfare Operations Group from the Navy Ordnance Laboratory concerned with degaussing all U.S. naval vessels to counter German use of magnetic mines became part of ASWORG. Efforts of this team were especially significant in mining related to Truk, invasion of the Marianas, the battle of the Philippine Sea, and mining Japan's Inland Sea using bombers and fatally damaging Japanese shipping in 1944.

OR effort in the Pacific brought to light that Japanese antiaircraft fire was relatively ineffective at 9,000 to 10,000 feet. Tactics were changed, and U.S. aircraft losses significantly reduced.

In October 1942, ASWORG, at the request of NDRC, arranged to assist the US Army Air Force. Early efforts quickly produced an Army Air Force manual on operational use of radar in sea search, study and report on bombsights and photographic coverage of antisubmarine operations.

Review of ASWORG's record reveals a response time from the inception of an action to implementation in the order of one or two months. The Bay of Biscay anti-U-boat offensive, the destruction of the German blockade-runners in the South Atlantic, and the initiation of large convoys in the Atlantic are representative of quick and successful responses.

May 1943: The Turning Point in the Battle of the Atlantic

The meeting of the allied leaders in Casablanca during early 1943 ended with a fresh and firm resolve to counter the U-boats more aggressively. After this, momentum in the ASW battle in the Atlantic increased steadily with a significant increase in U-boat sinkings beginning in May. By the end of the month, Grand Admiral Doenitz removed his U-boats from the north Atlantic to positions west of the Azores and into the Mediterranean.

May 1943 The Turning Point

January - April *41* U-boats sunk

May *41* U-boats sunk

Why after years of engagement did the tide turn against the U-boats? Men and materials are essential to success in modern wars. Significantly, the rapidly growing availability of allied weapons, aircraft, and naval ships signaled the end of the period of getting ready to fight.

A further crucial change was the 20 May emergence of Admiral Ernest J. King's TENTH Fleet as the consolidated and centralized command of all Atlantic ASW with the broadest possible support to defeat the U-boat challenge.

Earlier in May, King's specifications for the new fleet included a civilian scientist research statistical analysis component headed by Vannevar Bush. ASWORG became part of the TENTH Fleet in August and moved from Boston to Washington, DC. The OR group evolved into a center for the entire U.S. ASW effort. An IBM state of the art data processing system provided help in analyzing and tracking the expanding U-boat data. A large percentage of the OR team were eventually widely scattered at various Navy and Army commands in both the Atlantic and Pacific.

Scientists' recommendations on tactics and even strategy were included in the decision processes. As Admiral King pointed out later "...Operations research, bringing scientists in to analyze the technical import of the fluctuations between measure and counter-measure, made it possible to speed up our reaction rate in several critical cases."

Summary

The impact of the civilian operations research scientists, engineers and others with scientific orientation is abundantly clear upon examination of WWII weapons and weapon systems from the aspects of research, development, production, introduction and implementation by the military. OR civilian scientists assisted the military in fighting the war both in the continental U.S. and *in situ*.■

ENDNOTES

* In June 1940, President Roosevelt appointed Bush chairman of the National Defense Research Council with the charge to the Council to implement all science and technology necessary to successfully defend the United States.

** In 1946, he received the highest award the United States can make to a civilian, the Medal for Merit for his application of scientific methods concerning the anti-U-boat campaign during the war. P.M. Morse, the American physicist, also received the Medal for Merit for his work with the Anti-Submarine Warfare Research Group in the Atlantic. (See p. 10.)

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FIRST SOVIET NUCLEAR SUBMARINE

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

The United States of America pioneered in development and building of the first nuclear powered submarine. In August, 1945 atomic bombs had been dropped on Hiroshima and Nagasaki. In March 1946 Dr. Abelson completed the study Atomic Energy Submarines. In August 1951 the first nuclear submarine, USS NAUTILUS, was ordered from Electric Boat Company and on 17 January 1955 she was underway on nuclear power for the first time in history.

Designing of the first nuclear submarine in the Soviet Union began a little bit later. But initial plans about creation of a native nuclear ship power plant were developed at the end of 1940s. Then Moscow's Institute of Atomic Energy under leadership of Academician Igor Vasilievitch Kurtchatov began developing the reactor AM with 5,000 kw power for the first in the world nuclear electric power station in Obninsk, near Moscow. Kurtchatov and his assistants believed that their uranium-graphite reactor would be suitable for ships. The letter M in its name meant marine.

On the initiative of nuclear physicists, the USSR Counsel of Ministers on September 9, 1952 issued the decree about beginning of works for creation of the first native nuclear submarine. General management of the program was authorized to Vyatcheslav Alexandrovitch Malishev--USSR Counsel of Ministers Deputy Chairman who was responsible for development of nuclear technology (his previous job was the Shipbuilding Minister). Anatoly Petrovitch Alexandrov, Deputy Director of the Moscow Institute of Atomic Energy, was appointed as chief scientific leader. Two working groups were organized in the Moscow Institute of chemical building machine (NIIchimmash) for designing the submarine and her power plant. Vladimir Nikolaevitch Peregudov, Deputy Director of the Leningrad Shipbuilding Ministry's Central Scientific Research Institute # 45 (CSRI-45) was appointed as chief submarine designer. Nikolay Antonovitch Dollezhal, Director of NIIchimmash became chief designer of her power plant (later a new Scientific Research Institute # 8 was established in Moscow under auspices of the Medium Machinebuilding Industry--SRI-8 headed by Dollezhal which was designing nuclear reactors).

Appointment of Peregudov was a deeply thought out decision. A graduate naval architect of the Shipbuilding Division of the Naval Engineering Academy, which in September 1998 celebrated its 200th anniversary, he was an active duty officer, Captain-Engineer I Rank, had research and design experience both in the Navy and the shipbuilding industry. In the 1930s, being a researcher of the Navy's Institute of Military Shipbuilding in Leningrad, he participated in designing of IX series (class C) submarine and was sent abroad to the Deshimag company which collected in Holland some German submarine designers under its roof and participated in designing of that Soviet submarine. After that, staying as a naval officer, he was sent to the Shipbuilding Ministry. In 1941-1947 he worked in the Central Design Bureau # 18 first as head of hull division and as Chief Designer of Project 613 mass production (215 units) middle diesel-electric attack submarine. In 1947 Peregudov went to CSRI-45.

For preliminary designing of the atomic submarine Peregudov invited in his Moscow's project group specialists with which he worked earlier and which he knew personally as reliable professionals. The backbone of the group were: deputy chief designer of Project 611 newest diesel submarine V.P.Funicov (Central Design Bureau # 18 – CDB-18) who became the right hand of Peregudov, CDB-18's departments heads A.V.Basilevitch and N.V.Anutchin (general design questions, general arrangement, sub's systems), deputy chief designer of Project 617 steam-gas-turbine submarine from Special Design Bureau # 143 (SDB-143) V.P.Goryatchev (electrical equipment and radio-electronics), SDB-143's department head P.D.Degtyarev (main power plant) and CSRI-45's department head B.K.Razletov (hull's strength and structure).

As project development moved forward, the group increased up to 35 designers. Taking into account extreme secrecy, the circle of invited specialists was very limited. Even navy representatives were not allowed to participate in preparation of tactical-technological requirements (TTR) of the first nuclear submarine.

To get a departure point for the beginning of the design, Alexandrov, Peregudov and Dollezhal had agreed about the horsepower of their power plant, its approximate sizes and weight. It allowed the both groups to begin design works.

In March, 1953 the Peregudov's group had finished a submarine preliminary project. According to the designers' idea the submarine had to accomplish the absolutely nontraditional task—of a nuclear strike (indeed she had to be a double nuclear and strategic submarine) against shore targets (naval bases, ports and so on) by one super large caliber huge torpedo (1,550-mm caliber and length 24 m) with a nuclear warhead. The traditional weapons, 533-mm torpedoes, were accepted only in limited quantity for self defense. The sub had to have speed up to 25 knots and a test depth of 300 m.

The next stages of the submarine designing were made in Leningrad's SDB-143 under leadership of its Head and Chief Designer Peregudov. The Project was designated #627. Its pretechnical stage was finished in October 1953 and technical project was completed in June 1954.

But excessive secrecy backfired. When the technical project was presented to the Government's approval it was at last decided to enlist Navy's specialists. The experts group headed by WWII experienced submariner Rear Admiral A.E.Orel analyzed the project materials and elicited serious deficiencies, the main of which was that the submarine's mission was wrong. It was determined without proper analyses of military-geographical and tactical situation and without taking into consideration the antisubmarine capabilities of a potential adversary.

The Navy required another mission: actions on sea and ocean communication lines against warships and transports of a potential enemy. Instead of one huge torpedo tube it proposed to install six to eight 533-mm torpedo tubes with double or triple the number of reserve torpedoes. An additional reason for canceling the ridiculous 1,550-mm torpedo was a near possibility of creating 533-mm torpedoes with nuclear warheads.

Corrected working project (blueprints and specifications for shipyard) was finished in July 1955, but the submarine was laid down in Molotovsk (later Severodvinsk) Shipyard #402 yet in May 1954.

From 1954 to 1956 the author of this article participated in the building of this submarine (shipyard #254) as a junior navy supervisor, naval architect, Lieutenant-Engineer.

Several words are appropriate about those days, the situation in the country and about Molotovsk.

It was after Joseph Stalin's death and Lavrenty Beria's execution. The Soviet Union had a little more freedom, economic conditions were not bad and people had some hopes for better life.

Molotovsk was a town with a population of about 100,000 some 30 miles west from the old Russian city Archangelsk (something like Groton or Newport News) connected with it by only railway and river boats in summer time. The shipyard building began before World War II for building battleships, cruisers, destroyers and submarines. Stalin's prisoners participated in building of that shipyard. Even in 1954 I saw them on trucks when they were transported to work.

The climate in Severodvinsk is not severe and is not extremely cold. Winter is dry and sometimes in summer it was possible to swim in the White Sea from a nearby beach with white sand. But all the shops of the yard were big buildings and ship construction occurred inside of them.

The town had one theater, two small hotels, a couple of cinemas, one public restaurant and three professional clubs: shipyard's, civil engineers' and naval officers'. For a young naval officer, it was enough.

The shipyard was very modern. It had a dozen shops, including (from east to west) #5-steel plates and small section processing, #7 -block sections production and #50-huge covered shed for assembling ships with adjacent flooded basin. About 25,000 engineers, technicians and workers worked on the yard, including some 50 naval supervisors. Director of shipyard was Evgeny Pavlovitch Egorov, Chief Engineer-Vladimir Ivanovotch Dubovitchenko and Head of navy supervisors-Captain 1 Rank-Engineer Kuznetsov.

At first I worked in #7 and #50 shops supervising the building of Project 611 diesel attack submarines and the first in the world Project V611 ballistic missile diesel sub but at the end of 1954 I was shifted to the super secret shop #42 on the western part of the yard where I first saw the first Soviet nuclear submarine and began inspection of her hull structures including testing of her hull, bulkheads and tanks by water pressure.

Although I was not a sentimental person, my impression of the submarine was futuristic. It was amazing to know that I was participating in building of Captain Nemo's/Jules Verne's NAUTILUS. Unlimited underwater speed of 25 knots was a really revolutionary step. And the ship's architectural form as a torpedo like body of revolution was also futuristic.

In that time I worked with Chief Builder of the submarine Vladimir Ivanovitch Vashantsev and met with Vladimir Nikolaevitch Peregudov.

At the beginning of 1956 I was sent to Murmansk to the Rosta naval repairyard to participate in testing the first Project V611 ballistic missile submarine with her missile tubes by diving to her test depth (200 m) and measuring her hull penetration parts' stresses.

After that in the summer of 1956 I was appointed to the Leningrad's Central Research Institute of Military Shipbuilding as a junior research fellow to work on preliminary design of new Soviet nuclear submarines.

The second time I was involved in building of Project 627A submarines series production from beginning to end, including sea trials, in 1961-1963 when I was sent again to the Severodvinsk shipyard as a naval supervisor, Lieutenant-Captain-Engineer. The most memorable impression of that time was steaming underwater on a Project 627A and other nuclear submarines with high speed and watching nuclear reactors control devices through transparent boxes. The impression combined admiration and some fear of nuclear radiation.

But let us continue the story about building the first Soviet nuclear submarine.

She was launched in August 1957. In September her mooring line tests began on which main attention was directed to the nuclear power plant. Physical starting of ship's reactors on minimal controlled power took place 14 September. Chairman of USSR Council of Ministers Commission on military-industrial questions D.F.Ustinov, Navy's Commander in Chief Admiral S.G.Gorshkov and other high officials were present on that event on the shipyard.

The first commanding officer of the submarine which got the tactical number K-3 was an experienced submariner Captain 1 Rank Leonid Gavrilovitch Osipenko. His executive officer was Captain 2 Rank Lev Michilovitch Zhiltsov and commander of electromechanical department – Captain 2 Rank Boris Petrovitch Aculov.

Sea trials of K-3 took place in the White Sea from 3 July to 1 December of 1958. On July 4, 1958 at 10 hours 3 minutes AM, for the first time in history of the Soviet, fleet the submarine was underway on nuclear energy. Academician Alexandrov had written in the sub's log: "For the first time in country's history steam was produced without coal and oil".

In those sea trials K-3 made 5 sailings and was at sea 25 days. She did 29 dives, went underwater 3,801 miles in 450 hours, including 860 miles underwater with an average speed of 15 knots and dived to depth 310 meters. The sub reached 23.3 knots with 60 percent power from nominal.

It is interesting to compare characteristics of the first Soviet and American nuclear submarines:

	K-3	NAUTILUS
First underway	July 1958	January 1955
Surfaced displacement, t	3,065	3,533
Submerged displacement, t	4,750	4,250
Length, m	107.4	98.7
Number of compartments	9	6
Reserve of buoyancy, %	30	16
Test depth, m	300	210
Number of reactors	2	1
Number of turbines	2	2
Power, hp	35,000	15,000
Underwater speed, knots	30	23
533-m torpedo tubes	8	6
Torpedo payloads	20	22
Complement	104	105

So, generally the first Soviet nuclear submarine had better tactical-technological characteristics with one crucial exception: her nuclear power plant was initially unreliable and was used with only 60 percent of its power providing speed 23 knots. The major problems were her steam generators and reactors' active zones which had very short time of life. And another problem was absence of kingstons in all of her main ballast tanks.

But NAUTILUS also had her shortcomings. With 16 percent reserve buoyancy and 6 compartments she had a less degree of surface unsinkability with one flooded compartment. On K-3 surface unsinkability with one flooded compartment had been provided.

The advantage of the Project 627 submarine was that she, under Project 627A with minor improvements, became a sub of series production. From 1959 to 1964 the Severodvinsk shipyard built 12 such subs and modernized K-3. In one of them 30 knots speed had been reached.

On 11 July, 1962 K-3 left her North Fleet base and under command of Captain 2 rank L.M. Zhiltsov and leader of voyage Rear Admiral A.I. Petelin steamed to the North Pole and on 17 July had reached it but without surfacing because of unfavorable ice conditions.

In September 1963 K-15 Project 627A submarine under command of Captain 2 Rank P.I.Dubyaga accomplished the first transarctic cruise from the Barents Sea to the Pacific Ocean. She left her North Fleet base on 3 September and on 11 September she was in the Chukotsk Sea and soon arrived to her new base on Kamchatka.

Another of this class submarine, K-181, under command of Captain 2 Rank Y.A.Sisoev (the leader of voyage was Commander of the North Fleet Admiral V.A.Katasonov) left her base 25 September 1963 and surfaced at the North Pole 29 September.

Unfortunately, service of the first Soviet nuclear submarines was not without heavy accidents.

One of them happened 8 September 1967 with K-3 which was returning from an autonomous sailing. On the 56th day of steaming and in the Norwegian Sea, 950 miles from her base. At 2 AM the fire erupted in the hold of the first compartment and penetrated to the second compartment. It resulted in 39 submariners dying but the sub reached her base by herself.

The more serious accident happened in April 1970 with K-8 (Commanding officer - Captain 2 Rank V.B.Bessonov). From 17 February she was in the Mediterranean and at beginning of April had to return to her North Fleet base but instead got the order to participate in the widely publicized Ocean exercises. She sailed to the Atlantic.

On the night of 8 April she was in depth 120 m, 750 km from Spain's shores. At 22 hours 30 minutes in her 3rd and 7th compartments a fire started, probably from electrical short circuits. The sub increased speed and surfaced at 22 hours 36 minutes.

In the 3rd compartment the fire had been extinguished by the air-foam system but the compartment was heavily smoked and filled by carbon oxide and it forced the Commanding Officer to evacuate sailors to the sail.

In the 7^{th} compartment fire was fed by oxygen from air regeneration cartridges. The personnel from 7^{th} compartment had to go to 8^{th} compartment, but smoke and carbon oxide began to penetrate it. In that stress situation submariners could not open the hatch and had broken its handle. The emergency party opened the hatch from outside at 2 AM on 9 September. Fifteen men had been carried out by hand. Soon after they died.

In desperate situation were submariners in the 4^{th}, 5^{th} and 6^{th} compartments. They had been cut out by fire from both sides in smoked area. After surfacing of the sub, the system of emergency defense stopped the left board reactor. The right board reactor had been stopped by the control group. The emergency party was able to take out only three sailors from the middle compartments.

On the morning of April 9 K-8 was drifting without power in open ocean. Diesel-generators worked only one hour and had been stopped because of failure of their cooling system. Radio communication means were destroyed by fire. Of 125 submariners 30 had perished. The fire in the stern compartments was continuing and sea water began penetrate them.

By the evening sea roughness and tossing were increased and stern began sinking. Nevertheless the crew was continuing to struggle for the sub's life, periodically blowing the stern ballast tanks.

On 10 April, in the morning, the Bulgarian vessel AVIOR approached the submarine only by chance. With her help the senior officer on the submarine Captain 1 Rank V.A.Kashirsky went to the vessel and sent the radiogramm about the accident to Moscow.

In the meantime weather was worsening. Wind had reached 7. Bessonov transferred to the Bulgarian vessel 43 worn out, exhausted sailors.

On the night of April 10 the Soviet steamers KOMSOMOLETS of Lithuania and KASIMOV and later the Navy's hydrographic ship CHARITON LAPTEV approached K-8. At day time on 11 April KASIMOV three times tried to fix the towing rope to the submarine but stormy sea tore the rope.

To risk all the crew Bessonov decided to organize two shifts staying on the damaged submarine. In the first shift at night to 12 April he and 20 submariners were onboard. Going from the sub by his order Commander of electric-mechanical department Captain 2 Rank V.N.Pashin warned him about dangerous increasing of draft differences because of stern compartments flooding and the critical condition of the submarine. But Bessonov did not considered the situation as such dangerous.

The denouement of tragedy happened near to the morning of April 12. Just preceding dawn, K-8 lost longitudinal stability and perished. Nobody from those submariners remaining onboard escaped.

In conclusion it is necessary to say that, in those times, the Soviet press almost did not report about the first loss of a nuclear submarine. Ocean exercises were phrased as successful. Nobody was punished although Navy's leadership was mistaken to use this submarine which was such a long time at sea before the exercises, and the level of submariners' training for damage control was insufficient. Instead the Brezhnev's Government decided to award the survivors and honored Captain 2 Rank Bessonov title of Hero of the Soviet Union posthumously. No serious investigation of the tragedy took place.■

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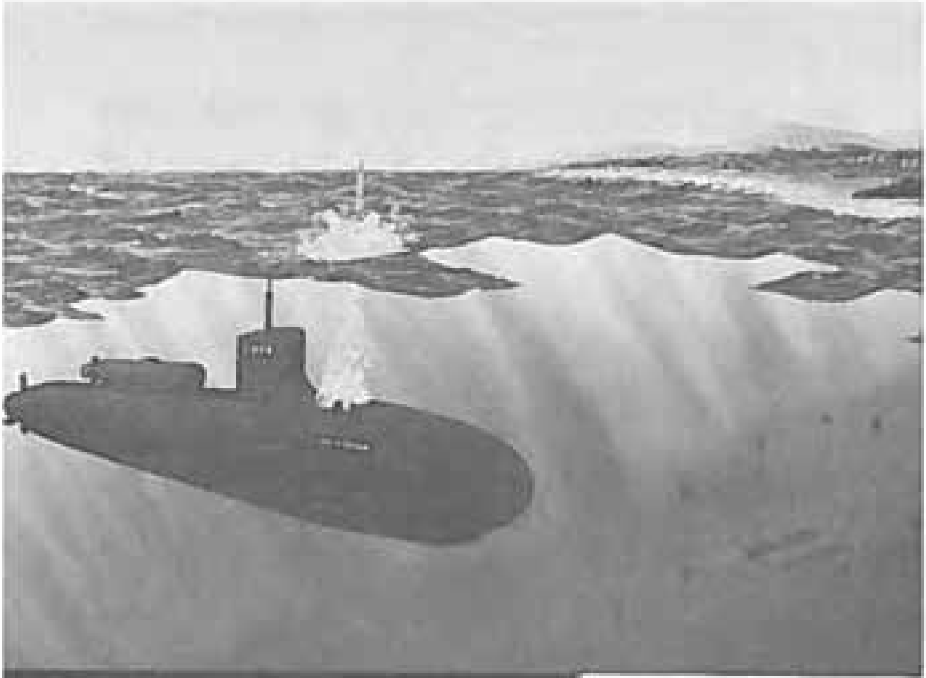
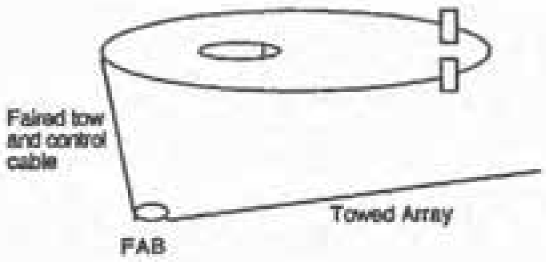


FAB, THE FIRST SUBMARINE TOWED ARRAY?

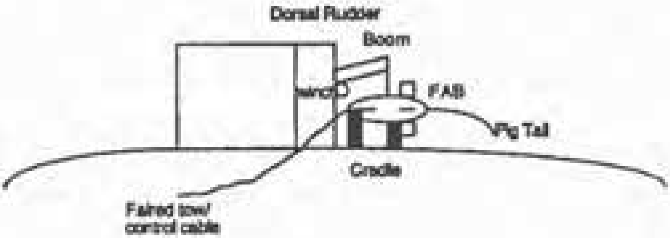
By Jack Hunter

As every submariner knows, the noise radiated from a submarine is a key factor in determining a boat's detectability. Many noise quieting techniques are employed to reduce this radiated noise and periodic measurements are made to determine submarine noise signatures. In the *old* days, limited sound measurements were taken alongside a *sound pier* in a quiet area of a shipyard. Today, more sophisticated measurements are made with the submarine submerged passing by an array of hydrophones on an instrumented range. The limited number of these ranges (the only one on the east coast is at AUTEC) necessitated several days to transit from homeport to the range. The Navy sought to come up with a more economical way to gather noise data—one that could be used at each submarine homeport.

The engineers at the David Taylor Model Basin (DTMB) developed a prototype portable noise measuring system that could be deployed from the submarine. The system was known as FAB—Fly Around Body. It consisted of a buoyant airplane-like device towed from the bow of the submarine, a faired tow/control cable, a neutrally buoyant hydrophone array, and an instrument package to record signals from the array. Once deployed, the towed body (the real FAB) with its trailing array, could be *flown* 360 degrees around the sub's hull from inside the boat. The concept was to take near field noise measurements while turning on and off various pieces of equipment. Once the first set of readings was complete, the array would be moved farther away from the hull by increasing the scope of the tow cable and a second set of readings would be taken. The collected noise data would be processed to determine the boat's radiated noise signature.



After running some preliminary trials with the system in the Portsmouth, New Hampshire area in the spring of 1967, ALBACORE deployed to Fort Lauderdale, Florida that October to run a thorough test of the system. The typical operational sequence went as follows: In port, the FAB was placed in a cradle located just aft of the sail. The faired (for noise reduction) tow/control cable was connected to the sub/s bow tow point by a diver, adjusted to the desired length, and the other end attached to the FAB on deck. A boom and an air driven cable winch were mounted on the aft end of ALBACORE's dorsal rudder. A series of electrical and mechanical checks were run on the FAB controls and the winch to ensure proper operation at sea.



At sea, ALBACORE would rendezvous with a support vessel carrying divers and the array. The array connector was mated to the connector on the FAB's pigtail and continuity checks conducted. The support vessel placed the array in the water and stood clear. The winch lifted the FAB out of its cradle and the dorsal rudder swung the FAB over to the side where the array was deployed. The FAB was lowered until the pigtail connector was submerged. Final electrical checks were made and the FAB was placed in the water. The hoist cable on the FAB was released by a diver, the dorsal rudder was then center-lined and the winch and boom removed and stowed. ALBACORE would get underway in a slow turn toward the FAB to keep the array out of the screws. With several knots of forward motion, the operator could *fly* the FAB and array away from the sub and the boat could submerge in a normal manner.

Once the sub attained the desired course, speed and depth, the FAB would be flown into position for the first series of data points. Ship's course, speed and depth would be maintained while the FAB was repositioned for the next series of readings. Course and depth changes were coordinated with the FAB operator to ensure that the array was kept clear of the screws.

When it came time to surface, the FAB was positioned on what would be the lee side of the sub to facilitate recovery operations. With the boat on the surface, the boom and winch were set up on the dorsal rudder and the rudder positioned to the lee side. Divers from the support vessel attached the winch cable to the floating FAB and brought the end of the array to the support vessel. Once the FAB was winched out of the water and set on its cradle, the pigtail connector was disconnected and the array was hauled aboard the support vessel. While it sounds like a cumbersome operation, each deployment and recovery evolution was usually completed within a half hour.

ALBACORE deployed twice to Fort Lauderdale with FAB. The first set of trials ended prematurely when a casualty to the control system caused the FAB to crash into the sub and crush the fiberglass body. On the second deployment, the system worked well and produced the intended results. The Fort Lauderdale noise data taken by FAB was verified when ALBACORE went to AUTEC and made multiple runs first past an array suspended from a barge and then past AUTEC's (then very new) bottom mounted sound array.

So why isn't the FAB system in use today? Probably the major reason is because of the requirement to put divers in the water. We were limited to sea state two or less for diver operations. Many days were spent in port because it was too *rough* to put swimmers in the water. Those of us who had our families down for the two weeks of trails manfully endured the canceled underway days. After holding a morning clean up of the boat, a noontime liberty call usually followed. While the Fort Lauderdale Navy League enjoyed having the sub alongside and holding frequent visit ship days, ship's company suffered ashore, for liberty in Fort Lauderdale was not inexpensive. The Navy's bills for having the ship sit in port (including motel rooms rented by DTMB for crew members whose bunks were filled by racks of test instrumentation) mounted up. Deployment of the FAB system was too dependent on the weather and the cost savings of using the FAB system were not realized.

While the FAB system didn't provide the desired economic benefits, some of the lessons learned were evidently later put to use. In the days before boats were ShipAlted to install reels for their towed arrays, a small boat with divers was used to carry the array to the underway submarine.

So, was the October 1967 deployment of FAB the first submarine use of a towed array?■

A VISIT TO USS TORSK (SS 423) IN BALTIMORE'S INNER HARBOR

by Richard Thompson

On a sunny March Sunday we toured USS TORSK, a Tench class fleet snorkel boat, now a memorial in Baltimore's Inner Harbor. TORSK is one of four main exhibits of the Baltimore Maritime Museum, operated by the Living Classrooms Foundation. The sub is tied up alongside the national Aquarium in the Inner Harbor, a well struck 3-iron shot from the Harborplace shopping complex. Parking was convenient (if K Street pricey) underneath the Renaissance Harborplace Hotel on Pratt Street (one of many available lots) and admission to the submarine, U.S. Coast Guard cutter TANEY (WHEC 37), lightship CHESAPEAKE (WLV 538) and Seven-Foot Knoll Lighthouse was $5.50 for adults (call (410) 396-3453 for times).

TORSK was one of 26 Tench class boats completed near the end of World War II and she completed two war patrols under the command of Commander Bafford E. Lewellen, when she sank two cargo vessels and two escorts, including the last ship sunk in the war before the Japanese surrender. After the war TORSK underwent fleet snorkel conversion (she is the last surviving example of the type) and went onto serve with distinction, being awarded the Presidential Unit Citation for operations during the Lebanon Crisis in 1958 and the Navy Commendation Medal for participation in the blockade of Cuba during the 1962 missile crisis. Having set a record with 11,884 career dives and following a brief period as a pierside training vessel, TORSK was decommissioned in 1971 and came to Baltimore as a memorial.[1]

Our tour began in the after torpedo room and proceeded forward through the maneuvering room, after and forward engine rooms, crew's mess, crew berthing, control room, wardroom, chiefs and officers' berths, to the forward torpedo room. Most spaces off the

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[1]These details are taken from a brief history of the ship which (together with a diagram) is available to visitors. Further details may be found in Norman Friedman's excellent illustrated design histories *U.S. Submarines Through 1945* (Naval Institute Press, 1995) *and U.S. Submarines Since 1945* (Naval Institute Press, 1994); the latter has an elevation of TORSK following her fleet snorkel conversion.

main passageway were off limits, such as the radio room, conning tower, wardroom, and head, but all were readily visible through the large plexiglas partitions. The ship was uniformly in good shape, clean, and appeared well maintained. A World War II veteran submariner was patiently answering questions in the forward torpedo room, but the other eleven persons in the compartment had first call on his time, and I didn't have the opportunity to speak with him. A Mark 27 torpedo was also on display in the forward torpedo room. I was struck by how spacious the boat seemed in comparison to the captured German Type IX U-boat U-505 at the Museum of Science and Industry in Chicago. It was also interesting to see how little some equipment had changed in 40 or 50 years. There are modest displays of the ship's battle record and a few mementoes, but mainly the ship itself is the focus of attention. We exited more or less through the torpedo loading hatch in the forward torpedo room.

If you are in the Baltimore or Washington areas, take the time to tour one of the last surviving examples of World War II era submarines.■

DOLPHIN SCHOLARSHIP FOUNDATION APPLICATION

The DSF updated application is now available for distribution to potential applicants, high school counselors, and submarine-related commands.

The new form reflects DSF's decision to change the requirement for an applicant's sponsor to have served in the Submarine Force for a minimum of 8 years or a minimum of 10 years in submarine support.

As in the past, the deadline for completed applications and supporting documentation to arrive on premises is April 15.

For further information, please contact Tomi Roeske at (757) 671-3200 or write to the Dolphin Scholarship Foundation at 5040 Virginia Beach Blvd., Suite 104-A, Virginia Beach, VA 23462.

A BOGUS SAYONARA MESSAGE

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

During the period 1972 through 1974 while I was serving as Chief Staff Officer of COMSUBFLOT SEVEN (later COMSUBGRU SEVEN), we always sent a *Sayonara* message to each boat as it departed at the end of its Westpac tour. In it we spoke briefly to the submarine's outstanding accomplishments and bid them a heartfelt farewell.

However, there was an exception. This departing boat had managed to screw up almost everything it touched. The staff decided that the usual Sayonara message was not really appropriate, so the bogus message below was drafted and then carefully placed on the Commodore's morning message board for his routine reading of all incoming and outgoing traffic. Needless to say, we had numerous people posted to intercept him and keep him from committing one or several acts of homicide when he read this particular message. He came in, got his cup of coffee, and sat down to read.

After what seemed a very long moment to the waiting conspirators, a suitably colorful verbal explosion took place. As I recall, it took several minutes to collect the Commodore off the overhead and convince him that the message in question was totally fictitious and that he was looking at the only copy in existence. Later that day he even smiled about it.

> "As [blacked out] departs for home, her officers and men can be proud of the relief which will be felt throughout Westpac, your sub-standard performance left no area unblemished. Although assigned to operations of great importance to the U.S. government you managed in every instance to either retreat to an upkeep port or proceed blindly and unprofessionally, always to the chagrin of naval authorities. We have watched the internal management of [blacked out] with interest. Never before have so few done so little with so much. To amass as many non-performers into one wardroom is truly a triumph in detailing.
>
> "We pray you make it home to your loved ones. Keep the vents shut."■

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NSL would like to have all our members' e-mail addresses, so if you have been remiss, please send yours in to our new address: **subleague@starpower.net.**

RE: A LOGICAL EXPLANATION TO THE LOSS OF USS SCORPION

28 November 1999

Captain Smith argues that SCORPION likely was lost through an uncontrolled depth excursion after losing the bubble at high speed. Unsatisfied with other loss theories, and citing his experience as a submarine weapons officer, he concludes that a SCORPION torpedo warhead explosion could not have occurred because the explosion of one torpedo would have detonated all the other torpedoes, visibly opening the pressure hull surrounding the torpedo room. In arriving at his conclusion, however, he does not account for evidence that an explosion did occur at or near periscope depth.

Facts that must be accepted, accounted for, or disproved include:

1. There was an explosion. The explosion was recorded by SOSUS and pinpointed the tragedy's location. Had there been no explosion, SCORPION would not have been found.
2. The explosion almost certainly took place at or near periscope depth. The observed time between the explosion and later implosions was demonstrated to match computer modeling for an uncontrolled dive from periscope to crush depth.
3. SCORPION was headed east. Within days after starting his analysis of the SOSUS tapes, Dr. Craven determined that her course was eastward. Many months later, when SCORPION was found, she was observed in fact to be pointed toward Europe. The point is that SCORPION did not, in her final dive, undergo some unusual course reversal. The course reversal had been completed at or before the telltale explosion.
4. The torpedo room was not visibly distorted; i.e., did not implode. Therefore it was flooded before reaching crush depth.
5. The after compartments did implode; i.e., their watertight integrity was at least essentially intact until reaching crush depth.

Other pertinent factors include the position of the topside hatches, the position of periscopes and radio antennas, the condition of the torpedo tube outer doors and shutters, and—possibly—the condition of the torpedo tube outer doors and shutters, and--possibly--the condition of the ship's 126-cell lead-acid battery. These factors must support, or be explainable within, any final solution of the problem

A mystery as absorbing as SCORPION's loss will continue to spark discussion and new theories. But to be productive such discussions must take into account incontrovertible facts. The essence of the SCORPION mystery is, "what exploded and what caused the explosion to happen?" Without encouraging them, but knowing they will happen, I will continue to be absorbed by future iterations. But it seems sure to me that the last chapter will not be written until--if--new hard facts come to light.

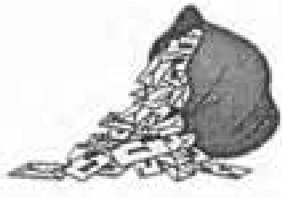
CAPT Gordon W. Enquist, USN(Ret.)

REQUEST FOR INFORMATION

December 8, 1999

I am searching for any information about the embarkation of Lord Louis Mountbatten in USS SKIPJACK (SSN 585) sometime in 1959 or 1960. I am particularly interested in contacting any of those onboard for that event.

Norman Polmar
4302 Dahill Place
Alexandria, VA 22312



TORPEDOMAN

by Ron Smith
Published by Ron Smith
29119 Sedgefield
Spring, TX 77386
$18.00 (incl. shipping)
ISBN 0-9643390-0-5
Reviewed by LCDR Kevin G. Mooney, USN

As the lack of a big name publisher might imply, Torpedoman is not a ghost written or professionally edited masterpiece destined for literary awards. Instead, it is a somewhat unpolished, but very personal account of a young submariner during World War II. Unlike Thunder Below or most other submarine classics, Torpedoman provides insights which could only be seen through the eyes of an enlisted man. It tells the story of those not in command, but of those subject to the commanding officer's orders, both good and bad.

Torpedoman is an autobiographical sketch of a rural Indiana teenager who answers his country's call to arms after the attack on Pearl Harbor. The book takes us from Ron Smith's pre-Navy days, when as a private pilot he hoped to become an aerial gunner, to near the end of the war, when as a battle hardened submariner he became despondent over his limited chances for survival under the sea.

After *Ronnie* completes Submarine School in San Diego, he joins USS SEAL (SS 138) in Mare Island Naval Shipyard at Vallejo, California, under repair and upgrade after her fifth war patrol. A bit cocky, but very capable, he quickly assimilates with the crew and performs well on SEAL's sixth war patrol, earning his Silver Dolphins as well as playing an important role in a successful torpedo attack against a Japanese freighter. However, the mood on board darkens during the seventh war patrol, and SEAL limps back to Pearl Harbor with a shaken and emotionally drained crew. Nevertheless, one of SEAL's officers notes Smith's leadership potential and recommends him for a commissioning program, allowing Smith a break from SEAL to contemplate his future in the Navy. The remainder of the book revolves around

Smith's personal life as he comes to grips with the realization that he must eventually return to battle and risk survival against daunting odds.

Smith's blunt writing style makes Torpedoman a war story more akin to Saving Private Ryan than to a patriotic John Wayne classic. He portrays the real but unsavory aspects of war that most of us would like to ignore. He tells of incompetent officers who demonstrated poor leadership and of sailors whose fear and hopelessness led them to a near mutiny. Other realities of wartime life such as coarse language and the crew's *live for the day* liberty antics run throughout the book and might offend more prudish readers, even though they admittedly brought a frequent smile to my face. More than anything however, Torpedoman brings the reader down to the deckplates—to the after torpedo room of a WWII fleet boat in battle, and into the heart and mind of a young sailor trying to squeeze a lifetime into every moment. At this, Smith succeeds. His vivid recollection and detailed description of a 300 plus depth charge attack from a group of Japanese destroyers left this reader glued to every page, and finally stunned me with a totally unexpected conclusion. For me, Smith achieved an author's often-illusive goal in that he was able to touch my emotions. The shameful account of a near mutiny made me feel uneasy and bothered, just like many of those who hatched the foolish, and thankfully, unfulfilled plan. When he fell in love and got married at the age of 19, it was easy to feel a young man's yearning for joy and satisfaction before returning to battle to face an uncertain future.

While Smith's honesty and motivation in writing Torpedoman are never in doubt, the book has its rough spots. The opening chapters are somewhat confusing, and I found myself rereading many sentences and paragraphs. Numerous spelling, grammatical and printing errors throughout the book proved bothersome. Despite its claim to be a *novel*, Torpedoman is in fact, a true story. More significantly, the story ends rather abruptly, leaving many unanswered questions, which could have easily been covered in a more thorough epilogue or simply another chapter. In short, Smith's presentation needs better editing and a more thorough conclusion.

Regardless of its shortcomings, I recommend Torpedoman to readers interested in an unvarnished glimpse into the life of a young WWII submariner. It is a short book that can be easily read in one sitting. I especially recommend Torpedoman to today's junior officers, since it would expose them to some interesting leadership challenges, and teach them a few things about motivating a cadre of intelligent and technically capable sailors. WWII submarine aficionados will also appreciate this story as an opportunity to view submarine history from a different perspective—that of the bulk of the men who made it. I thoroughly enjoyed reading Torpedoman. It captured my imagination, tugged at my emotions and made me even more thankful for the service of men like Ron Smith.■

Reviewer's Note: I became aware of Torpedoman in a somewhat interesting manner. Last year, while serving as Military Editor of the Submarine Force's official magazine, Undersea Warfare, I was researching the origin of World War II Submarine Battle Flags. Frustrated by the total lack of any formal history, even at many of our fine submarine museums, I turned to the Internet. After posting a request on Ron Martini's famous Submarine Bulletin Board Service (BBS), Torpedoman's author, Ron Smith replied within hours. After a short discussion, I managed to cajole him into writing a short piece on Submarine Battle Flags for the magazine (see Undersea Warfare, Winter 1998/1999 issue). Thereafter, it came to my attention that Ron Smith wrote more than just short, pro-bono pieces for naval magazines, and I purchased a copy of this thoroughly enjoyable Torpedoman.

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