THE SUBMARINE REVIEW

APRIL 1989

A QUARTERLY PUBLICATION OF THE NAVAL SUBMARINE LEAGUE

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FROM THE PRESIDENT

Let there be rejoicing in the NSL -- We moved the mountain!

When Admiral Bruce DeMars [then DCNO(Subs)] asked that the NSL undertake the sponsorship of a Submarine Documentary, coordinate the efforts to raise $525,000 from our Corporate Donors and oversee the myriad of details necessary to make a documentary happen, little did we realize the adventure we, the NSL, were about to embark on.

Now, 25 months later, with the funding goal reached, the film "in the can" and final editing underway, we can breathe a sigh of relief and look back at our accomplishment.

Let's skip over the evaluation of the film for now and analyze what has happened. The NSL with 3850 members has helped give life to an educational vehicle which will reach tens of millions of people over the next few years. We understand the submarine mystique, but after the PBS showing, our belief in the value of submarines will be shared by countless more. This is a real example of a force multiplier in action. Of course, we hope the Submarine Force and the Recruiters will find the video useful for a decade or so. I thank all those contributors who made it possible.

As a special attraction, a 15 minute Sneak Preview of the Documentary entitled **SUBMARINE! Steel Boats - Iron Men,** will be shown at the NSL Symposium Banquet on 8 June 1989. This will be an historic event. Try to attend.

As a bonus, the NOVA program producers for PBS Television have offered to fund a sequel to the NSL Documentary focussing on the science and technology surrounding submarines. Vice Admiral Cooper, ACNO(USW) has agreed with the NSL to start preliminary discussions for such an effort.

Hang on NSL -- Here we go again! When I review our NSL goals and objectives, I feel a great sense of pride in seeing what is happening.

Finally, the NSL Seventh Annual Symposium will be a great treat with some new ideas and a few surprises. It will be a sell-out, so when your reservation applications arrive, return them early!

Shannon

P.S. Our data bank listing NSL Treasurer volunteers is at the low level alarm point. If you know of someone familiar with IRS dealings and accounting procedures who would be interested in applying for the position, have them give us a call. We would, of course, give preference to qualified volunteers who are NSL members, but others would not be ruled out.

S. D. C.

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NAVAL SUBMARINE LEAGUE

A KEEL-WING TO SOLVE THE SNAP ROLL

Because of the complex forces and moments resulting from the roll/yaw coupling (caused by the sail's interference with the hull-induced upper vortex system), an approach to simplifying lateral control is to eliminate roll-angle in a turn and, subsequently, the snap role from a high-speed turn.

A comparison to a modern fighter plane in a steep turn might be useful, Figure 1:

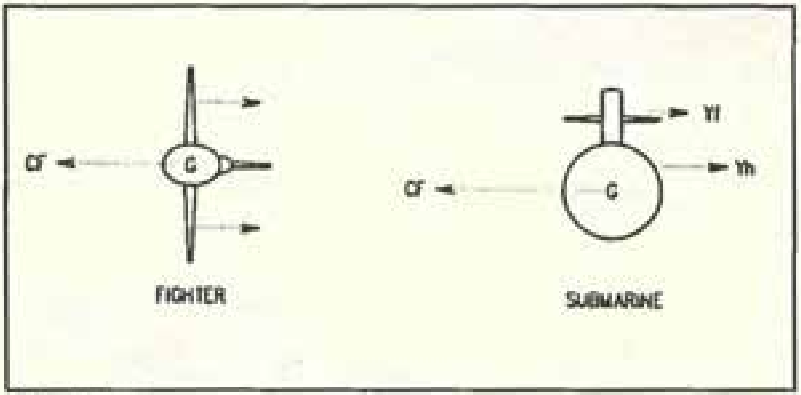

Figure 1

Note, however, that the fighter plane has TWO half-wings, both pulling together to create a side force. This offsets the centrifugal force that is trying to pull the fighter plane out of it's turn. Unhappily, the sub has only ONE half-wing which promptly rolls it over into a very difficult situation whenever it tries to turn at high speed. An obvious solution is to add another half wing, on the other side of the hull, directly opposite the sail. This will not only counter the sail's rolling moment and keep the hull upright, but also adds a substantial side force to assist in tightening the turn.

The sail of today's attack submarines typically measures 400-500 sq. ft. in size and -- acting like a lifting wing on its side -- generates a side force nearly 50% of that created by the two hull vortices that start at the bow and roll up on the lee side of the yawing body of revolution, Figure 2. This side-force, centered well above the center-of-gravity of the sub, is the cause of the infamous "snap roll" that has prevented routine, high-speed turning maneuvers by our submarines.

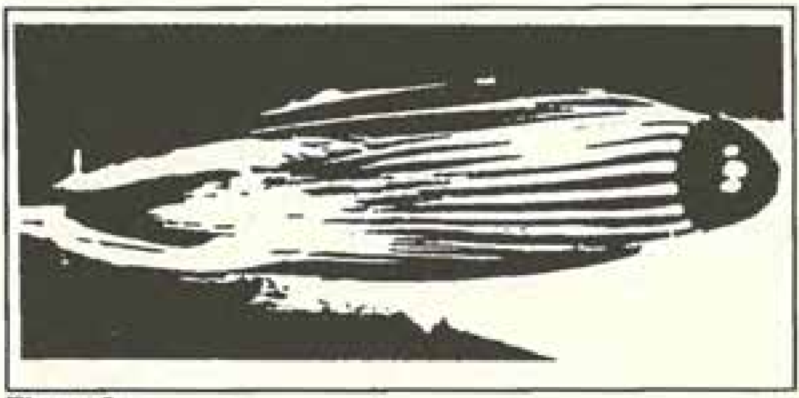

Figure 2

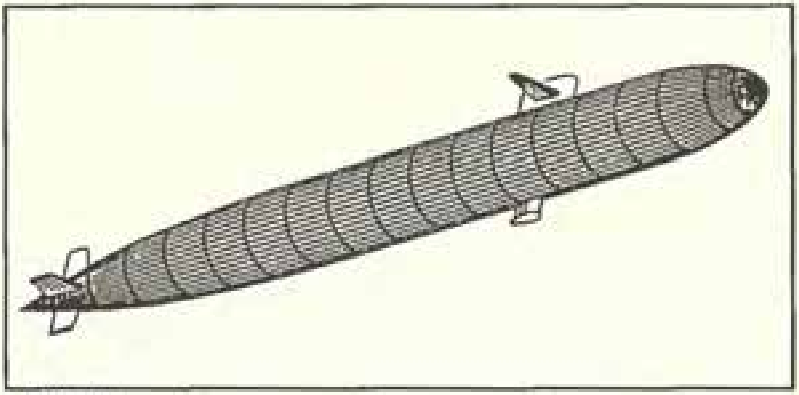

Figure 3

Figure 3 illustrates one possible solution: "a keel-wing" (like a center-board on a sailboat) with a design similar to classic bow planes and utilizing a folding mechanism to retract the keel-wing for long transits or when going into port. By using modern computer-designed, multiple-element airfoils with end-plates -- analogous to the sophisticated rear wings on Formula 1 and Indy 500 race cars -- the folding keel-wing can generate equal and opposite side forces to the sail, yet it need be only 1/3 to 1/4 the size of its topside counterpart. In addition, the two moving flap segments of this wing can be hydraulically linked to the rudder -- at some appropriate ratio -- to maintain an upright hull throughout the turn. This greatly simplifies the control task, and opens up the possibility of single-man control with existing hardware. Further work might even lead to the addition of a trailing flap on the sail, in the same control circuit, to complement the keel-wing.

Assisting this effort to minimize the size of the keel-wing will be the conventional metacentric stability, i.e. pendulosity, of the basic hull design. With the center of buoyancy (C.B.) above the submarine's center of gravity (C.G.) for any rolling motion, this strong righting moment is the other major reason why the keel-wing does not have to be nearly as large as the sail in performing its task of keeping the hull upright through a high-speed turn.

Figure 4 describes a computerized simulation of the vortex flow field on a modern submarine hull that is yawed towards the viewer approximately 15 degrees. Figure 5 is a view of this same hull with the addition of the folding keel-wing. Note the difference in the position of the twin vortices.

The side-force generated by the "circulation" from the sail in Figure 4 shows its influence clearly. By countering this with the equal and opposite side force "circulation" from the keel-wing, it is possible to contain the twin vortices at the same time that the "snap roll" rolling moment has been negated. (Both the sail and the keel-wing will also generate small "wing-tip" vortices as a result of their side-forces but they are not shown here).

Containment and control of strong, bow-generated vortices is well known in the aerospace world. In fact, most of the published literature on vortex generation is for aircraft and missiles. For a beautiful and thrilling view of the prettiest vortices you will ever see, watch the Concorde land and take-off on a damp day. You'll see the vapor trail of its strong leading-edge vortex. The Concorde's aerodynamicists spent many long hours in the wind-tunnel laboring over the refinement of this vortex structure to assist the SST take-off and landing with vortex-generated lift.

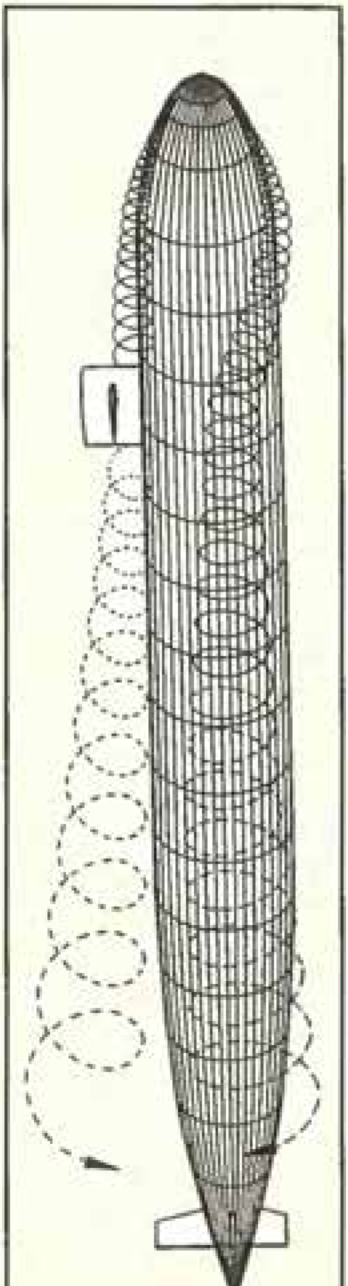

Figure 4

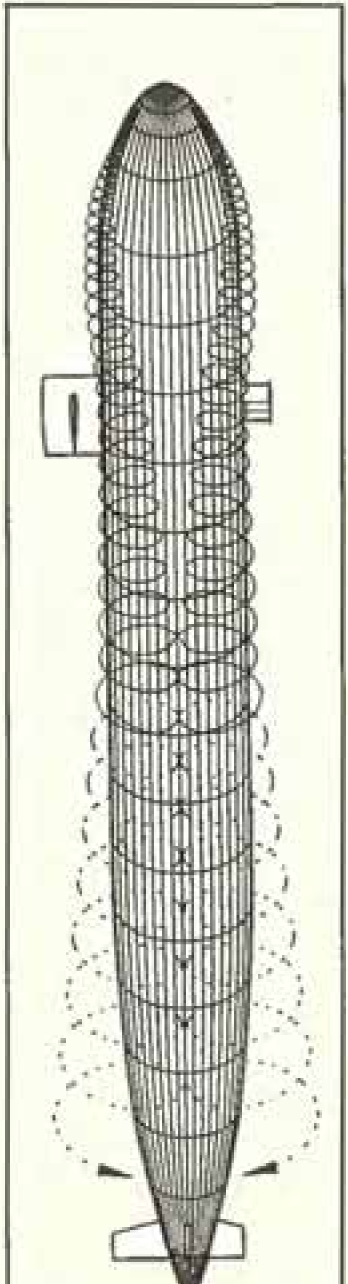

Figure 5

Why not do the same for our nuclear submarines?

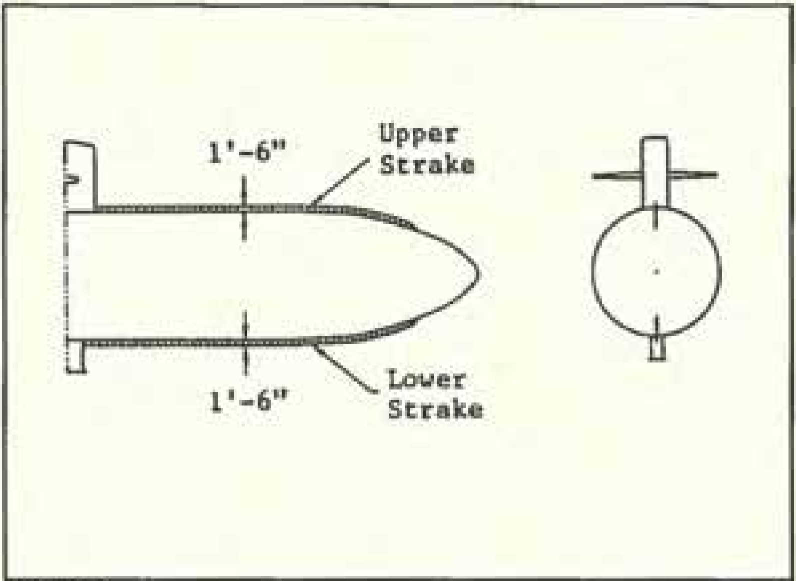

Figure 6

In the same manner that modern aerodynamics shaped the leading-edge of the Concorde to strengthen and control its vortex, one can also modify a similar area on the forward hull of a modern submarine to improve its vortices. Simple longitudinal strakes on the top and the bottom of the hull, per Figure 6, present an interesting possibility to improve the turning diameter radius in an upright underwater turn. These strakes -- similar to the sharp leading edge of the SST -- will promote an earlier and more positive creation of the two vortices seen in Figure 3. Calculations indicate that each vortex will be stronger and will be spaced further apart, allowing the hull to generate a higher side force. Higher hull side forces allow the submarine to make tighter turns.

Why do we need to make tight turns?

The following quotation from John Trotti's excellent book, Phantom over Vietnam, may provide some insight if one substitutes "torpedo" for the "SA-2", and "submarine" for the aircraft.

"The main threat was a surface-to-air missile. The SA-2 was the kind of missile that brought down Gary Power's U-2 over the Soviet Union. It was a large missile ..... and the missile was guided through a pursuit curve (by ground-based track-while-scan radar), which differs from a lead collision profile in an important way. Whereas the lead collision approach calculates an aim point in front of the target, the pursuit curve vectors the missile to the rear of the target.

Because the SA-2 had to continually respond to target position updates from the ground-based radar site as it sought to follow its target, it could be treated in much the same fashion as an enemy aircraft. Turning into the SA-2 would throw it to a higher and higher angle-off, forcing it more and more to the outside of the turn. While it was capable of higher speeds than an aircraft, its turn radius was incapable of dealing with a fighter's maneuverability. As the missile was forced to an ever-increasing crossing angle, its closing rate decreased as it fell farther to the outside of the turn. The firing circuit in the missile warhead was designed to fire when the closing rate dropped off to a predetermined value. Regardless of the actual proximity of the missile to the target, when the Doppler value dropped below a certain level, the warhead exploded."

The above scenario could very well happen at any time in the next few years if our submarines have the ability to tightly maneuver at high speed, and how to avoid torpedoes is learned.

The fighter aircraft analogy can also be applied to the fluid forces involved. Maneuvering any vehicle in a fluid medium, whether it be air or water, requires that the vehicle overcome its own inertia forces as well as the force of the fluid impinging on the hull or rudder, etc. To appreciate the magnitude of these fluid forces, imagine if you will, how the air pressure feels on one's hand out the window of a car travelling at 60 mph. This pressure (engineers call it "q"), will be about 10 lbs per sq. foot.

For a submarine travelling at 20 knots, this pressure will be about 1140 lbs/ft^2! Oddly enough, this same 1140 psf pressure is also experienced by an aircraft at Mach 2 and 40,000 feet -- or 700 mph at 6,000 feet. To fly and maneuver at these speeds with these forces requires a stable, well-built platform, whether it be an F-4 Phantom fighter or an SSN.

Today's aircraft can maneuver all over the sky at great speeds, while the "modern" submarine can only go fast in a straight line. To be sure, when the pilots of the P-47's and P-51's in WW II found out about the "sound barrier" towards the end of the war, U.S. aircraft designers set to work in a big hurry to investigate and solve the control problems due to the new aerodynamic characteristics at high speeds. Chuck Yeager was the first to break the "sound barrier" in the fall of 1947 in the X-1, and the U.S. aircraft industry soon mastered the pitch/yaw coupling hazards of supersonic forces and moments with new streamlining, new controls, and new control surfaces. But supersonic aircraft still had a fuselage, wings, and a tail structure, and they were simply arranged and coordinated together in a better way.

Less than 10 years after Yeager's historic flight, the submarine community found its equivalent to the "sound barrier." After their great WW II success in the Pacific, American submariners saw a revolution in undersea warfare* with the simultaneous development of nuclear power and the "body of revolution" high-speed underwater shape. Nothing is free in this world, however, and after only a few flights the ALBACORE found the infamous "snap-roll." Several ALBACORE captains with skill and visionary thinking soon laid a solid database for the future of high-speed, maneuvering submarines. The rest of the engineering world was stunned and amazed at the submarine potential made possible by such foresight. By 1960 the 50 year-long German leadership in submarine design was but a distant memory. U.S. submarines were not only light-years ahead of the rest of the world, the multiplicity of different designs going to sea promised even more incredible ships in the future -- but then it all stopped in the mid 1960s.

**Nuclear power permitted, for the first time, unlimited undersea travel, therefore, the surface-ship V-hull of all previous submarines could now be changed to a perfect underwater, torpedo-like shape.*

Today's 688 class ships, with twice the power, can barely exceed the 1956 ALBACORE's flank speed, and cannot even come close to turning with her. All work towards solving the pitch/roll/yaw coupling problems uncovered by the snap-roll came to a halt. American submarines became slow -- but very stealthy -- underwater blimps. Turning at high speed was ruled out.

After 30 years the Navy's research people have a good theoretical understanding of these problems, and with new submarines costing nearly 1 billion dollars per copy, we should make every effort to make the small modifications necessary to allow all of our attack subs to maneuver freely. Certainly, it appears that keeping the hull vortices always in the lee of the turning hull -- by maintaining an upright hull -- offers a simple and potentially very reliable solution to the turning problem.

FOR FUTURE DISCUSSION

Finally, it should not be forgotten that an upright submarine in a fast turn is the world's greatest "knuckle" generator. If you think a 700,000 odd pound jumbo-jet generates powerful long-standing vortices, what do you think a 14 million pound submarine will generate? There is no question that a rapid rudder change at 20 knots of a 688 submarine will generate a world-class vortex pair that would attract every enemy torpedo from 10 miles around. After generating such a knuckle, the generating sub can back down to stealth levels and skulk around for awhile to see who wants to sniff at his residue.

What about the classic "submerged operating envelope?" Giddings and Louis have already shown in a paper published in 1966 and again in 1988 how one could provide satisfactory jammed-plane safety margins by rearrangement of the stern planes. The "X" plane arrangement, first tested on the ALBACORE in 1960-61, is now being utilized by European submarines and provides a much larger operating envelope than the conventional cruciform used by U.S. ships. It would appear that the keel-wing, by eliminating the unstable snap-roll, will provide an operating envelope nearly as large as that of the "X" stern. In fact, after a quick analysis, one suspects that the existing cruciform stern planes would actually be the optimum control structure for a folding keel-wing.

Henry E. Payne, III

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THE MENACE OF THE MIDGETS

The midget submarine threat has undeniably resurfaced and except in Sweden, harbor defenses have largely fallen into disrepair or been shamefully neglected. Most thinking has been concentrated on the large submarines far out at sea; hence, standard anti-submarine measures have not been designed to cope with what, more than a century ago, the prescient French journalist Gabriel Charmes called la poussiere navale -- mere specks of dust, the tiny torpedo boats of his day which he declared would replace giant battleships. Charmes would view today's situation sardonically.

The arguments for and against high-performance small submarines will doubtless continue; but meanwhile it might be worth looking closely at veritable midgets, right at the bottom of the size-scale, in light of the technology now available.

There are few people still around who have had actual seagoing experience in midgets; and some, especially those who were connected with the short-lived USS X-1 in the 1950s might well say that once tried was enough. But those who were lucky enough to drive an excellent British X-craft or a German Seehund -- both types arguably way ahead of a large field of mini-submarines during World War II and the immediate post-war years -- will remember how extraordinarily powerful and effective the tiny craft could be. Even some of the so-called human torpedoes -- by no means submarines proper -- were devastating. The Italian Maiale ("pigs") not only achieved significant tactical triumphs (as did similar British "chariots") but they upset the strategical balance of naval power in the Mediterranean when, led by de la Penne on 21 December 1941, they crippled the 30,000-ton British battleships Valiant and Queen Elizabeth in Alexandria Harbor. Then, the British X-5 and X-6 -- true midget submersibles -- returned the compliment by putting the 42,000-ton German battleship

Tirpitz out of action in September 1943. "The Beast", as Churchill called her, was lying far up in a Norwegian fjord behind supposedly impregnable defenses where no other attackers could reach her. She was sheathed in 15-inch armor and had a crew of 2,500. Yet eight men, in two tiny craft, with half-inch pressure hulls, prevented her from ever setting out to sea again. The British mini-submariners had removed at a stroke the greatest single threat to Russian convoys which had kept two American battleships and the bulk of the British Home Fleet on guard -- when those important units were desperately needed elsewhere.

These were not the only midget successes. German Seehunds sank something in the order of 100,000-tons of shipping between January and May 1945. Besides other harbor attacks, X-craft preceded the Normandy invasion fleet to mark Sword and Juno beaches.

In addition to over-engineered and suicidal human torpedoes, the Japanese devised some excellent midgets -- much better than those which initially attacked at Pearl Harbor. Yet, despite vast numbers of mini-subs being built, the Japanese achieved practically nothing. True, an unsophisticated Fly seriously damaged the British battleship Ramillies at Diego Suarez at the end of May 1942 -- a feat that deserves more recognition. But other Japanese midget operations were, on the whole, less than impressive. This raises some questions. Bearing in mind that midgets of various kinds were available in huge numbers to the Japanese Navy, why was it that they had so little impact on the war? Why, by contrast, were the Italians along with the British, so very much better at mini-submarine operations?

One should look at the answers to those questions before assessing mini-submarine underwater warfare today, because the midgets are far more relevant than they were during World War II.

There were several crucial factors which spelled the difference between success and failure -- and the Russians as is their wont have almost certainly recalled them and taken to heart the wartime lessons learned. In summary:

- attacks at source, i.e. in ports and anchorages, had a strategic effect out of all proportion to the effort involved;

- suicide missions were doomed in more than the obvious way, from the start. Kamikaze tactics worked with aircraft because the pilots attacked with exhilarating speed and a fairly short flight time. But prolonged mini-sub submerged operations, requiring meticulous navigation and the ultimate precise positioning of weapons, did not succeed when the small craft was easily detected by visual or radar observation of the intruder. It was invariably necessary to expose parts of the submersible for long periods in order to hopefully estimate where it might be as it closed its target. Thus, destruction before death at the target was all too likely;
- thorough, realistic training lasting months rather than weeks, was, and is, mandatory. The Japanese failed by and large to provide it. Moreover, considerable risks had to be accepted during pre-operational exercises. (That proved to be a primary reason for disbanding the British X-craft Unit in the late 1950s.);
- a single mini-sub operator, alone by himself (as in certain German midgets) tended to lose heart quickly even if he could cope with the control and attack problem -- which often enough he could not. There had to be at least two in a crew and, for lengthy operations, four was about the minimum;
- covert attack units had to be allowed to develop team spirit in their own unconventional way. A very special kind of man was required. Self discipline was more important than discipline by rank. Naval orthodoxy necessarily went by the board;
- no enemy antisubmarine or anti-torpedo defenses wholly defeated an assault by determined and properly trained midget operators. They were a hindrance, and frequently they trapped a craft, but a few of the mini-attackers usually got through;
- complexity in design of the midgets was disastrous when it came to the test of war. Simplicity and ruggedness won the day.

There is a lot of meat in these seven points. The Soviets, now reckoned to have a couple of hundred midgets, have long been chewing on it. Since 1962 very small Soviet submersibles have frequently penetrated Swedish waters without being caught; and they are suspected of having been active off Brazil, in San Francisco Bay, around Japan and South Korea -- and virtually going unchallenged. This suggests that the above lessons have been duly digested. With today's greatly increased submerged endurance, and with accurate navigation during totally submerged transit, midgets can now arrive at their targets undisclosed, efficiently carry out their missions and make their getaway -- all at little risk.

Whether or not a midget can attack targets in the open sea depends on its propulsion and weapon systems; and those systems together with the number of weapons carried, determine its size. Given that propulsion and endurance are adequate, the minimum weapon load to make a coastal or bluewater operation worthwhile is probably two heavyweight torpedoes (or missiles) or four lightweight ASW torpedoes for each unit in a sizeable flock of submarines. Seehund, for example, carried two external torpedoes, had a two-man crew, was only 11.9 meters long and had a displaced tonnage of 14.7 tons, but had such a limited surface and submerged endurance that it could only be used out to about 100 miles from its base, at most. This made it good only for defence against an invasion fleet or to interdict inshore traffic, but not much else. Nevertheless, a large number of modernized Seehund successors, operating from a Soviet-controlled Norwegian port in war and with their range greatly extended by present-day technology (using fuel cells, or far higher capacity batteries, or closed-cycle engines like the Stirling or Maritalia diesels) might very well swamp the ASW defenses of an incoming amphibious force. Bearing in mind that the USSR has historically considered submarines as essentially defensive, it would not be at all surprising to find that a proportion of the Soviet midgets are intended for that purpose.

Low-frequency active sonar is not likely to have much joy against very small submerged attackers. Nor are the usual ASW weapons well suited to destroying them. During World War II, German midget commanders noted that depth-charge explosions actually illuminated the inside of their craft through the plexiglass dome. Yet no damage was done. The reason seems simple: most big submarines were cracked or ruptured by reason of shock waves arriving at fractionally different times along the length of the submarine. It was this differential, causing a kind of whip effect, which seems to have resulted in destruction, according to German guesses. A midget on the other hand was too small for that to happen. Clearly, a charge detonating against the hull would write it off. But if it was displaced, the shock waves, although rocking the craft severely, did no real damage. German midget submariners offered the analogy of a long plank of timber in a heavy sea where it would likely be smashed; but a matchstick tossed into the waves would simply ride with them. A similar analogy might be applied to low-frequency active sonar.

That aside, the primary and logical purpose of a true midget submarine is to intrude where its big sisters cannot or dare not trespass. Up estuaries, deep into harbors, along hazard-strewn shorelines, etc. are the mini-subs' preserve.

Little has been openly published by intelligence sources about current intruding Soviet midgets. It seems certain though, from tracks photographed on the seabed, that they count amphibians amongst them. There is something to be said for an amphibious vehicle if heavy stores for agents have to be humped onto a shelving shore -- and there is no need for the amphibious mini-sub to come right out of the water. Perhaps more significantly, an amphibian would be useful for interfering with seabed communication links. It is also reasonable to assume that the Soviets have a general purpose class of midgets for harbor penetration which would be armed principally with ground and limpet mines. Finally, some "Seehundskis" for anti-surface and possibly anti-submarine work could be expected. Needless to say, all intruder types are likely to be equipped with exit and re-entry chambers. Spetznaz troops, male and female, are the obvious choice for agents and combat swimmers. But the actual crews should be "special" submariners conforming to the lessons learned during a war.

Another lesson that's been learned is that midgets can be constructed easily and cheaply, while the building process, training and the operational base can be entirely secret. Hence it is not surprising if detailed intelligence is in fact lacking on the Soviet midgets.

However, as always, it is best to look ahead. While the

Soviet mini-subs briefly outlined are probably of yesteryear's technology, there is a need to see what is possible today and tomorrow -- and for that there are some good ideas from present developments which can be highlighted. A present closed-cycle, diesel-propelled midget, for example, with an estimated 200 meter diving depth, and 200-mile range at 6 knots, serves to indicate where midget submarines are headed. Inside a 29-ton displacement-envelope there is a large "moonpool" kind of chamber amidships which can be used for planting mines or as a lockout chamber for swimmers who can be deployed out through the bottom hatch after being brought to saturation pressure inside the chamber. In the case of laying ground mines, they would be lowered through the bottom hatch using block and tackle while the midget submarine hovered just above the seabed. Then, assuming that the bottom is mud or sand, an ingenious method of letting the mine dig itself deep into the bottom is offered. A diver in the moonpool using a pole with a vibrator attached to it can circle the bottomed mine with the device and vibrate the soil around the recumbent mine, making it sink under its own weight deeper into the bottom. Buried, it is much more difficult for mine-hunters to find and dispose of. As for the radiated noise of such a midget, there is no exhaust system, which reduces airborne noise considerably, while a thick internal quilting around the engine would reduce radiated noise to sea. The midget's navigation system could be an adaptation of the well-proven Doppler equipment used for berthing large tankers. Operating at between 500 and 600 kHz it is undetectable at ranges in excess of 500 meters, even with specially tuned listening equipment. The Doppler against the seabed produces an estimated position which is true within one mile in a hundred. In conjunction with a gyro which is self-compensating for precession and with occasional satellite fixes, a commander will be able to readily find his way with the aid of a computerized display to his target, even in the most confined channels. This means that today's mini-sub can remain totally submerged for a long run in to a target -- almost eliminating the chances of being detected both getting there and getting away.

Two major roles are envisaged for such midget submarines.

As an intruder, the craft can carry mines for seeding in critical channels and in such a way that they cannot easily be swept, and they would be planted in waters of generally less that 20 meters. Alternatively, the midget can be equipped with two lightweight torpedoes and an electronic periscope. In the defensive role, a high-resolution scanning sonar can be fitted for controlling six miniature torpedoes for use against swimmer delivery vehicles, or for neutralizing combat swimmers. This should prove to be a more effective method for combatting this underwater threat to coastal areas of the world, than the static installations under present consideration in the West.

In accordance with the last wartime lesson mentioned earlier, simplicity and ruggedness are keynotes of the design of today's midgets. What might seem like sophistication is actually very straightforward and uncomplicated.

Above all, midgets can strike at source before enemy ships and submarines spread out in the open ocean. As President Woodrow Wilson said in 1918, "I despair of hunting for hornets all over the sea when I know where their nest is."

Indeed, if any enemy can be destroyed in the nest or be prevented -- by mines for example -- from leaving it, this particular application of seapower by the attacker results in command of the sea. Midget submarines, in their renewed configurations, enjoy the potential for conferring just that kind of sea power.

It might well be asked why other navies (outside the USSR and Italy) have not pursued the midget concept vigorously. This is because most navies have apparently been mesmerized by immensely powerful, and enormously expensive, underwater giants and have forgotten the menace of the midgets -- a menace which an enemy could be made to face, as well as mainly ill-equipped defenders.

Richard Compton-Hall

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SUBMARINE USE OF THE OCEAN ENVIRONMENT

Submarines are unique as military machines in their degree of stealth. In all forms of conflict at sea, invisibility and the unpredictable nature of the ocean yields great advantages to the submarine. For example: the stealth of submerged SSBNs is widely agreed to be a factor that helps to deter the use of strategic nuclear weapons in a crisis.

The ocean environment, while providing good protection for the submarine from antisubmarine forces -- whether above, on, or below the surface -- also makes it difficult for the submarine to use the depths for its own benefit. The variations of temperature, salinity, and currents over time and locale, changes in bottom contour and composition, the effects of matter suspended in the water, noises caused by nature and human activities -- all create a complex medium in which it is very difficult for the crew of a submarine to tell what is happening around them. Nonetheless, a submarine's advantage lies in its ability to use the veil of seawater around it to choose its opportunities to attack or evade.

Warfare involving submarines may take place in virtually any ocean area, under any kind of conditions, and therefore with a wide variation in sensor performance. Sonar may detect a particular submarine or surface ship at hundreds of miles in one environment and at a few thousand yards in another. Nonacoustic detection systems such as magnetic anomaly detectors may be seriously affected by the occurrence of certain types of solar storms. Some of these changes in time or space are predictable, and some can only be described with statistics.

Some generalizations about the behavior of passive acoustic detection can illustrate the importance of environmental conditions. Several factors are important for passive acoustic detection: how quickly sound intensity decays over distance traveled and the amount of noise present. The ability of the sonar system to discriminate between noise and a submarine signal may also depend on the local environment. Conditions associated with relatively good and relatively poor detection can be outlined at the risk of oversimplifying a very complex physical problem.

GOOD CONDITIONS FOR DETECTION

The deep ocean is generally one of the best environments for sound transmission, and in areas where shipping is remote and winds are low, detection ranges may be relatively great. The main shipping lanes between North America and Japan, and North America and Europe are more noisy than many other regions, but under good conditions, very noisy targets have been detected at ranges of hundreds of miles.

Many shallow water areas transmit sound more efficiently when oceanographic conditions can support propagation paths that are totally refracted. Such conditions may obtain during the winter, when lower surface temperatures do not cause sound to refract strongly toward the bottom, or in particular geographic areas such as straits where the water is stratified in such a way as to create totally refracted paths.

The central, deep Arctic can be a very favorable environment for detection when the ice cover is nearly continuous, the temperature is stable so that the ice is not forming stress cracks, and the wind is not strong.

POOR DETECTION CONDITIONS

Even when favorable conditions exist at some point in time and space, they can erode rapidly. Changes in the bottom type can change transmission characteristics over a few tens of kilometers. Fronts, such as those associated with the Gulf Stream, can create shadows in which sound from a point on one side of the front is refracted away from areas on the other side. Even a heavy rain shower can undercut detection performance by rapidly increasing the noise level over a broad range of frequencies.

Submarines are hardest to hear when their sounds do not propagate well through the ocean and when there is a great deal of noise present. Shallow water is generally a poor transmission medium because sound reflects from the surface and the bottom many times over its transmission range. At each bounce, sound is scattered in many directions and absorbed, especially by the bottom. In addition to attenuating the sound more rapidly, these repeated scatterings tend to make the sound less coherent, degrading the performance of arrays of sonar receivers. The transmission of sound through shallow water is particularly poor in the summer, when the higher sound speed at the warm surface causes particularly strong refraction of sound into the bottom. Even deep water can be so-called bottom limited if surface temperatures are high enough.

The Mediterranean Sea combines large changes in salinity and temperature over depth to produce very difficult detection conditions. Because of the large number of different nations with naval forces in that sea, the undersea picture can be particularly sensitive in a crisis. For example, at one point during the 1973 Arab-Israeli Crisis, the Commander of a U.S. aircraft carrier was completely surprised by a foreign submarine that surfaced nearby, in spite of the large ASW component associated with carrier battle groups. As it happened, the submarine was Israeli.

Coastal waters have the greatest concentrations of shipping, particularly near ports and harbors, and therefore some of the highest levels of noise. This shipping noise creates an acoustic thicket because it can be similar to submarine noise and both are concentrated in frequencies below a few hundred cycles per second. The poor transmission characteristics of the coastal waters can actually mitigate the effect of high shipping concentrations from distant locations, since the noise itself is highly attenuated. However, many submarine versus submarine scenarios involve the use of passive sonar relatively near a hostile port, where detection ranges would be reduced.

The Arctic region contains a wide diversity of ocean acoustic conditions, including all combinations of shallow water, deep water, open water, ice-covered water, high and low wind speeds. In general, the Soviet continental shelf, which extends over 500 mile from the shore, is characterized by poor detection conditions: depth of less than about 1000 feet; broken ice that grinds together; relatively high wind speeds that can disturb the ice; and, near the Soviet Arctic ports, high shipping noise levels.

Deep water in the lower latitudes does not always transmit sound well. If a ridge such as the one in the North Atlantic lies in the transmission path, the sound may not propagate nearly as well as it would in the absence of such a ridge. This is true even if the top of the ridge rises no higher than several thousand feet from the surface, because sound in deep water travels via long refracted paths that reach great depths, and when those deep refracted paths are cut off, much of the sound energy is lost. In some circumstances, however, that same ridge can cause signals to bounce into refracted paths and improve detection conditions.

LIMITS OF THE OCEAN ENVIRONMENT

The sea masks the presence of submarines in a number of ways. First, seawater is virtually opaque to most electromagnetic radiation. The exceptions to this rule -- blue light and very low frequencies -- are currently being used or investigated for communication to submarines, but do not appear to hold much promise for detection.

Sound energy, at frequencies below those corresponding to the highest octaves on a piano keyboard, travels with relatively low losses through seawater. Navies make use of this fact by detecting the sounds that submarines produce using passive sonar, or sounds they reflect using active sonar that generates a strong "ping."

The effectiveness of passive sonars depends on five basic variables: the loudness of the enemy submarine -- often called the source level; the loudness of the environmental noise background; the loss of sound intensity over distance; the ability of the sonar receiver to "listen" in a specific direction and shut out noise from other directions; and the ability of the signal processor to detect a weak signal in noise. The first four factors determine the signal-to-noise ratio that enters the signal processor, which in turn determines whether or not a signal is present with given probabilities of detection and false alarm.

Except for the source level, each of the variables above are themselves influenced by the ocean environment, and two of these are purely environmental parameters. The ambient noise level is the sum of noises from distant shipping, wind, waves, ice, organisms, and other sources. The loss of sound intensity over the transmission range is determined partly by the geometric spreading law, partly by energy absorbed as molecular components of seawater undergo compression and relaxation, and partly by refraction, reflection, and scattering in the water column and its boundaries.

The other two parameters influenced by the environment are sonar array directionality and the detection of signals in noise. These variables can be thought of as being related to the design of a particular system, while being limited by the environment. The limits are imposed by the random variability in the ocean, both in time and space, and at many scales.

The directionality of an array, and its corresponding ability to shut out noise arriving from all directions other than the one specified, depends on several factors. The performance of the array increases with the size of the array, the number of hydrophones, and the method of processing the data. The gain is limited, however, by irregularities in the ocean which distort the sound waves in a random fashion. Improvements in the array gain have been attained at the price of a great increase in computer processing requirements, but these improvements have been small.

The threshold at which a signal buried in noise can just be detected depends on the ratio of signal to noise power in the frequencies of the signal, and on the statistical properties of the signal and the noise. The sounds of machinery and propellers generally have components that fall into narrow frequency bands. To the extent that all the energy of these sounds is confined to very narrow bands, they can be more easily detected against the background of noise. Once again, however, the variability of the ocean imposes a certain degree of limitation by smearing the energy over a wider bandwidth over the course of its propagation through the ocean. In addition, the submarine signal itself may vary, which has the same effect of spreading the signal energy over a wider band.

One of the most important features of the ocean that determines how sound travels is the profile of sound speed over depth. Changes in the speed of sound govern the refraction of sound as it travels through the sea, and this refraction governs the rate at which sound is attenuated over distance. In the deep water of the latitudes below the Arctic, sound tends to propagate along a depth layer where sound speed is a minimum, resulting in relatively good transmission. In the deep water of the Arctic, cold surface temperatures cause sound to refract upward and scatter off the rough undersurface of the ice.

From this discussion it becomes clear why submarine quieting has such a fundamental impact on antisubmarine warfare: the unpredictable, uncontrollable environment has at least a major influence on every other variable in the passive sonar equation and efforts to improve the sonar system will always meet with sharply diminishing returns.

With submarines becoming quieter, and the environment forcing limits on detection of faint signals in noise, the detection range of individual sensors is bound to decrease. These two facts in conjunction (not simply the quieting of submarines) will alter the military assessment of submarine forces. The new look at submarines will create incentives to adopt new approaches to ASW, or to revive ideas that have been tried in the past, but that were discarded because other, cheaper alternatives were available to detect louder submarines of that era.

Some of the technical directions in which submarine detection could evolve include the use of many small distributed sensors to detect over a wide area. This is a way of avoiding the limitations of array gain and signal processing by simply reducing the distance between the sensors and the submarine. If the sea floor were covered by sensors, then a submarine would never be more than a few miles from one of them. The technical problem becomes one of making sensors and connecting cables that are affordable in the numbers that would be needed.

Other means of surveillance might include small arrays that could be covertly placed by a submarine near the ports of its adversary. Using different physical principles, nonacoustic methods of detection from air or space are the subject of intense scrutiny. These means would be of particular concern if their functioning could threaten the confidence of the nuclear weapon states in the survivability of their sea based nuclear forces.

Thus, an important set of choices may confront the major military powers in the future regarding sea-based strategic nuclear forces. The obscurity of the ocean environment provides a measure of security in the sense of providing a relatively safe, stable haven for these submarines. To the extent that a hypothetical future surveillance system allows the nuclear nations to peer under the waves on a global scale, it may create some military problems while solving others.

Submarines will continue to be potent naval platforms for large and small nations, and will figure in international military affairs across the spectrum of violence. The submarine's ability to use the environment to its own advantage will consequently be an important element in the development of armaments.

Tom Stefanick

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SUBMARINE FORCE, U.S. ATLANTIC FLEET

The mission of Commander Submarine Force, U.S. Atlantic Fleet is to maintain combat ready strategic and attack submarines. COMSUBLANT, unlike other Type Commanders, is also an operational commander. The current Submarine Force is made up of three Submarine Groups and ten Submarine Squadrons consisting of 31 strategic and 56 attack submarines. The Submarine Force consists of 2,500 officers and 29,000 enlisted personnel. Today's Submarine Force operates in all oceans of the world, including the Atlantic, Pacific, Arctic, and Indian Oceans, as well as the Mediterranean Sea.

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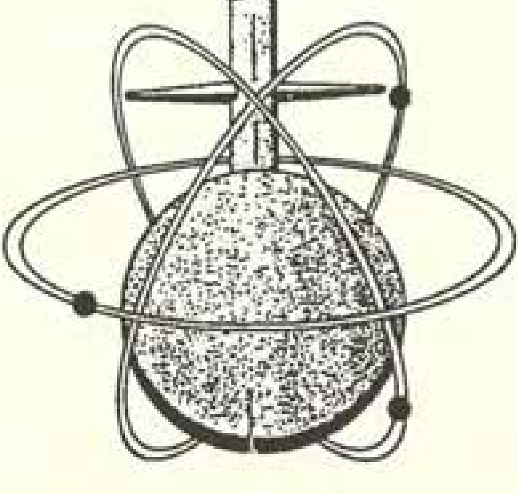

AN ASW PRIMER FOR SUBMARINE PLANNERS

Anti-submarine warfare (ASW) is probably the most complex form of maritime conflict. The search for solutions of the "submarine menace" tends to be focussed on technological "fixes" -- more powerful and longer-range means of surveillance, faster and more accurate detections systems, and stand-off, high-probability-of-kill weapons. Little about the technologies of modern submarine and anti-submarine warfare is comparable with the methods of history's first ASW campaign, World War I. By contrast, ASW strategies have basically remained the same ones that were first tried out more than 70 years ago. What then are the fundamental choices of ASW strategies that provide the framework for the exploitation of ASW technologies.

Anti-submarine warfare (ASW) fought mainly at sea, is aimed at defeating the war-fighting purposes of the submarine. ASW is practiced at three levels of planning: strategic, operational, and tactical. Basic ASW strategies are of three kinds: (1) destruction of enemy submarines (2) containment of them, and (3) limitation of their war-fighting efficiency. The operational level of ASW planning is concerned with where and how to destroy, contain, or limit the efficiency of hostile submarines. The operational choices are whether to defeat the submarine at (1) its sources, i.e. operating bases and construction yards, (2) in transit, particularly in "chokepoints", or (3) in the patrol areas themselves. ASW tactics are concerned with the local coordination of platforms, weapons, and sensors in the area of encounter itself. Tactical ASW consists of four phases: (1) surveillance and reconnaissance, (2) detection, (3) tracking, and (4) attack.

As background, ASW emerged as a strategy preoccupation for naval planners during World War I. Pre-war defensive measures against the "submarine torpedo-boat" were little more than ad hoc adaptations of tactical procedures that had been adopted by most fleets to guard against the other "sneak attack" weapon, the torpedo-boat. The principal offensive measure relied on the warship's superior speed to run down and ram his underwater opponent; defensive measures included sailing a "zig-zag" course and, in port, the erection of physical obstacles (such as harbor booms and blockships, and anti-torpedo nets), and night-time illumination.

The pre-1914 failure to anticipate the strategic scope of the submarine problem can be attributed to the dominant "image" of the submarine. First, the submarine was expected to seek out naval targets; few Allied or Entente naval planners on the eve of World War I foresaw that the submarine would be a commerce-raiding weapon first and an anti-fleet weapon second. Furthermore, most naval professionals doubted that the submarine would be more than a "nuisance." Because of its inferior speed, limited combat radius, and near-blindness when submerged, the submarine was expected to limit its wartime contribution to coastal defense and occasional scouting missions on behalf of the fleet of battleships and battlecruisers. Six months into WW I the prognosis of a quick conclusion had collapsed -- so had the image of the submarine as an occasional nuisance. At sea, the pre-war plans for a "decisive battle" gave way to the search for long-term ways and means for defeating the most difficult opponent in recorded Naval history.

All things equal, the preferred ASW strategy is one that results in the physical destruction of the submarine -- the outcome is permanent and, with the underwater opponent eliminated, resources can be released for other wartime duties. Strategies of destruction have also proven to be the most difficult and risky, depending on the quality and quantity of the opposing submarine force, sinking submarines may take more time and tie up more sources than can be afforded. A different kind of risk may be associated with "strategic" ASW against strategic missile submarines. The destruction or even the threat of destruction of this particular type of submarine might undermine the stability of mutual strategic deterrence, and could force a decision to "use-them-instead-of-lose-them."

The preferred strategy of destruction at source is aimed at submarine operating bases, construction, repair and maintenance yards, and industries that manufacture critical components. The single most important advantage of this approach is that it circumvents ASW's most difficult problem: finding the opponent. Unfortunately from the point of view of the ASW strategist, enemy submarine bases and building yards also tend to be heavily defended and can therefore usually only be attacked at great risk to one's own forces. The allied naval planners of World War I shared President Woodrow Wilson's "despair of hunting for hornets all over the sea when I know where the nest is." But very few among them shared Wilson's willingness to "sacrifice half the navy, Great Britain and we together have, to crush the nest..."

The practice and planning of destruction at the source has known four methods: (1) physical seizure and occupation of bases and yards, (2) fleet bombardment, (3) aerial bombardment, and (4) mining. For reasons that are obvious, the first method is the most decisive one. Yet, for reasons equally obvious, the physical seizure and occupation of enemy submarine bases and yards is likely to be attempted and crowned with success only if they are part of a general campaign of territorial conquest. The Anglo-American and Soviet occupation, in 1944-45, of the French and Baltic coastal areas, respectively, deprived the German U-boat fleet of key operating and construction sources. This outcome was not the result, however, of a deliberate ASW strategy, but instead the "bonus" reward of the Allies' general advance.

Excepting the sporadic shelling, by the Royal Navy, of Germany's U-boat bases on the Belgian coast in World War I, the strategical choice of destroying the submarine menace at its source through fleet bombardment has historically been stymied by the fear of disproportionate losses.

The destructive record of mining and aerial bombardment of submarine bases and yards is a mixed one. During World War I a single U-boat was lost among the more than 44,000 mines that were scattered in the Heligoland Bight; altogether 14 U-boats were destroyed in their Baltic Sea training grounds during World War II. Arguably, the most productive result of the Baltic mining offensive was the interference with crew training and new construction work-up, i.e. with the U-boats efficiency, and may have prevented 20 Type XXI U-boats from becoming operational.

Especially disappointing were the results of the World War II air offensive against the operational and industrial sources of the U-boat. Principal operational targets were the concrete submarine shelters on the French and Norwegian coasts. Even the heaviest bomb of the war, the 12,500 pound "Tallboy," failed to penetrate the roofs up to eight meters thick. One U-boat was destroyed at its base in Trondheim, Norway in July 1943. Post-war tests by the Americans indicated that a future air assault against "hardened" submarine pens would probably require nuclear weapons.

Industrial sources for the Allied bombing campaign included four broad target sets; (1) the U-boat building yards themselves (2) centers for the manufacture of key components (e.g. the Hagen center for the construction of batteries) (3) the German industrial and transportation system generally, and (4) the labor force. The British Bombing Survey Unit concluded that the bombings directly and indirectly contributed to a production loss of 111 U-boats and that another 42 operational units were destroyed in port. The reasons for the low profitability of the anti-source, bombing campaign were (1) the inaccuracy of bomb-laying techniques (2) the enemy's better-than-expected recovery capabilities (3) the generally efficient German air defense system, and (4) the "cyclical" pattern of the "direct" offensive against U-boat pens, yards, and other facilities.

Because of the difficulty of destroying the submarine at the source, the ASW planners are usually compelled to find ways to defeat it at sea, including the submarine's transit and patrol areas.

A key determinant for the success of a strategy of destruction in transit is local geography, i.e. the length, width, and depth of the "chokepoint." The collective ASW benefit of a long and narrow area of submarine passage is" (1) a high predictability of the submarine's comings and goings (2) multiple opportunities for attack, and (3) minimum submarine escape volume.

The opposite conditions usually exist if the submarine's patrol area is in the high seas. It follows that an ASW strategy aimed at finding and destroying the opponent in the open ocean is highly dependent on strategic intelligence about his general whereabouts, strength, and direction of movement. Normally a hunt-and-kill strategy without the benefit of strategic "cueing" has historically shown to be a cost-ineffective search for a "needle in the haystack."

Strategies of destruction in the transit areas have generally relied on minefields, sometimes backed up by mobile surface and air patrols that are linked to "bell-ringer" detection devices. A successful ASW barrier system will destroy few enemy submarines, however. After the first few losses, submarines are likely to be diverted to a less dangerous route of passage; if this does not exist, they are effectively contained. The latter was the fate of the submarines of the Soviet Baltic Fleet during World War II. From the spring of 1943 until the capitulation of Finland in September 1944, the German-Finnish "Walross" barrier of steel nets, mines, and mobile patrols across the Gulf of Finland excluded the Soviet underwater flotillas from the Baltic Sea.

Destruction strategies in the patrol areas comprise "offensive" hunter-killer (HUK) and "defensive" armed-escort of the targets of the submarine, i.e. the convoy system. Between the two, falls the system of "protected lanes." This last strategy combines intensive hunter-killer and close escort operations in the approaches to ports and harbors where seagoing traffic is "funneled," and where enemy submarines may be expected to concentrate. Although a failure in the past, some Western naval planners today believe that, between much improved detection capabilities and a shortage of convoy escorts, the strategy can and must work.

Today, as in the past, the prospect of a hunter-killer strategy is vitally dependent on strategic cueing. During World War II, Allied "hunting groups" achieved spectacular successes thanks to two sources of "strategic" intelligence: (1) the interception and location of U-boat radio traffic through high-frequency direction-finding and (2) the de-cryption of the U-boat fleet's "Triton" cipher. Contemporary strategic intelligence about enemy submarine movements still relies, in part, on communication interception, but ASW plans cannot depend on a repeat of the Triton-breaking success of World War II's "Ultra" group. Instead, billions of dollars and rubles are being invested in extremely long-range acoustic and non-acoustic ocean floor-mounted and satellite-carried ASW "early warning" systems.

Today, the convoy system is usually labeled a "defensive" ASW strategy and considered "inferior" to "offensive" HUK. The two world wars show that (1) the convoys were the single most successful means for defeating the purpose of the U-boat -- to sever the Allies' economic and military arteries, and (2) ships and aircraft on convoy escort duty destroyed more submarines than did their counterparts engaged in HUK operations.

Destruction of the enemy's submarine is a bonus; the essential purpose of the ASW strategist is to defeat the war-fighting purpose of his opponent. Containment strategies have historically depended on physical obstruction of the submarine's movements, including minefields and nets.

The advantage of an ASW strategy of containment is twofold: (1) it minimizes the risk of casualties that is part and parcel of destruction strategies, and (2) it reduces the need for current intelligence about the submarine enemy's plans and movements; in theory at least, all the ASW defender needs to do is to find the right "cork" to "bottle up" the opponent. The disadvantage of containment is also twofold: (1) it is quite difficult to create a hermetically-sealed barrier, and (2) containment schemes are likely to tie up forces that are badly needed elsewhere.

Most close-in ASW containment schemes have relied on minefields. Few have proven effective. Success in mine warfare ultimately depends on the relative stamina of the two sides, i.e. the relative persistence of the mine-layer and the mine-clearer. The Allied mine-laying campaigns of the two world wars failed to contain the U-boats inside their bases because the Allied navies were unable or unwilling to patrol the fields within easy reach of enemy counter-attack, and prevent the Germans from clearing a safe passage through the cordon.

Static containment strategies without the presence of mobile reactive forces have proven equally unproductive in the submarine's transit and patrol areas. A determined submarine opponent will find means to find or "create" a crack. The most famous anti-transit barriers of the two world wars were the Dover and Northern mine "barrages." The first involved a combination of minefields and "tripwires" laid across the English Channel; the second depended on tens of thousands of mines planted in the Greenland-Iceland-United Kingdom "gap." Neither were effective. Four-to-six U-boats were lost on the Dover barrier and a single U-boat may have fallen victim to World War II's northern barrage.

Strategies for Limiting the Submarine's War-Fighting Efficiency. If the enemy submarine cannot be destroyed or contained, yet is denied the full use of its destructive capabilities, the ASW strategist has achieved his purpose. The choice of efficiency-limiting strategies begins at home, and is dependent on the war-fighting purpose of the enemy submarine fleet. For example, if the purpose is economic strangulation, the ASW defender may counter by reducing his dependence on seaborne commerce (by food rationing, and boosting domestic sources of supplies). If the threat is one of strategic missile attack, various passive and active "damage limitation" measures are possible.

Production efficiency may be reduced by aerial "harassment raids," aimed at forcing yard workers to repeatedly stop work and seek shelter. One of the hoped-for effects of the Allied city bombings was the lowering of the morale and hence fighting efficiency of U-boat crews.

Efficiency-limiting strategies in the transit to patrol areas are designed to minimize the submarine's productive patrol time. Forcing the enemy to use a more time-consuming route does this. For example, the success of the "improved" Dover Mine Barrage of 1917-18 lay in the forced re-routing of the U-boats via the more distant waters between Norway and Scotland. Broad area search and surveillance by patrol aircraft may also delay submarines in getting to patrol areas. During World War II, the fear of airborne discovery forced the U-boats in transit through the Bay of Biscay to spend increasingly more time at slower underwater speeds.

The submarine's productive period in patrol areas is determined, in part, by the amount of fuel and weapons it carries. Thus, interfering with its logistics infrastructure may be important. The best known illustration of this particular strategy is the systematic Allied campaign of World War II to destroy the "Milch Cows" -- the U-boats replenishment submarines.

Summary:

The table below compares the destructive productivity of different ASW methods during the two world wars. Not shown are submarine losses due to scuttling, collisions and other marine accidents, capture, or own forces.

Subnarine Losses Due to Enemy Action in the Two World Wars

	Surface ships[1]	Aircraft[2]	Surface ships and aircraft	Submarines	Mines[3]	Other	Unknown	Total
World War I								
Germany	73	1	-	18	48	-	19	159
Great Britain[4]	7	1	-	5	10	-	8	31
World War II								
Germany	246	349	50	21	26	7	29	728
Great Britain	25	5	1	4	27	-	7	69
United States	18	5	6	1	5	-	9	44
Japan	65	13	7	21	2	-	16	124
Italy	32	23	4	19	2	1	4	85
Soviet Union	70	5	-	5	41	1	43	115

1) includes naval and non-naval surface ships, using ramming, gunfire, explosive sweeps, and depth charges.
2) includes submarines destroyed in port.
3) includes losses "probably" due to mines.
4) includes 3 Canadian and 2 Australian submarines.

Table 1

Jan S. Breemer

SUBMARINES IN THEATER NUCLEAR WAR

There seems to be some discomfort in accepting the increasing importance of submarines in future sea wars, and their ability to carry out their assigned missions. In addition, there is a pervasive worry about war in general and the danger that any war can escalate to the use of nuclear weapons. Given such observations, it is appropriate to first look at the capability of the theater submarine, SSN or SS, in a nuclear war environment; then to examine the probability of a theater nuclear war-at-sea.

How effective is the theater submarine in a nuclear war environment?

To understand this, there are three major categories of factors to consider: the operational capabilities of submarines which may use either conventional or nuclear weapons in nuclear war; the effects of nuclear weapons which can impinge on those submarines at sea; and the nature of nuclear ASW.

Because the strongest foundation of deterrence is a credible war-fighting capability, and because the concept of deterrence includes the discouragement of escalation at all levels of conflict (with an implicit linkage from one level to another), the operational capabilities of each and every U.S. force, vis-a-vis its opponents, form an armor of deterrence with which the United States protects its citizens and interests and supports its allies in their security pursuits. It is thus those operational capabilities of submarines in a theater nuclear war that form one of the strongest links in the deterrence of that level of conflict. And, since nuclear war most probably will happen at sea if it breaks out anywhere, the submarine potential for deterrence of any nuclear war -- at sea or ashore -- should help deter any superpower hostilities.

Deterrence by any force has to be posed both before hostilities start, and during any phase of conflict which can lead to full engagement. Importantly, most modern U.S. theater nuclear naval forces are dual-capable in that they can participate in both conventional and nuclear weapon encounters. By viable participation at lower levels of violence, while remaining ready to fight at the higher levels, they contribute to deterrence at both levels of conflict.

Significantly, the operational capabilities of theater submarines are uniquely suited to that deterrent posture -- with their potential to fight effectively at both the conventional and nuclear level.

Those capabilities have to show two simultaneous faces: the ability to deliver punishing damage, and the strength to withstand the damage which the enemy is capable of inflicting. An ideal naval force in a theater nuclear war should therefore feature stand-off weapons of over-the-horizon cruise missiles or possibly ballistic missiles and very long range torpedoes, all launched from undetectable platforms that can survive relatively close-aboard bombardment explosions and out-run homing weapons. These are characteristics inherent to attack submarines maintained at the leading edge of technology.

Obviously, the question of gaining these warfare characteristics with modern SSNs or with up-to-date carrier battle forces is one of money and resource allocation. Significantly, the strength of a CVN or a modern CV is itself a powerful deterrent to any war-at-sea. When it comes to actually fighting a theater nuclear war, however, it stands to reason that the U.S. theater submarine should be the preferred platform to carry the war to the Soviet fleet, simply because of its hardness and stealth attributable to being submerged. In addition, the allocation of resources has to consider the probable conditions of such a battle at sea. As most planners now see the at-sea situation, it would be a U.S. ASW action against Soviet submarines attempting to interdict the SLOC's in the open ocean and a U.S. submarine action against the Soviet surface fleet, theater submarines, and strategic submarines in their "bastion" areas. It would seem, therefore, that if the threat of theater nuclear war-at-sea can be considered real to any extent, the resource allocation scales should be tipped to the attack submarine components of the future U.S. fleet, as it has been done in the Soviet Navy.

Since credible survivability is so important in this context, the effects of nuclear weapons in a very general way at least need to be looked at. These are usually considered to comprise blast, radiation and heat. As far as submarines are concerned, the attenuation properties of sea water mitigate both radiation and heat effects. Blast has always been considered the critical factor in nuclear ASW, with overpressures and shock being-means of concern. There is no intention to minimize these effects on submarines, but it is appropriate to emphasize that a modern submarine is a very tough structure, and its water environment is one that permits translation with force, rather than upset like a highway truck in a hurricane. In the same manner that overpressure can be addressed in the design of a submarine and its systems, shock forces can be taken into account in its mechanical equipment foundations and the internals of electronic systems. In short, while direct hits will continue to be bad news, the near miss distance for a disabling shot on a submarine tends to be far less than on a surface ship or aircraft.

Two other effects are of concern to the theater nuclear war-at-sea forces. EMP, or electro-magnetic pulse, is a phenomena caused by exo-atmospheric nuclear bursts which generate large electrical currents in bodies which act as antennae. A nuclear weapon detonation over Sicily, for example, could cause currents in shipboard systems which could critically damage every unprotected naval computer between Gibraltar and Israel, and seriously affect all communications except the lowest frequency ones. The submerged submarine however rarely presents an antenna susceptible to EMP effects and requires very few external communications to function properly -- while the necessary transmissions to submarines of very low frequencies are basically hardened against the effects of nuclear explosions. The other effect of a nuclear weapon which needs to be recognized is the noise generated by an underwater nuclear explosion. The reverberations within the ocean caused by a nuclear underwater blast are likely to be overwhelming as to sonar use, but there are variations in this effect due to basin geography, size of warhead and water conditions. Yet, a useful rule of thumb is that the bigger the ocean and the further away the detonation is, the less effect that it will have on the sonar performance of a submarine. It is a problem, but it is probably not disqualifying to a competent submarine's ASW effectiveness. It may even serve to mask the sonar performance of an enemy's countermeasures.

The third major category of effects from nuclear explosions has to do with the nature of nuclear ASW, or the realities of how submarines can be attacked with nuclear weapons. In ASW the kill mechanism is one-half of the problem. The tendency, in considering nuclear ASW, is to assume that the lethal radius of the weapon will make up for inaccuracies in localization of the enemy submarine by the detection system employed. That may not be a valid assumption. ASW weapons are basically depth bombs or homing weapons. Depth bomb attack is inherently more inaccurate than attack with a homing weapon due to the potential for submarine movement during the firing approach to an assumed target position and the sinking time for the depth bomb to go to a lethal depth. Homing weapons, while being more susceptible to countermeasuring, however, have the potential to make up for fire control errors. If decoyed, moreover, a homing weapon is likely to be more traumatic to the hunter than to the hunted -- if the homing weapon is then triggered closer to the attacker. Occasionally, ballistic missile attack is considered as a viable ASW killing measure. Although proposed as an anti-SSBN measure, it could be useful against theater SSNs or even SSs. The first problem is that ballistic missiles are expensive and may be husbanded -- because of short supply due to arms control actions. The second problem with ballistic missiles in ASW is the unpredictable target travel during a relatively long time of flight, particularly if fired from shore emplacements.

It must be recognized that the much bigger bang available in nuclear weapons may not solve most of the problems inherent in any type of ASW.

The modern submarine can inflict heavy damage during a nuclear war-at-sea with both conventional and nuclear weapons. In addition, it can safely be said that today's submarines have a significant potential for surviving in engagements in either level of sea warfare. It is therefore reasonable to accentuate the positive qualities of submarines in order to better assure their deterrence of nuclear war-at-sea.

A number of capability enhancements can be postulated which should do that. Nuclear weapons employed for under-ice warfare make sense due to the ocean anomalies encountered in this environment and which affect homing weapon use. The most important enhancements however should be in the submarine platform itself. Keeping a force of submarines at the leading edge of technology will not be inexpensive, but it should suffice to hold an advantage in this most stressful naval situation -- that of nuclear war at sea. Keeping that advantage is what will deter nuclear war. That seems to be a necessary step in the escalation process. A decisive submarine fleet may be thought of as a critical force with a deterrent warfighting value well in excess of cost and risk.

Although both submarines and nuclear war are subjects of general concern, it can be noted that understanding of the one operating as a vital part of the other is not high on the agenda of students of naval warfare. In fact, apart from a certain emotion which both subjects engender, the details of each are considered so arcane as to be difficult to understand. Therefore, one seldom sees them tied together for serious consideration as a credible influence on the outcome of a future war. There are two chains of logic which might explain this failure. On the nuclear side, there are many in the west who do not see the need for nuclear-equipped theater forces as well as strategic forces for the deterrence of war. There are also many who do not appreciate the importance of what happens at sea as well as from the sea. On the submarine side, some see the only tasks for western navies as the protection of the resupply lines to the Eurasian battlefields. In their view, the most logical use for submarines is as sophisticated ASW platforms for direct coverage of those SLOCs or to reduce the number of enemy submarines which might threaten high seas shipping. Others believe that the only job of navies is to provide a potential for shore strike and sea control, and submarines should merely offer an ancillary support as opposed to providing a major part of the shore strike capability and necessary sea control so that other forces can carry out their missions successfully. No matter what logic is used, submarine operations apparently remain much of a mystery because they take place outside the realm of instant intelligence and on-demand response to modern communications. As to a war at sea being possible between the superpowers, the likelihood is good because the superpowers have intersections of vital interests there and they have the available forces to fight each other. That conjunction of conditions is apparent in several areas of superpower competition -- the eastern Mediterranean, the northwestern Pacific, sometimes in the Indian Ocean and always on the northern flank of NATO. It can then be stipulated that a major war at sea is possible and the rationale for escalation to nuclear war should thus be examined.

The general case for escalation can be delineated in terms of vital interests which are at risk when conventional arms have failed to achieve desired war goals. In addition, there must exist a potential for answering an increased level of violence. Specifically, the incentives for either side to resort to theater nuclear force can be shown by using the northern flank of the NATO-Warsaw Pact confrontation as an example. If the Soviet's DELTA and TYPHOON submarines were put at serious risk by U.S. and other NATO SSNs the Soviets might escalate to nuclear war. They may also risk using nuclear weapons if they find themselves unable to prevent western aircraft carriers from coming to within strike range of the Soviet Union. In the North Atlantic, the Soviets may need to neutralize or delay the Allies' resupply convoys to within the time constraints of the central front air-land battle action. It has to be noted that similar incentives to escalate can be expected on the NATO side. It should also be recognized that there can be a need to neutralize Soviet interdiction submarines on the Atlantic SLOC -- should allied ASW fail or prove too slow. This could, for example, cause western Allies to use nuclear Fleet Air Defense weapons to protect logistic ships and Battle Groups from mass missile attack by land-based Soviet naval aircraft.

In addition to the various incentives to use nuclear weapons, the instabilities which may exist in the conventional battle and which might hasten the move to a higher level of violence, must also be considered. A force asymmetry is one type of wartime instability which can be due to one side not having enough in numbers of either platforms or required weapons, or by one antagonist not having sufficient speed, weapons capability or sensor effectiveness. It should be noted that one often cited instability is the assumed vulnerability of U.S. aircraft carriers to the nuclear-tipped anti-ship cruise missiles of the Soviet submarine force. However, it may well be found on closer examination that this instability does not actually exist. In fact, the toughness of large CVs and CVNs against conventional weapons may militate against the initiation of a war at sea, itself. A single hit in the hangar deck by a cruise missile with a 2200-pound warhead of high explosives might cause uncontrollable fires which could sink a carrier, whereas half a dozen torpedo hits might only slow it to 20 knots.

It is hoped that two points have been made clear: (a) that nuclear war at sea is quite possible and does not have to be closely coupled to a nuclear war on land; and (b) that diesel-electric submarines which can employ nuclear weapons will become more, rather than less, important in both alliance and national interests -- as the threat of nuclear war at sea increases. But most importantly, the capability of a submarine, whether nuclear or conventional, to pose a threat of nuclear weapon attack is an important factor in the deterring of an escalation to nuclear weapons in a theater conflict.

James C. Hay

TORPEDO PROPULSION: THEN, NOW, TOMORROW

Whilst forty years ago the torpedo was solely an anti-surface ship weapon, over the years it has increasingly assumed a primarily anti-submarine role. The requirements and resulting technical specifications called for to engage the two targets are radically different and until recently achieving a weapon to perform both tasks was a major challenge. The air-dropped weapon, which was first developed as an anti-ship device, today poses fewer problems of compatibility. The heavy-weight torpedo can be either ship or submarine-launched, but the ship-launched weapon has, in the main, only an anti-surface ship role to fulfil.

Because of these varied requirements, different nations have viewed the balance between these roles in a different light. For example, over the past thirty years whilst Germany and

Sweden have developed 533mm torpedoes primarily to counter a surface vessel threat, both the U.S. and U.K. have regarded the submarine as the heavyweight torpedo's main target. These differing operational requirements have had a significant effect on the propulsion systems chosen in different torpedo designs.

Propulsion Requirements

To achieve those roles, a modern torpedo design, be it lightweight or heavyweight, has to meet a number of requirements which are at times mutually exclusive. In particular, as far as the powerplant is concerned:

- o The torpedo has to be fast enough to overtake and attack an evading target;
- o It must be quiet enough not to be detected itself, thereby allowing the target to launch effective countermeasures;
- o It requires sufficient range and endurance, to attack at the maximum practical range and to compensate for any inaccuracies in the target's computed position;
- o It should have sufficient endurance to re-attack if it misses first time -- a capability unique to the "underwater missile;"
- o Its combustion products should not produce a detectable wake;
- o The power plant and propulsor contribution to self noise, which interferes with the torpedo's homing capability, should be low;
- o Engine start-up must be rapid, to ensure safe discharge from a torpedo tube or water entry after air drop.

All the above requirements must be achieved whilst leaving sufficient space to carry the necessary guidance system and a lethal warhead.

A torpedo propulsion system consists of three main separate elements; the energy source; the prime mover; and the thruster. Together, they form what is generally known as the torpedo after body.

Battery-powered Homing Torpedoes

The main thrust of U.S. developments during WW II and of the U.K immediately post war was to achieve effective homing weapons, for which a quiet, electrically-driven torpedo offered the most promising platform. In the U.K., the Mk20 passive homer became the Mk23 wire-guided version, to be replaced by the dual-mode active/passive-homing Mk24 (later TIGERFISH) in the late seventies. In the U.S., the wartime Mk18 anti-ship passive weapon went through successive changes via the Mk27 to be replaced eventually by the wire-guided Mk37, a short 5m, 485mm-diameter weapon for anti-submarine use only (the contemporary anti-surface ship torpedo was the Mk45, capable of carrying a nuclear warhead.) France developed the F17, Italy the A184 and Germany the anti-surface ship SEAL, its shorter submarine-launched SEESCHLANGE companion (for ASW use only) and the dual-purpose SWT export model. The later versions of these weapons are still in service, and will be for some time.

All these battery propulsion systems had common features, if many details are different. The lead/acid battery has been replaced by a silver/zinc battery (developing some 125kw in a full-size weapon) which was stored in sealed bags in each cell. The battery is primed immediately before firing and will develop full power within 20 seconds, the firing sequence thereby starting at launch minus 20 seconds. Typically the priming mechanism is a coiled rod which, on rotating, releases a plunger in each cell which ruptures the bag allowing the electrolyte to flow in under gravity. As silver/zinc batteries are temperature-dependent, it is necessary to warm tube-borne weapons to about 12-15°C.

Dual Speed, whereby the torpedo searches at low speed to enhance homing and increases speed for the final run to the target, is a common feature usually achieved by the simple expedient of connecting the two battery stacks either in series or in parallel (a more sophisticated solution, adopted for instance for the Swedish TP43XO 400mm-dia. torpedo, is to have the battery supplying the main motor via a thyristor switch unit, giving access to three speeds selectable during the run). The power thus generated drives a series-wound DC motor with a contra-rotating field rotor and armature, driving the forward and after propellers, respectively, by direct shafts without the need of a gearbox. A performance in the order of 26/28 knots for 30,000m, or 36/38 knots for 15,000m, is achieved. Later versions may do slightly better.

This propulsion system is thereby relatively simple, inexpensive and reliable. The battery-driven torpedo offers another advantage: it makes "swim-out" tubes possible.

Thermal Powered Torpedoes

The advent of the SSN capable of speeds of up to 30 knots and hitherto unanticipated diving depths threatened to outpace the weapons. It was necessary, therefore, to recreate the classic torpedo speed advantage of 1.5:1, and at the time there was no battery available which could generate the necessary power (75kw) within the space constraints of the light-weight torpedo dimensions. Secondly, U.S. homing technology had advanced to the state which made active homing at 45 knots a practical proposition.

The result was the Mk46 torpedo. In its initial Mod 0 trial version the engine was driven by hot gases generated by the burning of a solid, cordite-type charge. This system was, however, too noisy to optimize homing and was soon replaced by the Mod 1 variant, which entered service in 1965. A mono fuel known as "Otto fuel" powers a five-cylinder reciprocating engine, which drives two contra-rotating propellers via a gear box.

Otto fuel, a propriety compound, contains its own oxygen. It is relatively energy-efficient, safe and easily handled. Once ignited by a pyrotechnic charge, combustion is self-sustaining, the high resulting temperatures being reduced by sea water injected into the combustion chamber; the resulting gas and super-heated steam drive the engine. The fuel storage and handling system therefore, is simple and does not need complex pumps or pressure vessels.

When the U.S. replaced the Mk37 with a dual-role torpedo, they decided, at the start, on the thermal propulsion system to achieve the required specifications of 900m depth, a variable speed (55 knots top) and a range approaching 40km.

Range is linearly related to fuel capacity for a given speed, but increased speed demands an inexorable rise in power following a cube law. An increase from 45 to 55 knots, therefore, calls for the doubling of the power transmitted to the propulsor: better propeller design goes some way to achieving these power levels, but the key is an efficient fuel engine combination.

A Gould weapon powered by Gould's own swashplate engine, competed against a Westinghouse turbine driven torpedo, which was much quieter. But the Gould engine was more efficient, particularly at maximum operating depths where the combustion products are ejected against very high back pressures. As torpedo noise was not, at the time, considered to be a problem when U.S. submarines had both the sonar and weapon advantage, the Gould design, the Mk 48, was selected.

New Systems

The British STINGRAY is not strictly new in that it has been in service now for some four years, but it most certainly has an effective, improved sea water battery.

STINGRAY's sea water battery consists of stacks of magnesium alloy/silver chloride cells using sea water as the electrolyte, the water being circulated by pump. The voltage is controlled during battery discharge by regulating the sea water intake, making performance sensibly dependent of sea water temperature and/or salinity. The battery-powered motor provides auxiliary power, both hydraulic to power actuators and AC for the nose sonar. The DC motor is contra-rotating with the field coupled to the forward propulsor via a hollow shaft, and the armature coupled to the after propulsor via the central shaft. The contra-rotating propellers are ducted, which both reduces noise and enables the weapon to run closer to the surface at full power without cavitating. Only one speed is used -- full power -- matching the thermal engine's speed.

Perhaps the most critical feature of the sea water battery is to achieve rapid fill on water entry -- otherwise, battery fires can result. Though not strictly part of the propulsion system design, careful parachute design is an essential element to ensure controlled water entry and pull out.

Battery development has continued and both France, with MURENE, and Italy with the A290 lightweight torpedoes due in service in the early nineties are using an aluminium/silver oxide battery with potassium hydroxide dissolved in sea water as the electrolyte. In comparison to Mg-AgC1, Al-Ag0 provides a somewhat better energy density, is unaffected by salinity, and is less critical in its start-up or fill requirements. A separate lithium battery powers the electrolyte pump, delivering the electrolyte at constant rate via a closed-loop circuit which includes a heat exchanger and a gas separator to inject the generated hydrogen. Battery temperature is thereby adjusted to provide constant voltage but the electrolyte management system at present is battery.

SPEARFISH: *Back to Thermal Propulsion*

In deciding to develop a new torpedo rather than buying the Mk48 in its updated Mk5 ADCAP version, the U.K. were concerned that the reciprocating engine could never be made sufficiently quiet to achieve "stealth" at slow speed. To sustain a 1.5:1 speed advantage over the ALPHA, a top speed of over 60 knots would be needed, demanding a power output in the region of 1000hp. Also, with the reported diving depth of the ALPHA exceeding 1,000m, sustained high speed at this depth would be needed. Batteries were out of the question; a turbine was essential if "stealth" was to be achieved, and a fuel with greater energy density than Otto fuel was required.

The solution was to adapt the Sundstrand engine, originally developed for the Mark 48, double its power output, and enhance the thermal efficiency of Otto fuel by 40% by mixing it with an oxidizing agent, hydroxylamine per-chlorate. Great care has been taken to ensure that on no occasion does this agent come into contact with Otto fuel until intended.

Seawater is added at the combustion chamber and the resulting hot gas and superheated steam mixture drives a single rotor via the turbine and gearbox, operating in a duct with a rear mounted stator. The auxiliary power alternator is driven via the gearbox. Quiet operation has been achieved by careful duct and propulsor design, effective suppression mounts, exhaust-silencing and hull baffling. The combustion products are nearly all soluble thereby giving a wakeless track.

Closed Cycle Thermal Engines

The main disadvantage of thermal engines is that the exhaust gases have to be ejected outside the torpedo.

The U.S. Mk50 Advanced LightWeight Torpedo is nearing the end of its development. The required speed of 55 knots and long endurance call for some 150kw of power, which could not be met within lightweight dimensions from any conventional source, thermal or battery. The Garrett closed cycle engine was eventually selected as the technical risks of the advanced battery development were assessed as being too high.

The principle of this engine is simple, but the technical complexities of achieving a reliable torpedo engine are not. Metallic lithium is melted by pyrotechnics in a boiler, whose internal and external boundary is a coiled stainless steel tube through which water/steam is passed. Gaseous sulphur hexafluoride is injected into the lithium and the resulting violent but controlled reaction generates steam at very high temperature to drive a high-speed turbine. The steam is then passed through a hull section condenser, and recirculated through the boiler. The combustion products take up less space than their original constituents, and therefore there is no exhaust -- both fuel and steam are sealed systems. Performance is, thus, independent of depth.

The final weapon has emerged some 100kg heavier than the Mk46 it is to replace. The same diameter has been retained, but the weapon is slightly longer. A number of major problems had to be resolved. Variable speed is essential, but the residual boiler heat makes quick acceleration or deceleration difficult. Quick start-up on water entry causes similar problems.

Both France and the U.K. are carrying out feasibility studies and demonstrators of closed cycle engines as potential power plants for their own next generation weapons. Closed cycle technology promises increased power, quieter propulsion, full performance at depth, no exhaust (silent and wakeless running) -- all features that would dramatically improve the Mk48's performance.

Whilst there is no actual torpedo which calls for an advanced lithium battery, research continues and the lithium/thionyl-chloride battery is still the most likely contender from a number of lithium-based options. Overall efficiencies similar to that of closed cycle engines are likely. A lithium anode, coated with lithium chloride by the resulting reaction, acts with liquid thionyl-chloride serving as both cathode and electrolyte. Thionyl-chloride is corrosive and lithium potentially dangerous, and units are, therefore, hermetically sealed, but it is a flexible battery and varying the ratio of anode to carbon current collector surface area makes cells with very variable discharge rates. The battery has a specific energy density some seven times that of Al-Ag0. It is perhaps not surprising that high rate batteries still present considerable safety problems.

The future path of torpedo propulsion is by no means decided. There will be very few opportunities for major developments other than the planned U.S. Mk48 update. In the mid-1990s Germany plans to install a new power plant in her silver/zinc battery-powered DM2A3 torpedo. Beyond that, STINGRAY, MURENE, A290, Mk50, SPEARFISH and other modern weapons will assuredly be updated, but no new torpedoes are apparently planned before 2015 -- except, perhaps, in the Soviet Union. Torpedo propulsion is perhaps reaching a plateau of high capability, beyond which it will not significantly advance.

[*This article is condensed from an article by Brian R. Longworth in Military Technology 9/88, and is published with the permission of that publication.*]

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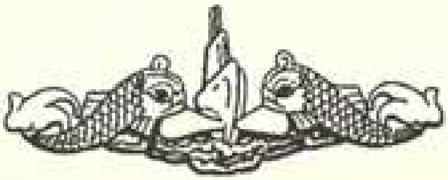
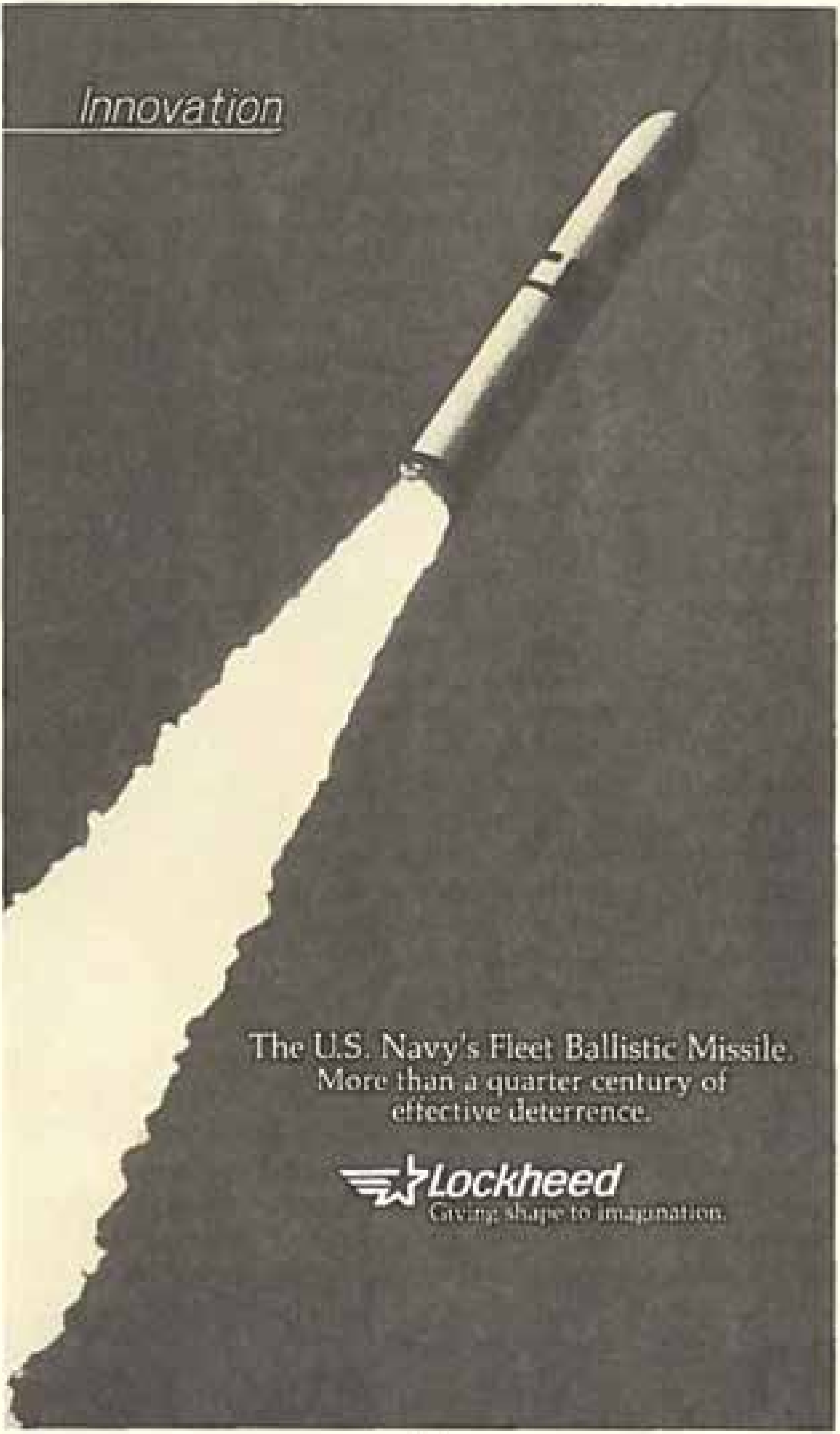


DOLPHINS

The insignia of the U.S. Navy Submarine Service is a submarine flanked by two dolphins. Dolphins, traditional attendants to Poseidon, the Greek God of the sea and patron deity of sailors, are symbolic of a calm sea and are sometimes called the "sailor's friend." A gold insignia is worn by officers and a silver insignia by enlisted men.


In the defense of our nation, there can be no second best.
716
Newport News Shipbuilding


Innovation
The U.S. Navy's Fleet Ballistic Missile.
More than a quarter century of
effective deterrence.
Lockheed
Giving shape to imagination.

SUBMARINERS' INGENUITY

On the first patrol of the USS S-31 off the Paramishiro Islands in the North Pacific, a large ship appeared out of the ever present fog, close aboard -- with avoiding action necessary for the S-31 to avoid a collision. Having radar would have eliminated this embarrassing wartime situation.

Returning to San Diego in late 1942, the S-31 had an SJ radar with an A-scope presentation, installed.

Later, while acting as a training submarine at Espiritu Santos, and in combination with this chore, the S-31 tracked, with her new SJ radar, a good many warships as they came and went from this refit base in Noumea, Caledonia. One of those ships, the USS SOUTH DAKOTA, our newest battleship at that time, brought into port an ex-submariner who was eager to get back into submarine duty. Chief Radio Electrician Dolan had cruised with the SOUTH DAKOTA since her commissioning and knew that this battleship had the latest electronic equipment on board, the latest radars and the latest communications gear. Fortunately, he was transferred to the S-31 because of a vacancy we had in our crew. Dolan knew there were spare General Electric Plan Position Indicator (PPI) scopes on board which would never be used and were just what the S-31 should have to greatly improve her radar readouts. Hence, along with Chief Dolan, a plan was developed to purloin a spare PPI console from the battleship and bring it aboard the S-31. The plan called for a midnight snatch, or "an appropriating for one's own use without proper authorization" a spare part, for which a forged requisition was duly left behind on expropriating the spare PPI console.

The deed, though clandestine in nature, was easily done and a G.E. PPI console was quickly brought back to the S-31, on a hot night in June of 1943. This all sounds real simple, but the rest of the story gets far more complicated.

Upon delivery, it was discovered that the measurements of the console, prior to bringing it aboard, had been in error by an eighth of an inch. It would not pass through the conning tower of the S-31. Every conceivable method was tried in order to fit the console through other hatches on board the submarine -- all without success. Finally, since the decision had been made that the PPI was absolutely necessary, it was agreed that it would have to be chopped up in order to get it into the boat; then it would have to be re-assembled after all parts had been struck below. Hack saws, chisels, screw-drivers, soldering irons, pliers and name tags were obtained and the work was started. On each console strength member, as it was cut, a colored name tag was attached in order to match up the joints when re-assembly was attempted. Likewise, each wire connector which had to be cut was tagged. Finally, the entire PPI console was deposited in the control room of the S-31 because the small S-boat conning tower was not large enough to hold the assembled PPI. Then the work really started. After some fifty hours of exceptional effort on the part of Ensign E. I. Malone and Radarman 3/c Reinsch, the console was re-assembled and made ready for electrical hook-up and testing.

It was discovered, however, that a compatibility electronics problem was just commencing. The SJ radar was a Western Electric product, while the PPI scope was a General Electric product. It was then belatedly discovered that different voltage supplies, different frequencies, and different components were involved. Even though neither Malone nor Reinsch were particularly experienced in the fundamentals of the G.E. radar, they rapidly acquired the knowledge for combining the differences between the two systems by substituting resistors and capacitors, adjusting the two sync voltages, substituting relays, and inserting delay lines where necessary in order to utilize a common frequency. In the space of sleepless application, they were ready to test their jury rigged system.

As in any new radar equipment of those days, warnings had been issued as to the danger of overloading a magnetron. Even though the "maggie" of this period was rated at only a half a megawatt, this was something to contend with since explosions and implosions had been recorded and written up in publications issued by the Bureau of Ships. Therefore, after the proper precautions had been observed, all hands were ordered to clear the control room when the system was energized.

Nothing untoward occurred. It seemed that our PPI was in business. Aside from such factors as the PPI not tracking with the A-scope of the SJ and the sea return of the PPI being of unusual proportions, everything seemed to operate well. With a few more adjustments and substitutions of various components by the trial and error method, all hands were truly amazed when the hand crank mechanism of the SJ finally influenced the PPI magnetic field to follow it with a reasonable amount of accuracy.

With the new SJ system under control, the modification team were given two-day passes to catch up on lost sleep. In the meantime, the skipper, a USNA graduate, who felt he could practice his mechanical and electrical ability on the basis of his eight year old BS degree, decided that a fully electrical training gear was much better than the hand-train presently installed. So, a half horse power motor was also filched from a warship and a spur gear was designed which could be inserted in the hand-crank-to-motor system in order to eventually provide a completely automatic system. This reduced the need for an additional watch-stander in the conning tower. It turned out, however, that the skipper did not remember very much about cutting gears. He designed the teeth from an old steam engineering text book found on board. His design was then sent over to the USS ARGONNE, a destroyer tender, but the ARGONNE'S repair officer sent word back that, with the gear ratio specified, the spur gear would not work. However after several boat rides to and from the tender, a satisfactory gear was designed, manufactured and installed. Even though it was noisier than a threshing machine, it worked admirably. Later modifications moreover quieted the mechanical aspects of the assembly.

It was believed that the SJ's new radar system would enable fleet-boat skippers to conduct night surface attacks without forcing them to stay on the bridge. In fact, a more effective fire control solution was obtained with the C.O. in the conning tower watching his PPI scope and the TDC simultaneously.

Thus, the marriage of the Western Electric SJ radar with the General Electric PPI scope in a submarine came into being. The concept, with a detailed design description, was submitted to the Commander Submarine Force. He then put qualified engineers on the job who provided the radar attack system which was used so successfully for the duration of World War II in all U.S. submarines.

Mike Sellars

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EVOLUTION OF MODERN U.S. SUBMARINES FROM END OF WORLD WAR II TO 1964

Immediately after World War II, despite advice from the British Admiralty that we were wasting our time to develop a snorkel for two-cycle diesel engines, we did just that and completed successful full power trials on our first installation.

Many other problems were solved and the installation of a snorkel became standard in the high priority GUPPY conversion program then underway.

GUPPY CONVERSIONS

(the Greater Underwater Propulsion Program)

The GUPPY conversions included primarily maximum streamlining and installation of the snorkel and a high capacity storage battery. Result: more than doubling underwater speed. One major problem was to develop effective ship control equipment and operation procedures to operate safely under the greatly increased speed and maneuverability of this dynamically unstable ship. COMSUBLANT made the first GUPPY, USS ODAX (SS-484), available for a month of sea trials. These trials provided the data necessary for developing ship control equipment and instrumentation for safe, effective operations of these GUPPY conversions of World War II submarines during that very vital post-war interval until new ships could be designed and built.

USS TANG (SS-563) Class (Six Ships)

The first post-World War II new design submarine, USS TANG (SS-563), was completed in October 1951. The shorter, more streamlined hull significantly increased submerged maneuverability. Increased test depth greatly increased both offensive and defensive capabilities. The major problem was maintaining the newly developed high-speed "pancake" diesel engines. Engines in three ships of this class had to be replaced during their first overhaul with more reliable engines at substantial cost in lost operating time as well as money. This experience emphasized the calculated risk of committing a shipbuilding program to inadequately tested major components.

USS ALBACORE (AGSS-569)

ALBACORE was more a revolutionary than evolutionary development in submarine design. Its optimum streamlined hull form minimized submerged resistance. Its large, single propeller on the ship axis significantly improved propulsion efficiency. The combination provided a 50-percent increase in speed and a dramatic increase in submerged maneuverability. These outstanding results provided the proof needed to overcome the tradition requiring two propellers -- long thought necessary for reliability, relocating the rudder and stern planes forward of the propeller, and eliminating the conning tower to minimize the fairwater (sail). These features were incorporated in the next new design submarines, both nuclear and diesel-electric, and became standard in all subsequent submarines.

USS NAUTILUS (SSN-571)

The NAUTILUS was every submariner's dream -- a ship with unlimited endurance. She was nearing completion and about to start dockside trials when I was transferred to Supervisor of Shipbuilding at Groton (Connecticut) as inspection officer.

Piping Problem

During propulsion plant hot water pressure tests, a small pipe connecting the two main steam generators burst. The reactor compartment filled with steam before isolation valves could be operated. Initial investigation revealed a split along a seam in a pipe which the specifications required to be *seamless*. The immediate problem was to determine whether this was a unique piece of non-specification pipe and, if not, what other pipe and piping systems were suspect. No pipe material identification marking system was in use. Seamless, cold-drawn steel tubing had been specified and ordered, but was not verified upon receipt nor was it marked for positive identification during fabrication or installation in the ship. Industry, laboratory, and university experts were contacted for nondestructive methods and equipment for positively identifying seamless steel tubing, but all in vain. Therefore, *all* steel piping systems were suspect.

Problem Solution

Emergency orders for replacement piping for all systems were placed and expedited. Material control and marking systems were developed. A large section of the pressure hull over the engineering spaces was removed to facilitate more rapid transfer of piping in the largest practical assemblies, from the ship to a fenced-in area in the shipyard. There they were used as templates for new piping assemblies which were fabricated as soon as new, pedigreed piping was procured. The procedure greatly expedited fabricating and reinstalling the piping, but the scheduling and recordkeeping problems were horrendous. It was almost 4 months and $4 million later before the job was completed and testing resumed, even though we worked 21 shifts per week with essentially unlimited overtime. This "incident" revolutionized pipe marking and handling not only at Electric Boat and other submarine shipyards, but also in the piping industry as well.

USS SEAWOLF (SSN-575)

When construction of the second nuclear submarine, USS SEAWOLF, was authorized, then-Captain Rickover decreed that in order to expedite construction, it was to be identical to NAUTILUS, except where necessary to accommodate the different reactor and propulsion plant. Fortunately, I had not been informed officially of this mandate. As the submarine design officer in the Bureau of Ships Design Division, I was under the impression that each new design follow-on submarine should incorporate those changes which would improve its performance without delaying its construction schedule.

Earlier model basin tests for NAUTILUS showed that her bow would go under as she approached full power and that she could probably not achieve full power on the surface. I initiated model basin tests on a redesigned bow superstructure which showed a gain of 3 knots on the surface at a cost of only 1/10th knot submerged as well as provide a location for a more effective sonar array. The ship drawings were changed and trials of the completed ship verified the model test results.

Steam Generator Problem

SEAWOLF had a General Electric Co. submarine intermediate-speed neutron reactor utilizing *liquid sodium* as the reactor coolant heat transfer medium. During hot dockside testing, sodium leaks were detected in the superheater. Very little was known about caustic stress corrosion at the time this equipment was designed and constructed. Expedited tests of various materials at both Electric Boat and General Electric duplicated the type leaks in SEAWOLF equipment. Design modifications were made, leaks eliminated and testing resumed successfully. In spite of these initial metallurgical difficulties with the primary plant, SEAWOLF subsequently operated for many months without requiring access for maintenance to the reactor compartment's shielded lower level. Unfortunately, this problem created enough concern in Washington before it was successfully solved that Admiral Rickover announced that this reactor would be replaced with the NAUTILUS type at the ship's first overhaul. More on this later.

SEAWOLF 60-Day Submerged Cruise

In October 1958, SEAWOLF completed a 60-day, 13,761 mile, continuously submerged cruise to uncover *habitability* problems which might arise during the 60-day patrols planned as a standard operating procedure for the POLARIS submarines then under construction. SEAWOLF surfaced off New London harbor and tied up alongside its tender where a news conference was scheduled. The first question a reporter asked was "How was the *habitability* during the record-setting cruise?" Dick Laning's response was "The *habitability* was great but the *co-habitability* left something to be desired."

SEAWOLF Power Plant Conversion to NAUTILUS Type

As mentioned earlier, Admiral Rickover had made the decision at the height of the SEAWOLF power plant problem to replace its nuclear reactor and main propulsion plant with the NAUTILUS type as soon as its first core was used up. One of the highest priorities in our navy at that time was ASW and these two nuclear submarines were by far the best targets for training our own ASW forces. As the SEAWOLF reactor was approaching the end of its useful life, I advised Admiral Warder that a spare core for the SEAWOLF reactor was available at General Electric and recommended that it be used to re-core the SEAWOLF reactor. I estimated that it could be done in 3 months instead of the 21 months estimated to replace its entire reactor and propulsion plant with the NAUTILUS type. This loss of SEAWOLF for ASW services at this critical time would be a severe operational loss. But Admiral Rickover had already directed General Electric to cut up the million dollar spare reactor core and reclaim the uranium.

USS SKATE (SSN-578) Class

The SKATE Class of five ships followed closely behind NAUTILUS. At the time its characteristics were approved by CNO, higher speed was considered secondary to increased ASW capability, and reduced size and cost. Since ALBACORE trial results were not available at the time of the ships' design, these ships were essentially scaled-down versions of NAUTILUS.

USS SKIPJACK (SSN-585)

USS SKIPJACK (SSN-585) was the offspring of the marriage of the NAUTILUS nuclear propulsion plant and the ALBACORE streamlined hydrodynamic hull with single screw. Its 50 percent jump in *speed* for the same horsepower and load capacity, and its far greater *maneuverability* exceeded all expectations. She was the new submarine hotrod and gave the ASW forces fits. The newly developed high strength steel, called HY80, significantly reduced the ratio of pressure hull weight to ship displacement and developed the fabrication technology for the next major jump in that very important operating characteristic, test depth, which was to be realized in the THRESHER class.

USS THRESHER (SSN-593)

The design, development, construction, and trials of THRESHER were among the most significant steps in the evolution of the "true" attack submarine. THRESHER's keel was laid on 28 May 1958, only 3 years after NAUTILUS' successful sea trials in 1955 had proven the practicality of nuclear submarines.

THRESHER was designed to incorporate significant improvements in submarine operational characteristics in three most vital areas -- reduced machinery radiated noise, increased sonar capability, and increased test depth. The same type nuclear reactor used in the USS SKIPJACK (SSN-585) class was installed to avoid potential problems and delays inherent in developing a new type nuclear reactor. All of these very significant operational advances were achieved with a modest increase in length and displacement and at a negligible decrease in speed.

Initial Sea Trials -- Pressure Hull Problem

THRESHER's initial sea trials started on schedule and proceeded without undue incident until the deep dive. As we approached a depth of about half of test-depth, the David Taylor Model Basin representative, Pete Palermo, who was monitoring the extensive strain gage installation, reported that several gages indicated stresses approaching the yield point of the HY80 steel. The ship was brought up to 100-foot depth while the experts onboard studied the data. With so much riding on THRESHER, it was decided to postpone the remainder of the trials, return to the shipyard, drydock the ship, and examine the hull structure and the exterior strain gage installation. No discrepancies were found. Meanwhile, Pete, who had developed elaborate strain gage monitoring equipment to try to expedite the very time-consuming deep-dive tests encountered on earlier submarine trials, was meticulously rechecking his equipment. About the time the hull inspection was completed, Pete approached me, the BuShips technical trial representative, with a very sheepish look. He confessed that one leg of his new strain gage monitor was grounded. He was able to repair it in record time and the sea trials were rescheduled. The deep-dive and full-power tests were satisfactorily completed, but several of the scheduled trials were postponed due to the schedules of the two BuShips admirals aboard. To the best of my knowledge, some of those trials in the BuShips official schedule were never conducted. THRESHER had a very successful year-long shakedown cruise during which it was later reported that she had operated at test depth on at least 40 occasions.

Loss of the THRESHER -- Naval Court of Inquiry

The loss of the THRESHER with 129 naval and civilian persons aboard, on 10 April 1963, while on sea trials after her post-shakedown availability, was the worst known submarine disaster in history. The official report of the Naval Court of Inquiry, which recorded 1700 pages of testimony over almost 2 months of hearings, concluded that "the most probable cause of the loss was a flooding casualty in the engine room due to a piping system failure in one of the seawater systems which, in turn, probably affected electrical circuits which caused loss of power."

What Happened, How Did it Happen, What Has Been Done to Try to Prevent a Repetition?

Immediately after the loss of THRESHER, a comprehensive review of the entire design and test data was initiated. Also begun was an extensive study of computer-generated ship trajectory traces through known or most likely points based upon SKYLARK's reports. The most probable sequence of events appeared to be as follows. The ship was at test depth at slow speed (standard operating procedure (SOP) for deep-dive trials). Immediately after the flooding was reported the captain called for full power, full rise on the control planes, and blow the main ballast tanks. The ship accelerated quickly and was well on the way to the surface when power failed. The ballast tank high pressure air blow system operated for a very short time but not long enough to overcome the negative buoyancy due to the flooding. It is possible the ship could have survived if either main propulsion power or the ballast tank blow system had not failed. With both failures she was doomed.

Why Weren't the Sea Valves Closed Immediately?

To shut the sea valves would cause immediate loss of power thereby eliminating the ability to drive the ship to the surface by hydrodynamic lift forces on the hull and its control surfaces.

Why Did the Ballast Tank Blow System Fail?

Immediately after the loss, a comprehensive review of the entire system design was initiated, as well as fabrication of an exact duplicate on one ballast tank control and blow system for installation and test in a mocked-up section of the hull. In order to install enough high pressure air storage bottles in the ship to provide the same standard blowing capacity of previous submarines of lesser test depth, the storage pressure had been increased from 3000 psi to 4500 psi. All system components had been thoroughly tested individually but, as mentioned earlier, the test of the entire installation in the ship during initial sea trials had been postponed. The test of the mocked-up system revealed that the control valves were acting like refrigeration expansion valves as the 4500 psi air expanded into the ballast tanks. This expansion caused the moisture in the high pressure air to freeze and block the airflow. The system and some components were redesigned substantially and became one of the major changes required under the very comprehensive "Sub-Safe" program for all follow-on ships of this class before they were authorized to resume operations at design test depth.

CONCLUSION

Admiral Ned Cochran's remark in June 1945 that submarines would experience the greatest development and offer the greatest challenges of any type ship was certainly prophetic. In less than 10 years NAUTILUS was at sea demonstrating the practicality of nuclear propulsion. ALBACORE was proving the quantum jumps possible in speed and maneuverability with her optimized streamlined hull and single propeller on the ship axis. Shortly thereafter these ship characteristics were combined in SKIPJACK, laying the foundation for the future trials. THRESHER's keel was laid. THRESHER included major advances over SKIPJACK in three vital areas -- reduction of machinery radiated noise, increased sonar capability, and greater operating depth.

W. D. Roseborough, Jr.
Captain, USN(Ret.)

WHITHER THE LEAGUE?

Nearly four years have passed since an article, Whither the League, was run in the April 1984 edition of the REVIEW. It's purpose was to determine just how extensively the silence of "the Silent Service" had been broken beyond the immediate ring of submariners themselves. It would appear an update is in order on this.

The Naval Submarine League Objectives imply a need for greater submarine awareness by the American Society, including those government agencies charged with procurement of submarines. These objectives take on greater importance in the face of tugging and pulling among services and warfare groups that will accompany inevitable budget cuts. Public attitude currently favors reduction of the deficit with defense taking a proportionate share. How this should be distributed is best left to the "experts." Here is the "rub," for without coercion from the electorate, legislators will nod to warfare groups with the greatest number and most persuasive "experts."

Rationale for one League objective assumes that the American Society has little submarine knowledge and is given bad impressions about submarines due to bad information. In effect, submariners and submarines have an image problem which must be overcome.

In the TV airing of Herman Wouk's War and Remembrance, the submariners were depicted as being led by men of questionable courage and integrity. In the same TV program, Nazi SS troops machine-gunned defenseless victims of the holocaust while later the crew of a U.S. submarine was doing the same to defenseless Japanese soldiers as they abandoned their torpedoed troop ship.

Though submarines performed well in WW II, the public imagination was captured by tales of battle in the Pacific skies and island hopping victories by the fore-runners of todays' carrier battle groups. In the public's mind, submarine involvement was non existent in all U.S. combat situations after WW II.

Much "turning around" of American society is needed in order to realize a second League objective -- the influencing of legislators to back submarine procurement. The public needs to understand the submarine's viability and importance in war situations that might occur in the near future. The League's efforts, mainly through the SUBMARINE REVIEW, can do much to develop a strong pro-submarine electorate.

A third League objective relates to "issues concerning United States submarines;" these must be expanded to include the adequacy of the Navy to carry out its mission in the face of the very real Soviet submarine threat. There is apparent doubt that carrier battle groups, the mainstay of our national maritime strategy, are survivable against a major Navy equipped with SSNs, and thus there are, in part, questionable current expenditures for battle group ASW protection. The purpose of the League is not to identify ways to reduce defense expenditures, but to clarify the League's responsibility to champion the best interests of American society. A simple "buy SSN 21s" will not achieve this without sound arguments to show that naval objectives can be so attained and less expensively than through other means currently planned. It would appear the League is able, and by its charter, obligated to assist the public in identifying those planned naval expenditures which are for "soft" programs, and how offsets may be made to provide more submarines. Well validated positions by the League in these matters strengthen its credibility. Indeed, if points made in the quarterly REVIEW and by speakers at League symposia are valid, then much good ground is here for the plowing.

League membership strength is substantial nation wide. It is a force to be reckoned with, especially if members are active among civic organizations. There is always a need to fill agendas with good speakers. If made to understand the importance of ASW and submarine warfare as America moves into the 21st century, civic group audiences are known to be quite vocal in the discussion of issues with legislators. A meaningful League slogan in addition to "every member get a member" is "every member avail himself of local targets of opportunity."

So then, Whither the League? How far has the ring of "silence" extended beyond our own members? Will opportunities be exploited through the media with the "submarine message" being extolled? Though a great forum, the League must reach beyond the pages of its quarterly. Perhaps the day is not too far off when the opening line of a major network evening news cast will begin, "A spokesman for the Naval Submarine League today expressed concern that our developed Naval posture may not be equal to the real submarine threat." We can only hope.

D. M. Ulmer

WHY TOM CLANCY IS WRONG

Tom Clancy writes captivating fiction. Ever since ***Hunt for Red October*** first appeared on the nation's bookshelves in 1984, millions of readers have devoured his mix of imagination and technology.

However, his views on the "system" of preparing submariners for command, as outlined in the Washington Post in December and recently in the Virginian-Pilot and the Ledger-Star ("The U.S. Navy needs better officer training, a warrior ethic") warrant comment from a submariner. I am a career submariner. My experience is in command of submarines.

Clancy's premise is that the Royal Navy's system is better than the U.S. system in preparing submariners for command. He contends that the British system, which has two pipelines -- one based in tactical development for potential skippers, the other for engineers -- results in a much better commanding officer, that the "American system requires that a submarine officer spend too much time in the engine room." He questions the "American fixation with engineering."

Clancy contends that the current U.S. "system is a community of officers so molded by their training that risk-taking is not rewarded and therefore often avoided. In the tactical arena, failure to run risks makes for predictable tactics -- which can spell death." I have not observed this postulated phenomenon. If anything, the U.S. Submarine Force has developed more unique tactical employment methods in the past 20 years than one could imagine.

A principle which is etched in the minds of every one of my officers as they take command concerns doctrine. The definition of doctrine was established by Richard. H. O'Kane, who, as commanding officer of USS TANG (SS-306), was awarded the Medal of Honor and was America's leading submarine "Ace" of World War II, credited with sinking 31 ships totaling more than 227 thousand tons. He said, "Doctrine is a set of procedures, established through experience, that provides a guide. But doctrine should be flexible, never rigid, for circumstances often dictate complete departure." The path to command that U.S. naval officers take includes that flexibility and readiness for departure. My skippers are risk-takers -- every day.

To address the other key issues he raises, let me first say that the British submarine force is a formidable force, composed of highly trained and dedicated officers. *So is ours.*

Admittedly, we have different methods of preparing our submariners for command. In fact, a point-to-point comparison of the American and British submarine forces would reveal other differences in platform numbers, capabilities and missions as well. Regardless of those differences, I believe that Royal Navy submariners are better trained in engineering matters than Clancy has surmised. Thus the differences in the tactical and engineering proficiency of British and American submarine commanders is not as great as Clancy would lead one to believe. But since he argues that one training regime is superior, I am compelled to offer more than just a passing comment.

I completely agree with Clancy that the "point of maintaining a military is the ability to go to war effectively ... [that the goal to which we should and do train is to] operate the submarine and kill targets." The submarine force mission is simple: Sink ships. In this day and age, submarines have many additional roles, but the primary mission is correctly stated.

In peacetime, training is a commanding officer's primary function -- making and keeping his crew and ship ready for war. U.S. Submarine Force skippers are responsible and accountable for the entire ship; not only combat systems, but also propulsion systems and the performance of their entire crew in operating those complex systems. They are required to maintain their ships so they can practice these tactics in the demanding environment of the depths that Tom Clancy writes so eloquently about in his novels.

The skipper's expertise in propulsion as well as in all other areas of the ship, ensures that we can get to and return from the battle. The skipper's expertise in all aspects of the ship's operation increases the probability of sustaining his ship's ability to continue to fight during a period of hostilities.

The survivability and effectiveness of a submarine at sea depends upon the skipper's knowledge and judgement in all mission areas -- navigation, sonar, tactics, communications, oceanography, weapons and weapons delivery systems, damage control and, yes, ship's propulsion, ballast and auxiliary systems. He is in charge of the entire crew in each of those areas. When a submarine leaves the pier, the knowledge and capabilities within it are the keys to his success.

While the ship's engineer is key to the operation and maintenance of the propulsion plant, the commanding officer is the one who maintains the big picture and who assesses the interdependence of all ship's systems and operations. Often, something affecting the ship's engineering plant has the potential to affect some operation on another part of the ship. The commanding officer requires a detailed knowledge of all systems and the people who operate them in order to make this judgment. The British training system lacks this foundation. In our Navy, it is the foundation of safe, reliable, aggressive and survivable submarine operations. A submarine cannot call for support to solve a problem at sea. If the man in charge does not have command of all the knowledge and capabilities to fight his ship, he is not truly in command.

It takes many years to develop the blend of knowledge and operating experience required in a commanding officer. These years of experience have afforded the submarine skipper the opportunity to receive basic training in submarining and to serve in all ship's departments (not just engineering or combat systems), to serve as an executive officer, to attend shore-based advanced tactical training to participate in fleet exercises and real-world deployments and to hone war-fighting skills.

In sum, today's U.S. submarine skipper has been trained exactly the same way he would fight. By the time he has reached command, he has been thoroughly tested and thoroughly prepared. He has operated extensively in the many oceans of the world and knows his potential adversary. He has served on submarines which have performed the mission of strategic deterrence. He has served on submarines that will be employed as a forward defense, to protect sea lines of communication. He has operated in support of battle-group operations against both submarine and surface threats. He has trained or conducted special-warfare teams.

He has done this in open oceans, in restricted waters, in deep or shallow areas from the warm waters of the tropics to under the ice in Arctic regions. He has fired many exercise weapons against an evasive and simulated hostile threat in a variety of scenarios and tough tactical situations. With this background, is the skipper prepared to fight his submarine should the need arise? Absolutely.

By the time our submarine skippers qualify for command, they are at the peak of their operations skills. Despite Clancy's assertion, youth neither guarantees that one is more capable of handling stress nor that one is qualified for command. Early command is certainly one of the rewards and objectives of submarine service, and achievement of that goal at an early age is important. I took command at age 35. Clancy asserts age 33 is the Royal Navy nuclear submarine command age. We are obviously close.

Clancy himself acknowledges that "Readiness requires that commanders know their profession." Both the British and United States submarine force commanding officers are true experts in their field. Like his counterparts in other warfare areas, the submariner must know the capabilities of his ship and people as well as himself. Navy pilots must know not only tactics, but systems and how to conquer in-flight emergencies. Surface warfare officers similarly must not know only how to fight their ship, but must understand the impact of an engineering casualty and how to minimize the impact on their ship missions.

U.S. submariners and other warfare specialists in the U.S. Navy are trained to "fight hurt," that is, to be able to overcome and fix our own problems that may develop at sea. This is a high-tech world in which we live, and to succeed as a warrior, we must either master the technology or be willing victims when it fails.

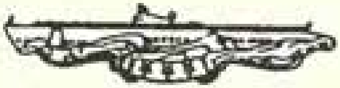
Although Clancy laments that the LOS ANGELES class design dates back to his college days and therefore, that "something is wrong," he also says the "LOS ANGELES is probably the best boat in the world."

Clancy asks, "Is it as good as it could be?" Yes. With improvements that have been added to that class over the years, it is as good as it can be. Do we need a better, more capable submarine? Yes. That is why the SEAWOLF (SSN-21) program is a vital part of our defense program.

Despite a numerical disadvantage, the United States submarine service is widely recognized as the best in the world. At the core of our quality are qualified and dedicated people aboard highly capable ships. The "system" that Tom Clancy has questioned is fine. Our commanding officers are the best. They are "total" skippers, and if the need arises, they will be total warriors.

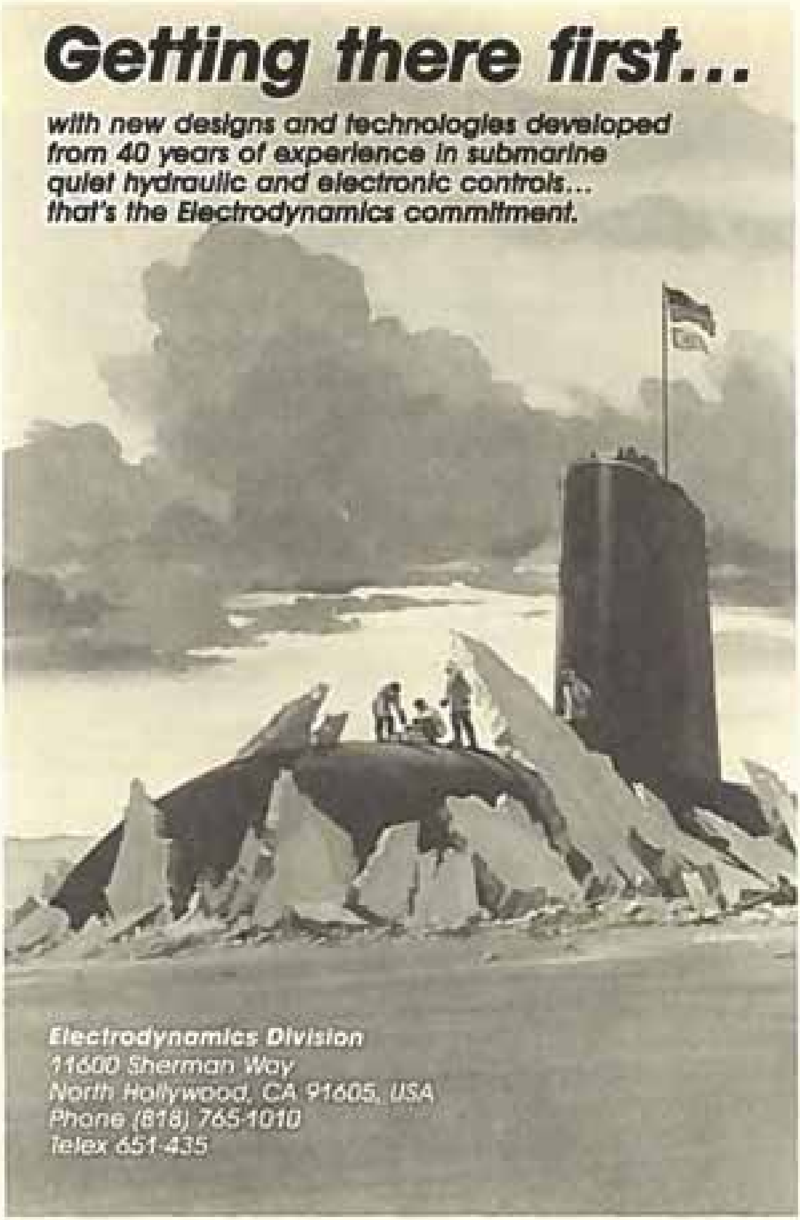
Vice Admiral Roger F. Bacon, USN

[Reprinted from the Virginian-Pilot and the Ledger-Star, Feb. 19th, 1989.]



SUBMARINE COMBAT PATROL INSIGNIA

The Submarine Combat Patrol Insignia was authorized on March 26, 1943. It is a silver color metal pin, showing the broadside of a "FLYINGFISH" class submarine proceeding on the surface with a scroll at the bottom of the wav e area. Gold and silber stars are used to indicate additional sucessful patrols.



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SUBMARINE DOCUMENTARY

The Naval Submarine League, with the assistance of the DCNO (Undersea Warfare) is sponsoring the production of a video film entitled **"Submarine! Steel Men, Iron Boats."** This film will be shown as an hour-long documentary on PBS. A special half hour version will be distributed to the Navy for recruiting and educational purposes.

Donors making this production possible are listed below in the order consistent with their contribution:

Newport News Shipbuilding and Drydock Company
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Mr. Zachary Fisher
Argo Tech
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Kaman Corporation
EDO Corporation
Trident Systems
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AFCEA

The funding goal of $525,000.00 has been reached. A Sneak Preview will be shown at the NSL Annual Symposium Banquet on 8 June 1989.

A PROJECT IN MEMORY OF FATHER JOHN F. ("JAKE") LABOON, S.J.

Many of us knew the same man under different titles. For some, he was "Father," and for others, "Captain." His family preferred "Jack," while close friends got away with "Jake," or at least "Father Jake." But names aside, Father Laboon's disarming smile and (despite his imposing 6'6" frame) his genuine, caring ways made him a friend to all of us. And we all lost a good friend when he died last summer, on August 1st.

From his early years at the Naval Academy, through distinguished service in submarine patrols during World War II, in Navy chaplaincy thereafter, and right up to the time of his death, Annapolis was always a place dear to Father Laboon's heart. In the early 80s, he returned to Annapolis, but this time to the north side of the "scenic Severn River," and to the Jesuit retreat center called "Manresa," that large white "manor house" that has served as an Annapolis landmark since 1926. Father Jake's assignment: to renovate the aging plant in order to make it "shipshape" for the next generation and beyond.

Some months ago, it occurred to some of his friends that one appropriate way to honor Father Jake's memory would be to see his plans for the Manresa chapel realized. The renovation of the Manresa chapel, complete with a bronze etching of "Father Jake' and a short biography, a list of all his friends who made it possible, and a special annual retreat and reunion for "the friends of Father Laboon" would be a wonderful tribute as well as a reminder that Father Jake still lives and that one more of his many lifetime assignments has been brought to a happy conclusion.

The total cost of the project is $200 thousand. Father Laboon's many friends can make it happen. More information concerning this endeavor can be obtained from, and contributions can be sent to: Manresa-on-Severn, P.O. Box 9, Annapolis, MD 21404. Contributions should be specified as: Manresa: Laboon Memorial.

■

The New England Section of the

AMERICAN SOCIETY OF NAVAL ENGINEER'S

is proud to announce

SUBMARINE ARCHITECTURE AND SUPPORT SYMPOSIUM 1989

sponsored by the Naval Sea Systems Command in cooperation with the Naval Submarine League and the American Society of Naval Engineers.

The purpose of SUBMARINE ARCHITECTURE AND SUPPORT SYMPOSIUM 1989 is to exchange information between the operators in the submarine force and the engineers who design, acquire, maintain and support the submarine platforms. The objective is to enhance technical exchange both during and after the symposium with a long term goal of broadening the cooperative base of engineering and operational expertise.

The SYMPOSIUM will consist of presentations in various submarine related fields. These will include:

Innovations in Submarine Technology
Innovations in Submarine Construction Techniques
Innovations in Submarine Maintenance
Innovations in Submarine Combat Systems
Innovations in Submarine Naval Architecture
Submarine Threat Assessment: The Operator's View and the Designers Challenge

(Presentations will be up to the SECRET level)

SUBMARINE ARCHITECTURE AND SUPPORT SYMPOSIUM 1989 will be held at PEASE AFB, Portsmouth, New Hampshire on 5 and 6 October 1989. Security will be coordinated through Portsmouth Naval Shipyard. Attendees must hold a current SECRET security clearance.

Individuals wishing to submit presentation topics should send an unclassified abstract by 12 May 1989 to:

CDR John Bowen
99 Mallard Drive
York, ME 03909
(207) 438 2210

Requests for registration packets can be sent to the same address.

SUBMARINERS AT PG SCHOOL, MONTEREY

As a professor here, teaching our Maritime and Soviet Naval Strategy, I have quite a quota of submariners which, I understand, is an improvement over not too many years ago. I don't understand the oft-heard criticism that the modern submariner is an "engineer" and a "technician," who neither understands nor is interested in the strategy of underwater warfare. My experience so far has been quite different -- most of my brightest and most thoughtful "Strategists" have been submariners. Naturally, they are all convinced that the submarine is the naval weapon-of-choice today and into the future, but that's fine; I happen to agree. Two of my favorite lectures/class discussions (and always a cause for considerable excitement) are (1) why not convert to an "all-submarine" fleet, and (2) why cannot (should not) submarines be used for "naval diplomacy?"

I have experienced the hardware-oriented bent most pronouncedly, in the course of my participation as the "token" social science representative on the NPG's Submarine Technology Group (STG). We were created as one of the CNO's "centers of excellence" that have been tasked to come up with new ideas for "pushing" the submarine fleet into the 21st century. I have found it extremely difficult to convince the Group's "technologists" that we ought to perhaps have some idea of what we want the submarine navy to do and accomplish before we foist a new or improved pet gadget upon the service!

Jan S. Breemer

[Editor's Note: See his article in this issue.]

ADVERSE ROLL CONTROL AT HIGH SPEEDS

In the January 1989 SUBMARINE REVIEW, I read with interest the article by Henry E. Payne III. In 1970 I had a two week training duty at NAVSEA in Silver Spring, Maryland. There I worked for a Naval Officer (1400) naval architect (submarine qualified) who was in charge of a submarine preliminary design group which sat near the "ULMS" design group that I think eventually became TRIDENT. One of his major concerns was the problem of high speed submarine "flight." My first observation was that they were trying to invent everything from scratch instead of using lessons learned from aircraft design.

The project I was given was to design a "<u>retractable</u> fin keel" that would extend in some manner when the rudder was put over. The intent was to balance the side forces which cause the adverse roll at high speeds. I did this for him but in the process of studying the hydrodynamics of high speed turns I proposed what I thought was a better solution. That was to put a "flap" on the trailing edge of the sail actuated by hydraulic actuators which controlled flap angle as a function of rudder angle and ship speed. A keel can be made with a high aspect ratio compared to the sail and thus have a higher lift coefficient than the sail, however it still must be large to be effective and also the loads are too high to be practical. A flap on the sail can work on the pressure distribution of the sail itself and significantly reduce sail side force in turns with flap loads being distributed over the length of the sail.

My naval architect felt my proposal was not practical because the increase in submarine wetted area due to adding the flap was too significant since the power required for normal cruising was a function of drag to the fourth power. At the time I did not do any drag calculations, however, I suspected that the increase in wetted area drag was probably cancelled out by the decrease in form drag due to the increase in sail chord.

It only makes good sense to make our submarines more maneuverable.

B. F. Dotson

<u>TO FRIENDS OF AARON THOMAS</u>

We are grateful to all of you who generously responded to our call for assistance for Aaron (SUBMARINE REVIEW January '89). Aaron is now in remission thanks to your response. Fifty-eight persons offered to donate blood. FTBCS(SS) Thomas and Mrs. Thomas have asked us to express their deep gratitude for your assistance.

Our contact at the National Naval Medical Center, Chief Spatz, is assisting in our development of a letter to explain to each volunteer how we will schedule appointments for your blood donations.

Those who have not yet volunteered, but who wish to do so, are asked to notify us at the address below.

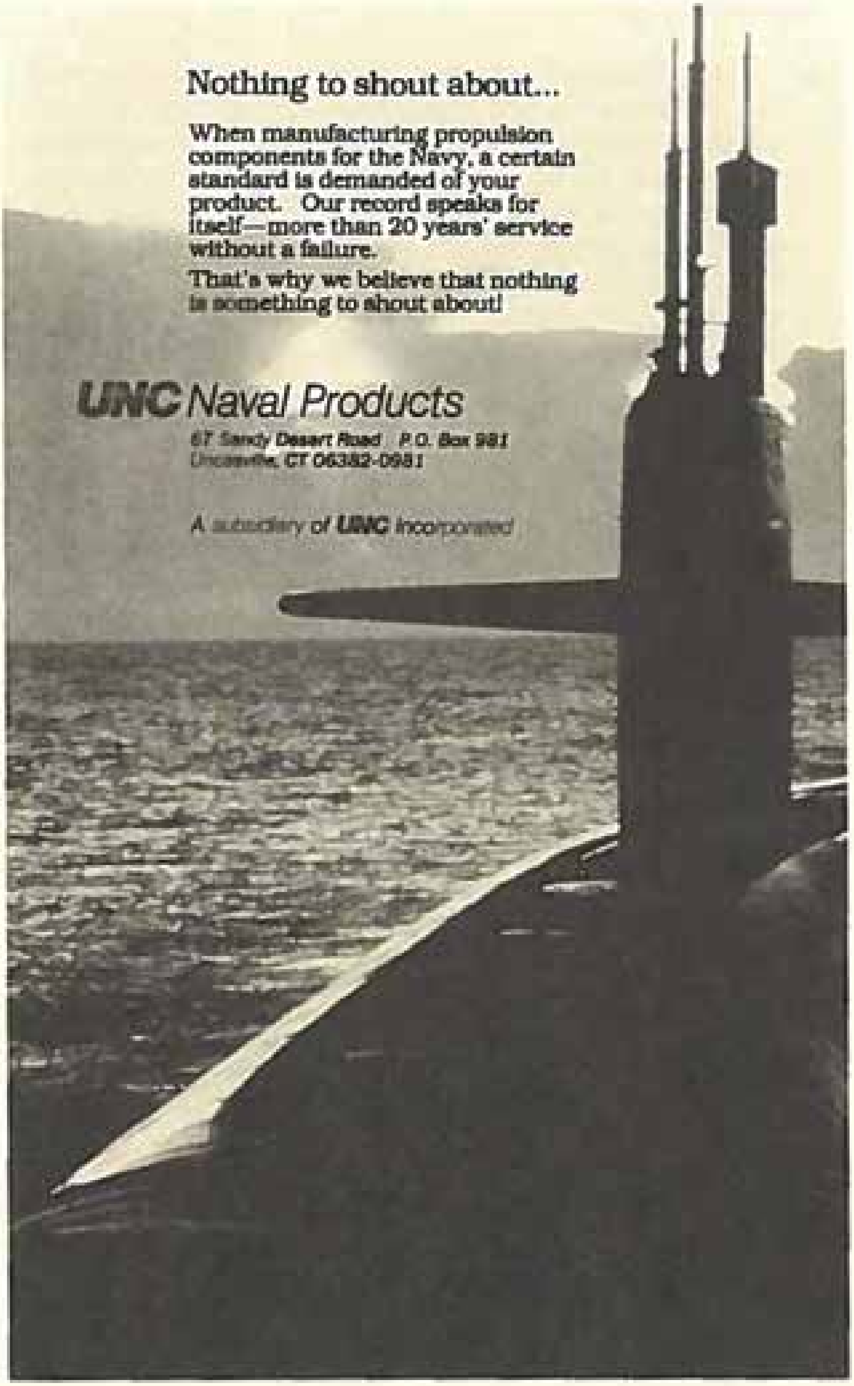
Ross and Helen Williams
13704 Turkey Foot Road
Arlington, VA 20878-3983

NUCLEAR SUBMARINES FOR CANADA?

My interest is subs was aroused in 1988 when our Canadian Defence Minister gave a speech at the annual meeting of the Canadian Nuclear Association in June. The minister told delegates to the conference that 10 or 12 nuclear submarines deployed by Canada could prevent NATO from having to use atomic weapons to save Europe in the event of war. The vessels could prevent Soviet submarines from entering the Atlantic and cutting off supply lines, an action which would leave NATO with the choice of abandoning Europe or using nuclear weapons. "In times of conflict, diplomatic protests are not good enough," he said. "You must have the ability to defend yourself as well."

Even with the nuclear standoff, there is no reason why the development of submarines should not continue. If, in a future war, surface ships would be sitting ducks, surely there will be more need for submarine craft than ever before to fill as yet unspecified roles.

John Crabtree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IN THE NEWS

o The Washington Post of 29 December, 1989, reported that the President had "extended the territorial waters of the United States from three to twelve miles to conform to the standard set by a U.N. agreement in 1982." The new sovereignty will extend U.S. jurisdiction to the air space over the 12-mile territorial sea as well as "to its bed and subsoil." The President also said that ships of all countries will have "the right of innocent passage" through U.S. territorial waters as well as "the right of transit passage through international straits." (Editor's note: the right of free passage does not include foreign submerged submarines.)

o A "News Brief" in the Trident Times of 3 February notes that Rear Admiral G. W. Davis VI has been assigned to the job of Deputy Assistant Chief of Naval Operations (Undersea Warfare) OP-02B, OPNAV, and Rear Admiral H. G. Jones, Jr., has been assigned to the job of Commander Submarine Group Nine.

o An Associated Press release of January 27 says that Admiral David Jeremiah, Commander of the U.S. Pacific Fleet, acknowledged that the Soviets in recent months had added a new strategic DELTA-class submarine to their Pacific fleet. The increase, according to Jeremiah, is "in contradiction to a speech by Gorbachev in September in which he said that the Soviet Union would not increase the number of any type of nuclear weapons in the Pacific region."

o Sea Power magazine of January 1989 has an article by Richard Sharpe, (a former submariner) the Editor of Jane's Fighting Ships, "Will We Have the Forces With Which to Counter Soviet Naval Strategies?" Sharpe makes many important points, most of which deal with Soviet submarines, in analyzing the subject he is writing about. First is the trap we are led into through the oversimplification produced by buzz words like "noisy nuclear submarine", "stealth", "smart weapons", "third party targeting" and "computer-aided automation." Illustrating the latter, he says, "it is astonishing how quickly even the most cynical human mind once again will project itself forward into some science fiction world in which advanced technology solves all combat information exchange problems." Sharpe does assure us that analysis of Soviet maritime policy, if expertly done, can be derived from the prolific Soviet writings on naval matters -- which he apparently does not consider to be disinformation for consumption by the West. In assessing the current Soviet Navy capabilities, Sharpe points out that conventional wisdom would say that training and deployment patterns "are the only real indicators of the professional competence of the sailors and the current maritime policy under which they operate." But unlike Western navies which "believe that efficiency is achieved by being at sea, with few technically skilled ratings, the Soviets are now dependent upon shore-based maintainers to keep their systems on top line and (they) argue that their ships are at highest readiness state when alongside the bases, fully stored, and at short notice to saii." Secondly, "the inherent distrust by the ruling party of the loyalty of its subordinates" is carried over into a limiting of ship deployments. So that, thirdly, though they might worry abou: "whole ships making wild dashes for freedom" it is more a case of a shore-command mindset to accept that the effective use of naval forces depends upon giving the scene-of-action commander much more autonomy than may be necessary in a land battle. "So" according to Sharpe, "the command answer is to keep them (Soviet ships) in home waters" with the bonus that "the West may construe (Soviet) intentions as being predominately defensive." This leads to the 1500-mile zone of defense of the homeland theory held by the West and the "bastion" theory for deployment of SSBNs close to the homeland -- along with the need to use a large proportion of the Soviet submarine force in protecting the SSBNs in their bastions. He calls this misconception by the West "a nautical Maginot Line -- neatly complemented by the U.S. Maritime Strategy with its emphasis on forward defense and penetration of the bastions (in strategic ASW)." Sharpe shoots down this point of U.S. strategy, noting that Western SSNs "are going to have great difficulty in engaging Soviet SSBNs, particularly if imaginative use is made of defensive minefields, the poor sonar conditions in shallow waters and along the ice margins, and acoustic deception and disruption devices." But "the West's SSNs will have little difficulty in decimating the Soviet surface fleet and launching SLCMs against the land bases." Then he says that, although Western analysts see few Soviet submarines left over from this Maginot line strategy to go after the merchant shipping of the West, the Soviet strategy which "exploits their strength with a much better chance of success is an aggressive forward-deployed policy by all nuclear attack submarines targeting carrier battle groups, merchant ports, naval bases, and reinforcements and economic merchant shipping at focal points preferably in shallow water." And that, "defense of the home base would be more realistically achieved by diesel submarine barriers." Sharpe notes that "by concentrating on an intelligence analysis, based in part on peacetime deployments, we are in danger of becoming more vulnerable to a Soviet forward strategy which exploits their real strengths as opposed to a bastion theory which looks to be a recipe for a Soviet self-imposed defeat at sea." Sharpe emphasizes that "the defender at sea now needs superior forces to the attackers," and that an aggressive Soviet submarine strategy will likely overtax the defensive forces of the West. He felt it important to highlight the Soviet's operational introduction of large numbers of SS-N-21 submarine-torpedo-tube-launched, land attack cruise missiles and the continued development of the longer range SS-NX-24 which is earmarked for a new class of SSGN to be launched early in 1989. As for actual cut-backs in Soviet submarine programs in accordance with Perestroika, Sharpe says that "If the Soviets are serious, the path of international stability is to cut out the propaganda and start winding down the shipyards."

- A note from the Admiral Nimitz Foundation describes a program for the public at the Admiral Nimitz Museum in Fredericksurg, Texas, on 19-21 May, entitled "Up Periscope! Submarine Operations in the Pacific, 1941-1945." The Friday evening opening of the Museum's annual exhibit will be a reception at the Museum for invited guests and will be sponsored by Rear Admiral Chester Nimitz, Jr., Captain Slade Cutter and Rear Admiral C. G. Mendenhall. The formal symposium on the 20th will feature the surviving Medal of Honor winning submariners as well as distinguished WW II submariners, Admiral Galantin, Captain Beach, Admiral Clarey and many others. Several Japanese submariners will present the Japanese viewpoint in the various sessions. Those interested in supporting the Admiral Nimitz Foundatioin can write to: Admiral Nimitz State Historical Park, P.O. Box 777, Fredericksburg, TX 78624, or call (512) 997-4379.

- o A Navy Times article of 5 December 1988, lists submarine rear admirals (lower half) who were selected for promotion to two-stars: Ralph W. West, Jr., Director of Human Resources Management Division (OP-15) OPNAV; Larry G. Vogt, ordered as Commander Naval Forces Korea; Henry C. McKinney, Commander Navy Recruiting Command; George W. Davis VI, presently Commander Submarine Group Nine; Walter H. Cantrell, Deputy Commander for Submarines, NAVSEA.
- o A Navy Times December 19, 1988 article by William Mathews tells of a speech by former Navy Undersecretary James Woolsey in which he says that tight budgets, arms reduction treaties and the loss of overseas bases are trends that will dominate the course of U.S. military change in the near future, therefore "cruise missiles, remotely piloted vehicles and other unmanned aircraft may be the hot weapons of the 1990s." To keep a strong force forward deployed without incurring the enormous costs associated with aircraft carrier battle groups, he sees sea-launched cruise missiles as a possible answer. Also, with our Navy threatened by arms control agreements, and with the Strategic Arms Limitation Treaty under negotiation prohibiting the U.S. from having more than a dozen TRIDENTS at sea, cruise missiles armed with nuclear warheads might be the solution for an adequate strategic nuclear sea-based capability.
- o The Washington Post of 10 January noted that General Dynamics (Electric Boat Division) was awarded a $726 million contract to build the first SSN-21, SEAWOLF attack submarine. The first SEAWOLF is scheduled to join the fleet in 1995.

- Richard Halloran, writing in the New York Times of October 9, 1988, said that a U.S. Navy assessment estimates that "the Soviet torpedoes armed with conventional warheads, have become so explosive that one hit could put a large American aircraft carrier out of action" and that the report "emphasizes torpedoes rather than cruise missiles launched from submarines -- representing a change from five years ago, when American naval officers said cruise missiles were the greatest threat to American warships."
- An article in NAVY NEWS & Undersea Technology of 30 October 1988, tells of " a next generation electric torpedo which should join the French fleet next year -- an antisubmarine lightweight torpedo called MURENE (meaning moray eel in French). The torpedo is capable of 60 knots, is operational to 800 meters depth and has a battery with an energy density more than triple the capacity of nickel/cadmium batteries. The MURENE's battery uses seawater to react with aluminum-silver oxide plates to develop 1.7 volts per cell.
- SUBNOTES, November-December 1988, advertises a one-man sub designed and built by International Hard Suits Inc. -- called the SEA URCHIN. The sub can dive to 300 feet and costs $40,000. In the same issue of SUBNOTES a West Germany company is fitting a closed cycle diesel engine in one of its 4-man SEAHORSE II submarines -- of 300 meters operating depth. Using liquid oxygen and diesel fuel, this configuration is expected to be tested at sea within a year. Also in the same issue is an article telling of DARPA's development of an autonomous underwater vehicle named SCOUT, 40 feet long and 4 feet in diameter. The battery powered vehicle is intended to be used as a bistatic sonar receiver to help provide a 3D sonar picture for the launching platform. A smaller version may be developed to be launched by SEAWOLF-class SSN-21 submarines.
- NAVY NEWS & Undersea Technology of 7 November 1988 tells of a French invention of large (1.5 by 3 feet) hydrophone-type, 2-inch thick panels to be attached along the length of a submarine -- instead of conventional hydrophones. The panels are made up of a rolled film of

alternating layers of piezo-electric films and metallic electrodes. Sea trials have reportedly confirmed that these panels "give a better signal to noise ratio, and a longer (passive) detection capability -- compared to classical ceramic hydrophones." The device is "already in service with the Norwegian Navy and is scheduled for the new generation French ballistic missile submarines."

o In the PROCEEDINGS of February 1989, Fleet Admiral V. N. Chernavin, Commander-in-Chief of the Soviet Navy, answered questions posed by the U.S. Naval Institute. When asked "What is the relative importance of submarines, surface ships and aviation in naval doctrine?" he answered, "We consider both nuclear and diesel submarines along with naval aircraft to be the main forces of the fleet. They are intended above all to hit those of the enemy's strike groupings and those areas of the World Ocean that pose a threat to our country. In this case, diesel submarines will operate mainly in areas adjacent to the Soviet coast. They are capable of making a weighty contribution to raising the effectiveness of the naval forces' defensive operations -- they may be seen as one of the navy's main defensive forces in fighting at sea." Then as to surface warships: "We consider surface vessels to be forces intended mainly for the defense of our sea boundaries, lanes and coast. They also play a large role in anti-submarine warfare." As for naval aircraft: "The main purpose of naval aircraft is to support and cover the fleet's forces from the air, first of all submarines on their routes and their emergence from base, and surface vessels in areas of combat operations and transports in passage. The missile carriers will also be used for strikes against enemy groupings in long range approaches to our defense boundaries."

o In the December 1988 issue of the PROCEEDINGS, a study is described of how effective Soviet subs might be against the resupply shipping for a big NATO ground war. The study notes that "merchant ships in a conventional war today would be more vulnerable than their counterparts 45 years ago." It is recognized that although, since WW II, the U.S. ASW forces have greatly improved the detection of submerged subs with sonar, and they've acquired ASW patrol aircraft and helicopters and fixed passive arrays, totally submerged operations of Soviet nuclear submarines plus reduction of surface time by Soviet diesel submarines "somewhat offset these U.S. ASW improvements." The study, using assumptions based on the probable number of Soviet subs assigned to the North Atlantic convoy interdiction mission plus escorts available from NATO, shows that in the first 10 days of convoy operations, about half of NATO's 600 merchant ships would make it to Europe at a cost of 52 Soviet SSNs or SSs -- hence, "the Soviets would have been quite successful in blocking the resupplies from reaching NATO forces in Europe." Twelve escorts would have been lost as well.

o Business Magazine of November 1988 has an article by William Hoffman which describes a "resonant nuclear battery which uses nuclear wastes for fuel oil. The battery harnesses the radiation emitted by radioisotopes, such as strontium-O, and converts it directly into a continuous AC current. When operational, the battery is expected to have a 100-year life and cost approximately five cents per kilowatt." A prototype of the Nucell battery has been operational for limited periods of time. Measuring 18 inches in diameter by 36 inches tall, it supplied enough electricity to power five houses at peak load. "Production is perhaps three years away," and, "If it works, the battery should yield up to 100,000 times as much energy per weight of isotopes as the best conventional nuclear battery." The principle is described thusly: the nuclear batteries used in satellites are basically heat driven with their nuclei of radio isotopes emitting alpha and beta particles which collide and produce heat. For such batteries, only about 5% of the available heat is converted into electricity. In the Nucell battery, "the particles act like electric currents in their moving, charged state. Like all currents, they have a magnetic field around them. These fields collapse as the randomly moving alpha and beta particles collide, slowing them down. Electricity can be produced if all the magnetic fields can be made to point in the same direction while collapsing." The inventor, Brown, found a way to organize the magnetic fields and solve the nuclear Rubic's cube.

- o NAVY TIMES of 27 February 1989, notes that the seniors (First Class) at the Naval Academy, on February 7, made their selections for duty after graduation. Those who chose submarine duty were in greater numbers than in the previous two years. In 1987, 142 chose submarines; in 1988, only 119 chose submarines; but in 1989 the figure is 181. In all three years the graduating class strength was about 1050.
- o Recent selectees to the rank of Rear Admiral (lower half) were: Douglas Volgenau, Director Submarine Combat Systems, NAVSEA; George W. Emery, Executive Assistant to the Under Secretary of the Navy; Millard S. Firebaugh, Program Manager SSN-21 Class Submarine Acquisition; David M. Goebel, Deputy Director Strategic Submarine Division, OPNAV; Howard W. Habermeyer, Jr., Commandant U.S. Naval Academy; Karl L. Kaup, Director Strategic Submarine Division OPNAV; James R. Lang, Director Ship Maintenance and Modernization Division OPNAV; George R. Sterner, Program Manager, Mk-48 ADCAP, NAVSEA.
- o Defense Week of February 21 notes that "The Navy's plans to equip its TRIDENT C4 and POSEIDON C3 ballistic missiles with a Navstar Global Positioning System navigation aid will be delayed two years because of budget cuts." Spending on improvements to the two nuclear missile systems was trimmed $11.5 million in FY '88, and $15.4 million in FY '89 -- delaying the outfitting of the missiles with equipment to receive signals from orbiting Navstar satellites.
- o In the same edition of Defense Week, a note says that the first full-function AN/BSY-1 Combat Control/Acoustic System was delivered by IBM to NAVSEA for installation on the MIAMI, a 688-class attack submarine. A significant capability improvement for 688s, "it integrates navigation sonar and weapons system data to provide improved target detection and localization."
- o NAVY NEWS & Undersea Technology of 16 January shows the Budget requests for weapons. Of interest is the buy of TOMAHAWK cruise missiles, used by submarines: FY '89 has a buy of 510 at a cost of $635 million; the FY

'90 request is for 400 at a cost of $572.2 million; and FY '91 requests 400 at a cost of $662.6 million. The SEA LANCE antisubmarine missile which can be torpedo-tube launched is funded at $198.5 m. in FY '89 for development costs, for FY '90, 200 are requested at a cost of $260.1 m., and for FY '91, 270 are requested for $328.5 m. Mk-48 ADCAPs' buy for '89 is 320 at $485 m., for FY '90, 320 are requested to cost $493.6 m., and for FY '91 320 are requested at $408.8 m.

o Jane's Defense Weekly of 11 February notes that the People's Republic of China had tested its first deep submergence rescue vehicle. Capable of rescuing submarine crews up to a depth of 600 meters, it has a crew of four and can rescue up to 22 personnel per trip to the surface. It is equipped with underwater TV, a manipulator arm, position fixing sonar, and acoustic imaging sonar.

o Aviation Week & Space Technology of 30 January says that the Navy successfully conducted its final flat pad test of the TRIDENT-2 D5 missile on 26 January and will commence submerged tests in March from the TENNESSEE.

o Jane's Defense Weekly of 18 February tells of approval of a plan to withdraw the MEMPHIS (SSN-691) from service later this year and make her an "interim" platform for R&D projects. Modifications to configure a permanent platform for R&D will be made during refuelling overhauls in 1994. "By designating an R&D submarine, the navy will increase its flexibility to test concepts -- primarily those which lend themselves to rapid prototyping."

o Defense Week of 21 February, has an article by Anne Rumsey which says, "Serious concerns about the adequacy of operational and live firing tests of the Mk-48 torpedo arose from two General Accounting Office studies -- the ADCAP (tests) had several limitations and the GAO had concerns with whether the mission capability would be demonstrated before they are delivered to the fleet."

o The Washington Post of 23 February reports, in an article by Molly Moore, that "Soviet President Mikhail Gorbachev's military budget cuts forced the Soviet Navy to scale back submarine production, reduce Pacific fleet operations, keep vessels in port longer and spend less time at sea -- the U.S. Navy's chief intelligence officer told a subcommittee of the House Armed Services Committee." However, according to Rear Admiral Thomas A. Brooks, director of U.S. naval intelligence, "technological improvements in new submarines have left the Soviet navy more capable now than when Gorbachev came to power." Brooks also reported that "Soviet naval exercises last year were relatively short and were conducted near the Soviet mainland." And that, "the exercises emphasized defense of the homeland and submarine bastions." Brooks also reported "that the decline in steaming hours and the increased time at anchor has also increased the number of ships in port ready to respond to an enemy attack, thus improving the ability of the Soviet navy to transition rapidly to war."

o An article in The Beacon, January/February 1989 by Alva Chopp tells of LT(jg) Alex Will putting on a pair of hand-me-down, well-worn gold dolphins when he qualified in submarines last November. "Was he disappointed?" No way! The dolphins had belonged to his father John Will Jr., and before that to his grandfather "Dutch" Will. Young Alex is serving in SILVERSIDES as reactor control assistant. "He's only been in the Navy for three years, but has already made three North Atlantic deployments on SILVERSIDES." Alex's father, John Will Jr., was commanding officer of the nuclear powered PUFFER and later commanded the submarine tender CANOPUS, based in Rota, Spain. Alex's grandfather, Dutch Will (John M. Sr.), commanded the fleet boat PORPOISE before World War II and had a submarine division at the start of WW II. He commanded the Navy's Military Sealift Command before retiring. He died in 1981.

(This article raises the question, "Are there any other 3-generation submarine families that should be noted in the Submarine League's FACT BOOK?") ■

THE NUPOC PROGRAM

Individuals who desire to enter the Nuclear Propulsion Officer Candidate (NUPOC) program and then serve as submariners, and who are in their junior year or recently graduated from a college, must be exceptional engineering students.

A qualified applicant can enlist as an E-3 during his junior year of college and will earn about $1,000.00 per month. After one year he advances to E-4 and upon graduation he advances to E-5. After completing Officer Candidate School (OCS), he is commissioned as an Ensign, USNR, and commences Nuclear Power Training and drawing submarine pay. A college graduate selectee becomes an E-5 when he attends OCS.

Each individual entering the NUPOC program receives a $4,000.00 accession bonus. After completing nuclear power training, he receives an additional $2,000.00 bonus. As an active duty member of the Navy, the NUPOC selectee qualifies for all the benefits and privileges associated with active duty (medical, dental, commissary, exchange, etc.).

Applicants interested in pursuing this program should contact a nuclear officer recruiter at the nearest Navy Recruiting District. Additionally, information can be obtained by calling the Navy's toll free number 800-327-NAVY or by calling Commander Kai Repsholdt at Navy Recruiting Command, Washington, DC, (202) 696-4733.

To continue the successful trend of the NUPOC Program, we need the support of Submarine Leaguers in helping us inform the following people about the NUPOC Program:

- College leaders (President, Deans, Placement Counselors, Guidance Counselors)
- Professors in engineering related courses.
- Individual students
- Technical clubs

Any assistance given will be a great contribution to the continued excellence and readiness of our Navy.

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SOVIET SUBMARINES - *Design, Development and Tactics*
by Jan Breemer, Ph.D.
Jane's Defense Data; released February 27, 1989
ISBN # 07106-0526-9

The Soviet submarine force is receiving considerable attention. Not only is it the largest force in the world, but its technological quality, in some respects, is supposedly equal or better than that of Western fleets. It has forced the United Kingdom and the United States into producing new ASW submarine designs and has prodded the once-passive Canadian defense establishment to attempt to build its own nuclear submarine force.

Now that the subject of Soviet submarines is on many minds, along comes a book on that same subject from the respected Jane's Publishing Group. While no match is a pound-by-pound comparison to their better known *Jane's Fighting Ships*, this diminutive document is, nevertheless, packed with good information. Its title, *Soviet Submarines - Design, Development and Tactics*, would be more descriptive of the contents if the "*Tactics*" were removed; however, it offers a good background schooling as to how this force was developed from the early Tsarist days, through the Stalin era and into its current status.

Both the obscure and the obvious are covered. For example, the first Russian-owned submarine, the DIABLE MARIN ("Sea Devil") was designed and built in 1855 by a Bavarian naval architect in the Luechtenberg Yard in St. Petersburg. After some encouraging sea trials, it sank twice in the Baltic, the second time for good. While several attempts were made by indigenous Russian designers at building an operational model, it was not until 1877 that S. K. Dzhevetsky produced a model similar in appearance to the early subs built by John P. Holland. Eventually 50 of these mini 20-ft. undersea craft were built, some sporting innovations such as a primitive periscope that was probably 25 years ahead of its time. And did you know that Russia's first diesel propelled submarine that joined the Imperial Russian Fleet in 1911 was named AKULA? It translated to "shark" and is probably why NATO chose the name for this menace after running out of letters in the English alphabet with which to assign to new Soviet submarine classes.

This study of Russian/Soviet submarine history continues through the periods leading up to and during World War I, the post-War period, the naval buildup of the thirties, World War II, and the more familiar times since then. It is a fascinating and instructive lesson that not only discusses major trends, but also throws out little sparking tidbits of information. The immediate post-WW II era was particularly helpful to the Soviets as they obtained, as a result of the Potsdam tripartite naval commission, four complete Type XXI German models, probably the most advanced submarine at the close of the war. The Soviets also swept up thousands of German technicians and scientists, as well as tons of hardware and technical documentation, in their quest to build a modern submarine force.

The author has conducted painstaking research through archives, libraries and declassified literature to show that the Soviet Union's submarine fleet is no unfathomable accident. It is particularly interesting that one of his "invaluable" sources for the post-WW II era are declassified 1945-62 issues of the *ONI Review*. He has done his homework well.

Despite the temptation to overwhelm the reader with information and analyses about the current state and operational practices of today's Soviet submarine force, Breemer maintains sober descriptions and explains that contrary to some recent official U.S. Navy statements about an "unprecedented" building rate, the "newest [Soviet] submarines are evidently being produced at a slower rate than were their predecessors of 20 and 30 years ago." He does, however, note the "quiet revolution" represented by the AKULA, MIKE and SIERRA nuclear attack classes, as well as the unwillingness of Soviet naval planners to abandon diesel-electric designs and midget submarines. He provides much to think about, offers explanations, but where no answers are clearly present he does not forcefeed his own opinions.

The book is amply sprinkled with good and historically interesting photographs. The writing is crisp and thoroughly understandable, which should help new students on Soviet naval history grasp this important subject. A listing of Soviet submarine accidents, documented and rumored, is included, as are appendices on Soviet transfers of submarines abroad (1948-1988) and Soviet submarine basing infrastructure with reference maps. There is even a useful index. The only lowmark that is evident is the irksome 9-point type size.

Soviet Submarines is recommended reading for Naval Submarine League members. At a time when we are spending so much time and energy to counter this mighty force, it should only be right to make every effort to understand it. This one will help.

Deam W. Given

■

U.S. SUBMARINE ATTACKS DURING WORLD WAR II
by John D. Alden, The Naval Institute Press, Annapolis, MD
ISBN: 0-87021-767-4

This book will be no "Hunt for Red October." Neither will it result in more, or fewer, Navy Crosses.

It is, as the dust jacket claims, the most complete compilation of data on U.S. and Allied (British and Dutch) Submarine Operations against Japan. It will serve for years to come (and there may never be a more complete effort) as a research tool for WW II buffs or authors of yet another submarine tale.

There is a degree of "ego-trip" in this excellent research report for those of us who fought the war. I wanted to see how DRUM fared since I was aboard for patrols 1 to 11.

After an hour of research, I concluded that one DRUM JANAC 'sinking' was reduced to a 'Probable.' In addition, of eight claims of damage in DRUM patrol reports, three were verified, and one was credited to an aircraft.

CDR Alden acknowledges that he used as his model Axis Submarine Successes, 1939-1945 by Dr. Jurgen Rohwer. And indeed he did, with some omissions, as we shall note later. In fact, the Naval Institute commissioned this book as a companion to Dr. Rohwer's 1983 English language update of his 1968 study.

[Rohwer makes it easier to make assessments because one of his indices contains names of all submarines and pages where they appear in the data table. A second index treats the skippers in like manner.]

A look inside Alden's book reveals some 35 pages which describe his reasons for conducting many years of research, his sources, many of them untapped Japanese data, and more important, the significant errors in attack position, target identification and size, and in some cases, the attribution for the sinking. An explanation of the 16 column heads in the data table, a bit complex in spots, completes the introduction.

Then follows 226 pages containing a chronological listing from 9 December 1941 to 18 August 1945 of most, if not all, of the ships sunk or damaged, even including sampans attacked by gunfire. Columns 10 to 15 are unique in that they cite primarily Japanese sources which were used to verify U.S. patrol reports and JANAC (Joint A-N Assessment Committee 1947) data. The final column contains useful comment to clarify discrepancies or question previous claims.

The book concludes with an extensive multi-country bibliography, two appendices and an index. The first appendix describes and lists U.S., British, and Dutch submarine minelaying and augments the meager reported results in the main table, noting that accuracy is even more difficult to establish than in torpedo attacks.

Appendix B is an index of all submarines appearing in the main table by hull number, with Commanding Officers listed by patrol numbers.

The concluding index is alphabetically by name of target ships with the date and time of attack.

In sum, John Alden deserves kudos for a job well done in his U.S. Submarine Attacks During World War II.

M. D. Rindskopf

■

THE ATLANTIC CAMPAIGN
World War II's Great Struggle at Sea
by Dan van der Vat
Harper & Row, New York, 424 pages
ISBN: 0-06-015967-7

The Atlantic Campaign, is a magnificent portrayal of the pivotal Battle of the Atlantic. Dan van der Vat is fluent in German and has mined archives on both sides of the Atlantic with finesse. Access to de-classified "Ultra" intelligence data has thrown new light on earlier versions of the Battle.

Part I places World War I submarine and anti-submarine warfare tactics in excellent perspective, and includes a superb account of disarmament conferences held between the wars. Submarine re-armament efforts by Germany were supported by clandestine design, construction and testing of submarines built for Turkey in Holland between 1926 and 1928. Similarly, three submarines were built in and for Finland during the period 1926 to 1930. Continuity of effort is best described by the following quote from the book: "Even as the First World War flotillas were being surrendered, shared or broken up, the great store of accumulated knowledge was being put to work to lay the foundations of the submarine fleet that would fight the next war, ... and it was the same men, whether civilians or naval officers, who did it. Just as the Second World War rose out of the first, so the better-known Battle of the Atlantic grew out of its underestimated and under-reported but no less serious predecessor -- and the boats which fought in both, like their crews, were as closely related as parent and child. The most striking embodiment of this continuity was Admiral Karl Doenitz, ..."

Part II is called "The Main Event."

When war broke out on 1 September, '39, British appreciation for a major lesson of World War I, the convoy, was taken seriously, yet a lot of fuel (and assets) were also wasted searching vast ocean areas for submarines. (On 30 August '39, Doenitz had only 22 U-boats capable of Atlantic patrols.) The British carrier Courageous was sunk by U-29 on 17 Sept '39 while on such a search and destroy ASW mission off the west coast of Ireland. U-29 got away from the escorting destroyers.

British preoccupation with the threat of German pocket battleships was another distraction.

Lack of aircraft and teething problems of airborne ASW forces in the early days of the war caused part of the crisis atmosphere which prevailed for many months.

At the outbreak of the war, airborne depth charges were non-existent. Throughout the early stages of the conflict, long range aircraft were not made available for Iceland to protect convoys because the British Bomber Command had priority in mounting massive raids against Germany. This short-sighted view exacerbated the efficacy of Allied forces involved with the emerging Battle of the Atlantic.

At the climax of the Battle, feverish wolf pack attacks were mounted by Doenitz against the by now accomplished ASW forces. On 3 May '43, for example, two U-boats (U-439 and U-659) sank each other when they collided while opposing a convoy about 250 miles off the NW coast of Spain.

In maturity, a combination of Enigma decodes, the resulting diversion of convoys, airborne radar, and HFDF locating techniques turned the tide of battle. Airborne ASW was described by Doenitz at Nuremberg: "... in the spring of 1943 the airplane, the surprise by airplane, and the equipment of the planes with radar -- which in my opinion is, next to the atomic bomb, the decisive war-winning invention of the Anglo-Americans -- brought about the collapse of U-boat warfare."

Battle statistics can vary from source to source, depending on the definition of "lost," but at times the Atlantic nearly boiled with sinkings. Van der Vat's interpretation of the data lists Allied merchant shipping losses during the Battle as 12.8 million tons; while U-boat sinkings by Allied forces in the Atlantic totaled 696.

By October '43, shipbuilding capacity finally overtook the tonnage losses suffered since the start of the war. Once mobilized, American shipyards built Liberty ships with incredible speed. With the help of fabrication, ROBERT E. PEARY was built by Kaiser (Richmond, California, November '42) in four days and 15 hours.

Although packed with facts and figures, data are deftly integrated with the narrative, which is enthralling. This landmark book should stand as a superb piece of work for years to come.

Richard J. Boyle

THE SUBMARINE REVIEW is a quarterly publication of the 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 content of articles is of first importance in their selection for the REVIEW. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the REVIEW.

A stipend of up to $200.00 will be paid for each major article published. Annually, three articles are selected for special recognition and an honorarium of up to $400.00 will be awarded to the authors.

The views expressed by the authors are their own and are not be be construed to be those of the Naval Submarine League. In those instances where the NSL has taken and published an official position or view, specific reference to that fact will accompany the article.

Articles should be submitted to the Editor, W. J. Ruhe, 1310 MacBeth Street, McLean, VA 22102. Discussion of ideas for articles are encouraged: phone (703) 356-3503, after office hours.

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

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Total	3877	3935	3683

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