THE

SUBMARINE REVIEW

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ARTICLES	PAGE

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FROM THE PRESIDENT

Based on last year's initial success, the League will jointly sponsor with The Johns Hopkins University/Applied Physics Laboratory a second classified Submarine Technology Symposium, to be held in late May, 1989, at the Laboratory. VADM (Ret.) Bud Kauderer will again chair the event. The theme for this Symposium will be "The Technologies to Support the New and Expanded Submarine Roles and Missions." The CNO, Admiral Carl Trost, has accepted our invitation to be the Symposium Banquet speaker. Details on the Symposium may be found in an article in this REVIEW. We look forward to another success!

I believe that from most any aspect, we all feel a real sense of pride when one reflects on how far the NSL has come since 30 June 1982. Our early growth rate was excellent and one that we could administratively handle with personalized treatment. Likewise our accomplishments have been significant and a short list will be repeated here for those unable to attend our annual business meetings:

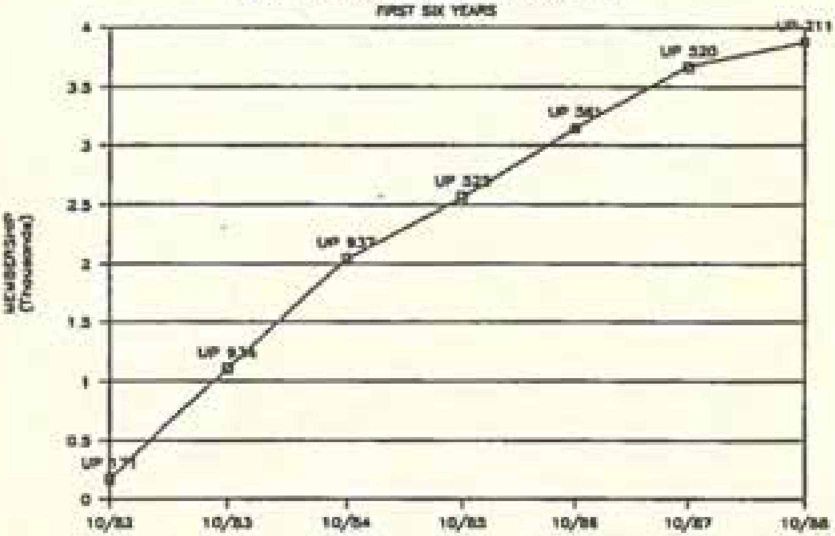
- o Conduct Annual Business Meeting and Symposium
- o Sponsor Annual Corporate Benefactor Meeting
- o Sponsor Submarine Technology Forum
- o Publish THE SUBMARINE REVIEW professional magazine
- o Publish NSL FACT BOOK and DIRECTORY
- o Distribute Speakers Package "Submarine Navy" (Loan program)
- o Distribute submarine oriented 16mm films and VHS tapes (Loan program)
- o Distribute VHS films to Chapters (Loan program)
- o Distribute submarine oriented photographs
- o Sponsor production of Submarine Documentary
- o Sponsor NSL Literary Award Program
- o Sponsor Complimentary NSL Membership Program
- o Sponsor NSL ad hoc studies

- o Distribute THE SUBMARINE REVIEW to ships and stations
- o Present one year complimentary membership to each Sub School graduate and SOAC graduate
- o Distribute THE SUBMARINE REVIEW to USNA and NROTC units
- o One year complimentary memberships to new Dolphins, EDO, MC and Supply
- o Authors stipend increased to $200.00
- o Support DASO Visit Program
- o Support Submarine Guest of the Navy Ship Visits
- o Distribute Information to Corporate Benefactors
- o Support Submarine School SOAC/SOBC graduation ceremonies
- o Conduct NSL Fleet Awards Program
- o Provide NROTC Outstanding Achievement Awards

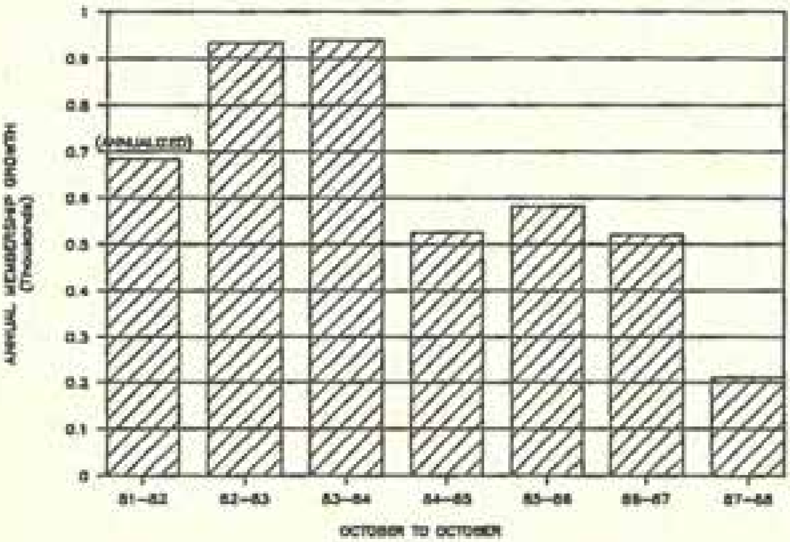
Well then, one might say: "Where's the beef?" In a nut shell we have a vexing problem and the problem can be simply stated that the NSL has only had a net gain of just over 200 members over the past twelve months.

NSL MEMBERSHIP GROWTH

FIRST SIX YEARS



NSL MEMBERSHIP GROWTH RATE



Studies conducted by the NSL Directors indicate that a controlled positive growth is very desirable to fulfill the various missions of our organization. This number has averaged 500 new members net per year. It would be folly to expect us to achieve that number indefinitely but a drop of 70% is worthy of discussion in this forum.

One asks, "What are the reasons for this drop-off?" Perhaps it is the seven year itch -- perhaps complacency -- things have gone so great, we individually slacked off on our goal to acquaint people with our organization and its purpose. Do you still carry a spare NSL registration form in your briefcase or tack an NSL brochure on the company bulletin board? Probably not, and I'm just as guilty as most.

So what do we do? For starters we need to follow Admiral Long's observation that our best recruiting tool is not advertising or big promotions, but the day to day interest and solicitation efforts by our own members. I don't believe we have reached the knee of the membership growth curve yet, so it's up to each one of us to get our second wind and rejuvenate our membership growth momentum. Get a few spare brochures from Pat Lewis and sincerely try to get several new members. Call our new NSL Membership Chairman, Dave MacClary, at (703) 637-4595, and unload your ideas on him. He needs your thoughts and help. Finally, if you're going to even a small submarine associated meeting, get a few spare registration forms and make them available. Many of our new members still relate that they have just heard of the League and a surprisingly large number found us by seeing a reference to the NSL in the written press.

Let's turn this around by our individual efforts. I'll give you a status report next year on the results of this appeal. LET'S GO TEAM!!!

Finally, I wish you all a very prosperous New Year. Without a doubt, this is the greatest country in the world. There are lots of complex forces at large that are working against us. But by unity, individual efforts and concern we can keep the USA as a model of freedom and liberty. The NSL is dedicated to this cause. I ask in this New Year, your sober reflection and personal rededication to this wonderful country of ours.

Shannon

STRATEGY PLANNING FOR SUBMARINES

Submarine warfare today is vastly different from the conventional submarine operations of WWI and II.

Present submarine technology, conversion to nuclear power, the advances in environmental control (fresh air to breathe), and supporting activities (including missile development), which extend to the outer reaches of space have all contributed to radical improvements in efficiency and capability.

Such advances and changes which have been introduced in the past few years certainly call for a review of the role of the submarine in sea power.

Our strategy planners are confronted with problems so diverse that the submarine has been taken for granted -- i.e., it must be a better ship than its counterpart in the Soviet Navy. So long as our planners and politicians believe that we do have better submarines, their attention is directed to other needs and applications of sea power.

From recent press reports summarizing a Russian appraisal of sea power, entitled "The Navy: Its Role, Prospects for Development and Employment," the Soviet Union intends to continue emphasis on its submarine forces. They have set goals for the future with regard to speed, depth, and futuristic weapons that appear somewhat unattainable in the near future, but the fact remains that they are pursuing new ideas.

Our Naval forces must be prepared to respond to a wide variety of crisis situations. Recent examples come readily to mind: The Cuban Missile crisis, the Persian Gulf intervention, the Falkland Islands War. They not only place a burden and strain on international relations, but they have perplexed the planners with a confused pattern of ship design and what used to be called gunboat diplomacy, a show of force, and task force composition. Ship design and technology -- to include naval aviation -- have advanced so rapidly in the past few years, it is obvious that sea power strategy must be continuously reviewed and revised.

Some examples from the history of sea warfare provide a perspective for present problems of strategy planning.

The Battle of Navarino, October 26, 1827, was the last fleet action wholly under sail. It was probably the most chaotic naval engagement of major forces in "recent" history. Naval forces of England, France and Russia engaged the naval forces of Turkey and Egypt. The political justification was to defend Greece's independence. The allied forces were considerably outnumbered but destroyed the Turk/Egyptian forces. The Turks had only 3 "line-of-battle" ships but a total of 1962 guns against 1294 allied guns.

Visibility was so bad from smoke and haze, that recognition of friend or foe was almost impossible. Communications were primitive or none at all.

The wind dropped to near zero and the ships -- all under sail -- could not maneuver -- whether to join in combat or to escape.

It was a classic example of the need to provide ships with "sea power," (i.e.), propulsion not dependent on the vagaries of the elements. The classic ship of the line evolved over the years. Sails gave way to steam turbines. Ships became truly mobile. And today the submarine is the most mobile of all ships -- and its mobility is least affected by weather.

The Battle of Tsou-shima (1905) between the naval forces of Russia and Japan demonstrated the value of communications, surveillance, and intelligence.

The Paris magazine Le Monde, published the sea route of the Russian force in advance. The Jap ships had radios and maintained almost continuous data on the location of their enemy. There was no element of surprise.

Until WWII lack of knowledge of the location of ships -- the movement of naval task forces -- played havoc with opposing forces. Witness the surprise attack on Pearl Harbor.

Until that memorable day, hardly anyone would dispute that mighty surface ships would ensure mastery of the seas. Battleships with heavy armor were the centerpiece of fleet operations. But as war at sea evolved, the Battle of Midway established the pre-eminence of the carrier.

Our U.S. present-day strategy now dictates a battleship- carrier task group with the ships-of-the-line protected by "anti" units: anti missile, anti submarine, anti aircraft, anti mine, and perhaps anti satellite capability and a capability for electronic warfare.

Alfred Thayer Mahan wrote authoritatively of the value of sea power. His books stressed that lessons of history were not changed by replacing sails by steam power. Yet there have been decisive examples of armadas and fleets severely damaged by the ravages of storms which were not foreseen. Weather can still be a factor, but it is predictable.

Impressive as the battleship-carrier task group appears, we need to appreciate that surface ships can no longer remain invisible. Satellites give us accurate information on weather, navigation and precise location and movement of units.

Advances in technology have imposed new hazards to surface ships-of-the-line and have raised embarrassing questions relative to U.S. strategy planning.

Sea power is not confined to the seas. The dimensions of space must now be added. The combination of missiles and both land-based and sea-based, air, nuclear powered submarines, satellite-surveillance, electronic-warfare, and sophisticated "smart" weapons has inevitably lead one to the conclusion that control of the seas can not be achieved by merely adding more ships. To try to do so puts too heavy a strain on national defense budgets.

Submarine planners will not argue against the unique characteristics of the submarine, but strategy planners, at least in the U.S., have seemingly limited the role of the submarine to (A) Deterrence by means of strategic ballistic or cruise missile carrying submarines, and (B) to Anti Submarine Warfare using mainly SSNs.

The mobility, stealth and fire power of the submarine, even the diesel-electric submarine, deserves far more attention by strategy planners.

Other countries with far less experience in submarine warfare are experimenting with midget subs, non nuclear propulsion, mining, robots, the destruction of shore facilities, arctic operations, and the Russians, with many nuclear submarines still foresee a role for the conventional submarine. What are they planning by sending conventional subs into the well defended fjords of Sweden?

If the navies of the world have even a handful of disciplined, well trained submarines, there is a diminishing future for carriers and other high value warships. The submarine has attained the status of capital ship on an equal footing with the high visibility large surface ships which have no place to hide.

Admiral Lockwood assembled a small group of experienced commanding officers immediately after

WWII and posed the question "What improvements do you want in the next generation of subs?"

The impossible "pie in the sky" desires of the WWII submarine skippers included a full-time propulsion plant not dependent on the diesel engine; environmental control of the atmosphere to preclude the need to ventilate; a missile capability -- a long-range stand-off weapon; a better torpedo -- "smart"; a long range sonar; and highly accurate navigation.

It appeared in 1945 to be an exercise in futility, but when the nuclear submarine NAUTILUS sent her message "underway on nuclear power" in 1955 most of these were approaching reality -- and the ALBACORE single screw torpedo-like hull allowed SKIPJACK and the follow-on SSN's to dive deeper and go faster than any other submarine at that time. Later in 1960 the nuclear powered POLARIS missile- submarine GEORGE WASHINGTON sailed on her first patrol. Both were the pathfinders for a new revolutionary submarine capability in the world's navies.

Other nations obviously have differing views of the role of the Navy in international affairs and due to fiscal restraint cannot maintain high visibility forces. Many have relied on the U.S. umbrella. In turn, others are examining the potential of small ships, with considerable attention to submarines. They may not be highly visible, but they can be formidable and strategy planners must take this into account.

Strategy planners, War Colleges, and Submarine Schools as well as submarine staffs should establish units to develop the impossible.

Arnie Schade

THE CREDIBILITY OF OUR SSBN DETERRENCE

Can the OHIO-class SSBN, armed with the D-5 (TRIDENT-II) missile, be relied upon to execute all strategic options assigned? Until recently, conventional wisdom suggested that the SSBN was invulnerable. However, detractors claim submarine launched ballistic missiles (SLBMs) are not as militarily capable as land-based ICBMs; and the communications links to the U.S. SSBN force are fragile. By this rationale, the submarine leg of the Triad would not be as capable or reliable as the ICBM and air breathing systems -- bombers and cruise missiles -- under wartime stress, or when it really counts.

It needs to be argued that the OHIO-class SSBN with the TRIDENT-II weapon system can successfully execute all strategic missions assigned as well as, if not better than, land or air systems. This can be shown by discussing SSBN hardware, listing SSBN strategic missions, and then assessing the TRIDENT-II system's ability to fulfill these missions in terms of the SSBN's capability and survivability, the D-5 missile's penetration and performance characteristics, and lastly, communications vulnerability.

The USS OHIO-class submarine exceeds design specifications in both performance and quietness. The navy presently wants 20 OHIO-class SSBNs, 10 each for the Atlantic and Pacific Fleets. The 16th ship was funded in the FY-89 budget and the remaining four seem a certainty. All of these strategic submarines are designed for a 70/25 day deployment/turn-over cycle. Today, OHIO-class SSBNs are armed with the TRIDENT-I (C-4) ballistic missile. The USS TENNESSEE is scheduled to reach initial operational capability in December 1989 armed with the first load of D-5 SLBMs. By 1989 the D-5 missile production line will turn out about six missiles per month until the entire OHIO class is fully equipped.

The D-5 is a 44-foot long, three-stage missile with a range of about 6,000 miles. Each missile will carry 8 multiple independently-targeted re-entry vehicles (MIRVs), although it could carry more. The ninth of 20 scheduled missile tests from land-launch pads was completed on 21 January 1988 with a record of eight successes and one failure. The system is "on track" and the navy claims the D-5 can match the targeting capabilities of land-based ICBMs.

The D-5 will deliver a larger payload with better accuracy than the C-4 missile. It will create a hard-target capability from launch ranges that insure SSBN survivability now and into the future. The SSBN can utilize the NAVSTAR system. With existing on-board position-keeping qualities, own ship's location within 10 feet is guaranteed. Improved submarine position fixing and the mid-course stellar up-dates of the D-5 missile will insure that eight 150 KT highly accurate reentry vehicles can be delivered on target at ranges up to 6,000 nm's. To achieve a hard target kill capability, a larger and heavier high-yield warhead, the MK-5, is being developed. With the MK-5, the same number of reentry vehicles on the C-4 become hard target capable at 4,000 nm's. As usual, throw-weight versus range are trade-offs.

Strategic nuclear options available to the Joint Strategic Target Planning Staff include variations of both counterforce and countervalue targeting. Counterforce attacks include:

- o A First Strike Disarming Attack,
- o Launch On Warning (LOW),
- o Launch Under Attack (LUA),
- o Limited Nuclear Options (LNOs)
- o Prompt Hard-target Retaliatory Attacks, and
- o Intrawar Fighting.

The "first strike" and launch-on-warning are preemptive attacks planned and executed in a peace-time environment. Both are possible, but highly unlikely actions by the U.S. The remaining counterforce options are most likely to occur in a nuclear environment where only the SSBNs at sea are invulnerable to attack (permitting their missiles to be withheld); and where the SSBNs remain durable for months, not hours as are manned bombers in flight. Nation-wide communications disruption is probable in a nuclear exchange because the electromagnetic pulse (EMP) from a high-altitude nuclear detonation can produce total electrical power outages. Also, physical destruction of communication facilities from weapon blast is likely. This disruption across the entire electromagnetic spectrum will affect all communications to satellites attempting to relay messages to any surviving strategic forces. Reconstitution of communications, "one-way" for submarines, appears a key to conducting successful war fighting with surviving strategic forces.

Countervalue attacks deal with:

- o Retaliatory Attack by U.S. SSBNs, and
- o War Termination Bargaining.

Both these options depend upon survivable forces, but are not necessarily time-sensitive. Certainty of retaliation is the real deterrent, not the exact time it will occur. It follows that if sometime during an SSBN's 70-day patrol a properly authenticated emergency message is received from the national command authority, a retaliatory attack will take place.

SSBNs at sea maintain prelaunch survivability through mobility in ocean space. Their ballistic missiles are difficult to defend against for the same reason -- the position location uncertainty of the launching platform. SSBNs can operate in the vast regions of ocean-space and launch missiles from many azimuths at their targets. On the other hand, the location of ICBM silos are well known and the missile flight-paths approximate a great circle to the target. Since the enemy has a good sense of what is being targeted, his active defenses can be positioned in the best locations.

Should deterrence fail, ballistic missiles from forward deployed U.S. submarines, having a short time-of-flight, could be the first strategic weapons to arrive on target. Because of SSBN survivability, withheld missiles could be available for retaliatory strikes, or saved for war termination bargaining. The manned bomber, of course, also can attack from various azimuths, but it has limited airborne endurance and is more detectable than the SSBN prior to weapons launch.

To appreciate the enormous patrol areas available to the SSBN, 71 percent of our planet is covered by water with a volume of 360 million cubic miles. All the world's population -- some four billion people -- would not displace a single cubic mile of sea water. In this vast space, the OHIO-class SSBN, carrying the TRIDENT-II missile, can patrol under some 50 million square miles of ocean surface. Close to merchant traffic, naval formations, fishing boats, sea mammals and miscellaneous flotsam and jetsam, locating, classifying and attacking the submerged SSBN is analogous to locating a needle in a haystack.

U.S. submarine security has outdistanced U.S. and Soviet anti-submarine warfare capabilities. The ongoing SSBN Security Program incorporates in-depth intelligence, laboratory experiments, mathematical models and real-world tests to identify and evaluate potential submarine threats. Technologies with a potential to threaten our SSBNs are not only assessed, but countermeasures are developed before a need arises. Critics of the "blue-water" deterrent raise the possibility of a "transparent ocean," but there simply is no credible evidence to indicate that technologies to do this are even on the horizon.

Communication reliability between the National Command Authority and the U.S. SSBN force under conditions of wartime stress is often questioned by strategists and politicians. Redundant world-wide communications are in place. Submarine UHF, HF, LF, VLF, ELF, the USAF,s National Emergency Airborne Command Post and Emergency Rocket Communications System, Strategic Air Command Air-borne Command Post, the Defense Satellite Communications System and the Navy's E-6A TACAMO aircraft system, exist and work.

The primary world-wide "receive only" method of communicating with submarines at sea is the very-low frequency (VLF) network. This system consists of two primary and seven back-up sites in the U.S., and another primary site in Australia. The submarine receives a VLF signal on its underwater loop antenna down to a depth of about 150 feet. The submarine also can receive the VLF signal on its submerged trailing-wire antenna or by raising an antenna above the surface on a hydraulic mast. At deeper depths the submarine can stream an antenna buoy that floats to the surface. VLF sites are "soft" targets, and like many other communications, can be affected adversely by electro-magnetic effects from nuclear bursts.

As "insurance," the navy operates two squadrons of TACAMO aircraft that fly continuous random patterns over the Atlantic and Pacific Oceans providing VLF relay capability. These aircraft operate under conditions of electronic silence and guard multiple sources for emergency action traffic. The E-6A aircraft can remain airborne for up to 72 hours providing additional communications survivability, since TACAMO, -- far at sea -- is not likely to be affected by nuclear detonations on or over the United States. As further "back-up," the VLF network is augmented by many low frequency transmitters in and outside of the U.S.

The extremely low frequency (ELF) system provides low data-rate alerting information for submarines operating at varying depths or at high speeds. Although the transmitting sites are not hardened, this system is not susceptible to electro-magnetic pulses or jamming. When the submarine hears an alerting sequence or loses the continuous broadcast signal, it may come to communications depth and monitor other navy, air force and joint command frequencies. Since most analysts consider an "attack from the blue" the least likely of all nuclear war scenarios, probability is high the ELF system will provide the SSBN force with strategic warning.

Submarines can receive traffic on ultra-high frequencies via four satellites in the FLTSATCOM system. When the MILSTAR system becomes fully operational in the early 1990s, SSBNs will have another satellite communication option that is jam proof through frequency-shifting techniques, and placed at an altitude higher than anti-satellite systems now operate. Also, laser communication systems are in research and development for future submarine applications.

Does streaming a trailing wire antenna, communications buoy or raising a whip antenna mean that the SSBN will be detected? Not likely, considering the size of the antennas versus the surface area of the ocean. Neither does enemy jamming pose a real threat since the SSBN is operating closer to one or more of the world-wide system of U.S. transmitters than to Soviet jammers.

The issue, however, is how useable are these systems in a nuclear environment? The Navy is confident that some communication links will survive, thus providing at-sea submarines with warning and an "execute message" with the same or a higher degree of reliability than expected for ICBMs and bombers -- if the latter survive at all! If an "executive" message is released, the SSBN force will receive it. Even in the worst possible case where all surface facilities are destroyed in a preemptive nuclear attack, SSBNs at sea could respond. U.S. and allied naval and merchant ships are routinely located throughout the world's oceans. These ships can provide high-frequency relay for an "execute" message if one is released by a reconstituted U.S. national leadership and put "on the air" by any means.

In addition to the OHIO-class SSBN being able to execute a full range of strategic options under all conceivable conditions when equipped with the D-5 missile, other fringe benefits occur. For instance, this sea-based system is cost effective in that fifty percent of the U.S.'s total reentry vehicles are carried on SSBNs at a cost of about ten percent of the navy's budget. Also, because sea-based systems are survivable, they do not require the massive strategic operational and warning organizations needed to provide the ICBM and strategic bomber forces with enough warning to preclude the "use-'em-or-lose-'em" dichotomy. Nor does the SSBN force act as a "lightning rod" for incoming ballistic missile attacks on the continental U.S. In a domestic political sense, the SSBN system has a minimal effect on continental U.S. issues.

Every indicator points to a continuing SSBN system survivability and invulnerability. The D-5 missile is designed for both hard and soft targets with the accuracy and yields necessary to accommodate the widest range of strategic options. The issue of unreliable communications with strategic submarines simply is a non-issue. The redundancy of communication paths throughout the electromagnetic spectrum, along with the multiple options for message relay via friendly ships in port and at sea provides connectivity equal to, and perhaps better than, that available to other Triad systems. Taken in total, the OHIO-class SSBN armed with the D-5 missile is a credible and durable strategic deterrent with significant and survivable deterrent and warfighting capabilities.

Richard T. Ackley, Ph.D.

SLCMs in ARMS CONTROL: The VERIFICATION CONUNDRUM

In the April 1988 issue of The SUBMARINE REVIEW, I wrote that the United States and the Soviet Union had agreed in principle that long-range, land-attack sea-launched cruise missiles (SLCMs) could be the subject of an arms control agreement independent of, but related to a Strategic Arms Reduction Treaty. The principle remaining impediment to such an agreement is effective verification. The U.S. negotiating position is steadfast and clear: there can be no arms control limits on SLCMs without air-tight verification provisions. But such provisions are virtually impossible of achievement.

At best, verification of compliance with any arms control limits on SLCMs would be exceedingly difficult. Unless a complete ban on <u>all</u> SLCMs of <u>all</u> types and <u>all</u> ranges were agreed to, verification would have to be implemented in two stages: first, verification of overall missile deployments, and second, verification of specific missile capabilities. Confidence in an arms control agreement limiting SLCMs would require that both stages be carried out fully and flawlessly.

Limiting SLCMs to an equal aggregate level would require a precise numerical accounting. At the outset, therefore, the U.S. would need to verify that the USSR did not exceed the Treaty-agreed deployment level. However, it is doubtful whether this could be accomplished. This is due in large part to the small size of the USSR's SS-N-21 cruise missile and its ability to be launched from standard Soviet torpedo tubes. It is impossible to determine with National Technical Means of verification whether a given torpedo tube on a given submarine contains a land-attack SLCM, a torpedo, an anti-ship missile, or is empty. Moreover, even with intrusive, periodic on-site inspection of Soviet submarines, the U.S. could not be positive that the USSR was not exceeding the SLCM limit. Unless every submarine in the Soviet fleet were inspected simultaneously -- something the Soviet Navy surely would not permit, and that would be logistically almost impossible even if it did -- it would not be certain that they were not above the aggregate limit. Even if such a feat could be accomplished, the U.S. could not know whether excess SLCMs in violation of the agreement were hidden ashore or on nearby support vessels.

A total ban on all SLCMs would ameliorate the problem of numerical accounting somewhat, but would by no means remove it. Under such a highly doubtful scheme, the U.S. would merely need to detect a single SLCM of any kind anywhere in the Soviet Union or aboard a Soviet submarine or other naval vessel to consider the ban violated. The prospects of detecting that SLCM in the face of a concerted Soviet concealment effort, however, would be exceedingly slim.

If the problem of numerical accounting could somehow be resolved, the U.S. would still face the problem of verifying SLCM characteristics. Specifically, the U.S. would need a means to verify that non-accountable SLCMs do not meet the threshold of accountability in terms of range and payload.

The U.S. and Soviet negotiators have agreed that only long-range SLCMs should be limited. However, "long-range" should mean greater than 600 kilometers. How then is the U.S. to verify that a given Soviet SLCM model does not have long-range capability? Conventional wisdom holds that we could verify SLCM range by observing flight test activity. However, there is nothing to prevent the Soviets from concealing a SLCM's true range capability by testing it to less than full range. Indeed, the Soviets already have several modern antiship SLCMs that are credited by the United States with ranges very close to the 600 kilometer SALT II threshold (i.e., the SS-N-21 and SS-N-19). Perhaps we have already been deceived! If so, the Soviets could readily deploy land-attack variants of these missiles as they did in the 1960s with the SS-N-3. If not, they could readily develop such missiles with the necessary attendant deceptive testing.

As for the payload question, although it is conceivable that conventionally-armed SLCMs could be included in a U.S. Soviet SLCM agreement, it is probable that SLCM limits will only be applied to systems fitted with nuclear warheads. It would then be necessary to verify that "non-accountable" SLCMs were in fact non-accountable -- i.e., not armed with nuclear warheads. As with the verification of aggregate limits, this could not be accomplished by national technical means alone. On-site inspection would be necessary. This would involve U.S. inspectors physically examining cruise missiles aboard Soviet submarines, and Soviet inspectors doing the same on U.S. submarines. Not only would the Soviets be certain to reject such a proposition, the U.S. Navy certainly should reject it! Under no circumstances would it make military or political sense to grant the Soviets direct access to our most sensitive submarine technologies. Even if the U.S. did, and the Soviets reciprocated, the U.S. would still be unable to verify that SLCMs armed with conventional warheads when inspected would not be refitted with nuclear warheads at a later time.

In sum then, the verification problem appears to be insoluble. The U.S. will never be able to assure with absolute certainty that the Soviets are not exceeding agreed SLCM limitations. Moreover, the Soviet record of non-compliance with past arms control agreements -- SALT I, ABM Treaty, Limited Test Ban Treaty, Biological and Toxin Weapons Convention -- does not inspire confidence in this regard.

Dr. Edward J. Lacey

SUBMARINE FLEET POTENTIAL

For mankind the destructive powers of a submarine fleet are but a fragmented patch of memory. Few can recall the unleashing of unrestricted submarine warfare in World War I. More can remember the submarine inflicted terror of the Battle of the Atlantic in the second World War. These negative memories for the Allies were somewhat compensated for when the submarine contributed to a win in the Battle of the Pacific. In the 1950's, prior to the SPUTNIK distraction, the submarine became a source of optimism. With knowledge of submarine fleet potential fresh in their minds, Americans had the desire and opportunity to raise this potential to new heights. Submarine technology took a giant leap on two fronts: the platform and its weapons. The nuclear-powered NAUTILUS gave the submarine high submerged endurance and the ALBACORE optimized the submarine hull. The REGULUS and POLARIS missiles gave the submarine a capability to attack at great range. The foundations were quickly laid for a brilliant future. This brilliant future, however, slipped from the American's grasp.

Is is to be regained?

It has been a long time from the positive early-fifties to the uncertain late-eighties. Should we expect anyone under fifty, other than an unusually good student, to have an appreciation for the potential of a submarine fleet? The sinking of the BELGRANO during the Falklands War simply provided a mini-refresher course for those beyond middle-age and a mini-introductory course for others. If the positive benefits of the submarine are to be enjoyed, the meaning of the words SUBMARINE FLEET POTENTIAL must be reestablished.

The chosen meaning of "fleet potential" is most easily understood within the context of a game. For our purposes, we will define a fleet potential as a capacity for scoring; that is, the capacity for scoring hits or kills. This measure equates to the practice of awarding medals with citations for tonnage sunk by individual submarines and submarine squadrons. The potential of surface and air arms can be measured within the same context. Just as in football, points may be scored for the ground game and the passing game. One will recognize that this definition is a measure of offensive power; it contributes to victory, but by itself does not assure it. Victory is a product of force against force including both offensive and defensive components. The submarine is seen as a brilliant offensive instrument, particularly when it is "in the open ocean" -- it is hard "to defense." For these reasons, its offensive fleet potential excites. But games go both ways. Excitement can be turned to terror with the threat of defeat. Before closing we should look beyond submarine fleet potential to submarine force potential. This brings with it the capacity to defend against the submarine.

The potential of a submarine fleet is dependent upon its ability to get into the open ocean. Thus a requisite of its potential is a secure basing structure. Such a structure must provide the facilities for readying the submarine for combat patrol and the secure access routes which permit the submarine safely to enter and leave its base or system of bases. During World War II the Russians had a large submarine fleet but failed to provide a secure basing structure. This failure negated most of the potential the fleet might have possessed. In contrast, the Germans in WW II quickly moved to increase the security of their submarine basing structure by adding heavily protected bases in occupied Norway and France. In so doing the potential of their submarine fleet was greatly enhanced.

There is little doubt that the Russians have learned this lesson. Americans have also been attentive to base security in their design of the POLARIS and TRIDENT strategic submarine fleet. It is less obvious that a secure basing structure is consciously considered in Western designs of non-strategic submarine fleets.

This requisite is doubly important. Not only is the provision of a secure basing structure an essential step in the development of submarine fleet potential, but should one try to negate the submarine fleet potential of an opponent, he should concentrate on rendering the supporting base structure insecure. In the case of a prudent and well-situated opponent, this task will not be trivial.

If a secure basing structure requisite is met, submarine fleet potential is defined by its offensive capacity to threaten and destroy: a. surface shipping, b. surface combatants, and c. shore facilities -- ports, bases. These are the primary offensive targets of the submarine over which it will hold a significant advantage.

Submarine fleets were and are created to take on such targets. This is also the prime measure of submarine fleet potential. As to the matter of submarines targeting other submarines, this is a "defensive" activity within which the submarine must seek out an advantage through its inherent design. Attriting enemy submarines in forward areas is a defensive mission preventing enemy subs from their offensive missions. Strategic ASW is a defense against the enemy's projection of strategic weapon power. Associated support of a battle group is a defensive screening-measure mission.

With this background in place, the task of developing a fleet concept which maximizes submarine fleet potential is almost trivial. The basic building block is the quiet nuclear-powered submarine. Its high speed and great operating depth are nice but not essential. The key decision to be made for the nuclear submarine is the choice of payload. There is little doubt that when it comes to targeting surface shipping, surface combatants, and shore targets with conventional warheads, the weapon with the greatest potential is the torpedo-tube launched cruise missile. A nuclear submarine is capable of carrying twenty-five or more such weapons; the more weapons and weapon launchers per ship the greater the potential. The torpedo, no matter how modern, has been supplanted as a primary offensive weapon.

The basic submarine fleet is thus one of submarine "cruisers" (in the Mahan sense), capable of a large volume of fire at long standoff ranges. Submarine potential has been, and will continue to be realized in the form of cruiser warfare. The number of submarines will also contribute to submarine fleet potential, but there will exist clear limits as to useful fleet size. The modern target is fatter and the modern submarine is far more powerful. It might be found, after careful consideration, that a submarine "cruiser" fleet of, say, in the order of thirty (twice as many as carrier groups) is an optimum force. But, there exists no submarine in Western navies which is tailored to meeting the tactical potential as here defined.

Current naval practice, East and West, has focussed on the submarine's newly developed capability for attacking shore targets with nuclear warheads delivered by ballistic missiles. This strategic mission is sufficiently unique to justify a dedicated submarine fleet. The existence of a secure basing structure remains a requisite. A quiet nuclear-powered submarine again serves as the basic building block. Very high speed and great operating depth do not have strong positive effects on this fleet potential. It is the weapon choice which is special -- a long range missile capable of penetrating defenses and delivering nuclear warheads accurately. Today the ballistic missile fulfills this need. Again, very large weapon loads equate directly to fleet potential. Also, since the number of strategic targets is limited and the strike capabilities of an individual fleet ballistic missile submarine are great, the size of the offensive strategic submarine fleet can be modest.

In a straight forward fashion, two, and only two submarine types have been defined which contribute directly to a submarine fleet potential -- stated in terms of a capacity to perform offensive submarine warfare tasks. The provisions for quieting, submerged endurance, and large payloads, are basic. Naval super powers could readily justify two such offensive submarine fleets composed of a total force level in the order of sixty submarines. Larger sized fleets could be justified should the capabilities of the individual submarines fall short on potential.

Most of us know that the naval super powers already have substantially more than sixty submarines, and it is not just because these craft fall below their potential as we have defined it. The justification lies in the fact that submarines have an important role to play in defensive as well as offensive submarine warfare. It is obvious that a submarine has no superiority over another submarine, unless it is through its design characteristics. Thus, the submarine has found another niche, a defensive role seeking to reduce the potential of an opponent's submarine fleet. The submarine can most effectively accomplish this goal by undercutting the security of the opponent's basing structure -- particularly by threatening any movements to, from, and within the basing area.

The design of a defense-oriented submarine force, unlike an offensive one, involves no quick and ready answers. Unit capabilities and numbers come into play. Historically, the offensive submarine fleet potential provides little comfort to those who wish to set a modest ceiling on ASW force levels whether air, surface, or submarine. For this reason, the question of affordability becomes an equal, if not dominant, factor in the conceptual development of ASW forces, especially submarines. Anti-submarine warfare requires the development of force multipliers which will yield the desired defensive effect while recognizing the realities of budget constraints.

It is not the least bit clear that the building blocks exist for a submarine force capable of denying an opponent the security of his submarine basing structure or one classified as an affordable ASW specialist. It is easier to rationalize that existing designs are multi-purpose -- both offense and defense capable. Yet, when such craft are assigned to defensive missions, they will not exist in sufficient numbers -- and hence their potential for offense will become both unavailable and at risk. Today, it is very difficult to speculate as to what could be accomplished in the design of a defensive submarine force dedicated to the denial of base structure security. What weapons would be used? Is its stealth of prime importance? Can it perform in the shallow water environment? Can such submarines win in a melee situation? Are there effective submarine laid mines available? Without answers to such questions and/or positive weapon system solutions in hand, little can be said about the defensive components of a submarine's force and its possible contribution to winning.

Returning to the lessons which may be derived from the consideration of games, it is quickly noted that, if the rules do not prohibit, players tend to become specialists. This has a dual advantage: their physical capabilities and training can be better focussed upon specific tasks. This pattern is permissible and highly developed in football. In baseball, when the option of using a designated hitter is offered, it is seldom refused. In the realm of submarine fleets and forces, the options are open. Both of the superpowers have chosen to develop a fleet of dedicated strategic missile submarines. Beyond this option the United States has declined to pursue any further development of specialized submarines. It has displayed enthusiasm neither for maximizing its offensive submarine fleet potential, which embodies a capacity for scoring, nor for minimizing defensively the opponent's potential for scoring. Has the goal of winning slipped from the agenda?

The above neglect of further submarine specialization by Americans can be explained; it cannot be justified. In the brief interlude between the Battle of the Pacific and the peacetime Battle of the Budget, American submariners actively pursued the concept of specialization and seriously began the development of an anti-submarine submarine involving all the critical technologies. At that time the U.S. had more than an adequate offensive fleet potential across the board -- submarine, surface and air. The only standing naval threat, Russian, was a force of more than three hundred submarines. The U.S. priority for ASW defense was obvious. Interest in the dedicated ASW submarine was, however, not long lived. Americans have the bad habit, in peacetime, of self-imposing force ceilings rather than budget ceilings. The idea of the force-multiplying austerity of the ASW specialized killer submarine was abandoned in favor of the general purpose attack submarine. The attack submarine, as it has evolved, mocks the notion that any benefit, cost, or effectiveness, can result from self-imposed force ceilings. The attack submarine has never been configured to realize a true fleet potential for offensive submarine warfare. With respect to weapons, it is a hermaphrodite; its cruise missile installation is not primary, it is an afterthought. Moreover, the urgency of creating a solid, submarine-based ASW defense has never diminished. Force ceilings, not budget ceilings have cut the rug out from under any further serious American effort to fill this need.

The concept of submarine fleet potential is readily recognized when one reflects upon the capabilities of a fleet of ballistic missile submarines, or a fleet of cruise missile armed submarine cruisers. Such craft, in the open, have a capacity for scoring. Their very presence creates a demand for defense. A winning force must have balance between offense and defense. Of the two, the burden of achieving a satisfactory defense is heavier, it should not be put off by self-defeating policies.

John S. Leonard

OUR SUBS FLY WITH ONE-HALF A WING

Back in the mid-1950s naval architects thinking about ideas from the aerospace world wondered if the ALBACORE could "fly underwater" just like an airplane?

An aircraft flies in the fluid medium of the atmosphere with virtually no constraints in the vertical or horizontal dimensions. Its only problem is that it needs wings to help support it in such a thin fluid as air.

Submarines fly in the fluid medium of water with no constraints in the horizontal dimension but with very serious limits in the vertical dimension due to the very high pressure of water as one goes deeper into the ocean. Crush depths of only 4-6 ship lengths contrast quite markedly with the 10-15 mile vertical space for the aircraft world. Nonetheless, one can continue the analogy somewhat more accurately by comparing the modern submarine with the airship or dirigible that was so popular before WW II.

Neither submarines nor airships require wings to support themselves in flight. Their displacement of water and air, respectively, take care of this little detail, which makes life much easier when one wants to slow down or stop and talk things over. Airplanes don't stop very well in mid-air.

Indeed, for the early ALBACORE experiments with single man control, a number of ALBACORE crewmen were sent down to NAS Lakehurst. Here they practiced flying the ZPG 2 and ZPG 3W airships to become familiar with the control responses that were expected with the new, slippery body of revolution hull.

Although the original HOLLAND submarine was nearly perfect, streamlined, underwater body-of-revolution, its ideal shape was to change very soon. The reality of operating on the surface forced the addition of a "conning tower" to prevent flooding of the captain's hatch from wave motion and to support the periscope necessary for performing its stealth mission underwater. Unfortunately, these early submarines were only surface ships that were able to go underwater for very short periods of time due to the lack of a suitable powerplant. If nuclear power were available in 1900, I am sure that modern submarines would have a very different look today.

Nonetheless, with the arrival of the "GUPPY" submarines, a fairing was installed over the periscope/snorkle/antenna protuberances and the "conning tower" gave way to the sail or fairwater. Quite inadvertently, the modern attack sub was now saddled with a wing that would severely limit its maneuvering ability in the horizontal plane (because it wasn't balanced by a wing sticking out from the bottom), and soon lead to the discovery of the roll/yaw coupling phenomenon known as "the snap-roll."

This writer first heard about this instability in 1959 while working in the development of a Navy airship as a "flying wind tunnel." Since the ALBACORE was the first submarine to explore the other side of 30 knots, it did not take long for rumors to surface about the "submariner's J.C. maneuver," where the crew nearly found itself hanging upside down from their seat-belts after attempting a high-speed, 30-degree rudder turn.

It makes sense, of course. What does one suppose would happen to a fighter plane in a turn if it lost one of its two half wings? So how can one expect a submersible to fly in the horizontal dimension with only half a wing?

The ALBACORE engineers and crew worked for several years to solve this basic limitation to horizontal maneuvering, and there were many possibilities. For the time being, limiting the degrees of rudder used in a high-speed turn was used. But how can one avoid a hostile torpedo or sonar contact on a potential enemy sub at 2-3,000 yards if limited to modest, large-radius turns? One does not have much time to avoid or reposition to make ready for a quick counter-attack and getaway.

Recall the famous ALBACORE demonstration in 1956 -- with Admiral Arleigh Burke and Admiral Mountbatten on board -- while being hard-pressed by a friendly destroyer off the Florida Keys. When the destroyer thought she was almost on top of the submarine, the ALBACORE suddenly heeled over into a 180 deg. turn. With a skilled pilot using their single-man controls in cooperation with an aggressive captain, the ALBACORE quickly broke the pursuing destroyer's active sonar contact and disappeared into the azure-blue depths of its natural habitat.

Today, however, we are losing the luxury of being able to detect the Russian at over 20,000 yards. With quiet submarines now proliferating all over the world, the underwater melee or "underwater dogfight" is becoming increasingly likely. There is no question the Russians have been working on the problem. Look at the ever smaller, blended sails on their subs. It is already acknowledged that many can dive deeper and go faster than we can. The ADCAP torpedo is not enough, we must learn to outmaneuver them in the horizontal plane.

THE TURN PROBLEM:

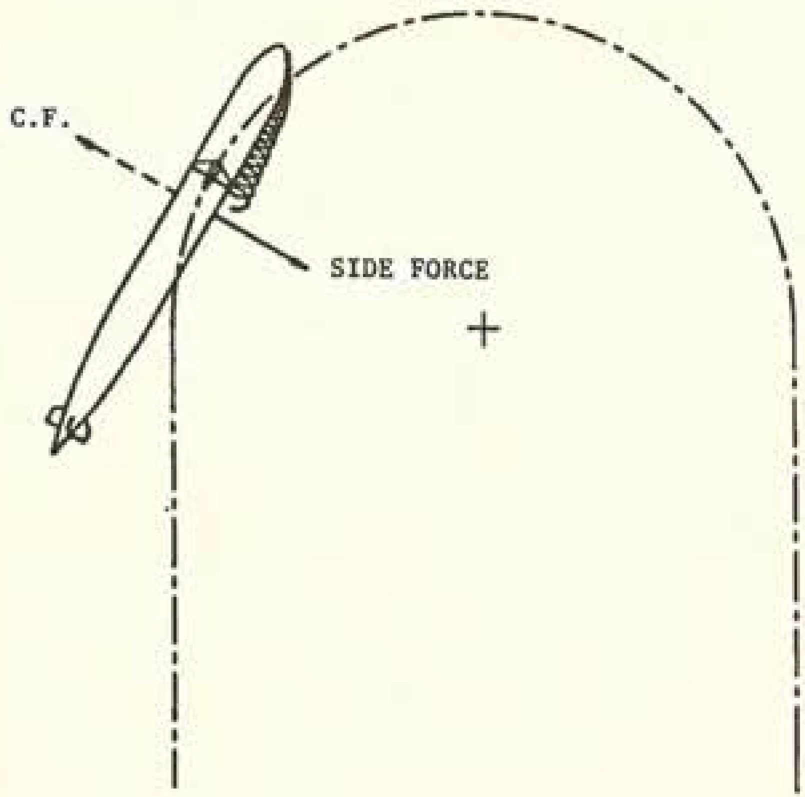
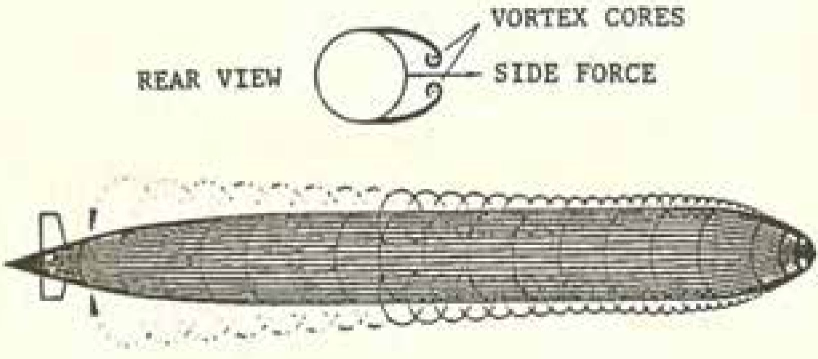


FIGURE 1

For any untracked vehicle entering a turn, it is necessary that the outward centrifugal force generated by the mass of the vehicle be offset by an inward force generated by the vehicle itself, Figure 1. An aircraft simply rolls its wings over to allow the horizontal component of the wing lifting force to counter the outward centrifugal force of the weight of the aircraft. An airship or a submarine, without lift generating wings, has a problem. The only sizeable surface available to these large, buoyant bodies of revolution is their hull -- which is basically a total disaster with it's inability to generate large side-forces for tight turning in air or water. Nonetheless, let us examine how it works.

Most of us have observed, on a rainy day at any airport, the peculiar wing-tip vortices twisting up and trailing behind aircraft -- Boeing 747's, etc., --. These are the result of the high-pressure air underneath a wing sliding around and equalizing pressure with the low-pressure air above the wing. These vortices are visual evidence of a wing's lifting ability, and are the only evidence of the term "circulation," used by aerodynamicists to describe the phenomenon of lift forces in fluid flow. When you see such a vortex, whether it be on an airplane, the rear wings on Indy race cars, or even off your hand in the bathtub, you are seeing "circulation" and a lift or side force in the fluid medium.

To visualize these vortices on an airship or submarine body of revolution, simply eliminate the wing between the two wing-tips -- leaving only the two, half-circular tips -- which when joined together, form a body of revolution. If this is now inclined to the air or water flow, the two vortices will still be present. This indicates that there is "circulation" available, with the resultant side-force facing leeward perpendicular to the body between the two vortices on the lee side per Figure 2.



10 DEG. YAW

Figure 2

Unfortunately, the two wing-tip shapes clamped together to create the hull form of a modern submarine now generate theoretically weaker "circulation" than when they had a long thin wing between them. As a result, the side force available to allow a submarine to turn is only sufficient to allow turns in, perhaps, 5-6 lengths. The presence of the sail, by happenstance, improves this turning performance considerably, if one is brave enough to deal with the resultant roll/yaw coupling problems.

It is important for submariners to have a complete understanding of how essential these vortices are to the opportunities available in high-speed maneuvering "flight." Referring to the photographs of the SKIPJACK flow visualization studies (ref: January 1988 SUBMARINE REVIEW, pg. 48), one can clearly see the strong influence of the sail as it pulls the upper bow vortex out of its place along the hull and up into the wake of the sail itself. The resultant crossflows and separated hull-flow decrease the vortex-generated side force and push its center-of-pressure toward the stern. The initial problem of a 30-40 degree snap-roll is now hugely complicated by a pitch-up of the bow and further increase in depth as the rear half of the submarine "squats" down. All this because of the rude displacement of the very powerful twin vortices created by the yawing hull at speed.

Since the vortex itself consists of a swirling mass of water rotating inward towards the center of the hull -- similar to the rotation of the top of a 20 foot high surfer's wave, but with much more energy --, it will also be a potential source of turbulent noise. This sound energy must be contained and minimized for quiet rapid maneuvers in the lateral or horizontal plane. Happily, the twin vortices are huge drag generators which will produce a marked slowing of the submarine whenever they appear, thus discouraging a possible inverted spin.

It is clear that the best solution to such a problem is to keep the sail structure upright in any high-speed turn and not allow it to influence the vortex patterns from the bow. This powerful vortex structure must be left alone to seek its normal position on the lee side of the hull with no interference from any hull protuberances forward of the sternplanes.

Part II of this article in the next issue will discuss possible retrofit solutions for all 637 and 688 class ships which should allow them to make 180 degree turns, fully upright with no roll angle at 30kts. This retrofit should also allow single-man control without the pitch/roll/yaw coupling difficulties and undue drama that require a Chinese fire drill to handle today.

Henry E. Payne III

TEMPO IN SUBMARINE OPERATIONS

In the past, the control of the "tempo" of operations was so erratic and chancy that it could not be considered essential for military success in battle. Today, however, with good communications, all-weather systems, computer aids for decision making, accurate navigation, well-trained men, devastating weapons and highly mobile units, control of the tempo of warfare has become so important for battle results as to be thought of as a "principle of war," and submarines have good control of the tempo of their operations.

Tempo is defined as the rate of activity, the speed at which events occur. That sounds like a scalar quantity but, in warfare, it would apply to speed of movement, speed of action, and concentration of effort, which makes tempo a more complicated concept.

Tempo is very much at play with the U.S. Maritime Strategy which depends on a rapid decimation of enemy submarines by U.S. submarines in forward barrier positions.

In warfare, control of tempo provides the space-time-power advantages of position, initiation, and intensity which are critical to success. Being truly dynamic, the elements of tempo interact and therefore it must be treated as a system rather than as a singular aspect of action.

Tempo is particularly critical to the probability of escalating to the use of nuclear weapons -- rapid, decisive action can create a cessation of war before nuclear weapons might be brought into play.

In the days of frigate battles, the quickness in obtaining the weather-gage and to deliver rapid, accurate gunfire were the elements of tempo that produced victory. In World War II, wolfpacks, submarine stealth, communications, surfaced mobility and torpedo fire-power provided the control of tempo that gave the advantage over convoy defenses. In today's environment of high speed computers and electronics, submarines, it will be shown, have better control of tempo in wartime operations than any other naval unit.

For many years, the mobility of carrier groups and the speed of their aircraft have given them good control of tempo in operations against surface ships and land targets. However, surveillance from satellites and space stations has greatly increased the carrier's detectability and, together with the threat of long-range missile attack, has severely restricted its ability to control tempo in order to reduce its detectability by enemy naval forces. Moreover, surface ships must eliminate or minimize their energy radiations produced by propulsion, search and communications -- all of which are needed for their control of tempo.

But submarines need not present any visual or radar target; they are designed for minimum acoustic radiation; they can use high speeds at depth without cavitation; can operate effectively without radio transmissions; and are equipped with high-performance passive acoustic detection systems. Maintaining these advantages gives the submarine good control of tempo during tactical operations against surface forces.

Against other submarines, the game becomes more difficult. In World War II, successful attacks on other submarines usually depended on advance intelligence information which allowed optimum search to be conducted and firing positions obtained. In today's sub-vs-sub operations, this advantage cannot be assured. Against enemy SSBNs, while "bastion" operating areas may be deduced, their defenses can be expected to be formidable, including measures to confuse the searcher as well as having equally capable SSNs to attack the searcher. Penetration of enemy waters can be expected to be opposed by various ASW forces, including smaller, quiet diesel or air-independent submarines. Tempo here can be expected to involve a long-duration process as the SSN strives to achieve undetected transit and, failing that, to get the advantages of first detection and first fire-control solution. A thorough understanding of the elements that affect control of tempo will be as vital to success as tenacity and quick reaction.

Against SSNs which are a threat to friendly surface forces, whether battle groups, logistic support ships, or overseas transports, the tempo may well be different. Here the end-game is not necessarily the destruction of a prime target, but rather the elimination of its threat to the surface forces. Keeping enemy SSNs outside their effective firing range, eliminating their chance for surprise, and reducing the efficiency of their attacks may be the primary ASW objectives. Instead of a limited-area bastion, our SSNs would have a moving "sanctuary" to defend, thereby introducing changing environmental conditions into the equation which controls the tempo of the operation. Knowing the areas of poor sonar conditions and the prospects for adverse weather conditions are important factors in the timing of tactical options.

Surprise has always been a key factor in successful combat, but in the future it may not always mean catching an enemy unaware -- as may be the situation just prior to the outbreak of hostilities, where surprise is likely to come as a result of confusion or misinterpretation of enemy intelligence. D-Day in Normandy is an example. ADM Gorshkov notes that with computer collation of data and computer-aided decision-making, staffs can now make plans for complex operations so rapidly that, when an opportunity is presented, a staff plan can be generated to exploit it almost immediately. This kind of surprise is a product of rapid staff planning and rapid movement of forces, and will be available to the side with the strongest computer support and the fastest all-weather weapon delivery systems. The effect of speed on tempo is well illustrated by the arrival of four British SSNs off the Falklands almost at the start of combat operations. Their high tempo of response helped have a decisive effect on limiting the plans of the Argentine Navy, illustrating the truth of cavalry General Nathan Bedford Forrest's dictum "Git thar fustest with the mostest!"

A great change has occurred in surface ship operations as a result of incoming air and missile attacks at about Mach-1 or above. Before the Vietnam War, release of battery for air defense was the prerogative of the C.O. or, if surprised, by the OOD of CDO on watch. With the advent of radar detectors as the first warning of missile attack, and with only seconds to initiate counter-action, the control necessarily passed to CIC and in some cases, to junior personnel. Recent actions, i.e., SHEFFIELD off the Falklands, STARK and VINCENNES in the Persian Gulf, give testimony to the extremely rapid tempo of surface ship air defense. Consider, then, the effects on control of tempo which would result from multiple missile attacks designed to saturate defense systems. Without an AEGIS system, human brains and older fire-control systems would be quickly overloaded. Even AEGIS has design limits, which may be stressed if faced with multiple attacks of Mach-2 and 3 missiles.

The tempo of submarine combat operations against surface ships is leisurely by comparison. The high mobility of the nuclear submarine and its capability to attack with surprise allows for precise timing for gaining a weapon launch position. For torpedo attack, tracking time and fire control solution can be long and deliberate without degrading the probability of success. The attack tempo increases with bearing rate near the firing point, but remains well within the capability of the submarine to control. Torpedo travel is relatively slow, and there is sufficient time to assess attack results while taking countering or evasive action. Minutes are involved, not seconds as with surface ships responding to ocean-hugging missiles. The tempo of defensive action is leisurely by comparison. For missile attacks, however, a considerable acceleration of tempo can be expected, particularly in closing for coordinated multiple missile launches. The high speed arrival at firing positions, the concentration of firings to achieve near-simultaneous missile impacts, and the high speed of the weapons create a high tempo of attack. Even so, with the submarine's speed capability, low detectability, and rapid fire-control solutions, it remains in control of the tempo of operations by establishing a time for attack well ahead of weapon launch. Surprise in attack minimizes external pressures which would change the planned tempo. That's important -- if one recalls how bombing operations were hurried by the arrival of enemy fighters.

The capability to provide a very low, deliberate tempo for the employment of strategic weapons is crucial to the political decision makers to allow them to make proper and adequate response to strategic threats. Only the SSBN leg of the triad can provide the deliberate, slow-timed use of strategic weapons. Missile silos and bombers must respond rapidly to a possible nuclear attack or risk destruction -- a use-them-or-lose-them pressured tempo. Today's SSBNs are sufficiently survivable to ensure control of tempo of response to a nuclear threat, whether it be false, limited, accidental or full scale -- and this means that SSBNs can be used <u>anytime</u> during a long war.

All of the above critically depends on another aspect of the control of tempo, and that is the performance of personnel. The well-trained crew gives a much higher probability of getting the information and taking the actions promptly for success in combat. The well-motivated, healthy crew stands a much greater chance of maintaining capability under the stress of long-duration penetrations of enemy waters and of providing the quick reactions needed when contact is made. Minimizing the effects of fatigue on the judgment and reactions of commanders and crews will be an important aspect of assuring a high tempo of operations. Submarine crews are selected and trained efficiently to control the tempo of warfare and get optimum results.

In conducting its operations, the important factor of tempo is well-controlled by the submarine; better by far than by any other sea system. Coupled with the capability to deliver a variety of weapons, both short and long range, against surface, land, and submarine targets, the submarine's potential to exert seapower, mainly at times of its own choosing, is more credible than for other systems and can be planned with greater reliability. SSBNs have a slow deliberateness in their tempo of operations; SSNs attrite other submarines at a high tempo; SSNs destroy shipping at a high tempo; SSNs project cruise missile power against the shore at a discreet, planned tempo; and, SSNs in other missions can meet tempo expectations to produce the best results.

Charles B. Bishop

STRATEGIC ANTISUBMARINE WARFARE

Attack against strategic missile-carrying submarines, often termed "strategic antisubmarine warfare", is a controversial topic for those interested in deterrence, escalation of war and war termination. The concept involves the potential for unwanted escalation during the conventional phase of a war, some difficult command and control issues and a potential new area for arms control between the superpowers.

Attack on strategic missile-carrying nuclear submarines already involves more than just the two superpowers. Three other nations have such submarines: China, France, and the United Kingdom. Also many nations have existing antisubmarine forces that might be involved in military operations against the nations who have submarines carrying strategic ballistic or cruise missiles.

The prospect of many nations potentially conducting strategic antisubmarine warfare reinforces the Soviet concept of "equal security." The Soviet military argues that, in order to have the same level of security as that enjoyed by the United States, it must have a defensive capability against all possible enemies.

There is general agreement by all nuclear powers that a nation must have a survivable nuclear reserve force capable of striking back, even if subjected to a coordinated, surprise first strike.

Traditionally, nations have looked to navies to provide strategic nuclear delivery systems that can survive enemy attacks and threaten nuclear retaliation. Western strategists often argue that as long as sufficient warheads remain on survivable submarines at sea they provide a threat so powerful that nations would hesitate to escalate a war to the use of nuclear weapons or to all-out nuclear strategic war.

The Soviet Union fired a ballistic missile from a submarine in 1955, well before POLARIS appeared in the U.S. As sea-based ballistic missile ranges improved, Soviet submarines did not have to close enemy shorelines in order to threaten North America. However, some Soviet submarines carrying ballistic and cruise missiles have continued their pattern of patrolling off the shores of the U.S. and Canada over the years.

The U.S. Navy's first maritime nuclear deterrent force was one of REGULUS cruise missiles on submarines and surface ships. Then, sea-launched ballistic missiles were developed and married to submarines, and strategic cruise missiles were abandoned until the advent of the very long-range land-attack TOMAHAWK.

The Soviets argued, in the first Strategic Arms Limitations Talks (SALT), that they required compensation in numbers of missile submarines, because their shorter missile ranges required them to sail their submarines long distances to forward patrol areas. SALT I gives the Soviet Union a significant advantage in numbers of missile submarines; indeed, the USSR has almost twice as many of these submarines as the rest of the world combined. The advantage in numbers of submarine hulls is understood once one attempts to plan campaigns to attack all of them.

An interesting asymmetry developed between Western and Soviet navies. The U.S., French, and Royal Navies retained the shorter range POLARIS, POSEIDON, M-20 and M-4 missiles and relied on stealth to provide security for their ballistic missile submarines on patrol. The Soviet Navy, on the other hand, deployed its newer submarines in bastions, such as the Sea of Okhotsk, with a protective array of air and sea power and favorable geography to ensure that its forces retained their "combat stability" (mission capability). Implicit in the deployment of protecting forces providing combat stability to strategic missile-carrying submarines is the assumption that the Soviets obviously expect them to be attacked during war.

Despite this asymmetry, nuclear-capable nations could feel relatively secure that no matter what happens during the conventional phase of war, "sufficient" nuclear weapons on submarines will remain to threaten an enemy credibly with an unacceptable response. However, many in the West feel that offensive operations should not be taken against Soviet missile submarines during the conventional phase of a war, since it would automatically trigger vertical escalation because the USSR would rather use than lose them. Implicit in that argument is the assumption that Soviet submarines with strategic missiles constitute _the_ nuclear reserve of the Soviet military -- _the_ force that threatens the West with retribution no matter what happens to the other two legs of the triad. But, there is no evidence that either the Soviet Navy or sea-based nuclear systems will be _the_ force that directly influences the outcome of a war. It would be decidedly non-Russian to allow the _navy_ to field the _only_ nuclear reserve.

Another problem with viewing Soviet missile-carrying submarines as only a nuclear reserve is that older and shorter-range missiles deployed off the coasts of enemy nations can perform unique damage limitation missions. For example, Soviet SS-N-6 SERB missiles aboard YANKEE submarines can strike U.S. Strategic Air Command bases or vital command, control, and communications facilities much more quickly than can intercontinental missiles launched from the USSR, or from protected bastions. Such missions are consistent with Soviet military strategy and tasks given to the Soviet Navy.

Some of these sea-based systems deployed in theater oceanic areas also allow the Soviets to circumvent the loss of SS-20s, dismantled by the new INF Treaty.

Fortunately, when the Soviet Union deploys its submarines outside protected bastions, it moves them closer to enemy antisubmarine warfare forces. Because of military utility and lack of survivability, it is likely that some submarine systems have a role in a first nuclear strike -- rather than only as a part of the strategic nuclear reserve. Moreover, as the Soviet Navy deploys hard-target capable warheads, it is likely that the number of submarines assigned to first strike missions will increase.

If these short-range sea-based systems deployed within striking range of Europe, Canada, Japan, China, and Korea were a part of a secure nuclear reserve, the Soviets should have withdrawn them to protected home waters, such as the Sea of Okhotsk, where they could present a subsequent escalatory threat if surge-deployed close to enemy shores. Instead, by siting them in relatively exposed forward areas, we must conclude that they are designed to be used as part of a combined arms attack in the event of war, or that the Soviets have a high regard for their survivability. It could also mean that they serve only a pre-war political role and are either expendable in combat, or would be repositioned.

Another theory suggests that the USSR intends to hide these units in the territorial -- and perhaps internal -- waters of other nations. Although originally suggested with regard to the Baltic, is this option present in Japanese waters or the Canadian far north? It would certainly present unique challenges. For example, what should be the Canadian response if it again detected a Soviet submarine near its shores -- this time a missile-carrying submarine in Arctic territorial waters during a NATO crisis not directly involving Canada? Does the response change if a NATO/Warsaw Pact war is raging in Europe, but the submarine is in Canada's Pacific 200-mile fisheries zone?

Despite the large portion of Western missile submarines deployed in the deep ocean expanse. Soviet military spokesmen have openly stated that the destruction of enemy sea-based nuclear assets is a strategic goal for them and a main mission of the Soviet navy in any future war. Such statements, coupled with aggressive antisubmarine warfare programs and other actions taken to reduce further homeland vulnerability to attack, reinforce the conclusion that the USSR has never accepted the theory of assured vulnerability required by mutual assured destruction. Fortunately for the West, Soviet antisubmarine warfare capabilities have never matched their aspirations.

Essentially, to the Soviet military, it is far better to strike an enemy submarine in the conventional phase of a war, and destroy perhaps hundreds of warheads before they launch, than allow that threat to exist. The destruction of even one OHIO class ballistic missile submarine armed with TRIDENT C-4 missiles might cause the loss of 192 nuclear warheads. This damage limitation mission is totally in conformance with Soviet military strategy for deterrence.

The Soviet theory is that the capability to alter the correlation of forces, by sinking enemy strategic missile-carrying submarines on the high seas during the conventional phase of a war, will both prevent nuclear escalation in the event of war and limit damage to the Soviet homeland, if the war turns nuclear. The Soviets, on the other hand, apparently do not anticipate that the U.S. - or any enemy nation - would initiate nuclear war over the loss of strategic missile-carrying submarines during the conventional phase of a war.

NATO and U.S. declaratory maritime strategies have long included the possibility of offensive action against Soviet strategic missile-carrying submarines during the conventional phase of war. A strong additional side benefit to NATO is that if the Soviets are engaged in defending their bastions, only minimal residual forces may be available for open-ocean strikes against vital allied sealanes of communication.

Whether an enemy submarine carries nuclear or conventional munitions, a prudent assumption military planners should make before a war is that <u>any</u> enemy submarine found off one's shores is a potential threat that must be neutralized in the event of armed conflict with that enemy. Forward-based submarines are prime targets for enemy navies, since they represent not only a first strike nuclear threat, but also provide vital attack assessment and other intelligence information -- and because they present a conventional torpedo and missile capability. Additionally, every submarine sunk during the initial stages of a war is one less that can be re-used if reloaded. Most nations have the necessary antisubmarine forces to deal with Soviet intruders close to their shores.

Actually attacking a missile-carrying submarine is a far more difficult task than generally credited by civilian analysts unfamiliar with antisubmarine warfare operations. One must assume, however, that submarines deployed near an enemy's main antisubmarine forces, including mines, (as is the case with submarines of the West trying to attack Soviet submarines in their bastions) are more likely to be destroyed than stealthy strategic submarines in the broad expanses of the world's oceans trying to avoid ASW units.

Attacking enemy missile-carrying submarines in defended bastions is much more difficult and will undoubtedly involve a high cost. Yet if the benefits of such actions are substantial, one must assess the relation of benefits to costs. For example, if the United Kingdom, France, or China took every possible precaution to ensure the survival of their sea-based nuclear forces during the conventional phase of a war, but the Soviets could destroy them anyway, then the United Kingdom, France, or China might not have any nuclear "cards" left to play at war termination -- and, therefore, might not participate -- a political result well worth a few Soviet ASW units.

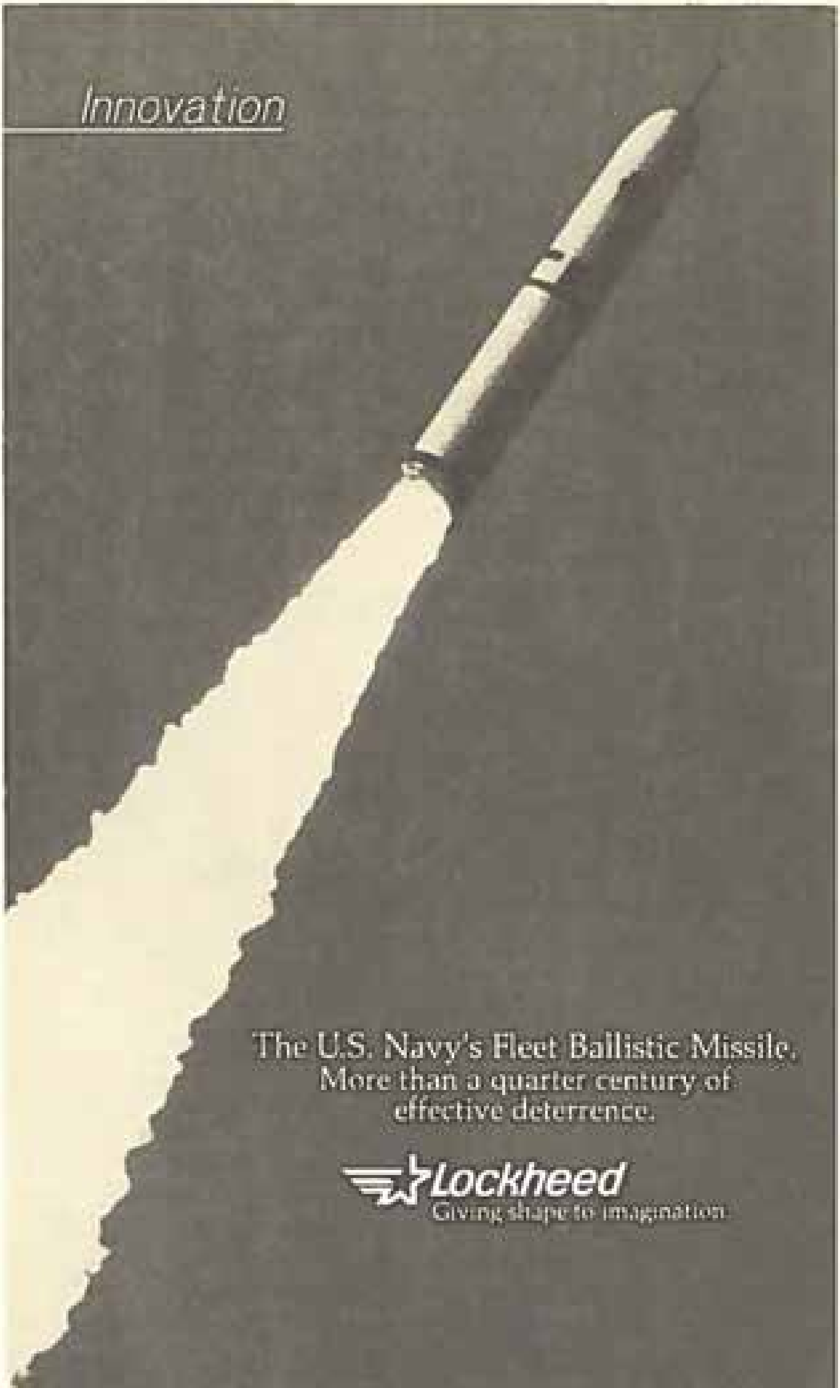
Posing a strategic antisubmarine warfare capability does not necessarily undermine deterrence, but rather reinforces the belief that deterrence is best served by a credible capability to prevent an enemy from achieving his own war aims. The U.S. understands that to deter the Soviets, the West must present a capability that the Soviets respect. A credible capability to limit damage to its homeland by attacking nuclear weapons delivery vehicles during the conventional phase of a war is a principle that the Soviet military has advanced for years, and conforms totally with the Soviet philosophy of deterrence.

In a war, attacking an enemy force before it attacks you is militarily sound. The numbers of Soviet strategic missile-carrying submarines of all types on forward deployments or in bastions make it unlikely that the West could ever destroy sufficient numbers to deplete the Soviet strategic nuclear reserve. Marshals of the Soviet Union, Nikolai Ogarkov and S. Akhromeyev, have written over the past few years that it is impossible to destroy all of either superpower's means of nuclear attack.

The loss of a submarine at sea is not likely to "require" a nation's political leadership to seek overwhelming retribution through nuclear escalation. Conversely, opportunities to reduce enemy nuclear forces in the event of war should be seized. Soviet missile-carrying submarines should not be listed as targets that require authorization to attack, once armed conflict commences. The Soviet military has stated repeatedly that they will attempt to attack enemy missile submarines during a war; we should attack theirs.

Every submarine destroyed reduces the number of warheads providing a threat by the Soviet Union during the conventional phase, or which could be used in nuclear combat operations, or which could be used or threatened to be used during the termination phase of the war. Even the threat of such actions will cause the Soviets to consider defending their missile submarines in bastions and is likely to influence the numbers of submarines left over for attacks on the distant sealines of communications. No matter how much we talk before war about avoiding actions that might risk military reaction, in war, political leaders will demand options from their military for actions to create as favorable terms of war termination as can be achieved. Altering the nuclear correlation of forces by attacking an enemy's submarines is the type of step that might lead to war termination before vertical escalation.

CDR James J. Tritten, USN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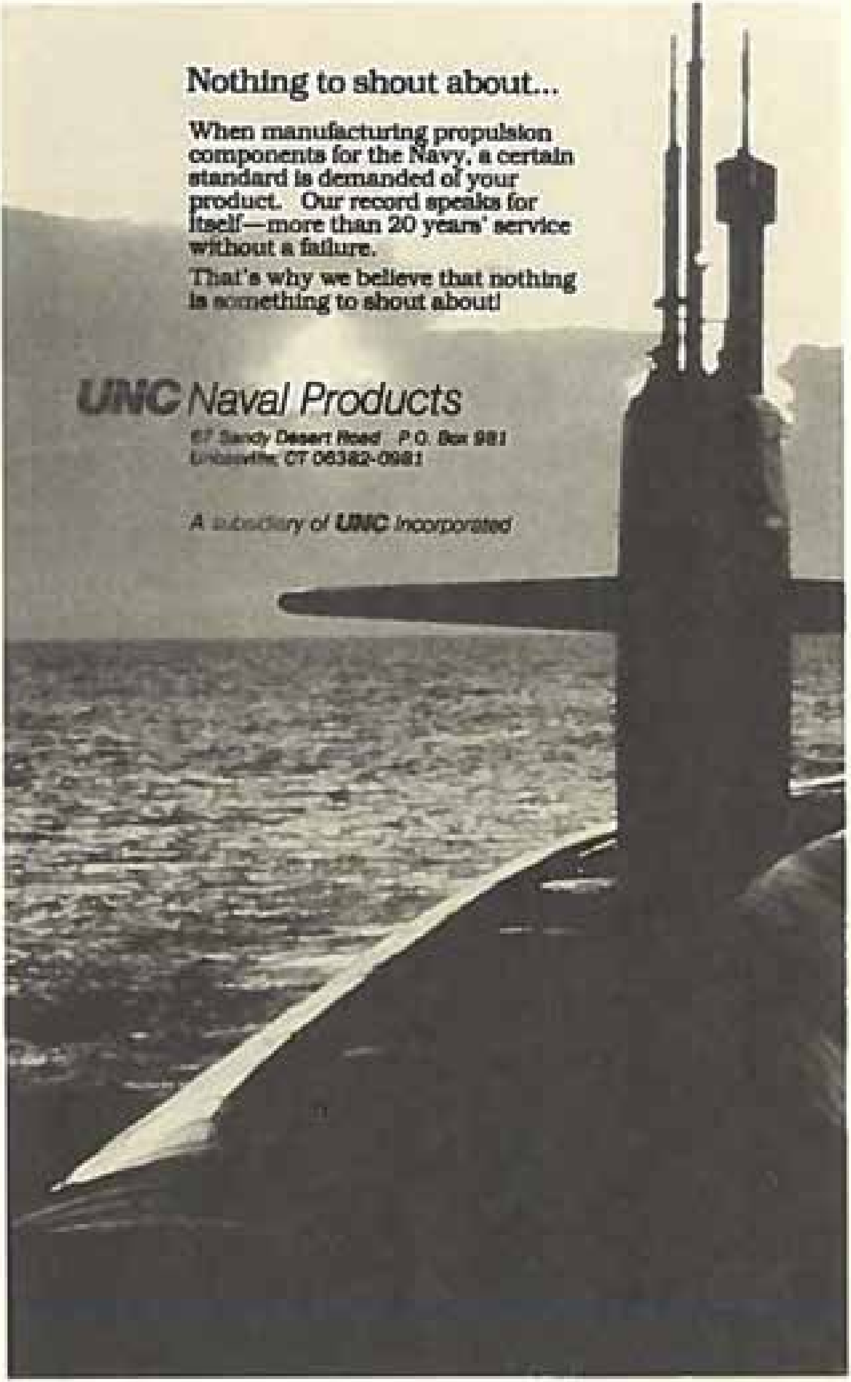
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DISCUSSIONS

THE NEXT STEP FORWARD

The world is in the midst of a data explosion. No longer is it the one who has the most toys at the end who wins, but rather the one with the most data.

The predecessors to today's submarine fleet had to process only a very small amount of data, this being limited to visual sightings, short range radar, infrequent radio communications and limited frequency band sonars. The onboard equipment was not very sophisticated, requiring that only a limited amount of reference data be readily available. In contrast, today's nuclear fleet has a plethora of data not only to process, but to store as well. The complexity of the modern nuclear submarine itself requires a wealth of technical data to be kept handy at all times, in order to maintain the ship and crew combat ready.

The storage of all this data has not kept pace with the technology currently available. No longer is valuable space required for storage of bulky, reel to reel recording tapes onboard a submarine preparing for deployment. Cabinets and safes filled with manuals of various sorts can also be eliminated. Optical disk storage systems, which have been in development for over a decade, can now adequately handle the data explosion at sea.

Just one 12" optical platter holds up to 3,000 million characters -- the equivalent data of 15 magnetic storage tapes. Two cubic feet of optical disk storage space replaces 32 cubic feet of tape storage. Data can be packed on a disk at up to 42,000 bits per inch. Current progress in optical disk technology is expected to double this storage capability within the next few years.

Optical disk storage has other added benefits. The typical military data recording rate for tape systems is 30,000 thirty-two bit words/sec. The best recording rates for current systems is less than 200 Kbytes/sec. Optical disk systems can achieve a storage rate well in excess of 300 Kbytes/sec. The optical disk error rate can be held to less than 1 in 10^{12} bits. The optical disks themselves are very easy to handle and use. They have very little risk of becoming contaminated and are not affected by magnetic fields. They also have a typical shelf-life of greater than ten years, with some manufacturers claiming up to a 100-year shelf life.

The more popular optical disk systems on the current market are called WORM systems. These optical disks can be written to only once, but can be read back many times. Thus, once data is placed on these disks, it cannot be erased or changed. However, the data can be updated through the use of pointers which link groups of data, thereby allowing the addition of new information to old data or using new data entirely in its place. This feature provides a convenient audit trail for data which is frequently updated and which requires a historical reference.

The Interactive Compact Disk can contain text, audio and video stills. It has the capability of indexing and searching. Just one 5 1/4" disk can hold up to 120,000 pages of text. Significant printing costs could be saved by converting to an optical disk library. The cost to make one of these disks with data is under $250. The cost to print 120,000 book pages is well over $4,500. Just a small box of these disks could conceivably replace every manual onboard a submarine.

When an unknown contact appears in the crosshairs of the periscope a few keywords which describe the contact can be typed into a computer keyboard. Almost immediately a graphic picture is displayed, along with textual descriptions of everything contained in the optical disk system database which matches the inputted keywords. By scrolling through the graphics, the one which matches the contact can be spotted easily. A graphic display makes it easier for a larger number of people to view at the same time. No longer will there be a mad scramble to find the proper document in order to identify the contact nor is valuable time wasted looking through references. Only a limited number of recognition features can be utilized by conventional documents, whereas in an optical disk system an almost unlimited number of keywords can be utilized to identify a contact.

The very time-consuming task of document maintenance is eliminated with an optical disk system. Whenever the ship pulls into port it simply turns in its entire set of optical disks for a new, updated set. The old disks are either updated by the shore facility, if space remains on the disks, or are destroyed. Accountability is greatly enhanced, especially for classified documents. Classified destruction is simplified. The costs of mailing and transporting these documents is also significantly reduced.

The space saved onboard can be put to much better use. Shelves no longer need be occupied by documents which are rarely (if ever) used during an entire deployment. This new-found space can be utilized for additional crew comforts. The very fact that optical disks hold so much information means that more data can be carried onboard than ever before. Extensive crew training programs can be placed on a disk.

This system can also be easily configured for simultaneous multiple users. One system can supply the data needs of the entire ship through strategically placed data terminals. Existing systems can be connected to this elaborate database. Word processing systems now can have not only a complete dictionary and thesaurus to reference, but also an extensive library of graphics for onboard desktop publishing. Crew members also are relieved from the burden of looking through indexes (should they exist) of several different documents to find the information they require. Just a few inputted keywords and the system does all the searching at a greatly accelerated rate.

Technology is rapidly creating a paperless society. The submarine community should be leading the way. Having the most data only ensures a win if one can readily access it. An optical disk storage system is the next step forward.

Richard D. Lanning, Jr.

THOUGHTS FROM THE ORAL HISTORY of CAPTAIN R. B. LANING, USN(Ret.)

At the end of WWII, the Navy wisely collected all the good ideas they could get from anywhere and built them into the "Fast Attack" class of 6 submarines. I was commissioning CO of HARDER in '52 and had a fascinating time with a faster, deeper diving, snorkeling submarine with novel sonar, fire control, 1,000-volt electrical system, no-bubble torpedo ejection system, powered torpedo and mine handling system, improved environmental controls, hovering system, improved shock protection, better streamlined hull, more maneuverability, and compact high speed diesel generator sets.

In the complex geometry of these submarines it is not surprising that the use of full-scale wooden mock-ups allowed hundreds of changes prior to installations. These involved changes in pipe and wire runs and equipment locations to allow operator access for operation and repair. Early arriving commissioning crew members were the ones who identified the changes needed. Perhaps modern computerized design could obviate the need for these expensive mock-ups.

Many of our new systems could be tested only in an operating submarine and we identified hundreds of necessary alterations. For example, the piston driven torpedo ejection system so jolted the torpedoes that batteries were crushed; the system would not work at speeds of over 10 knots because hydraulic pressure on the nose of the torpedo pushed it against the rotating stop bolt preventing operation; the system was also very loud. Electrical transients picked up by the starter control circuits could start the torpedo engine in the tube in port, as happened in TRIGGER. Rapid brush wear in the 5 KVA motor generator set evidently was due to freon leaked from the air conditioning systems. The 400-cycle IC electrical system and the 3,000 psi hydraulic systems were generally successful in providing more compact and faster acting indicators and actuators. Greater care in fabrication was required. In these areas we derived much benefit from experience in aircraft.

The 1,000-volt electrical system produced some puzzling pyrotechnics. The boats preceding HARDER had all made shakedown cruises in calm warm southern waters, so I took HARDER into a monstrous north Atlantic storm. Intuition drove me to invite along the leading electrical engineers from BUSHIPS. As seasick as they were, they were very helpful when we lost all power 13 times with circuit breakers blowing out of sequence and 4-foot arcs jumping out of propulsion control cubicles. It turned out that the main problem was that the new type of wedging used between cells in the battery well allowed the cells to work in the heavy seas, loosening the celltop seals and allowing electrolyte to cause complex grounds the effects of which appeared all over the boat. The BUSHIPS people saved me probably hundreds of shipalt requests. In similar fashion, we later made 100 changes in the torpedo ejection system without a single shipalt request.

The Mk 101 Fire Control System was, to me, a very welcome addition in that it provided very rapid rate-control fire control analyses as had the anti-aircraft director computers with which I'd been earlier connected in carriers. Further, the system allowed better use of active sonar in fast moving dog-fight situations. These computers contained large numbers of analog circuit boards. The theory was that we would carry a few spares onboard and ship failed boards back to Arma for repair and return. However, when the MTBF (Mean Time Before Failure) turned out to be about 1 hour, I ordered sets of dentists tools and set up on-board repair.

These weaknesses were later fixed, and even later digital systems were developed.

So far, what I've described in the "Fast Attack" class were interesting (if vexing) problems to solve in providing much improved submarines, and leading to systems in future subs. Now I come to the Main Engine Generator sets of the Propulsion and Charging system. Here, there are many lessons to be learned.

In hope of making the submarines of the "Fast Attack" class more compact, GM and Fairbanks-Morse had been paid to develop engines of about twice the RPM (1500) and power density of the WWII engines of 1500 HP. GM came up with a pancake radial engine with generator suspended underneath. It was very compact, fairly accessible, vulnerable to oil seal leaks into the generator, extremely loud in the engine room (over 120 decibels), and with a MTBF of only a few hours, as unknown vibration effects and high speed tore the engines apart, (4 in each boat). More than once, a submarine lay dead in the water with all engines out, as crews valiantly raced to repair them before the battery went dead.

A similar experience was had with the Fairbanks-Morse slightly larger engine (3 per boat) which were conventionally mounted and not very accessible. Almost every part of the engine was vulnerable and the spare parts flow was incredible. We were fortunate that no fatal accidents occurred though there was one almost tragic incident. TRIGGER (GM engines) was alongside State Pier, New London, next to HARDER one night, conducting a battery charge, when suddenly there was an enormous siren-like roar as an engine went into overspeed in a few seconds. Only the immediate response of a First Class Electricians Mate saved the ship from an explosion. After 48 hours of continuous investigation (we had to assume that all the class were similarly vulnerable) we found that a 10 ampere fuze in the battery compartment had blown. It turned out that this fuze controlled the circuit which controlled the reverse current relay protecting the engine-generator from being motorized by the enormous 1,000-volt battery. I later concluded that the kind of analysis conducted by nuclear reactor safeguard studies would have detected this error in design.

Worthy as these efforts at engine development had been, the cost in operations and repair and in eventual re-engining all the boats was very high. It would have been much better to spend the effort in development and testing in a shore based prototype, before installation in the boats.

A characteristic of these power plants worth considering is that they were not unitized like an aircraft engine. Each was in a room surrounded by a maze of pipes, tubes, wirebanks, valves, gauges, and levers with accessories spread about the room. Men watched gauges and reached for valves and levers and switches. Accessibility was needed all around for maintenance, not to mention repair. There was no computerized data recording or diagnostic analysis. Men recorded reams of readings every 15 minutes -- these useful only in case of failure analysis. There was no automatic sequencing of start-up or shut-down through remotely operated valves and switches from computerized central control.

Many, but not all, of these lessons were applied to the development of the nuclear propulsion plants for surface ships and submarines.

Now to some lessons from nuclear power development. In those days, and now, there operated the theory that a high command, established "Requirements" on the basis of which "Feasibility" was established by funded study. But how could a requirement for an advanced system be established until a feasibility had been shown? This leads to a paralyzing logical circularity which has repeatedly hurt the U.S. in its hi-tech efforts. An arbitrary input is required either between feasibility and requirement or between requirement and feasibility. One of the main useful functions of Admiral Rickover was to provide this arbitrary input. It may be that DARPA can provide this for fuel-cell submarines.

He collected a staff of very bright, tough, dedicated officers and civilians and ran a very centralized operation. With all this centralization, however, he delegated enormous initiatives to a large number of naval and contractor personnel.

He didn't have to go on the cheap. He insisted on full sized land-based prototypes, extensive testing, realistic training, rigorous safety analysis, and rigid quality control. He used the safety issue to maintain control. Communications were frequent, dense, and tightly reviewed with dedicated sources at each activity.

There was a black Thursday emergency at the STR prototype in Idaho early in its history, when the reactor was slowed by an unexpected build-up of a neutron absorbing fission product. There was another when "crud" was found to be built up in the primary loop. In each case the reaction was swift and massive and solutions soon found. When a steam pipe failed it was found to be seamed tubing instead of seamless as specified. Then it was found that inspection was an unreliable indicator and that quality control was a problem throughout U.S. industry. Admiral Rickover seized control of all the output of a steel mill and changed all tubing in all his plants.

In the SEAWOLF liquid metal cooled plant it was found that with the 347 stainless steel tubes used in the primary system, there was not only the threat posed by chloride stress corrosion producing rapid cracking found in the water plants and requiring rigid water purity specs, but also the threat of similar cracking produced by the high ph which might be produced by a leak of water into the liquid metal. One effort to avoid this was to substitute mercury for NAK (liquid sodium) in the heat exchanger third fluid systems. For our one plant, we used the annual U.S. production of the sodium which proved impossibly toxic and dangerous to steel.

The liquid sodium cooled reactor plant was in competition with the high pressure water cooled plant. The sodium plant had many potential advantages including greater potential for unitizing and the fact, as it turned out, that the sodium is much less reactive than water at the temperatures and pressures used in the water plants. In the total operation of the SEAWOLF plant, nothing had to be added to or removed from the primary fluid whereas water chemistry in the water plants is of concern every watch. A disadvantage of sodium is the higher level of radiation around the primary loop for some days after shutdown. Separation of primary and secondary fluids was much more important and freezing in the wrong places had to be guarded against. The sodium plant had the further advantage that higher temperature steam could be produced and that the pressures in the primary loop were much lower.

A further advantage of sodium was that the intermediate spectrum of neutron energies was much more favorable to breeding fuel. Progress in the system might have helped the civil development of breeders.

Good engineering and quality control could have kept the sodium plant competitive, but there was one very basic difficulty; the 347 stainless steel tubes which had to be used had a high coefficient of thermal expansion and relatively low thermal conductivity with the result that temperature waves in the excellent thermal conductor sodium, thermally stressed the steel and tended to crack it unless closely controlled. Water plants won the competition.

I won't go into the arduous task of developments of the special welding required and its inspection, the metallurgy of zirconium, beryllium, hafnium, and boron; and many others.

When a study of Korean War jet failures showed that most were caused by failure of fasteners which then went through the engines, ADM Rickover decided that all fasteners had to be captive in the primary loops and in many other places. The ingenuity of engineers here was remarkable and important, and probably will be important for fuel cell plants.

The early nuclear plants were heavily instrumented and automated in coolant flow/power level, rate of reactivity change, various scrams, and emergency cooling. Cumbersome magnetic amplifiers preceded digital computers, and the steam sides of the plants were conventional. The steam systems were distributed around an engine room and not unified as in jet engines. With individual pumps etc., separately sound and shock mounted, self noise was still excessive and rafting had later to be used. Large crews are required for operation, data recording, routine maintenance, and repair.

SSn, THE AFFORDABLE NUCLEAR SUBMARINE

It may be time to reconsider a high-low mix of attack submarine types in the U.S. Fleet. In the past the only alternative had been diesel-electric submarines and this was rejected. However the spectrum of choices is now broadened with some of the new "atmosphere independent propulsion" systems being developed in foreign submarine construction yards -- closed-cycle engines, fuel cells.

Clearly the next generation of "conventional" submarines will have greatly improved operating characteristics -- particularly long submerged endurance.

By far the most attractive alternative is the diesel-electric nuclear hybrid submarine, the "SSn", or the "budget conscious nuc." Recent research and development in Canada indicates that it may be feasible to develop a small, low-cost nuclear reactor which can be installed in either new construction diesel units or backfitted into some classes of existing conventional submarines.

A Canadian company, Energy Conversion Systems Inc., in the late 1970s was contracted to develop a very simple, low powered (100KWe) nuclear reactor for a research submersible. The reactor system was designated, "Autonomous Marine Propulsion System" (AMPS-C).

Although the research submersible program is not yet completed, this work encouraged ECS to consider an enlarged version of their reactor design. Designated AMPS-N, it would have the size and power capacity to be suitable for installation in existing diesel electric submarine designs. This would be done through extending the hull of existing or new design submarines by about 26 feet and adding about 250 tons of weight.

ECS did a computer study of the estimated performance of an AMPS-N installation in a modern diesel electric patrol submarine. The design chosen was the German 1700 ton diesel submarine "T-1700." The 500 KWe AMPS-N gave a sustained submerged speed of approximately 8 knots while keeping the submarine battery fully charged and carrying the sub's full "hotel load" power requirements.

The computer model study also showed that the addition of the AMPS-N installation would only increase the cost of a T-1700 by 20% -- less than 200 million per copy. Roughly five hybrid versions of the T-1700 could be acquired for the same price as the latest U.S. nuclear attack submarine.

ECS has also done some similar estimates on fitting a slightly uprated version of the AMPS-C into the well known Type 209 submarine (1,000-1,400 ton) which was designed by IKL with many built by HDW in Kiel, Germany.

While no AMPS system has yet been built, tests of many of its technological "building blocks" have been conducted. No real resolution of the claims made for this system can be achieved until a full size prototype is constructed and tested. But enough encouraging preliminary data, modeling results and full scale component testing exist to suggest that this would be an important and valid next developmental step.

Fitting a small nuclear reactor to a modern diesel electric submarine design can offer a formidable operational capability. Contemporary diesel electric submarine designs are very advanced in every respect -- but they need air-independent power plants. Standard reference publications on world submarines give the T-1700 a maximum submerged speed of 24+ knots. Of special interest is that this 1700 ton submarine has a crew of only 30. This small crew size is due to advanced automation of many shipboard functions.

New submarine sensors and weapons, developed by several navies, give all modern submarines significant standoff capability when making attacks. In this way speed and range advantages of opponents can be neutralized by the less capable SS_n_.

The whole idea of technology development of air-independent engines has been to prolong the time submerged without having to come up for snorkeling. However, each of the systems noted earlier require on-board fuels which limit mission length. On the other hand the small nuclear reactor, such as AMPS-N, does not have any practical operational restrictions with respect to fuel.

How would a high-low mix of SSN's and SS_n_'s support the submarine mission requirements for a large modern navy? Clearly the SSN's would be optimum for open ocean and distant ocean operations where speed, more sophisticated systems and endurance are required. The SS_n_ could be used for operations where these factors were less important.

Some examples of missions would be:

- Choke Point Patrols. This would mean operating in the vicinity of straits and other restricted transit areas where enemy submarines and surface ships might be expected to pass. If the SS$\underline{n}$ required to quickly close a target it could use its battery to achieve speeds sufficient for this purpose. In case of a combat situation, the submarine's standoff weapons could make up for any significant speed differences between the SS$\underline{n}$ and the transiter.
- Under Ice Operations. This is also an area of submarine operations where endurance, stealth and good sensors are more valuable than high speeds.
- Antiship Operations. The hybrid submarine would be quite effective against enemy shipping in logistics interdiction, as well as against less capable warships.
- Special Warfare Operations. These missions would involve the covert use of underwater swimmers (i.e., the USN SEAL teams) who would be launched and recovered nearshore off enemy coastlines. In addition the SS$\underline{n}$ would make an excellent platform for intelligence gathering operations.

There are undoubtedly many more missions that could be undertaken by the SS$\underline{n}$; these would become more evident as these submarines came into service.

There are difficult questions that must be answered in developing this type of reactor and as power levels are increased, their relative simplicity will be rapidly reduced. Technical, cost and safety tradeoffs must be studied more closely. Lifetime support costs for these reactors, including disposal of waste materials, must be factored into overall cost projections. But enough data exists at this point to strongly support the development of a full scale land based prototype with subsequent installation in an existing submarine hull if the prototype meets its design specifications.

It's important to note that the world's best submarine may not be needed for every Navy mission. Also it may not be affordable in the numbers necessary to cover every mission requirement. Recalling the words of the great airpower advocate, Alexander de Seversky, "Quantity is itself a quality." This may be the case for USN planhing as it considers its submarine mission requirements for the 21st Century.

Clearly it is time for the U.S. Navy to reconsider whether or not it could benefit from having a high-low mix of attack submarine assets consisting of SSNs and SSns.

Dr. Don Walsh, Ph.D

Editorial Review Board Comment: The Naval Submarine League's policy is not to prohibit the publication of articles that express various views or perceptions if the article is substantive in content. This publication in no way should imply NSL sanction or endorsement.

THE EFFECTS OF POLYMER ON QUIET SPEED

It is well documented that the introduction of certain polymer substances into a turbulent boundary layer results in a significant reduction in flow noise. This means that the detectability of the submarine is reduced in those frequencies where the flow noise is reduced. Further, the reduction of flow noises permits the submarine to move at increased speed while maintaining its listening ability. This increase in quiet speed, as it is called, results in an increased search rate. The search rate, which is the product of the forward speed of the submarine and twice the detection range, may be increased by use of polymers through a combination of two factors. First, because the detection range is increased by the reduction in self-noise, the search rate is increased with no increase in platform speed. Secondly, the reduction in self-noise at the original search speed allows the submarine to search at a higher speed at the same limiting self-noise level previously experienced at the lower speed. In both cases the search rate is increased. The maximum search rate will occur at an intermediate speed between the two.

Although a linearized model is not exact, if the actual variation of detection range with platform is a monotonically decreasing function, then the qualitative conclusions drawn will pertain.

The importance of the foregoing discussion is that the utilization of polymer additives to a submarine's boundary layer not only affords enhanced search capability but also affords that capability in a range of speed options, thus enabling the listening platform to adjust its listening capability at or above the maximum level achievable without polymer.

W.J.R.

SYNTHETIC TARGET MOTION ANALYSIS

Conventional target motion analysis (TMA) relies for the most part on regressive techniques (modified by Kalman filtering) for contact solution. While generally robust, even low levels of data contamination will frequently result in significant error, and even solution divergence. This article outlines a revolutionary target motion analysis technique. The synthetic solver (SYNSOLVE) presented here is intended to provide rapid (two leg), accurate solutions to primary and secondary contacts when more conventional solvers are either not available or fail due to mathematical difficulties. Developed during a recent deployment on USS LA JOLLA (SSN 701) when fire control system problems threatened the ships mission, SYNSOLVE was found to be both user friendly and capable of providing reasonable solutions to most non-maneuvering targets.

Fundamentally, the solver relies upon the generation of synthetic bearings arrived at by bearing rate extrapolation. Much like the Spiess, modified Spiess, or Darby ranging, the solver develops target ranges based on fictitious bearings. Unlike the methods mentioned above, however, the solver provides course and speed estimates by regressing on a number of ranges developed over time.

Consider the following example. Own ship is on course 045, speed 10 knots. A contact is gained bearing 000. Over the course of three minutes, the target's bearing rate is estimated to be left one degree per minute. At the three minute mark (target now bears 357) own ship turns (instantaneously, for simplicity) to new course 315, speed 10. Three minutes later, at time six, target bearing rate on own ship's new course is estimated to be zero (target bearing 357). If own ship had remained on it's initial course of 045, target bearing at the six minute mark would have been 354 (this assumes linearity in bearing rate, an assumption to be discussed at a later time). In other words, two lines of bearing are now available at time six. They are the one actually measured (357), and a synthetic bearing (354) generated by a bearing rate extrapolation. By solving for their intercept point we arrive at a target range at time six. This is in essence the mechanics of synthetic ranging.

It should be obvious that similar ranges are available for time seven, eight, and so on. If the linear bearing rate assumption were valid, then simply regressing on these range/time pairs would result in contact solution. What may not be quite so obvious is that synthetic ranges exist for times prior to the first own ship maneuver. Using the example described above, these synthetic ranges are developed as follows. At time one, the measured target bearing (359) is available. A second bearing can be generated by extrapolating the second leg backwards in time to estimate the synthetic bearing at time one. In the example outlined above, this would be 357 (zero bearing rate with a measured bearing of 357). Thus at time one (and all times prior to target maneuver) synthetic ranges are available. By regressing on all of the triples data (range/bearing/time) a synthetic solution is developed. If appropriate corrections are made for nonlinearity effects in bearing-rate estimates, this estimated solution should rapidly converge to actual target solution.

Weighting Scheme

Considering the realities, it seems reasonable to develop some sort of scheme which recognizes the various problems and is able to estimate intelligently the value or weight each data triple should have in the regression.

Our ability to model this accurately is highly dependent upon the level of noise present in the measured bearings. Unless this noise level is extremely low, or the time over which bearings are measured during a single time motion analysis leg is extremely long, any attempt to determine the appropriate coefficients would be fruitless. Since present sensors are incapable of providing the requisite level of bearing fidelity (in all but the best of acoustic conditions) we must explore alternative solutions to the non-linearity issue.

One option would be to collect data only over those periods where the linear approximation is relatively accurate. This presupposes that the observer is cognizant of the engagement geometry and is thus capable of determining when non-linearity effects might be minimized. Another option would be to extend the synthetic own-ships track out a very short period of time, thus obviating the need to perform non-linearity corrections. In this case, the short baseline formed by the extension will itself yield inaccuracies due to algebraic intercept considerations. Again, if the observer knew of the engagement geometry, he could intelligently estimate when non-linearity effects become an overriding concern.

It appears that any reasonable method of performing non-linearity corrections will rely on some sort of precognitive knowledge on the part of the observer. It is here that the synthetic solver provides strengths not available through more conventional methods. Since the solver will not begin to produce solutions until after the second TMA leg is commenced, we have available a variety of range estimates (Ecklund, cross bearings, etc.) with which to filter the synthetic ranges intelligently. With a variety of statistical data bases indicating that target speed can be reasonably pre-supposed by a point estimate, we are left simply with choosing that target course which results in a worse case error equation and adjusting our weighting scheme accordingly.

Included intercept angle:

As the included intercept angle decreases, the sensitivity to either real or fictitious bearing error increases. Errors in either real or estimated bearings lead to large errors in synthetic ranges. Since, in general, a small intercept angle may be directly related to a short synthetic baseline, it would appear that longer baseline extensions should be weighted more heavily. This line of reasoning is counter to that used in our discussion of non-linear bearing rates.

Artificial Intelligence Module

It is apparent that instead of the lack of information generally associated with conventional TMA methods, SYNSOLVE suffers from an abundance of target triples (along with ancillary data). The integration of data necessary to produce a most likely target solution indicates the need for an adaptive statistical data base, one capable of recognizing the many idiosyncrasies of the various data points and, accounting for the vagaries of the particular fire control party, producing the requisite target solution. Generally referred to as Artificial Intelligence, this module would consist of a comprehensive data base and associated weighting scheme, making it capable of objective evaluations of proposed solutions. In addition, it would recognize the expert rules applied by the ships commanding officer and thus provide real-time subjective evaluation and modification of target solutions.

Summary

The methodology discussed provides a revolutionary method of estimating target solution in the presence of noise corrupted bearing information. By providing continual ranging data through the use of synthetic bearings, target solutions are continuously updated and refined. The solver is sensitive to a range of measurement and geometry specifics and relies heavily upon a weighting scheme to provide for a robust regression. In addition, the cognitive analysis of the data triples will probably require the utilization of an AI module to aid in both objective and subjective evaluation. Implementation on the stand alone HP-9020 computer would provide a first cut evaluation for this solver and is recommended for an Automatic Data Entry configured submarine.

LCDR P. Kevin Peppe, USN

SOVIET SUB DESIGN BOOKS

Mr. Payne has done a commendable job drawing out several critical points about Western vs. Soviet writings on submarine design. As Mr. Payne sadly discovered, the West, in general, and the United States, in particular, lack a credible body of unclassified and publicly available works on basic and specific submarine design matters.

Today, the U.S. Navy finds itself under fire, both from within and outside its ranks, about submarine developments. Published reports imply that our submarine designers are losing the technology edge to the Soviet Union. In fact, recent public press reports even proclaim that the U.S. is losing the submarine technology edge to other nations, such as France, Japan, Sweden, Canada, and West Germany; nations who are reportedly constructing submarines out of very high-yield strength steels (i.e., Japan and France) and are introducing air-independent propulsion systems (Sweden, Canada, West Germany, and Italy).

As most historians and researchers well understand, information is power. But, when it comes to collecting, collating, organizing, using, and disseminating some 40 plus years worth of both classified and unclassified information on submarine design, the U.S. Navy has done a poor job. The Soviets -- the True Believers about the role of submarines in naval strategy -- clearly understand that information is power.

There are several striking things about the relative openness of the Soviet submarine design publication "machine":

* Most Soviet submarine books are authored by active duty Soviet naval officers (few civilians) who hold the rank of Captain 1st Rank or Rear Admiral. These men almost always have the U.S. equivalent of a Ph.D. in naval architecture, systems analysis, or marine engineering. Some of these men often have the equivalent of two Ph.D's!

* Soviet naval officers and civilians involved in submarine programs are prolific writers, and obviously have the complete support of their navy when writing their thought provoking articles and books. The volume of Soviet writings on submarine matters clearly indicates a desire to "get the word out" to both Soviet and foreign audiences.

* Soviet writings indicate an in-depth understanding of Western, Eastern bloc, and Asian submarine design philosophy. One wouldn't be surprised to discover that the average Soviet submarine designers and submarine officers are better informed about worldwide submarine developments than their Western counterparts. The Soviets do not draw the line on what they report about foreign submarine matters. They report everything that is published in the Western open press on non-Soviet submarine topics, including information that might be considered classified if it had appeared in official government reports. You'll rarely see a Soviet author referring to Western writings about Soviet submarine developments.

* Soviet submarine writings reflect a great sense of national pride, especially in areas such

as general design philosophy, systems analysis approaches to design and construction, hull structures and materials, and weapons attack-survivability. Soviet submarine design bureaus, along with supporting higher educational institutions, are truly "jewels" in the crown of the Soviet Navy.

It would seem that the U.S. is not going to move forward rapidly on new advanced technology submarine designs until it properly documents the history of U.S. submarine designs and operations. Today's and tomorrow's U.S. submarine designers must understand where the Western submarine design community has been, before they push ahead. In particular, people should understand that many of the ideas being brought forth today were in fact expressed over 25 years ago by a handful of prolific U.S. naval officers and civilian engineers involved in U.S. submarine programs. These men made the extra effort to express, in numerous professional journals and society meetings, their ideas and visions about submarine design matters and the role of the submarine in naval warfare.

The "old-timers" are constantly pointing out how the submarine design community of the 1950s and early-1960s was active, innovative, and more risk oriented. The air was electrified because everyone knew that the nuclear-powered submarine was going to be the capital ship of future navies. There was a sense of working toward some destiny and being part of a team of first-rate researchers and operators.

It suffices to say that today the U.S. submarine design community isn't intellectually bankrupt or devoid of creative and innovative thinkers, but they need the intellectual environment produced by an open forum on contemporary submarine design matters.

J. J. E.

SUBMARINE MAINTENANCE IN THE AGE OF BUDGET CONSTRAINTS

In order to increase submarine operational availability in the face of significantly increasing costs and longer overhaul duration, the Navy introduced the SSN Engineered Operating Cycle maintenance concept. Application of this concept has resulted in extending the time between major shipyard overhauls from 43 months to the present 84 months for the SSN 594, 637, and 688 class attack submarines. This phased increase to an 84-month operating cycle evolved from the early 1970s, based on engineering studies, technical reviews, monitoring of selected critical ship systems, and application of the resulting engineered maintenance requirements to ensure that these longer operating periods were feasible. Figure 1 shows the SEOC operating cycle.

In 1984, the Chief of Naval Operations requested that Commander Naval Sea Systems Command review the current 84-month operating cycle to evaluate the feasibility of increasing the operating interval between overhauls. A comprehensive technical feasibility study was undertaken that included engineering analysis of 1500 components in 103 submarine systems, special at-sea testing, and material condition assessment on components being overhauled. In addition, SSN 688s systems' performance was evaluated by the Submarine Monitoring, Maintenance and Support Office. As a result, NAVSEA determined that it was feasible to replace the regular 18-24 month non-refueling overhaul currently scheduled at the 84 month point with a 10-11 month Depot Modernization Period. This new availability is the key to executing the new Extended Submarine Engineered Operating Cycle.

This concept was approved by CNO in April 1987 for the SSN 688s -- and SSNs 700 through 718. The cycle shown in Figure 1 is the maintenance

SUBMARINE REPAIR ACTIVITY (SRA)

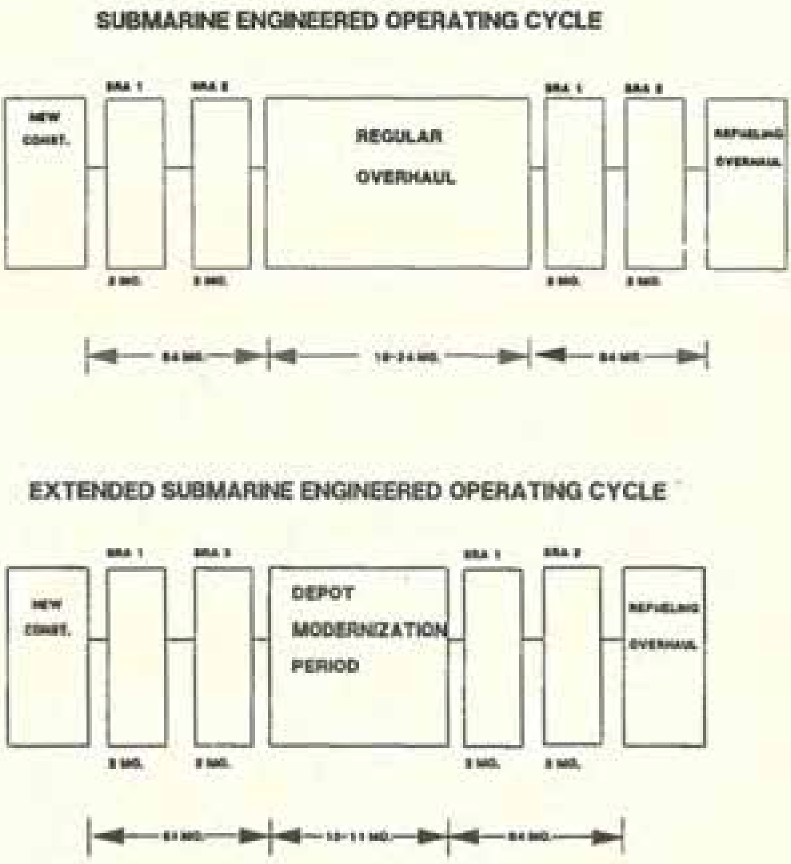

FIGURE 1

and modernization plan for these submarines. The major difference between the regular overhaul cycle and the new extended operating cycle is that the non-refueling overhaul (current average duration of 23 months and cost of $121,000,000) is replaced by a Depot Modernization Period (duration of 10-11 months and cost of $65,000,000). This modernization period is a labor intensive, well-defined, closely managed availability during which modernization and essential maintenance will be accomplished. Unlike overhauls, the submarine commences the availability with a minimum of deferred maintenance and no "open and inspect" scheduled on systems/components which are operating satisfactorily (i.e., "If it ain't broke, don't fix it"). The same scope of modernization as an overhaul is accomplished during the depot modernization period.

DEPOT MODERNIZATION PERIOD PLANNING

Having verified the technical feasibility of this concept, the next step was to establish a series of monthly planning conferences that started 20 months prior to the first depot modernization. Their objective was to identify all issues required to support the execution of the depot modernization. There were two major results: numerous problems were solved; and cooperation was fostered among all of the participants in the process.

Conferences started so far in advance of the first modernization period that the attention of senior shipyard management was focused on current availabilities. Fortunately, the Shipyard Commanders, in advance, appointed planning personnel to the depot modernization effort, enabling a team spirit to grow and to prevail. The results were greatly enhanced by the teamwork and communications that evolved.

The conferences led to spin-off meetings which addressed specific technical issues to shorten the modernization period's maintenance durations. Several examples include:

- air induction diesel exhaust-valve flame-spray modification to be moved outside of modernization period;

- special hull treatment tile installation procedure improvements were implemented to reduce time and effort; and
- it was determined that Weapons System testing could be accomplished in approximately 10 weeks as opposed to the 16-24 weeks experienced in overhaul.

The results were typical of the wide variety of other problem areas similarly treated. When it was determined that the modernization point would require a new set of test procedures, it was decided that the shipyard would test only those components on which work was accomplished. This meant that the shipyard's Inactive Equipment Maintenance programs and the Ships-Force Preventive Maintenance program -- which were inadequate to support the depot modernization requirements -- were analyzed and a manual developed to serve as a foundation for making them responsive to this new concept for submarine overhauls.

DEPOT MODERNIZATION EXECUTION

The time line shown in Figure 2 represents the countdown to the depot modernization period. The combined Work Definition and Forces Afloat Meeting is held at A-13 months prior to the modernization start and is the first opportunity for the joint review of the work package by the customers, shipyard and Ship's Force. Maintenance work is authorized by the Type Commander to be included in the work package. ShipAlt plans and material availability status is evaluated and the ShipAlt package is finalized and included in the work package.

A pre-test period is scheduled six to nine months prior to the depot modernization. It is conducted under the direction of the assigned shipyard and consists of at-sea (2-3 days) and in-port (15-18 days) portions. The test period

PRE-DMP SCHEDULE

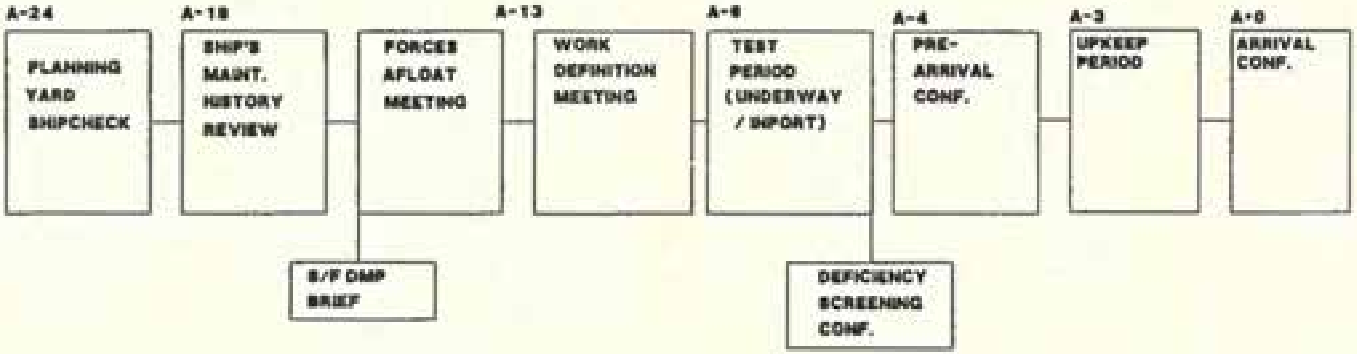

Figure 2

provides the opportunity to determine the material condition of the ship prior to the modernization period with the goal of having the ship enter the modernization period with a minimum of maintenance unknowns. A Deficiency Screening Conference is held at the conclusion of the test period. It screens each deficiency with emphasis on those which impact crew or ship's safety or mission essentiality. Those deficiencies which are within the capabilities of forces afloat, are accomplished during the pre-depot modernization period upkeep. The deficiencies beyond forces afloat capability are assigned the depot modernization. Three test periods have been successfully conducted so far. Nearly 95% of the total deficiencies identified were within the capabilities of the forces afloat to resolve.

The depot modernization upkeep, scheduled at 2-4 months prior to the modernization start provides the opportunity to ensure that the ship arrives at depot modernization with all systems operational. Major deficiencies not corrected are evaluated at the Pre-Arrival Conference for inclusion in the depot modernization as new work.

The ship's force is extensively involved in the depot modernization. Crew training and certification requirements are the same as for an overhaul; though the availability is half the length. The compressed time requires intensive support of the shipyard by ship's force. In addition, the ship's force will retain control of ship's systems, which remain operational to the maximum extent possible. All in all, ship's force support during the modernization period will closely resemble an SRA for intensity, only longer in duration.

Although depot modernizations are well planned, they are not without risk. Factors which can increase the risk of delays include:

- untimely changes in the repair of modernization work package;
- unanticipated diversion of resources due to higher priority shipyard work;
- unanticipated failure to clear the existing backlog of current work;
- unusual fiscal constraints; and
- failure to control growth/new work.

CONCLUSION

The first depot modernization started in October 1988. The stakes are significant: 1.08 billion dollars in cost avoidance already realized; and 12 months of additional operating time for each ship.

Success is achievable as the concept is technically valid. The price to ensure success may be at the expense of lower priority shipyard work concurrent with the depot modernization. Failure to meet completion time is the major risk, but this risk has been reduced by extensive planning. It is believed that the introduction of this concept will have a far-reaching effect beyond the current depot modernization program. The concept has also provided many technical decisions and resolved issues that will immensely benefit the entire submarine force.

CDR M. E. House, USN
Mr. K. G. Troxell

THE LEGACY OF TULLIBEE

TULLIBEE was decommissioned on June 25, 1988, after 28 years of service and 350,000 nautical miles of cruising.

Thus, as her first skipper, I think it is time to reflect on some significant aspects of

TULLIBEE design and operations. She had the smallest crew -- originally six officers and fifty enlisted, and with her smaller reactor plant producing 2500 hp, she was the slowest (about 16 knots) -- but quietest at that time. Displacing 2640 tons, she was 272 feet long and had a diameter of 24 feet.

She was the first to have the new family of sonars with a spherical bow array and torpedo tubes at the side of the ship.

She had many operational firsts -- much of which was classified as she developed new ways of using sonar and ship quieting.

One very challenging problem was the introduction of nuclear submarines to the Submarine Base, New London. We did have growing pains developing the support function.

One of the most interesting aspects of calling the Sub Base home was the challenge of making landings with a single screw ship whose whole bow area was very tender. We would head directly into an ebb current and deliberately touch the hard side of the boat (aft the torpedo tubes) against the corner of the pier, then use high power screw bursts alternating ahead and backing with standard maneuver. At first we used tugs but were weaned away from them. In getting underway, we oftentimes dropped the stern anchor and let the current turn us.

A real ticklish situation was that of letting Junior Officers make landings. I solved that problem by becoming the Conning Officer talker. He could give any order he wanted. If I considered it safe, it went through the 7 MC exactly as he said it with the telephone talker repeating the 7 MC order. If I considered it to put us in an unsafe condition, I automatically assumed the Conn with my order. It was quiet and provided freedom to the Conning Officer without any countermanding orders.

TULLIBEE had a turbo-electric drive which has the promise of the quietest propulsion system available. The rotating machinery generators and main motors are individually sound isolated and decoupled and can be run at various speeds, rather than a great mass rotating at the harmonics of the basic speed of the main shaft. The main motor can be supplied from the battery much more effectively than the emergency propulsion motor found on geared turbine ships. The turbo electric drive was an operational delight in quick response. The only mass to be reversed was the main motor and it was extremely fast, from full power ahead (200 rpm) to full power backing was a matter of seconds. Emergency backing under simulated stern plane failure was outstanding, and coming into a pier was so much easier. I remember Admiral Jack McCain being on the bridge coming into Norfolk. Swearing, Jack yelled out "You'll never stop it; you are going to ram it." After a one bell landing he said "Dammit Skipper, I never thought you could stop the SOB." A heavy immediate back bell with the wash against the rudder made landing much easier than the slower response experienced in a gear driven ship.

With such a small crew, personnel management had top priority. With our assigned 50 people, we could stand watch and man battle stations. We were weak in in-port maintenance. We solved that problem by adding a training allowance. In effect, we had a four section crew -- of which only three sections went to sea at one time. The section remaining in port took care of schools, training, and leave. In addition, people were assigned to Squadron or Sub Base activities, when ship's requirements had been fulfilled. During in-port periods, all personnel worked on the ship -- all four sections. The crew loved it -- we had a 100% reenlistment rate for three years.

On board utilization was unique. We would use a person's ears on sonar for a period of time, then rotate him to ship control or another station utilizing his eyes or mechanical members. In this manner, we attempted to maintain fresh physical senses in the various jobs.

We did a lot of ship control experimentation. One of our standard transit conditions was to run with the stern planes on zero in emergency control. The depth control was in automatic using sail planes only and one person for ship control. If there were to be any failure of the automatic control, the stern planes could immediately override any effect of erratic sail plane operation.

I think we were very fortunate in what Admiral Rickover permitted us to do. I qualified Chief Petty Officers to the same standards as Engineering Officers of the Watch. They were subjected to the same examinations and questions by the Naval Reactors team as were the ship's officers. They passed with flying colors and became our mainstays underway. The only times we had an officer in maneuvering were battle stations and special sea details.

Sonar research and development, trial equipment and operational tests were to consume much of TULLIBEE's early employment. Lessons learned were factored into new construction and I had a great time developing sonar improvements for FBM's while building HENRY L. STIMSON (SSBN 655). Much effort went into developing a good noise environment in the hydrophone locations. Material changes were made in ships plating and structure to change natural frequencies outside of a listening band and to change the Q factor of resonances. Our own sonar was used to monitor all shipboard noises and take action to reduce their effect on the sonars.

TULLIBEE was used to learn many characteristics of the inertial navigation systems.

The spherical array was used in many different modes to develop vertical angle techniques, using bottom echoes and bathy thermo-environmental observations. The third dimension had arrived in sonar.

One interesting operation took place in Exuma Sound when the sound measuring ship had a line caught in her screw as a tropical storm set in. She was drifting toward shore. TULLIBEE surfaced, took a tow line forward and kept the ship off the beach by towing while backing down for over two hours.

In the operational area, people often questioned the slower speed of TULLIBEE -- 16 knots. In my experience with the ship, I never found that to be a real problem.

There are three kinds of speeds:

1. Strategic Speed -- used to position the ship in the ocean in deployment. High speed makes more radiated noise and diminishes the capability of ships sonar. TULLIBEE did not suffer major reduction of sonar efficiency at her higher speeds.

2. Tactical Speed -- to approach targets, to determine target actions, and to close to weapon range. This speed can be utilized for passive ranging. Tactical speed becomes less necessary where effective weapons are available. A good weapon makes the need to close the target with a ship and crew unnecessary. It was necessary in the days of the Mark 14 torpedo, with its 5000-yard range; but with long range detection and classification, effective, long range weapons should negate the need to jeopardize the boat and crew by closing the target, unless necessary for other reasons.

3. Escape Speed -- to be used in departing contact area -- or to try to outrun a weapon fired at the boat. If long range weapons are used as above, the need for escape speed is diminished.

TULLIBEE's slower speed would result in slower -- but quieter -- deployments. With good weapons, it should not be a factor in tactics. It is questionable whether it would be a handicap in escape speed.

Dick Jortberg

A NAVAL SUBMARINE LEAGUE LIBRARY

The NSL is collecting any and all submarine associated technical, fiction and non-fiction written or video works. The NSL Library is principally intended to be a research library for submarine history or technical projects for researchers in the Washington Capitol area and to be responsive to government or civilian inquiries.

It is anticipated that the NSL library will be open for business in about a years time. Mrs. Helen Williams has volunteered to serve as organizer and Library Manager. NSL members are encouraged to give or bequeath their submarine associated written or video collections to the NSL. The NSL will arrange for shipping and handling. Those persons interested should contact RADM A. L. Kelln at (703) 256-0891 for additional details.

IN REMEMBRANCE

RADM FRANK W. BUTTERWORTH, III

A SUBMARINE FAMILY NEEDS YOUR HELP

Aaron Thomas, age 9, the son of FTBCS(SS) Edward J. and Theresa Thomas, has leukemia. There is sufficient blood (Type A, Positive) in the Blood Bank at National Naval Medical Center (NNMC) for this initial phase of his illness. However, over the coming year he may be hospitalized repeatedy. We of the submarine family who are living in the Washington area would like to assure Chief and Mrs. Thomas that a steady supply of Type A, Positive blood will be available for Aaron. The Blood Bank at NNMC has said they will cooperate with us in organizing a group of blood donors by notifying a coordinator when blood donors will be required.

The Blood Bank also said they could utilize Type O Positive and Negative, and Type A Negative blood, as they can be processed to platelets which will also be needed by Aaron.

Ross and Helen Williams have volunteered to act as the coordinators with the Blood Bank and the Thomas family. Their address and phone number are:

13704 Turkey Foot Road
Gaithersburg, MD 20878
(301) 258-0921

If you can help, please send a post card giving your name, address, phone number and blood type, if known, plus any pertinent information to Ross and Helen. They will maintain a file from which they will notify you when a donation is necessary.


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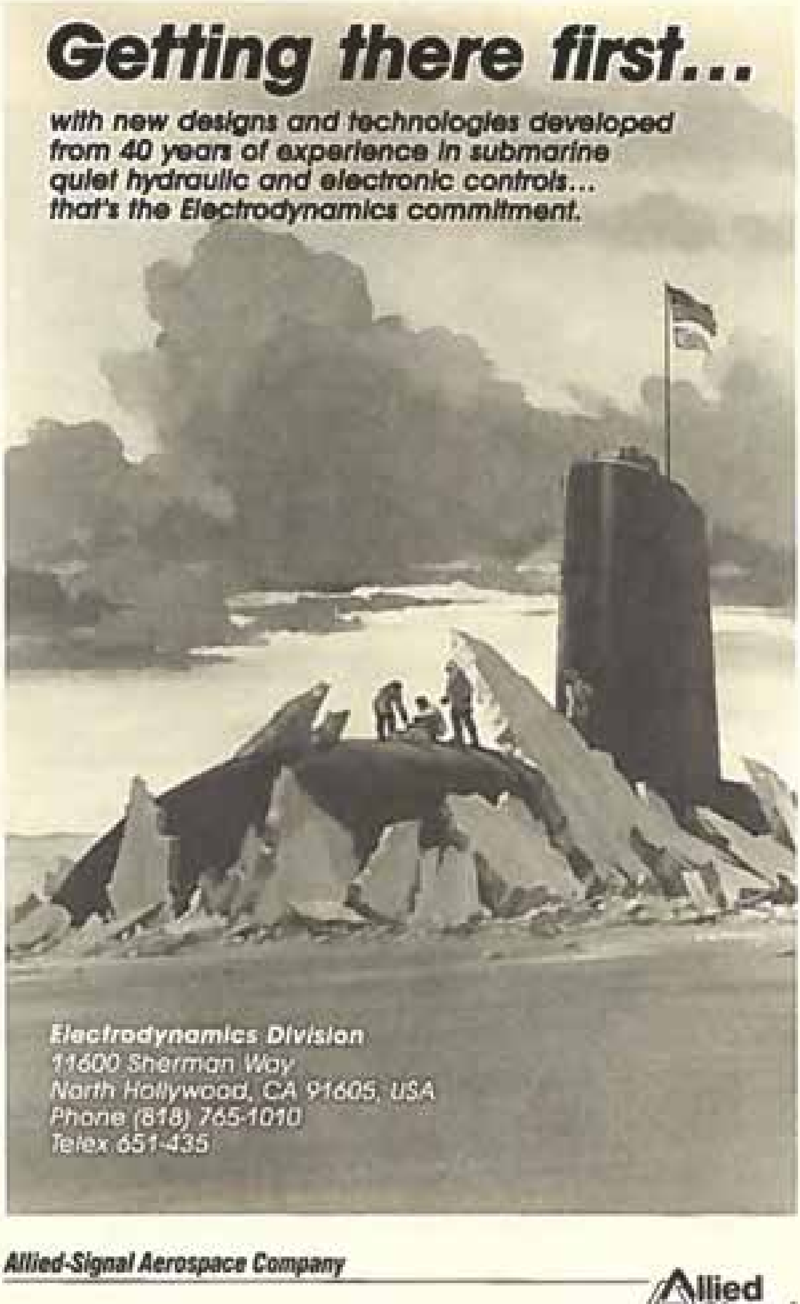
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USS LOS ANGELES
and the
AIDED DISPLAY CONTROL SYSTEM (ADSCS)

In the July issue of the SUBMARINE REVIEW there was an article by Ken Hart about the automatic submarine control system that was in use in LOS ANGELES for a short time. This system was designed, tested and installed in LOS ANGELES on the expectation that it would be approved for use in the class. The original concept was to provide a highly reliable and comfortingly conservative system, programmed to carry out maneuvers that would not alarm the most skeptical observer or frighten the most timid. One of its features permitted the operator to physically limit the magnitude of the command signal transmitted to any of the control surfaces. The vendor of the hardware, Autonetics, called this the "Variable Authority Control System." Another important feature was the follow-the-pointer display (actually a moving point of light at the edge of the rudder and diving plane angle-displays) that was intended to overcome the widespread reluctance in the Navy to turn submarine control over to a computer. This feature gave its name to the whole system, called the Aided Display Submarine Control System, or ADSCS. This Aided Display was driven through the computer using the same algorithm as the fully automatic mode, adapted to account for the added brief delay introduced into the control loop by the planesman.

There was an extensive and thorough shore based test of the system to demonstrate its reliability and its ability to cope with a horrendous series of simulated failures and operator maloperations without putting the ship in extremis. The system was installed in LOS ANGELES shortly after delivery.

The ADSCS was subjected to a formal TECHEVAL from 23 April through 7 May, 1977. The deployment that followed during the shakedown cruise served as the OPEVAL. Both evaluations resulted in favorable reports, with the most significant recommendations for change being to "spice up" the overly conservative automatic maneuvering algorithm and to open the system behavior to better exploit the ship's capabilities.

In regard to the comments of Ken Hart on the lack of training, there was a factory training program for officers prior to the installation, and there was a well prepared set of documentation aboard. (Since the installation was for T&E only, there was no established shore based training.) The system was easy to use and easy to learn to use. The design was such that failures would result in the system going into the OFF mode, with a flashing indication on the Ship Control Panel saying "Take charge of planes." Another design feature of the fully automatic mode was that any movement of a control column or helm wheel of more than a few degrees would result in the "Take charge of planes" display and the system took itself out of automatic. To re-set into automatic required deliberate actions by the operator to re-establish the desired operating constraints. In this respect, the design sacrificed convenience in operation for the assurance that inadvertent button pushing would not engage the automatic controller.

The system had an outstanding reliability record during the time it was in use. Even though the system operated with only one of the two AN/UYK-20 computers that it was designed to use, its record was exemplary. It was down for corrective maintenance only one hour in 185 days of operation, much of which was in the automatic mode.

It is interesting to note that there is still a "John Henry" complex at work in the submarine force, reflected in the widely held opinion that while automatic control may be useful on long, dull transit watches, it cannot be relied upon at periscope depth in heavy seas, or in any other demanding scenario. It is nonetheless a fact, however much sentiment might wish otherwise, that a modern control system can "drive steel" better than the best of the "steel drivin' planesmen" without fatigue and without coaching from the Diving Officer. The benefits of real automation, properly designed, tested and installed, cannot be fully realized in the submarine force until confidence in its utilization is as common as is the confidence in the controls of the propulsion plant.

Experience with the submarine control system in LOS ANGELES lends confidence that the newer control system to be provided to SEAWOLF will also be a highly reliable and useful system.

Alfred J. Giddings

BOWFIN REMEMBERED

Kudos are in order for those involved in the "submarine" segments of TV's "War and Remembrance" which aired November, 1988. Rather than opt for a less costly and unrealistic approach to shooting the submarine scenes, Director Dan Curtis obtained permission from the USS BOWFIN Memorial Association in Pearl Harbor for the use of SS-287.

BOWFIN looks the same inside and out as the day her sleek hull slid down the ways. For the TV production, BOWFIN was made surface operational and readied to play her major part in the television series. For the underwater sequences of "Moray", BOWFIN's fictional name in the Herman Wouk epic, Curtis called upon the Model Department at the studio to build an exact likeness of the

BALAO-class boat. Scenes of her cruising under the surface, torpedoes leaving the tubes and miniature depth charges exploding near her hull brought a fine sense of realism. All exterior surface and interior scenes were shot using BOWFIN.

Battle submerged and battle surface scenes, along with the attendant tension were highly effective by all actors involved as the crew. Before the sub scenes were filmed, actor Hart Bochner, playing the role of Byron Henry in the story, lived aboard BOWFIN for a few days with other members of the cast. He also went out in a nuclear sub so as to enrich the part he was tapped to play. Much of the success of the submarine scenarios was due to technical advisor RADM Paul L. Lacy Jr., USN(Ret.)

"War and Remembrance" pays commendable tribute to all who served at home and abroad, civilian and military alike. It is the one production that has finally done justice to those who went under the sea in boats.

Larry Blair

SUBMARINE DESIGN BOOKS?

Mr. Henry E. Payne III's provocative article in the October SUBMARINE REVIEW is thoughtful and timely. I agree with his call for a more open technical literature to stimulate critical review of submarine design within the U.S. technical community, to encourage innovation, and to promote broader competition.

Appropriate military classification is essential. However, in the opening months of World War II, our submarine force saw the terrible consequences of excessive secrecy within a closed bureaucracy. If only we'd questioned the Bureau of Ordnance's exclusive torpedo design expertise, challenged the Newport Torpedo Factory's production and testing monopoly, and critically reviewed exploder performance! Had we done so, American industry could surely have produced weapons with performance and reliability equal to the Japanese Long Lance Torpedo, and the Pacific War would have been shortened.

Prewar improvements in naval ordnance institutions, budgets, and designs would have changed the course of history. If the duds, prematures and deep-running U.S. torpedoes of 1941 to 1943 had been solid hits, our submarines could well have decimated Japanese seapower before the bloody invasions of the Philippines, Okinawa and Iwo Jima. Technical stagnation, obsessive secrecy, and a monopolistic torpedo establishment prolonged the war at enormous cost in lives and dollars.

Are the lessons of 50 years ago relevant today? Would we gain or lose from more open comparison of submarine technology, design, and performance in the U.S., Soviet and other navies? Should we encourage American engineers and submariners to debate alternative systems and approaches to speed, endurance, warhead lethality, sensors, system reliability, cost, diving depth, hull strength, damage control, habitability, crew size, safety, and other parameters? Could greater technical openness, broader institutional competition, and bolder experimentation strengthen our submarine technology base, stimulate innovation, lower cost, and thereby increase U.S. technological leadership? Or is strict secrecy within a closed establishment our best policy?

Mr. Henry E. Payne III's controversial call for more open U.S. submarine technical publication has merit. The potential benefits of "glasnost" are not confined to Moscow. The Navy should liberalize classification policy, and the SNAME and USNI should stimulate more vigorous technical discussions. A questioning National Submarine League with an outspoken SUBMARINE REVIEW can make major contributions to national security.

Thomas O. Paine

McKEE'S AXIOMS

Shortly after reading Admiral McKee's article "Fundamental Principles of Submarine Warfare" in the SUBMARINE REVIEW of October 1987, I conducted a series of wardroom seminars using McKee's Principles" as a basis for discussing the idea of SSBN war-fighting axioms. I presented the axioms we came up with to VADM Bacon, COMSUBLANT, this October, as a part of a deterrent patrol debrief. Since he showed considerable interest in the source of the original axioms, I forwarded to him a copy of the article.

For the Submarine League, this should be considered a success story. The REVIEW article generated serious thought and discussion concerning topics of submarine war fighting that apply to the fleet today.

CDR Steven G. Slaton, USN
C.O. USS HENRY CLAY (SSBN 625)

IN THE NEWS

o A special newsletter regarding the Naval Undersea Museum at Keyport, Washington, sends the especially good news that a Federal Government grant of $3.5 million for the Museum was included in the FY 1989 Navy Operations and Maintenance Appropriation Bill -- signed into law 1 October, 1988. Together with funds already raised, the nearly $7 million will permit complete construction of the facility except for the proposed auditorium and should have the Museum ready for tourists "some time in mid-1989." Congressman Norman Dicks spearheaded this Congressional support. The newsletter states that "at least $450,000 more funds will be needed to complete the construction and outfitting of the auditorium." Also, that the TRIESTE II arrived at Keyport in August -- and "signifies the Museum's stature as the Navy's primary site for the collection, display, and study of artifacts, documentation, and other materials associated with the underseas."

o Navy Times of 10 October reports that the diesel-electric submarine BONEFISH was retired 28 September, five months after a fire in the submerged submarine killed three crewmen and forced the others to abandon ship. USS BONEFISH was commissioned in 1959 and was the last diesel sub in the Atlantic Fleet. Three other diesel submarines are still in the Pacific Fleet.

o The TRIDENT Times of 12 August reports that a decommissioned destroyer, the JONAS INGRAM, was sunk by a Mk-48 ADCAP torpedo on 23 July. The test was the first live warshot firing of an ADCAP torpedo and completes a rigorous year-long testing program.

o Defense News of November 28, 1988, in an article by Peter Adams, notes that SDI phase-one planners are looking at submarines as a possible basing mode for future tactical ground based radar. The concept pictured, sees a submarine with radar onboard, surfacing at the time of ballistic missile attack. "The radar would be exposed, receiving the data from sensors in space -- the data helping to discriminate actual missile warheads from the thousands of decoys during an attack."

o SUB NOTES says that the Norwegians have spotted a Soviet 16,000 ton SSBN support ship, which is now operational in the Barents Sea. "She is equipped to carry at least 16 SS-N-20 SLBMs for an at-sea reload of TYPHOON class SSBNs."

o In the same issue of SUB NOTES, an article tells of a Norwegian Air Force plane photographing a retrofitted YANKEE class submarine in the Norwegian Sea. The YANKEE, formerly an SSBN, has been converted to a cruise missile carrying SSGN "which may carry as high as 40 SLCMs in the amidships missile compartment." The YANKEE was the test boat for the latest S-NX-24 missile -- with its estimated range of 2000 nm.

o Also, SUB NOTES mentions that RADM Bill Studeman, USN, "has said that the Soviet Union continues to deploy CLUSTER LANCE acoustic arrays along its Pacific coastline." He also pointed out that "the Soviets may be deploying ASW arrays around their ballistic missile submarine operating areas in the Greenland, Barents and Kara Seas. In addition, the Soviets may be testing longer range low-frequency arrays that could be mounted on the permanent Arctic ice pack."

o General Dynamics World of October 18, 1988, announced the Navy's awarding of a contract in October to Electric Boat, for the 16th TRIDENT submarine. This marks the second award of a TRIDENT to EB in 1988 -- the contract for the 15th being awarded in January, 1988. A competition with Newport News Shipbuilding and Drydock Company for three TRIDENTS was won by EB, so that EB can exercise an option for the 17th TRIDENT when that contract is awarded some time in 1989. Congressman Gejdenson of Connecticut said that this contract "is particularly important because it drives the final nail into the coffins of those who argued for a dual sourcing of TRIDENT submarines." It was also noted that the likelihood for another contractor to complete the program for 20 submarines, other than EB, had become highly unlikely.

o   <u>NAVY NEWS & Undersea Technology</u> of Sept. 19 reports that a KNACKEN-class submarine fitted with a closed-cycle Stirling engine was launched in September and would commence sea trials in October. The engine runs on liquid oxygen and diesel fuel. A Kockums source said that he expects the submarine to be capable of staying totally submerged for two weeks.

o   <u>NAVY NEWS & Undersea Technology</u> of Oct. 31, 1988, has an article by Stan Zimmerman reporting that the French unveiled a submarine design for a 231 ton submarine at their Exposition Navalle. The submarine, called the SAGITTAIRE, is capable of transiting more than 2000 nautical miles and uses an air independent Stirling engine. "One version has 6 torpedo tubes for torpedoes, another version provides a pair of swimmer vehicles allowing up to eight commandos to leave the submarine undetected and return. (The six torpedo tube doors can be easily replaced with doors for the swimmer vehicles). The "boat" is about 100 feet in length and 24 feet in height. Speed submerged is placed at 17 knots.

In the same issue, Doug Rekenthaler Jr's article on the Canadian sale of nuclear submarines (the SS<u>n</u>) to Turkey, places the sale as "imminent." The sale by Canada of 5 nuclear hybrid submarines to Turkey has been approved by all sixteen non-proliferation treaty (for nuclear things) member nations. These submarines are designed by Strata Corporation of Nova Scotia and use a low power nuclear reactor to continuously charge huge batteries which actually run the submarine. Independent of the atmosphere, such submarines offer "the autonomy of a nuclear sub with the stealth of a diesel-electric." The Strata hybrid is not being considered as part of the Canadian's program for purchasing 10-12 nuclear attack submarines (of either British TRAFALGAR or French RUBIS type).

In the November 7th issue of the same news source, the French exhibited a composite propeller for a submarine and demonstrated its lighter weight than bronze alloy propellers, its reduced acoustic signature, its elimination of corrosion and reduced magnetic signatures, its toughness and its uniformity of manufacture. "We can make them all exactly identical, and eliminate minute differences that add to a submarine's acoustic signature." Using composites (carbon fiber reinforced plastics), shows great promise for making lighter many parts of a submarine: decks, bulkheads, external non-pressure hull plating, shafts, etc. However, for use in a pressure hull, the degree of reinforcement necessary at penetration points appears to be a distinct disadvantage.

In the same issue of November 7th, it is noted that a French company is promoting large panels of hydrophones to be attached along a submarine's hull for passive sonar pickups. These panels, made up of layers of piezo-electric film alternating with metallic electrodes "promise a variety of advantages over conventional ceramic hydrophones -- greater sensitivity, better beamforming, resistance to explosions, high reliability and easy maintenance," are advantages cited. Rectangular panels of about 1.5 by 3 feet and two inches thick, attached along the length of a submarine should "give a better signal-to-noise ratio and a longer detection capability" than present array hydrophones. These new hydrophones are in service in the Norwegian navy and are scheduled to be installed in French ballistic missile submarines. "At present the system can only provide bearing information on frequencies below 5 kHz." But the panels, which can be recessed into a hull to prevent drag, "have a reduced sensitivity to flow noise and can be encapsulated in a polyurethane polymer."

o A news item from Boca Raton, Florida, tells of a 21-foot submarine found off Boca Raton.

It is believed that this submarine, submergible by remote control, was being used by drug smugglers who hid their drugs inside the submarine and sank it on the approach of drug agents. The submarine had 4000 pounds of lead bars in it as ballast -- when found. It has no port holes and is "not designed to carry passengers."

o <u>NAVY NEWS & Undersea Technology</u> of Oct. 17th reports that a contract was given to Kollmorgen Corporation in September for development of a prototype non-penetrating periscope. The only penetration of the hull being a small hole for fiber optic wires which lead from a periscope in the sail to the control room. The periscope optics can then be transmitted to wherever video monitors are located. No longer need the control room be directly under the periscope nor need the Captain press his eye to the lens for viewing the seas above him. Now, the control room can be built wherever the Navy wants it to be located inside the submarine, and the crew can see what's going on by viewing television screens. By getting rid of the bulky periscope mast and its attendant hydraulics, many of the characteristics of submarines can be changed -- for example, the sail's size and location. "The prototype represents the first of its kind in the world, and could conceivably be constructed in 18 months."

o In the same publication, but of October 10, the results of a study by the Congressional Research analyst Ronald O'Rourke show that "in terms of procurement and life-cycle costs, a notional eight-ship aircraft carrier battle group for the 1990s is equivalent to 12 to 21 SSNs. One might then envision a fleet not with 15 battle groups and 100 SSNs but with perhaps 13 battle groups and 124 to 142 SSNs." Also, "A force of 12 to 21 SSNs would require about 4,800 to 6,200 fewer personnel to man than a battle group; this figure being equivalent to about 1% of Navy end strength." And, "using cheaper 688-class boats, the numbers are even higher with one battle group equating to 14 LOS ANGELES-class submarines."

o The Washington Post of November 9, tells of the GROWLER, the Navy's first nuclear missile-carrying submarine, being towed to Tampa, Florida from Washington State. It will be added eventually to the Intrepid Sea-Air-Space Museum in New York at Pier 86 on the Hudson River. GROWLER will be overhauled in Tampa before being towed to New York City in March. From 1960 to 1964 GROWLER and her sister sub GRAYBACK patrolled the seas with REGULUS missiles onboard -- on deterrence patrols.

o NAVY NEWS & Undersea Technology of 24 October notes that the French Navy is attempting to purchase U.S. EC-130 TACAMO aircraft in the 1990s -- when the U.S. replaces these aircraft with E-6As, a Boeing 707 derivative. The TACAMO aircraft trails a long wire antenna for broadcast (on a very low frequency) of communications to submerged submarines. The aircraft tows a pair of wires, one about 5,000 feet long and the other 30,000 feet in length. The larger wire reradiates the signal transmitted by the shorter antenna.

o In the Times-Herald of October 29, 1988, an article by Molly Moore tells of the 10 U.S. ocean surveillance T-AGOS class vessels which tow linear arrays for the detection of submarines. These 224-foot, civilian crewed surveillance vessels, which use the Surveillance Towed Array Sensor System to complement SOSUS, P-3s on patrol, submarines on surveillance missions, and destroyers with towed passive sonar linear arrays, significantly expand the Navy's ASW ability to detect and track enemy submarines.

o The news item taken from the Naval War College Review, Spring '88, which was in the July issue of the SUBMARINE REVIEW and which dealt with Soviet Spetznaz teams being deployed to target areas by small Soviet submarines, neglected to mention the author of the article, Marc J. Berkowitz, from whose article the material was digested.

o A picture in Jane's Defense Weekly of 8 October, illustrates the type of pressure hull rupture which the Soviets are training their submarine crews to be able to shore up, and save their submarine. As shown, a damage control team wearing immersion suits and breathing apparatus is conducting a damage control exercise on a submarine damage simulator. A wide variety of other emergencies such as leaks, fires, collisions etc., are being trained for in this fashion.

o A translated article from the Soviet NAVAL AFFAIRS by Captain 1st Rank Ye. Nikitin, is titled In the SSN's Periscope -- the 21st Century. It describes the U.S. Navy's newest attack submarine, the SSN-21, SEA WOLF (sic) nuclear submarine. The article says (in setting the stage for the SSN-21) that the 688s were designed for a relatively narrow range of missions, namely close-in ASW cover for carriers and for combating submarines of the probable enemy. The article further notes (after a lengthy discussion of 688 problems in the Arctic) that the 688 "in the opinion of U.S. Navy command authorities, is not sufficiently capable of conducting combat in the polar latitudes." Also that "Foreign specialists feel the weak side of the LOS ANGELES class SSN is that it is not sufficiently outfitted with the different weapons to carry out a modern battle at sea." The article then described the SEAWOLF design. "A qualitative breakthrough in the words of Pentagon strategists." It is noted that the SEAWOLF "will be built and equipped on the basis of effective use in Arctic regions." It emphasizes "noiselessness, great firepower, and capability to fire a large number of torpedoes in one salvo." In one-on-one combat, "the submarine (quoting Vice

Admiral Thunman) will prove to be far more effective than what we have or anything that I see in the future."

o An article by Viktor Pavlov in The Soviet Military Review, July 1988, describes the present Commanding Officer of a TYPHOON submarine, the MINSKY KOMSOMOLETS, Captain 1st Rank Eduard Rybakov. He was a recipient of the Red Banner in 1987 "for success in combat training and political education." His submarine had earned the Naval Commander-in-Chief's prize for missile firing and a Red Banner from the Party regional committee. When higher headquarters asked if Rybakov's submarine could take the lead in an all-navy emulation drive, the Captain and his deputy for political affairs "decided that the crew would be able to take the lead." Rybakov is forty-two, but it is noted that "when clever enough, one can become a submarine commander in his early thirties." Rybakov's first wife had left him when "Eduard was at sea for months and the polar garrison could not offer her as many amenities as her Leningrad home." Then Rybakov met Valentina, "the girl (who) could see a kind and sensitive soul behind Rybakov's detachment, terseness and forbidding look," and then married him. He took command of the TYPHOON in April 1985. After he stepped aboard, his first words to the crew were "I want everyone to know that I am not going to hush up any fault or misconduct on the ship." The first year his submarine, rated as a "model ship" had so many reported failures and misconduct acts that the sub fell to second last in the submarine fleet ratings. But he did something. "No breaches of duty remained unnoticed. Some alcohol abusers were penalized, some discharged," and "breaches of duty began to fall steadily." Strict discipline alone did not do the job. Rybakov's golden rule was "Never ask subordinates to do their duties without first making them enjoy their rights." Thus, "when the submarine was in homeport, the men were told to go ashore exactly at 6 p.m., no matter what reasons they offered to stay over." And "the officers got used to it soon. They gradually learned to ration their working hours with enough time for self education or for studying a related specialty." The wives of the crew did their bit too -- "suggesting celebrating holidays in company." This meant that officers and mitchmans joined company with the ratings' families for prearranged festivals -- giving them a better chance to get acquainted. Also, "the crew has recently become keen on playing football. The Commander plays too, despite his status."

o An article by LCDR Michael Gouge, USNR, in the Proceedings of December 1988 shows the results of a comprehensive analysis of Allied merchant shipping losses in a war with the Soviets. The author assumes that ASW improvements since World War II have been more than offset by "the infinite endurance of the nuclear submarine and reduction of surface time by Soviet diesel submarines." His analysis then, of convoy shipping losses to Soviet attack submarines in the opening days of a big NATO-Soviet sea war, shows the losses to be unacceptable and that without enough U.S. cargoes of resupply materials being fed to the NATO land forces, the Allies ground forces "are not strong enough to win a quick war." Also, that Allied ASW forces cannot win a war of attrition against the large Soviet submarine force deployed against resupply shipping in a protracted campaign. Gouge, in the Naval Control of Shipping program since 1984 has assumed that about 35 Soviet SSNs or SSs will be assigned to North Atlantic convoys with 20% on station against any single convoy. The exchange rate he uses is 7:1, (a very modest assumption, and he still gets unfavorable results). Gouge's analysis merely notes that additional ships are likely to be lost to Soviet land-based aircraft using standoff missiles as well as "covert mining of choke points near the approaches to European ports." How many is not evaluated.

o In the same issue, James George recommends that the U.S. plays, for a few more years, a "kick the can" game (putting off serious discussions) for reducing SLCMs in the imminent arms control negotiations. This "will allow the United States to study the real importance of the SLCM (particularly for submarines) in the post INF and START world." See Dr. Lacey's SLCM article in this issue.


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

SUBMARINE TECHNOLOGY SYMPOSIUM

A Submarine Technology Symposium will be conducted at The Johns Hopkins University/Applied Physics Laboratory, Laurel, Maryland, on 23, 24, and 25 May 1989. The purpose of the Symposium is to provide a classified (SECRET-NOFORN) forum wherein those technologies that may be important to the capabilities of submarines and related systems can be advanced and examined by experts in government, industry and academia. The objective is to broaden the technical base available to the Navy and to assist the operational availability of that important technology. The theme of this Symposium will be, "The Technologies to Support the New and Expanded Submarine Roles and Missions."

Dr. Walt Grabowski of APL will serve as Program Chairman and Mr. Bill Chambers, also of APL, will take charge of all administrative and logistics arrangements for the Symposium.

A call for technical papers has been promulgated. Session chairman will select the most promising papers for presentation.

Attendance will be limited to 500, the seating capability of the Kossiakoff Center. League members holding a current SECRET clearance and a certified need-to-know who are interested in participating in the Symposium may obtain additional information by writing to:

The Johns Hopkins University
Applied Physics Laboratory
Johns Hopkins Road
Laurel, MD 20707
ATTN: Mrs. J. M. McLoughlin

or by calling (301) 953-6151

The Symposium will comprise five half-day sessions.

23 May 1989

Keynote Address	VADM D. L. Cooper, USN ACNO (Undersea Warfare)
The New Missions	Chairman: Dr. Ken Lobb CNA
C^3, Battle Management and Space	Chairman: Dr. H. Talkington NOSC

24 May 1989

Submarine Ship Systems Technology	Dr. Tom Taylor, DARPA
Sensors, Weapons, and Offboard Systems	Earl Messere, NUSC

25 May 1989

Advanced Foreign Technologies	Chairman: Bill Richardson JHU/APL
Round Table Discussion	VADM B. M. Kauderer, (Ret.) Symposium Chairman

SECOND ANNUAL

SUBMARINE TECHNOLOGY SYMPOSIUM

DOLPHIN SCHOLARSHIPS AVAILABLE

As college tuition costs continue to rise, parents and college students look for new ways to foot the bill. Submarine service families have a possible resource -- The Dolphin Scholarship Foundation.

The Foundation is currently providing financial assistance to 90 students. Twenty-five are freshmen. Since 1961, 367 scholarships have been granted.

During the 1989 college year, the Dolphin Scholarship Foundation will award $1,750 to each of approximately 25 college-bound freshmen seeking bachelor degrees.

The Foundation will renew the scholarship annually to students in good academic standing through their senior year. Those eligible to apply for the scholarship awards include children of members, or former members of the U.S. Navy, who have served a minimum of either five years in the Submarine Force (subsequent to qualification), or six years in Submarine Force support activities. Children of submarine sailors who died while on active duty in the Submarine Force are automatically eligible to apply for a Dolphin Scholarship.

Information about these Scholarships is available by contacting any Submarine Officers Wives Club representative or by writing to: DOLPHIN SCHOLARSHIP FOUNDATION, 405 Dillingham Blvd., Norfolk Naval Base, Norfolk, VA 23511; or COMMANDER NAVAL MILITARY PERSONNEL COMMAND (NMPC-641D), Navy Department, Washington, DC 20370. The deadline for acceptance of applications is April 15, 1989.

THE NAVY: ITS ROLE, PROSPECTS FOR DEVELOPMENT AND EMPLOYMENT

by RADM N.P. V'yunenko, CAPT 1st Rank B.N. Makeyev, CAPT 1st Rank V.D. Skugarev
and edited by Admiral Sergei Gorshkov
Publisher, Moscow: Voyenizdat, 1988; 272 pages

Often it is important to look at the past in order to understand the future. And, thus it is with those portions of the above cited book which forecast future submarine and torpedo technologies /characteristics.

As cited by the Associated Press, the principal submarine and torpedo projections contained in the new Soviet book are:

- o Submarine speeds of 50-60 knots (near-term) and 100 knots (far-term).
- o Wake, infrared, and laser homing torpedoes capable of speeds of 300 knots. (being developed)
- o Submarine dive depths of 400-600 meters (today) and 2000 meters (future).

Sound futuristic? Perhaps. But these much heralded projections were, in fact, stated 25 years ago in a Soviet book titled Atomic-Powered Submarine Design, authored by V. M. Prasolov and A. A. Narusbayev. Ironically, Bukalov and Narusbayev based their projections of submarine and torpedo advances on information contained in U.S. open press sources published 25-30 years ago. For example, the 1964 edition Atomic-Powered Submarine Design stated the following:

- o "Foreign specialists are of the opinion that if control of the boundary layer problem can be solved successfully, submarine speeds will increase to 50 to 60 knots, and if there is a simultaneous increase in installed horsepower, speeds will exceed 100 knots."

- "By 1970 to 1980, foreign specialists propose to create military submarines capable of submerging to 1200 meters (if high-strength steels are used for the pressure hulls), or to 1800 meters (if the technology involved in building hull structures of titanium alloys is worked out)."
- "In 1959, the United States Navy was presented the following torpedo goals for the 1970s: increase the tactical speed of ASW homing torpedoes to 55 to 60 knots ... develop new models of rocket-propelled torpedoes with speeds on the order of 200 to 300 knots, as well as rocket-propelled interceptor torpedoes to combat homing torpedoes ... devise a guidance system for future torpedoes which will be resistant to interference and which will be able to work successfully against a target taking evasive action; the most effective are considered to be the infrared (heat) instruments for homing, since they can guide the torpedo to the ship along its wake."

In summary, the Soviets haven't told us anything new. The Soviets have simply restated and slightly repackaged forecasts we made 25 years ago. As often happens, some Western naval analysts and news organizations have mistakenly "re-discovered" these old forecasts and attributed them to the Soviet Union rather than the U.S. People reading this new Soviet book should be cautious and read it in light of previous Soviet writings on naval strategy and submarine matters.

John J. Engelhardt

THE DEVELOPMENT OF FOREIGN SUBMARINES AND THEIR TACTICS

by
RADM L. P. Khiyaynen, Moscow: Voyenizdat, 1988
239 pages

Just when you thought the Soviets had written enough books about foreign submarine developments, along comes another one. This supposedly "new" book is really only an updated 3rd edition of an earlier book authored by Rear Admiral L. P. Khiyaynen (in 1979) bearing the same title (Razurtiye zarubezhnykh podvodnykh lodok i ikh taktiki).

All three editions of Khiyaynen's books are valuable reference sources and a must for collectors of foreign press materials on submarines. RADM Khiyaynen (and/or his research staff) have gone to extensive efforts to research all publicly available literature on foreign (i.e., non-Soviet) submarine developments. The result is an easy to read book outlining developments in submarine design, weapons, sensors, and tactics since World War I, with emphasis on the past 20 years. Several very useful tables are provided, depicting the technical characteristics of Western submarines constructed over the past 50 years. The book contains no pictures -- a usual Soviet practice.

A preliminary review of the new edition of the book suggests that there is little in the way of new information on Western submarine developments (SSN-21, TRIDENT, etc.), or Soviet views on submarine design philosophy and tactics.

Two interesting observations about this book. First, the book came into the United States around September 1988. A well-known Washington, DC area Russian book store had about 200 copies of the book for sale (cost $3.50) when this author purchased his copies -- the day after the book went on sale. <u>Within 3 weeks all copies of the book were sold out!</u> This may indicate a heightened awareness about submarine matters among both the Russian and U.S. defense communities located in the Washington, DC area. A second observation is that <u>Voyenizdat published 35,000 copies of the book</u>. This suggests two things: (1) the Soviets anticipated a large foreign readership and probably earmarked about 15,000 copies of the book for export to the West and (2) the Soviets have an in-country readership of about 20,000, of which perhaps 15,000 might be classified as submariners and civilians involved in the nation's submarine programs. These are impressive statistics about the Soviet submarine publishing apparatus and readership.

My only complaint about the book, as with most Soviet submarine books and articles, is that the author fails to footnote information sources properly, or to credit copyrighted material. This makes it impossible for researchers and scholars to re-trace the footsteps of Soviet researchers or to access public information sources used by Soviet researchers.

John J. Engelhardt

<u>SUBMARINE COMMANDER</u>

by Captain Paul R. Schratz, USN(Ret.)
University Press of Kentucky, Lexington, KY, 1988
322 pages

Paul Schratz has finally written the memoirs (journal or log) that those who know him well have long awaited. Predictably, it is fascinating. At the very beginning he quotes Arleigh Burke, "Any commander who fails to exceed his authority is not of much use to his subordinates," -- and George Marshall, "...if one can't disobey an order, he'll never amount to much as a leader." Paul adopted these as his credo and, as he takes us through his adventures in two wars, he sure as hell never varies from that credo.

Paul hit the submarine navy at absolutely the right time. World War II was fully underway. He was thus spared the inhibitions of those with years of cautious peacetime submarining. His first submarine was MACKEREL, under Johnny Davidson, where he qualified ahead of his class and qualified for command almost immediately afterwards. I don't know anyone with a better record than Johnny Davidson for picking naval officers or submariners. Johnny's subsequent career concentrated on doing just that. Paul's job was torpedo and gunnery officer, TDC operator, heart of the attack team. It was a job he never relinquished. He was always right alongside the captain, fighting a real war, unsullied by the contrived practice approaches of the peacetime navy. It was a great challenge for a young, inexperienced officer -- and Paul was loaded for bear.

Perhaps the most interesting, and certainly the most revealing of all the chapters are those devoted to his patrols in SCORPION and STERLET. Paul joined SCORPION, under Bill Wylie, during fitting out, again as torpedo and gunnery officer. Alarmed by tales from the Pacific about the sorry performance of torpedo warshots, and realizing that he was in a perfect position to do something about it, he immediately gave battle to the Newport torpedo organization. With his leading torpedoman, he secretly invaded the exploder lab and copied working drawings of the exploder mechanism. After studying these, he decided that increasing the tension in the arming impeller would reduce the chances of shorting the exploder, particularly when the warhead was carried to deep depth, and thus cut down on the distressing frequency of premature explosions. He applied this "loving hands at home" ORDALT to his own torpedoes and passed the word around as best he could. His reported torpedo record indicates that it worked. He also redesigned the lighting for the clinometers (bubble tubes) at the diving station. Portsmouth yard accepted that one and claimed it for their own. Newport remained Newport.

It is when SCORPION and STERLET get on war patrol that the real message of Paul's story emerges. As the leading member of the attack team, he frequently disagreed with the manner in which the two captains, (one a friend, the other much less so) conducted their patrols. He vigorously asserted his ideas, gave orders without the Captain's knowledge and eventually, in STERLET, virtually usurped command where operations were concerned. At one stage, in STERLET, he seriously considered requesting the captain's relief at sea, or even relieving him on the spot. That he did not do so was probably fortunate for Paul.

However, his account very clearly illustrates a situation that was not uncommon in submarines in World War II, or indeed, throughout naval history in ships under independent command. The brilliant, ambitious and aggressive young officer, exasperated by the tactics of a more conservative and cautious skipper was a frequent figure in the rest camps of the Pacific. I remember Mike Shea particularly. Their problem was fundamental. They saw the war all around them and they wanted to fight it. Now, these are the "gung-ho" guys who will sink ships and win wars for you. They are the Medal of Honor winners -- if they really know what they are talking about. The Division and Squadron Commanders and the Admirals had to sort them out and find the best captains. They could usually find out who could not cut it. How could they tell who could?

Paul's story is, of course, far more

encompassing than that single facet. He is truly irrepressible and he actually believes that it is possible for submarining, or any other naval activity, peace or war, to be fun; and he sets out to prove it. He is rarely in the position that his movement report promises and the diversions are usually because it is more fun that way. Some contraventions of rules or orders, as in straying beyond area boundaries, are in the interest of improved battle efficiency. Many others are because that's the way Paul wanted to do it. Many of the latter are outrageous. Examples are: faking orders from Admiral Lockwood in order to get a ride on a B-29 in a raid over Japan; or the 72-degree surfacing of PICKEREL which made the cover of SHIPMATE eventually but had to be hidden from Admiral "Babe" Brown when he did it. There are many more, less famous but no less bizarre, scattered throughout the story. They season the book and make it a delight for anyone who lived in a submarine in those days.

There is tragedy also. Reggie Raymond, exec of SCORPION, whom Paul idolized, was killed in a gun battle on the first patrol. The shock and sorrow this brought to Paul runs a thin line through much of the book. The subsequent loss of SCORPION was also a heavy blow, particularly when Bill Wylie wrote Paul, "I shall always believe that your detachment from SCORPION was a major contributing factor to her loss." It was a heavy load to carry.

The book covers operations from WICHITA in Iceland, just prior to the beginnings of our entry in World War II, through duty in MACKEREL, SCORPION, STERLET and finally with Jason Maurer in ATULE, where Paul finally found a skipper who met his specifications. The scene then shifts to early occupation days in Japan, command of the captured Japanese submarine I-203, bringing her to Pearl, and the peacetime and Korean operations of the new GUPPY submarine PICKEREL. There is adventure on every page, sometimes serious, mostly amusing and often downright scandalous. If you want to learn how to get away with murder and have a good time doing it, this book is for you.

This is Paul's story. It is intensely personal. It's the way he saw the war and how he fought it. His descriptions of the war patrols are more detailed than patrol reports and, at least in his eyes, more factual. It is a delight to read not only because it is well written but because it is so very real seen through the eyes of a completely involved observer. As befits an accomplished concertmaster, every note rings true. And this is only the first stage of Paul's distinguished career. I am sure that there are more concertos to come. Bravo! Encore!

Frank Walker

MEMBERSHIP STATUS

	Current	Last REVIEW	Year ago
Active Duty	898	918	898
Others	2744	2779	2590
Life	157	158	128
Student	27	31	25
Foreign	41	39	30
Honorary	10	10	12
Total	3877	3935	3683

HAVE YOU GOTTEN 2 NEW MEMBERS FOR 1988?

NAVAL SUBMARINE LEAGUE
HONOR ROLL

BENEFACTORS

AT&T
ADVANCED TECHNOLOGY
ALLIED CORPORATION, BENDIX ELECTRODYNAMICS
AMERICAN SYSTEMS CORPORATION
ANADAC, INC.
ANALYSIS & TECHNOLOGY, INC.
APPLIED MATHEMATICS, INC.
ARGOSYSTEMS, INC.
ARGO-TECH CORPORATION
ARGUS RESEARCH CORPORATION
BABCOCK AND WILCOX COMPANY
BATTELLE MEMORIAL INSTITUTE
BDM CORPORATION
BELL AEROSPACE TEXTRON
BIRD-JOHNSON COMPANY
BOEING AEROSPACE COMPANY
BBN LABORATORIES, INC. (BOLT, BERANEK & NEWMAN)
BOOZ-ALLEN & HAMILTON, INC.
COMPUTER SCIENCES CORPORATION
DATATAPE, INC.
DIAGNOSTIC/RETRIEVAL SYSTEMS, INC.
EDO CORPORATION
EG&G SEALOL ENGINEERED PRODUCTS DIVISION
EG&G WASHINGTON ANALYTICAL SERVICES CENTER INC.
ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS
ELIZABETH S. HOOPER FOUNDATION
ESSEX CORPORATION
FMC CORPORATION
GENERAL DYNAMICS UNDERSEA WARFARE
GENERAL ELECTRIC AEROSPACE MARKETING
GENERAL ELECTRIC MARINE & DEFENSE FSO
GENERAL PHYSICS CORPORATION
GLOBAL ASSOCIATES, LTD.
GNB INCORPORATED, INDUSTRIAL BATTERY DIVISION
GTE GOVERNMENT SYSTEMS CORPORATION
HAZELTINE CORPORATION
HONEYWELL, INC.
HUGHES AIRCRAFT COMPANY
HYDROACOUSTICS

IBM CORPORATION
IMI-TECH CORPORATION
INTEROCEAN MANAGEMENT CORPORATION
INTERSTATE ELECTRONICS CORPORATION
JAYCOR
KAMAN AEROSPACE CORPORATION
KOLLMORGEN CORPORATION ELECTRO-OPTICAL DIVISION
LOCKHEED CORPORATION
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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. 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.

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