THE SUBMARINE REVIEW

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FROM THE PRESIDENT

The NSL Submarine Documentary, "*Submarine - Steel Boats, Iron Men*" is completed. It will be aired on National Public Television in early 1990. The NSL will keep you informed as the date becomes firm. Preceding this national airing to an audience of millions, the documentary will be shown to local audiences in the Capitol area on 15 November 1989. The Producers and the NSL will try to arrange for similar local area viewings at submarine ports.

The video is a stupendous success and hopefully will be a national award winner. The film has been welcomed by all who have had a chance to review it. The Navy Recruiting Command has taken the 56 minute original and condensed it for the command's special uses. After the national viewing copies of the video will be available for purchase. I feel most submarine families will want their own copy to show when Dad is away.

Each of the 26 sponsors for this documentary will receive a master copy of the video for their own use and viewing. Now is the time for all members of the NSL to thank our sponsors for their support. This video will have a major impact for years to come. We are very grateful to the following Sponsors who made this production possible.

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The NSL Directors have selected Captain John Vick, USN(Ret.) to serve as the first NSL Executive Director. John brings much experience and many attributes to the job and we look forward to his help in making the NSL a better and dynamic organization.

Finally, I was pleased to be elected as your new NSL President. I hope in this last year of my eligibility as a Director, and your President, we can set a course that others can follow for many years. I am very honored to be recognized and elected as the NSL President. Many thanks!

Al Kelln

SUBMARINES AND THE PROJECTION OF SEAPOWER AGAINST THE SHORE

Seapower is a nation's ability to make use of the oceans in furtherance of its economic and political interests in time of peace and war. Its exercise entails both the projection of power against the enemy shore and sea control -- the ability to use the seas without hindrance and to deny that use to one's enemies. The initial applications of seapower were confined exclusively to power projection against the shore. The ancient Greeks first used sailing vessels to carry their armies across the Mediterranean. Likewise, the Norsemen used their longboats to carry raiding parties across the seas to loot and plunder. War at sea -- and the notion of sea control -- did not develop until after ships had become capable of fighting against each other with boarding parties, missile-projectiles, and rams. Archaeological evidence suggests that this was not generally the case until roughly the 7th Century B.C.

Many centuries followed, with ships on the seas preventing the movement of enemy sea resupply and troop reinforcement to their forces ashore. Maintaining control of the seas became of first importance. Naval warfare for the most part was confined to the seas with only small efforts directed against the shore through short-range cannon bombardment of shore objectives and the landing of troops to take or destroy shoreline installations.

Thus, submarines, developed many centuries later, were initially thought of solely as weapons of naval warfare. The first successful submarine, David Bushnell's TURTLE, was intended to sink British ships-of-the-line in New York Harbor during the War of the American Revolution. Subsequent submarine developments followed this pattern, and by the Second World War submarines had become one of the most fearsome weapons of war at sea. Nevertheless, it was perhaps inevitable that submarines would in time become instruments of power projection. This evolution in the concept of submarine employment began slowly in the mid-20th Century and, paralleling the evolution of submarine capabilities, mushroomed rapidly after the close of World War II. It has developed to the point that today submarines armed with continent-spanning missiles fitted with highly accurate thermonuclear warheads may be considered the ultimate means of projecting seapower against the shore.

"Amphibious" Submarines

It should not be surprising that the development of submarines as instruments of power projection followed the same pattern as surface ships. Specifically, as with the ancient Greeks and Norsemen, the earliest uses of submarines in the projection of seapower were in landing troops on the enemy's shore. Unlike traditional amphibious operations from surface ships, however, submarines have never been able to land large numbers of troops. Instead, submarines have been used to insert small numbers of special purpose troops and other covert action or guerrilla warfare operatives into enemy territory from the sea.

Importantly, small landing parties have to have a considerable element of "surprise" in their operations in order to succeed. Radar coverage of shore areas is likely to be so effective that supposedly covert landings from small craft or air-dropped forces would be discovered and destroyed before having a chance to attain their objective. Landings from submarines thus have a higher probability of success.

During the Second World War, most of the major belligerents on both sides undertook such "amphibious" submarine operations. In the Mediterranean, British submarines put Special Boat Party teams ashore in Italy to sabotage the railways. The Italian railroads ran very close to the shore through numerous tunnels in seaside cliffs -- which could be blocked by detonated demolition charges.

The United States Navy used submarines to place intelligence operatives, coast watchers, and military personnel ashore throughout the Pacific theater. In the Philippines, submarines were repeatedly used to reinforce and resupply guerilla forces during the Japanese occupation. Between February 1943 and January 1945, 41 such special submarine operations were carried out by 19 fleet submarines -- the lion's share of which were carried out by two U.S. submarines, the NARWHAL and the NAUTILUS.

The NARWHAL and NAUTILUS also were used to land Army patrols on Attu in the Aleutians, and the NAUTILUS conducted a similar mission at Tarawa. In August 1942, the NAUTILUS and another submarine, the ARGONAUT, transported a 221 man Marine Corps Raiding Battalion to Makin Island in the central Pacific where a successful raid was carried out against the Japanese garrison.

The ARGONAUT was the only U.S. submarine specially converted for troop carrying during World War II. After the war, however, three other United States fleet submarines were converted and operated as submarine transports -- the PERCH, SEALION, and TUNNY. Each was capable of carrying 111 troops, a tracked landing vehicle, a jeep, and over 85 tons of equipment. The PERCH actually saw combat as a submarine transport in Korea and Vietnam, being used to land small numbers of Marines and commandos.

Although large-scale submarine-launched amphibious operations of the Makin type appear to be a thing of the past, small-scale operations remain very much a reality of the modern world. Many nations have the capability to project power against the shore with special purpose units operating from standard patrol or coastal submarines. These units can come ashore from surfaced submarines in inflatable boats or from submerged submarines with scuba gear. In most cases, these special purpose units are a component of a larger naval or marine force, such as the Kampfshwimmer companies of the German Democratic Republic's Volksmarine. Moreover, a British Special Boat Squadron recently saw combat during the 1982 Falklands campaign. Boat Squadron personnel were flown from the United Kingdom to the South Atlantic where they parachuted to a waiting submarine. The submarine then transported them to the Argentine-occupied islands where they carried out reconnaissance and harassed Argentine troops.

The United States and the Soviet Union maintain larger units of submarine-capable amphibious troops. The U.S. Underwater Demolition Teams and Sea-Air-Land (SEAL) units are trained to operate from submarines against critical enemy targets near the coast such as port and harbor facilities and bridges. The Soviet Spetsnaz -- troops of the Soviet General Staff's Main Intelligence Directorate -- have naval brigades assigned to each of the Soviet Navy's four fleets. The brigades each have a parachute battalion, two or three battalions of combat swimmers, and a mini-submarine group. In addition to a substantial inventory of mini-submarines, the Soviet Navy has two India-class auxiliary submarines capable of carrying two small submersibles each. It is generally believed that Soviet special purpose forces using full-size and mini-submarines -- including an as yet unidentified tracked submersible -- have carried out operations along the Swedish coast.

The Inland Reach of Submarines

A submarine, like any other naval vessel, can reach inland only as far as the range of its armament. Traditionally, this direct projection of power ashore was performed by bombardment with a ship's guns. Indeed, the concept of naval bombardment is as old as the first ship's cannon. In general, submarines were less capable in this regard than most surface combatants since their gun armament was almost invariably limited to relatively small caliber cannon. Notable exceptions were the French Surcouf and British M.1 submarines built after the First World war. The Surcouf mounted two 8-inch cruiser guns while the M.1 carried a single 12-inch battleship cannon. Neither design proved to be tactically successful, however, and the large caliber gun submarine experiment was not repeated.

Despite being undergunned for the shore bombardment role, submarines nevertheless exercised this aspect of power projection from time-to-time. For example, during World War II, British submarines shelled Axis trains and bridges in Italy and north Africa. In June and July 1945, the U.S. BARB shelled six Japanese towns, including the port of Shari on the north coast of Hokkaido. The BARB employed its 5-inch deck gun and a 5-inch rocket launcher that had been specially fitted on the submarine's deck for that purpose.

Extending the Inland Reach

Toward the close of World War II, efforts were underway to extend the inland, power-projecting reach of submarines. These efforts were undertaken not by the victorious Allies, but by the crumbling Axis. The Japanese built four special-purpose submarines designed to carry seaplane torpedo-bombers -- the I-13, I-14, I-400, and I-401. The first two of these could carry two seaplanes apiece, while the latter two could each carry three. The Japanese planned to send these submarine aircraft carriers in a concerted attack against the locks of the Panama Canal -- but the plan was abandoned.

The Germans took a different approach and sought to marry their successful rocket technologies to a submarine delivery system. The plan called for V-2 rockets in waterproof launch canisters to be towed beneath the surface by U-Boats. When the U-Boats reached their launch points -- off the coast of the United States -- the canisters would be ballasted into an upright position and the rockets launched. This idea presaged the development of the submarine-launched ballistic missile (SLBM).

The first experimental launch of an SLBM from a submarine was carried out by the Soviet Union in 1955. Between 1955 and 1958, seven Soviet Zulu-class diesel-electric attack submarines were converted to the world's first ballistic missile submarines. The conversions involved enlarging the sail to accommodate two liquid-fueled SS-N-4 SLBMs. The SS-N-4, with a range of about 350 n.m., could only be launched while the submarine was on the surface.

The Zula conversions were soon followed by the Golf-class submarines. Originally deployed with the SS-N-4, in 1963 they were retrofitted with the more advanced SS-N-5 -- fired submerged and with twice the range of its predecessor.

The United States entered the SLBM arena with the solid-fuel POLARIS which was successfully launched from a submerged submarine in 1960. The POLARIS entered into operational service the same year aboard the GEORGE WASHINGTON, the world's first nuclear-powered ballistic missile submarine -- which carried 16 missiles of 1,370 n.m. range.

Thereafter, SLBM/SSBN developments followed rapidly one upon another. Today, the Soviet Union has the 16-tube DELTA-class SSBN carrying liquid-fuel SS-N-18s and SS-N-23s and solid-fuel SS-N-20s with ranges of over 4,000 miles. The U.S. now deploys the 24-tube TRIDENT SSBN with C-4 missiles of at least 4,000 n.mi. range and will shortly load D-5s of a range well in excess of 4,000 n.mi. and with exceptional accuracy. For the first time in history, such submarines operating submerged in distant waters could now strike deep into an enemy's homeland. The United Kingdom with four RESOLUTION-class SSBNs can use the POSEIDON C-3, while France uses a relatively short range ballistic missile on its six SSBNs and the People's Republic of China employs a variant of an intermediate range ballistic missile, the CSS-2 of over 1,000 n.mi. range in its XIA-class SSBN. The range of these SLBMs is still insufficient to allow the submarines to strike deep inland. As a result, such submarine launch platforms are compelled to operate near the shores of their potential enemies and to limit their target coverage to coastal areas.

The Proliferation of Submarine Power Projection Capabilities

With the development of global-range SLBMs and their deployment aboard submarine launch platforms, the submarine became the preeminent naval system for the projection of seapower against the shore. Notwithstanding this fact, few nations presently have this capability, and it is unlikely that many more will be able to devote the necessary resources to attain it. In contrast, the development of long-range, land-attack, submarine-launched cruise missiles (SLCMs) -- with or without nuclear warheads -- holds considerable promise for the worldwide proliferation of submarine power projection capabilities.

The first operational land-attack SLCMs -- the nuclear warhead REGULUS missiles of 400 n.mi. range -- were deployed aboard submarines by the United States in the mid 1950s.

The Soviet Union's first land-attack SLCM was the SS-N-3 SHADDOCK. Introduced in 1962, it was intended primarily as an antiship weapon but had a built-in land attack capability. It had a range of about 650 nautical miles, and was deployed on a variety of submarines -- initially the WHISKEY "Twin-Cylinder"-class. Although it could carry a nuclear warhead, in the land-attack role the SHADDOCK's accuracy was poor.

Today, the United States deploys TOMAHAWK in three variants -- the antiship SLCM, the nuclear-armed land-attack SLCM, and the conventionally-armed land-attack SLCM. The land-attack models have a range of about 1,350 nautical miles and an accuracy reportedly measured in feet. Current planning calls for eventual deployment of TOMAHAWKs aboard 26 nuclear-powered attack submarines.

The Soviets developed two modern, nuclear-armed, land-attack SLCMs -- the SS-N-21 and SS-NX-24, which is not yet operational. The SS-N-21 is equivalent in range to the U.S. torpedo-tube launched TOMAHAWK, and could be deployed aboard a variety of nuclear-powered attack submarines and conventional subs and specially converted YANKEE-class units.

Although the reach of these SLCMs is considerably less than that of the most modern SLBMs, they are capable of striking targets with little or no warning. The low-altitude flight profile achieved by terrain-contour matching, or altimeter and inertial guidance, make the SLCMs exceedingly difficult to detect and destroy. Moreover, their range is no less than that of the earlier generations of SLBMs and, like them, they are capable of striking land targets from multiple and potentially unexpected axes of attack. SLCMs also hold out the prospect of pinpoint accuracy. Indeed, the accuracy of the U.S. TOMAHAWK is estimated as sufficient to destroy certain categories of hard targets with conventional warheads.

Unlike SSBNs, therefore, submarines fitted with conventionally-armed land-attack SLCMs will be able to project seapower against the shore in a non-nuclear environment. Naval missions that today can only be accomplished by carrier-borne aircraft -- at potentially prohibitive attrition rates in the case of heavily defended targets -- can now be undertaken by SLCM-armed submarines. Not only will this benefit the carrier navies, allowing them to employ their manned aircraft against less heavily defended targets or in consort with SLCMs for improved, synergistic effects, but it will expand the power projection capabilities of the non-carrier navies -- i.e., most of the world's naval forces.

The conventionally-armed, land-attack SLCM with its high-accuracy and small size, making it capable of launch from a standard size torpedo tube, offers unparalleled power projection capabilities for submarine forces worldwide. These cruise missiles and their attendant fire control systems could be readily deployed aboard a variety of submarine types, including diesel-electrics. Such a proliferation of power projection capabilities would not be unprecedented. The global spread of modern antiship missile systems that has occurred in recent years offers ample precedent. Indeed, the probability that future SLCMs will be developed in families, like the TOMAHAWK, including both antiship and land-attack variants makes this proliferation all but inevitable.

Conclusion

In the late 20th century, after over two hundred years of development, the submarine has become the predominant naval weapon for the projection of power against the shore. It is capable, in its modern SSBN form, of raining thermonuclear destruction down upon land targets virtually anywhere on the face of the globe. At the low end of the conflict spectrum, the submarine is capable of deploying troops on enemy shores for a variety of combat operations. In between these two extremes, the land-attack cruise missile offers the submarine forces of the world the flexibility to launch surgical strikes against select facilities at medium ranges, or large-scale bombardment of enemy shores with either nuclear or conventional munitions. In short, the increasing inland reach of submarine weapons coupled with the essentially unrestricted access of submarines to offshore areas worldwide, guarantees submarines will continue to dominate the projection of seapower against the shore well into the next century.

Dr. Edward J. Lacey

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THE FINAL HOURS OF THE "MIKE"

[*Ed. Note: This condensation of Captain 3rd Rank P. Ishchenko"s article in Red Star, 19 April, 1989, plus other Soviet news releases, attempts to interpret points of interest in this event, for SUBMARINE REVIEW readers.*]

Captain Evgenij Vanin of the Soviet submarine KOMSOMOLETS (a "MIKE") noted at 1100 for the watch log: "The boat is on a course of 242 degrees. Compartments are secured, there are no deviations."

The "second crew" was taking their nuclear submarine on its first "combat" mission. The "first crew" had built the submarine and operated the MIKE in its training prior to deployment. "The necessary exercises were successfully executed in the operational training center and all of the pre-deployment tasks had been completed at base."

"What a submarine: an experimental one, representing in itself not only a submarine of great combat value but also one of great scientific value -- the sub was experimental in the use of 'unusual materials.'"

"There was nothing to complain about at sea. The submarine was 'carting' home so many confirmed ship contacts that there were enough for two or three such patrols."

"The peaceful atmosphere quickly turned into a dangerous one. The fire indicators began to operate alarmingly. 'Fire in the seventh compartment.'"

1103, 7 April: The LOKh (a system for fire extinguishing) in the seventh compartment was energized. "In this case the applied measure did not give any result." This seemed to be due to an influx of high pressure air into the compartment -- feeding the fire and critically raising the temperature, (an air line or air bottle rupture?). "This is why fire got into the sixth compartment (through composite bulkheads?) and then spread further. The submarine was at a depth of 50 meters." The order was given to go to periscope depth and at 1116 the periscope was raised for a look around.

"Captain Vanin directed the struggle for damage control. Everything aboard the submarine, and even moreso in an emergency situation, is done by the crew, but only by the order or with the knowledge of the Captain."

1121: "Fire in the fourth compartment." (the reactor compartment?). "The control station for pumps is burning. The pump is useless. Circulation of water from the reactor to the generators and back again ceased." Capital-Lieutenant Orlov said: "When the reactor's operation was no longer needed I cut its work in accordance with the emergency instruction. The operation of the power-unit was my responsibility and I was authorized to shut it down even if the conditions were a bit off-normal. After the emergency control rods went down automatically, I clinched the matter by bringing the fuel rods as far down as possible. All the cooler pumps were on and worked non-stop to cool the core. Before leaving the submarine, five minutes before the plunge, I inspected the central board. The first loop was 35 degrees centigrade. The cooling system was autonomous and would operate even if the submarine's power network failed. Destruction of the first loop is also excluded."

1127: "On the submarine movement control panel there appeared a source of open flame. Gasification and worsening of visibility in the central part."

At about this time the MIKE was surfaced. "Captain Vanin and the entire crew were hopeful of the possibility of saving the submarine."

1134: "List to port is increasing. Main ballast is blown."

1145: "The diesel cooling is not working. The diesel is stopped."

1158: "No communications with the fourth compartment. There are about nine persons in there."

1212: "Golovchenko in second compartment lost consciousness." Then an order was given: "Transfer the crew of the second compartment who lost consciousness, topside."

1241: "There is great smokiness in the fourth compartment. The condition in the first compartment is normal," (the location of the batteries.)

1336: Two hours after surfacing "the reactor is extinguished with all absorbers."

1402: "Kulapin and Bonder (who were brought out of the fifth compartment and taken topside) have died."

1418: "VHF communications with an aircraft established."

1518: "There is no inflow of water. The fire is being extinguished by hermitization."

1624: "Strikes are observed resembling explosions, in the regions of the sixth and seventh compartments."

1642: "Prepare for evacuation!". (The bow of the boat was so high that the bow horizontal planes were visible.) Captain Smirnov, in the water, was hit by the bow horizontal plane of the pitching submarine and perishes.

1645: "The first compartment is unsealed. Prepare the battery pit for ventilation." (Throughout the emergency there was worry about the consequences of a battery explosion.)

1651: A radiogram sent, reporting: "condition normal." (But about this time, the influx of water into the stern compartments through burned up cables through the hull, and other explosion damage, forced the Captain to discontinue damage control measures and evacuate all personnel.)

"It was determined that somewhere in the bilges of the third compartment was Captain 2nd Rank, Ispenkov, commander of the electro technical division" -- who apparently had not heard the command to evacuate. So Captain Vanin "dove back into the smokey interior of the perishing submarine. In the central post he bumped into Warrant Officer Slyusarenko who was hurrying toward the bridge hatch. Vanin told him to get Ispenkov and get into the escape chamber." Ispenkov was heard yelling "water coming into the third compartment." When Slyusarenko got to the escape chamber he was so exhausted that he had to be pulled into it by two of the four people already there. The lower hatch was closed tightly, when there was a knocking on the hatch.

Captain Vanin ordered the lower hatch opened immediately. But just then there resounded below a terrible cracking, (the bulkheads had begun to break.) Ispenkov perished. The depth gauge in the VSK was stuck on 400 meters "although the VSK was already at a far greater depth, and the depth of the water was about 1500 meters." Nothing happened when an attempt was made to free the VSK from the sinking submarine. But suddenly there was a sound like an explosion and the chamber had broken loose, at which Captain Vanin ordered: "Everyone plug into individual breathing apparatus." One man fell and went into convulsions before he got his mask on. It must have been that gases had entered the chamber when the VSK broke loose." A mask was put on Yudin, then Captain Vanin, in the lower compartment was noted to have not put on his mask and had lost consciousness. When the chamber hit the surface and the upper hatch flew open, Slyusurenko was blown out and Chernikov was half ejected into the water, where he died of hypothermia in the icy waters. Meanwhile the VSK filled with water and sank with the other three including Captain Vanin, going to their death.

1708: The MIKE sinks six hours after the fire began, and 4 1/2 hours after surfacing. (Neither the Captain or his crew seemed to have any basis for abandoning the submarine or for concluding that it would sink at any moment.)

The Soviet submarine sank in neutral waters of the Norwegian Sea. 27 of the 69 crew members were saved. When the MIKE began to capsize, the crew was forced to evacuate. "People jumped straight into the cold water. There was a force 2-3 gale at the time. Inflatable rafts were used, but several seamen got into a single liferaft, so they were semisubmerged. Aircraft appeared and dropped a number of rafts -- which landed in the water 300 meters away; too far away for the weakened seamen to risk swimming that distance. It was 1820 before the first ship arrived. Medics and crew members of a floating base which showed up spent the whole night rendering assistance to the casualties. All arrived at a hospital in Murmansk on 9 April -- suffering from hyperthermia. ■

ARCTIC SUBMARINE WARFARE

Why Arctic warfare must be conducted by nuclear submarines becomes evident as one examines the unique nature of the Arctic Ocean environment and the state of today's technology for operating in that Ocean area. Significantly, only submarines can control the Arctic Ocean and only submarines can contest this control. Moreover, the U.S. Navy has no other warfare area so distinctly different from all other sea areas of the world. In fact, jungle warfare comes the closest to being like Arctic warfare -- certainly much closer than Indian Ocean warfare or Mediterranean Sea warfare.

There are subtle similarities between the Arctic Ocean and the jungle. Both have markedly different characteristics which are little understood by the average military man. In fact, one has to have been in these environments to appreciate their uniqueness, and both contain many unknowns. They have a similar remoteness and are not fully explored, while providing harsh impacts on military forces operating within their environments.

So, with an image of the arctic as a jungle of the north, where cold water replaces the warmth and humidity of the jungle, where ice and snow replace the rocks, thickets and lush green trees, and where the unexpected is to be expected -- let's focus on why Arctic submarine warfare needs to be better understood.

The very things which make the Arctic Ocean different are the things which make it difficult to operate there. Specifically, they are the extreme cold, the ice cover and the remoteness. That the submarine navy has been in the Arctic for thirty years doesn't promise that much is known about operating there. The Arctic Ocean is still essentially an unknown area for there remain significant gaps in our knowledge and understanding with respect to ice thickness, ice distribution, sea water density, ocean currents, ocean eddies and fronts, Arctic weather, and most importantly acoustic propagation under sea ice. When these shortcomings are combined with the fact that up until recently the U.S. Navy's high latitude operations in the vicinity of sea ice were limited to an annual single-ship Arctic deployment -- usually by a submarine -- one can better recognize that our 30 year experience provides only a simple base with few refinements.

The Arctic Ocean is not the same as the open ocean. Because of its unique character, solutions to operational problems in the Arctic are different than for open ocean warfare. To operate effectively in the Arctic, whether it is a submarine or an ASW aircraft, the platform must have better all-around attributes than its counterpart designed for more temperate climates. For one, it must be more robust. And it must have undergone far more research and development to meet such standards. In today's warfare environments and with equipments designed for the open ocean, performing well in the Arctic -- on the ice, under the ice, or in the airspace overhead, is less efficient than in the open ocean.

To properly define warfare in the Arctic, there is a need to examine what the Arctic environment sets as limits on the various warfighting elements of the Navy.

First, is it possible to penetrate the Arctic surface ice-barrier, rapidly and repeatedly to allow use of operational systems? The actual answer to that question is "no." The only assured way of successfully delivering a sensor system or weapon from one side of the ice barrier to the other is through an opening in the ice cover -- such as an open lead or polynya. Actual penetration of the ice is a different matter -- it becomes a chance event or is impossible. There is an inability to measure the thickness of ice with sufficient accuracy, remotely and in real time, by any existing operational system. Current ice thickness measurement accuracies vary plus or minus 50%. Imagine ice estimated to be six feet thick -- the nominal maximum thickness of first year ice -- which might be as much as nine feet in thickness or only three feet thick. If the thickness is on the high side, a sensor which must get through the ice may not be usable. To counter the potential error in measurement, ice penetration devices are thus required in great numbers -- which do not exist. Thus, if Arctic ASW sensors must penetrate the ice to be effective with today's technology, there is a high probability of failure in such an ASW system when employing such sensors. A platform cannot properly execute a warfare task in the Arctic if it doesn't have an assured chance of breaching the ice barrier anytime it desires.

Why the nuclear submarine is, at present, the only effective means for controlling the underseas of the Arctic can be shown by examining surface and air ASW systems in the Arctic environment. Importantly, it must be recognized that the Arctic Ocean is and will be used by strategic submarines for their patrols, as well as for transfers of ships, including submarines, through and across this Ocean.

Surface Ships

Surface warships cannot operate in the near vicinity of the ice edge or in the Marginal Ice Zone because no U.S. Navy surface warships are ice hardened. In times of darkness or in daylight with a surface cover of fog, radar or visual detection of floating sea ice is not assured at safe ranges because of the low profile which such ice presents. Thus, the threat to the seaworthiness of surface ships in this ice zone is great. Consider further that the floating sea ice can move as rapidly as two knots when set in motion by both wind and current, and worse, that as little as four knots of wind is sufficient to put pack ice and free floating ice into motion. Thus, during a dark winter night -- or eighteen hours of poor visibility -- the ice edge with its threat to a surface ship, can move 36 nautical miles, the width of one convergence zone. Showing proper respect for this hazard reduces a surface ship's ASW effectiveness significantly as the vessel approaches the last reported position of the ice edge by closer than 50 miles. In fact, when one considers the lack of real time information about the ice edge, and the lack of knowledge of local winds and currents in the marginal ice zone, it is prudent for surface ships to stay at least 100 nm from the ice edge. Getting any closer merely courts disaster.

At the same time, because of the difficulty of distinguishing submarines from large ice rubble, surface warship capability is badly degraded.

Use of an air cushion vehicle (ACV) over the ice, is at first glance attractive. (With a V-22 Osprey tiltrotor aircraft aboard, the combined ASW system might seem even more attractive.) The use of ACVs alone seems to fit an ASW requirement for a medium-range, medium speed ASW platform and the ACV's previous performance over an ice covering would contribute to that optimism. However, one must realize that the platform has never operated over sea ice and over nothing more than benign shore-fast ice -- and that its maneuverability when on cushion is not readily compatible with abrupt surface irregularities; and that a long range high-resolution navigation radar with pinpoint accuracy is a necessary first step in this capability. But, one can recognize that the existence of such a system is not near at hand. Perhaps, if the performance of the ACV over sea ice can be improved, its best role would be as a platform to insert ocean surveillance systems or act as an Arctic SURTASS-like platform where the response time inherent to ASW weapons delivery would be less an issue. Additionally, the ASW system of an ACV carrying an Osprey would encounter the same limitations described below under "Aircraft."

Aircraft

What about aviation in the Arctic? As with surface ships, air ASW warfare is severely hampered by the environment. An ice-penetrating sonobuoy is still not operational. However, because 60% -- 3.3 million square miles -- of the Arctic is under permanent sea ice that is up to 20 feet thick, the effectiveness of sonobuoys which are ice-penetrating would still be low because of the time required to penetrate the ice cover.

It is recognized that within the areas of permanent sea ice there exist small open water areas or thin ice leads and polynyas -- even in mid winter. Deploying any sensor through thin ice or open water, however, requires an accuracy much akin to that achieved by a World War II bombardier. Otherwise, an ASW aircraft needs an accurate remote sensing system to measure and map ice thickness over large areas of permanent ice. Even then, the sensor mortality rate would be high -- producing a great reduction in ASW effectiveness. Also, with daylight being essential to use of this technique, there's so little daylight in the Arctic as to make this method undependable. Aircraft endurance also becomes a problem since there are few high latitude airfields from which ASW aircraft sorties can be conducted. If the aircraft must descend to a low altitude to deploy sensors with the accuracy needed, fuel consumption increases significantly and on-station time becomes critical. Conversely, if a sonobuoy barrier could actually be deployed at normal altitude, the loiter time on-station, waiting for ice-penetration of the sonobuoys, would further reduce profitable on-station time. Currently, thermal technology techniques provide ice penetration at a rate of one foot every five minutes. Thus, each sonobuoy would require upwards of 45 minutes to penetrate Arctic sea ice of nominal thickness -- of about 8 feet. Can an aircraft wait that long on station? Of even greater concern is how an ASW aircraft can determine where it should deploy a sonobuoy pattern. The traditional cueing methodology used in the open ocean is not usable in the Arctic. Two things degrade the speed of delivery of Arctic Ocean surveillance information which ASW forces might expect. First, there are fewer available detections because of the ice cover and second there must be a reliance on polar orbiting satellites. Time late over ASW contacts will thus be greater in the Arctic as will the ensuing radius of uncertainty of any contact. The problem is great.

Significantly, the foregoing ASW capability assumes that ASW aircraft can freely occupy the sky over the high Arctic regions without drawing a reaction from the enemy. But the Soviets, for example, would have as easy a job of interdicting ASW aircraft as the U.S. would have of protecting them. Thus, in the face of an air threat based on a land mass that circles over one-third of the periphery of the Arctic Ocean, air ASW becomes potentially too hazardous.

Arctic Capable Weapons

The foregoing discussion has stressed the challenges of sensors breaching the ice barrier in support of a warfare task. Proper rapid delivery and performance of weapons, particularly for ASW, is another matter. At present, the torpedo launched from a submarine is the only weapon that can be used under the ice satisfactorily. No ice penetrating weapons exist today.

The effectiveness of air-to-underwater and surface-to-underwater weapons is generally untested. Extensive R&D is needed to achieve: (1) target discrimination by the weapon; (2) sufficient accuracy of platform sensors for localization for weapon use; (3) timeliness of offboard information; and (4) effective high latitude delivery tactics.

An additional challenge for ASW warfare is the adapting of deep ocean surveillance systems to the Arctic Ocean environment, recognizing that the accepted techniques of ocean surveillance using the deep sound channel are not going to be as effective under the ice as in the open oceans -- even if it were economically and operationally feasible to install such systems today.

Other Sensors

Unfortunately, geosynchronous satellites have a coverage that only extends north to approximately 75° north latitude -- less than 600 miles above the Arctic circle, and are not usable over any area within 900 nautical miles of the North Pole. Truly effective high latitude satellites must be in polar orbit. In a polar orbit, a satellite would have to be dedicated to Arctic military use. However, most satellites in a polar orbit are for environmental purposes such as ice distribution. Further, their capability lies in being able to map ice anomalies, but without sufficient resolution and timeliness for warfare purposes.

The Nuclear Submarine

Only nuclear submarines can operate effectively in the Arctic Ocean -- and only nuclear submarines configured for the under-ice environment can operate safely there. The Arctic Ocean submarine must have ice-hardened sails, strengthened control surfaces and sonars which can: upward scan to recognize the irregularities of the under-surface of the ice cap; forward-look to spot deep ice keels (some of which project downward in excess of 50 feet); permit transit through narrow passages, (only Fram Strait to the east of Greenland provides a deep entrance to the Arctic Ocean). Additionally, nuclear submarines should have mine-locating devices because of the high probability of encountering submarine-laid mines in restricted and shallow waters of the Arctic Ocean.

Because of transit difficulties in moving to station in the Arctic Ocean, submarines operating there should necessarily be forward based to increase on-station time.

Significantly, submarine operations are not affected by the light of daylight or the darkness of night. Moreover, the underseas of the mid-Arctic Ocean is basically benign with low ambient noise except at the ice-cap edges. But it is afflicted with unpredictable densities due to variations in salinity, and currents which make vertical-surfacing through open leads or polynyas like trying to land against a moving pier.

With the very cold ice-cap making the temperature of the upper stratum of the ocean colder than the lower stratum, a positive sound velocity profile bends sound rays towards the surface, creating a near-surface sound duct which promises long sound-propagation ranges. But sound transmissions from submarines at the same time are scattered by the rough underside of the ice, reducing detection ranges, and may not provide the correct bearing of return echoes from an enemy submarine.

Within this environment, strategic submarines can use the undersurface of the ice cap to remain hidden from prowling enemy SSNs and can use open areas of the Arctic seas, or areas covered by thin ice, for discharge of their weapons. Also, submarines and surface ships in transit across the Arctic Ocean, while avoiding submarine-laid minefields, can, for much of their passage, defensively use the shallow waters of the Arctic Ocean.

Thus, it is only attack submarines -- SSNs -- which can control areas of the Arctic Ocean and only enemy SSNs which can contest that control.

<u>Summary</u>

Because of all the impediments to Arctic ASW execution, and because of system performance anomalies which must be overcome in the Arctic, only the submarine at the present time can successfully perform in the Arctic warfare role. Furthermore, the majority of near-term warfare improvements currently in development will support a better performance by the submarine in Arctic ASW.

In short, the submarine is the only platform capable of conducting warfare in the Arctic with any reliability. It is the only platform that can get there, stay there, respond to any kind of cueing, and deliver a weapon to kill.

George F. Newton

TRIDENTS

The increasingly larger force of operational TRIDENT submarines provide the primary base for U.S. deterrence of a massive Soviet nuclear strike against the United States. The inability of the Soviets to target and destroy this strategic nuclear weapon system with any degree of certainly, and the assured capability of TRIDENTs to retaliate massively after a Soviet strategic nuclear strike makes them unquestionably the most essential part of the U.S. Triad of strategic weapon systems.

Land based ICBMs and "stealth" bombers remain so susceptible to destruction in a surprise enemy strategic nuclear strike as to make these other two legs of the Triad only hedges against the possibility of an anti-submarine breakthrough by the Soviets. But at this time this is a highly improbable happening, as can be shown.

This present situation is clearly recognized and is evidenced by President Bush's acceptance that the TRIDENT's mutual assured destruction capability continues to be the base for the U.S. strategic deterrence strategy. The TRIDENT's assured destruction of enemy counter-value targets rather than counterforce targets is evidently considered sufficient to deter Soviet strategic aggression.

What is happening in today's climate of reduced budgets for U.S. strategic systems along with a serious attempt to reduce nuclear warheads through the START process, is a balancing of the great need for force modernization in all three parts of the Triad. The Midgetman and rail mobile Mx, the Stealth B2 bomber, and the TRIDENT's D-5 missile are seemingly essential to the force modernization programs. What these modernizations represent are: a relatively low cost (about $30 million per copy) single big warhead ICBM with a hard target kill capability; a rail mobile ICBM with at least 10 counterforce MIRVs per missile; a low radar-profile, long range (at least $600 m. per) nuclear bomber; and a submarine launched 8 MIRV missile with high accuracy giving it a counter-force kill capability. Importantly, the submarine launched D-5 missile with its hard target kill capability should be operational in late 1989, the Midgetman is expected to be placed in silos in the mid to late '90s, the rail mobile Mx should be ready for use in the mid '90s and the Stealth bomber might be expected in approximately the same time frame.

But before proceeding further, it should be recognized that the word TRIDENT has caused semantic confusion by being used indiscriminately to mean the submarine, its weapon, and even the total weapon system involved. Correctly, the term TRIDENT, as used herein, applies to those U.S. strategic nuclear submarines which are supplanting the POSEIDON submarines in the U.S. Triad. There are presently ten of these submarines operational with five more abuilding, plus one more funded. Importantly, TRIDENTs are replacing overage POSEIDON boats. And the term TRIDENT does not apply to the ballistic missile it carries nor does it imply the total weapon system unless so qualified.

There are two major concerns relative to the TRIDENT weapon system which are held by the planners for strategic nuclear war. They are an ASW breakthrough which would compromise the TRIDENT submarine's survivability; and the assured communications between the National Command Authority and TRIDENTs at sea on patrol.

As to the first concern, what is feared most is that there would be a breakthrough in non-acoustic detection of submarines. The U.S. submarine community has repeatedly stated that there is now no imminent breakthrough in the technology involved with non-acoustic detections -- nor is there any for the foreseeable future. Yet, as detailed by Tom Stefanick in his article Non-Acoustic Detection of Submarines in the March 1988 Scientific American, at least seven non-acoustic submarine signatures apparently exist most of the time and might be exploited by both the Soviets and the U.S., as a means to detect totally submerged submarines. They comprise the magnetic anomaly effect, the infra red scar, the Bernoulli dynamic hump on the surface of the ocean, the radioactive particle trail, the bioluminescence created by small sea life, the inner waves created in thermal layers, and the trail of tiny bits of peeled off submarine debris. Stefanick's detailing of the phenomena concerned along with the technology, as known today, to usefully record these signatures, shows that although all seven signatures are possibly detectable and distinguishable from similar ocean anomalies, when the TRIDENT was operating at shallow depths, they are not detectable in a practical sense if the TRIDENT operates well below the surface. Nor will further development of known technologies produce any more than very small increments of improved detection capability. Hence the non-acoustic phenomena exist but normal TRIDENT patrol operations so dilute their effects as to make TRIDENTS non-acoustically non-detectable -- with a continued assured survivability in the ASW environment at least through the end of this century. With 70% of the TRIDENTs continuously at sea, few can be destroyed by a surprise attack.

The assured communications from the National Command Authority to TRIDENTs on patrol has been equally suspect as a form of degradation of the seabased leg of the Triad. Little recognized is that the ELF (extremely low frequency) system in use provides one-way information to deeply submerged TRIDENTs -- even under conditions of nuclear war's EMP (electro magnetic pulse) effects. One is led to believe, however, that the slow data rate -- enough to spell out three letters of the alphabet in about 20 minutes -- makes this system no more than a "bell ringer" to alert a TRIDENT submarine to rise to a shallower depth in order to receive communications from VLF transmitters, or UHF transmissions via satellite. Significantly, ELF communications of merely two letters can provide over 600 variant instructions compiled in a code book. About all that cannot be readily detailed to a submarine in two-letter codes are changed coordinates for missile targets. Importantly, only in a massive nuclear strike is the ELF transmitting system likely to be targeted and put out of commission. But then a TRIDENT's massive retaliation becomes virtually automatic with weapon release activated by any one of a large number of alerting systems -- broadcasting a firing order. The robustness and multi-frequency means for communicating to TRIDENTs from U.S. shore installations is convincingly detailed by John Weinstein, the chief, Policy and Programs at the U.S. Nuclear Command and Control System Support Staff, in his article Command and Control of Strategic Submarines in NATIONAL DEFENSE, March 1989. He emphasized that: "Electro Magnetic Propagation (from nuclear bursts) does not disrupt communications across the entire radio spectrum, and that numerous Emergency Action Message dissemination modes are EMP hardened." He concludes, "The connectivity of SSBNs and the reliability of their weapons assure the National Command Authority that the sea-based Triad leg can and should be relied on to maintain the deterrent balance in any arms control regime."

TRIDENT's Warheads

If START achieves a 6,000 nuclear warhead limit for strategic weapon systems -- and it seems likely to do so in light of the present attitudes of the superpowers relative to cutting the total number of warheads at least in half -- then the split of warheads between the three parts of the Triad becomes a critical issue.

Since Midgetman involves only a single warhead per ICBM and only a relatively small number of Midgetman missiles (300-500 in most analyses) are programmed, there are not many warheads involved in this force modernization. The small numbers of rail mobile Mx's would also require only a small fraction (500 at present) of the 6,000 warheads, while Stealth bombers, which are counted as "a single warhead" per plane, would use up an even smaller fraction. Thus, the number of warheads allotted to the TRIDENT system can be far larger than a one-third share of the pool of nuclear weapons used by the Triad. This is also practical in a period of declining budgets because an 8-warhead missile provides a far less costly way of getting warheads on target than a single-warhead missile.

A program of 18 TRIDENTs using 3456 warheads (at 8 MIRVed warheads per ballistic missile) has seemingly been the lowest conceivable rational number of TRIDENTs for a U.S. strategic deterrence posture in the '90s. Then, no other types of SSBNs, i.e. POLARIS or POSEIDON, would remain in commission.

But only 18 strategic submarines in the U.S. inventory is also considered to be a dangerously low number -- because the fewer strategic submarines in operation, the greater is the Soviet ASW effort which can be focussed against each submarine at sea. Using active sonar as well as passive detection systems, considerable numbers of Soviet ASW units including satellites, diesel submarines, SURTASS-type ships, etc. can be mustered to hound down small numbers of TRIDENTs at sea -- at any one time.

Eighteen TRIDENTs are seemingly a minimum and involve, with their 8 warheads per launch tube, over 3400 of START's probable 6,000 warhead figure. But this allocation should not be unreasonable to the U.S. START negotiators. Their worry, since they recognize TRIDENTs using C-4s or D-5s as the basic U.S. deterrence system, is that Soviet ASW forces might reasonably overwhelm a small number of TRIDENTs or that an ASW technological breakthrough might seriously degrade the survivability of the TRIDENT system -- which is depended upon so heavily by the U.S. for national security.

TRIDENT Numbers

Eighteen TRIDENTs seem -- if Soviet ASW efforts were concentrated against them -- a marginally low number for the seaborne leg of the Triad. Hence, how to increase this number by a few submarines should be under consideration. A war between the superpowers with a massive strategic nuclear exchange and catastrophic devastation of the U.S. and Soviet homelands, appears to be highly unlikely. Hence, a war with more discreet use of strategic nuclear weapons must be considered.

In a war without massive nuclear exchange, the use of strategic nuclear weapons is likely to involve only enough warheads on critical targets to politically influence the outcome of a phase of a war or cause its settlement on favorable terms. Ending a war by devastation of the superpowers' countries seems no longer at issue. To launch a single C-4 with its eight warheads as a response to a Soviet use of only a few strategic missiles -- or in reply to an accidental firing of a nuclear weapon -- is likely to cause a good deal of overkill which would only induce further use of strategic weapons by the Soviets.

Having single-warhead strategic missiles is thus a desirable capability for political management of a limited war. But such a single warhead missile must have a high degree of survivability, both before launch and in its trajectory, and it should be usable after careful deliberation -- to optimize the discreetness of its use while maximizing the political impact from the target it destroys.

Again it would be the TRIDENT at sea that could best provide an assured readiness for limited response and offer the luxury in timing to permit carefully thought out political implications for a missile's use, while the TRIDENT's missile would be more difficult to intercept because of its shorter range to its target and its possible 360° attack direction due to any TRIDENT on patrol being available for selection as the firing platform. Midgetman missiles being used for the same sort of selective response would be far more susceptible to interception by a nuclear weapon because of the limited corridor through which the land-based Midgetman would be fired. Thus, a few single-warhead C-4s or D-5s seem to be indicated for loadout per TRIDENT submarine. This would maximize the concept of a fleet-in-being in time of war which could best control the war's progress and conclusion. But with the firing of a single missile from a TRIDENT the risk then of losing the rest of the TRIDENT's load of weapons seems great, due to the disclosure of the TRIDENT's firing position to enemy forces -- satellites, radars, infra-red detectors, etc. 160 nuclear warheads lost for a few warheads used? But it should be recognized that a single missile can be fired from any one of many TRIDENTS which would be deployed around the perimeter of the Soviet Union. Thus, firing of a missile could be planned from a sector which was not under observation, with a discreet timing to prevent detection by satellites in their known trajectories. Firing a single warhead missile from parts of the Indian Ocean, for example, would not be likely to disclose the TRIDENT's position until the TRIDENT had moved well clear of its firing position.

All that needs doing, to make the TRIDENT system compatible with START objectives, is to remove the assumption that every missile carried by a TRIDENT will have eight warheads and substitute a technique for counting the number of warheads on each missile. This would eliminate the possibility of having to cut the TRIDENT force by one submarine in order to stay within an arbitrary limit like, for example, the 3400 weapon limit. This would also allow each submarine to carry a few single warhead missiles giving them more political clout in protracted wars and at the same time make possible a force goal of about 20 TRIDENTs -- a safer, more survivable number in light of Soviet ASW strength today.

The total program for TRIDENTs -- while conforming to the constraints of budgets and allotted U.S. nuclear warheads -- has been designed to respond to a necessary level of national security, through the '90s and beyond the year 2000. However, by the mid '90s, at least three TRIDENT submarines would be undergoing overhauls, at any point in time. Such TRIDENTs would be of no use to the underseas strategic leg of the Triad -- since at the outset of a national emergency, they could not be made operational for many months. TRIDENTs in overhaul would thus be incorrectly counted as having 576 available warheads, making the total force of TRIDENTs almost 17% deficient in expected wartime potential.

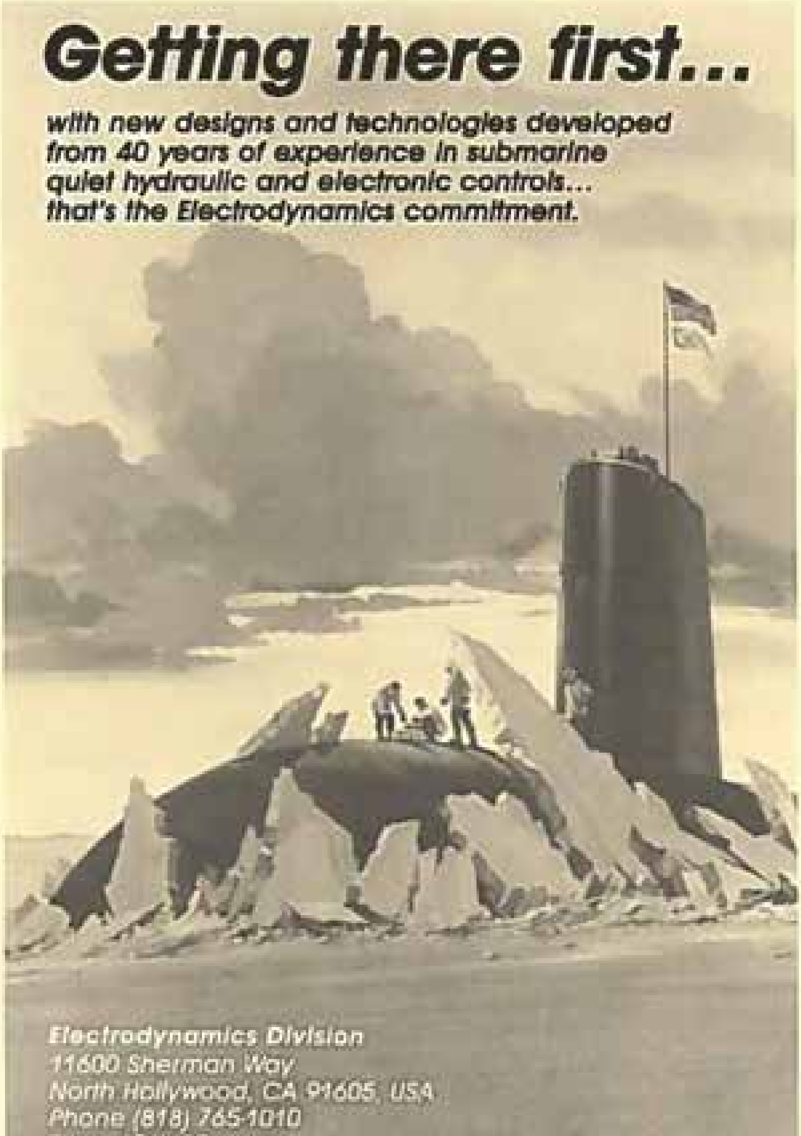
It should then be reasonable to have a TRIDENT program of three more TRIDENTs than that needed to utilize the some 3400 nuclear warheads which appear to be a logical distribution of START's proposed level of 6000 nuclear warheads for the sea-leg of the Triad.

Big Pluses for TRIDENTs

- They are manned by a higher grade of personnel than any other comparable strategic weapon system.
- There is no public resistance to the basing of nuclear warheads at sea on TRIDENTs.
- TRIDENTs do not encroach on precious land assets of the U.S. nor do they effect the environment or ecology of the United States.
- TRIDENT's missiles tend to have shorter flight times and lesser ranges to their targets.
- And conversely, can strike targets further inland.
- The TRIDENT's command and control is far more difficult for the enemy to focus his electronic warfare efforts against -- because of the TRIDENT's unknown location.
- An increasing knowledge of how to use the anomalies of the oceans to remain covert is increasing their survivability on patrol.
- TRIDENTs are the quietest of nuclear submarines in the world today.

- TRIDENTs are rarely forced to operate in any mode except a totally covert one.
- A significant quieting of enemy attack submarines does little to increase their threat against TRIDENTs -- it's a matter of a needle trying to find another needle in a haystack.
- TRIDENTs should be considerably less susceptible to sabotage than land based systems.
- The great areas of the oceans in which TRIDENTs patrol spreads out enemy ASW effort excessively.
- Electronic warfare has little effectiveness against underseas systems.
- Similarly, nuclear warfare should have little effect on the TRIDENTs at sea.
- TRIDENTs provide a fine and flexible control of the tempo of strategic war.
- In summary, the reliance on the sea based leg of the Triad must be maintained and the modernization of this leg by means of the TRIDENT program and its most modern weapon, the D-5, should have a high priority, particularly in this time of limited budgets for strategic weapon systems, and arms control efforts. A single-warhead SLBM option could increase TRIDENT's useful flexibility and, within START constraints, make possible deployment of some additional TRIDENT platforms. A 20-TRIDENT force would both enhance U.S. capability against Soviet ASW systems and provide valuable growth potential in the event START were to collapse.

Dr. Jon L. Boyes and W. J. Ruhe



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Allied Signal


In the defense
of our nation, there can be
no second best.
Newport News
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EMERGING TECHNOLOGIES FOR SUBMARINES

The implementation of advanced technology into submarine systems is making the submarines of many nations more effective in fulfilling national objectives. Conversely, the emergence of technologies not initially directed toward submarine applications is dramatically increasing the range of objectives which may be assigned to submarines. It is now being recognized, even in the less developed nations, that the characteristics of modern submarines and their ability to exploit emerging technologies allow them to contribute to many aspects of a nation's defense, including those not traditionally considered within the purview of navies.

Technology has removed the earlier constraints of speed and submerged endurance. Thus, the submarine, today, can outperform virtually all surface warships. In the Falkland Islands conflict, the speed and endurance of the nuclear attack submarine allowed the United Kingdom to achieve an initial presence in the adjacent ocean areas more than a week before the first surface detachment of the British Expeditionary Forces arrived.

The development of ballistic missiles and their incorporation into the nuclear submarine changed the contribution of the submarine to national policy during peacetime. There are other technologies now available that will similarly improve military capabilities when incorporated into the submarine. These technologies can further enhance the peacetime role of the submarine as well as its contribution to limited and large scale conflicts, to strategic defense and even to responses to terrorism. The emergence of low probability of intercept data exchange links, remote sensors, miniaturized electronics, improved missile fuels, and dramatic improvements in munitions offer a new level of mission opportunities for the submarine. Further, the development of several closed-cycle power options has put many new submarine capabilities within the grasp of nations which do not have the resources or infrastructure necessary to support nuclear powered submarines.

Technology Generated Threats

As in all aspects of warfare, technology can represent the double-edged sword of measure and countermeasure. Just as new technology has improved the submarine's capability, there are technologies which have improved the capability of ASW forces. The level of stealth achieved by post World War II submarines is becoming inadequate today. While steady improvements have made the submarine more capable, it is important to recognize that with little further improvements these submarines will become extremely vulnerable. The challenge is to ensure that we and our allies avoid the danger of believing a submarine's detection is virtually impossible and that we can stay ahead of countermeasures by continuing to "quiet" submarines.

Since technology is dynamic, it would be wrong to allow oneself to think only in terms of an acoustic advantage. What, for example, is the implication of a magnetic advantage? Why, in fact, reduce the magnetic signature of a submarine? Also, why do Soviet submarines have vortex annihilators on their after decks and around their appendages? Are the dispersal of vortices and the reduction of wake intensity and other hydrodynamic signatures becoming as important as sound quieting? If so, then who has the hydrodynamic advantage? These questions must be asked frequently and answered objectively.

Technology Sources

Recent research efforts in the United States have been described as being directed more toward reducing technical risk than toward the dramatic innovation displayed in the two decades following World War II. Nuclear power, the ALBACORE shark-shape hull form, high-yield strength hull materials, cruise missiles, ballistic missiles, inertial navigation, and revolutionary improvements in sonar were among the innovations in submarine systems during that period. New technologies, such as advanced hull materials, drag reduction techniques, coating systems, and new propulsors were examined, but in a desultory fashion. This has not been the case in other countries such as the Soviet Union, the United Kingdom, and France. Thus, to benefit from the latest technologies we must look at the capabilities developed by other nations.

Inherent and Technological Limitations

Selecting performance parameters for a new submarine class creates a series of dilemmas. For a given displacement, parameters such as speed, sound quieting, and diving depth each compete for weight allocation. Thus, an increase in speed may be achieved at the cost of diving depth; or sound quieting may be achieved only by increasing displacement.

Those constraints or limitations, which applied to older non-nuclear submarines, are often perceived as manifestations of the laws of physics and therefore as inviolate. But this is not the case. These constraints merely are reflective of the limitations of the technology being employed. There are technologies which can increase speed without demands on volume or without increasing noise. Similarly, there are sound quieting techniques that do not require the mass and volume associated with more traditional methods.

To suggest that a submarine "is inherently noisy and blind when using speed" is to suggest that increased speed is necessarily related to increased self-generated noise. In the past, the underwater speed of fleet submarines was increased by improving propeller design and reducing drag. Such increases in efficiency not only increased speed, but decreased noise. Certainly, today's submarines are not "blind" when they cruise at speeds more than double that of World War II submarines.

The challenge is to identify technologies which can simultaneously enhance the performance parameters. For example: there are technologies that can simultaneously suppress radiated noise, reduce drag, and enhance explosive resistance. It is stated in foreign literature that a submarine which employs polyfunctional technologies can achieve greater levels of performance for a given displacement -- and it may be less costly. Such sets of technologies that can satisfy the established performance goals simultaneously are those which are most worthy of pursuit. The challenge to the submarine R&D community is to identify and develop those technologies that can eliminate some of the performance and cost tradeoffs which now constrain the design of submarines.

The Technical Challenges of Stealth, Toughness and Flexibility.

Stealth must not be taken for granted. It is achieved only through careful operation and constant incorporation of emerging technologies. Submarine signatures not even recognized in the 1940s have been subsequently widely exploited. The submarines of nations which did not incorporate emerging quieting technologies have proved highly vulnerable. Moreover, new vulnerabilities can be avoided by maintaining a constant awareness of new developments in sensors and signal processing.

Relative to aircraft and high performance surface ships, a submarine is basically a tough structure. Its pressure hull and buoyancy tanks provide a stalwart structure which, when coupled with new blast-defense technologies, provide it with protection not available to other, similar-sized naval platforms.

Cumbersome is not an appropriate descriptor for a vessel that can maneuver in three dimensions in an environment that traditionally has been limited to two-dimensional movement. Submarines with multiple propulsors have been as agile as any surface vessel, and now boundary layer control technologies can increase that agility. The speed and ability to bring heavy firepower to bear on a wide array of targets contributes to the "flexibility" of submarines. Thus, new technologies must be developed and incorporated into future designs to ensure the continued stealth, toughness, and flexibility of the submarine.

Area Coverage

Being aware of what is going on, below and above the surface, offers similar challenges. In World War II that requirement could be described in terms of kilometers. Broader area coverage was provided by intelligence or other sources and relayed by HF radio broadcast to the submarine. Today, because of the submarine's speed and extended sensor and weapon ranges, the radius of coverage has been greatly increased. In World War II, collecting data on the enemy required extended periods near the surface. That is no longer the case. Still, the requirements will become more demanding as the area the submarine can affect and the number and type of potential targets continue to increase.

Quiet Speed

While today's submarines cruise at speeds never achieved by World War II submarines, they "see" at ranges far beyond those conceived as possible during that period. Increasing "tactical" or maximum "quiet speed" has been a continuous objective of submarine designers over the last several decades. Maximum speed and submerged endurance will continue to increase. This increase will be available even to those nations which cannot invest in emerging nuclear power technologies. The introduction of diesel-hybrid (battery/nuclear) power sources, fuel-cells and closed-cycle engines while still much less capable than contemporary nuclear power plants, opens up a new regime of submerged endurance for non-nuclear submarines. With that increase, ancillary technologies which suppress power generation, propulsor, and flow noises, will have to be developed. Without long term and continuous attention to this performance parameter, the potential of high underwater speeds cannot be realized without compromising "stealth."

Weapons

The remaining performance parameter relates to "combat means." The ability of submarines to participate in extended melees and to reengage escaping targets has improved significantly over the last decade and will see even more dramatic improvements over the coming decade. More and diverse types of weapons in their launchers ready for firing allow a submarine to simultaneously engage a variety of targets. It is the submarine, now equipped with an array of missiles and torpedoes, that can press a determined attack. Attack is always accompanied by risk, but today's submarines and those in the near future can be equipped with the means to reduce that risk. The maximizing of the covert qualities of weapons is equally as important as the stealth built into the submarine itself. Quiet, electric or closed cycle driven torpedoes, without wakes, with low self-noise from reduction of skin cavitation, with covert homing systems (the Soviets have indicated an interest in laser and IR homing systems) in addition to passive acoustic, wake-homing etc. are being developed in a number of countries.

Making Submarines Affordable

As with all the previous issues raised, affordability deserves constant attention. Evolutionary improvements tend to increase costs. Revolutions in technology however can reduce costs. The potential to reduce production and materials costs must be given high value in selecting technology priorities. Cost affects force levels; if not of the submarines themselves, then of the support systems and expendables they require to be effective. Promising advances in new materials and low cost, highly reliable production techniques need to be pursued to ensure the submarine force has the number of submarines and weapons necessary to assist in carrying out national policy.

Technological Surprise

Submarine leaders are looking for an "edge" to give their fighting men an advantage through technical developments. A technical advantage can be enhanced if new capabilities are unrecognized by an enemy until they are put into use. In fact, "technological surprise" can be as important as operational-tactical surprise. The achievement of technological surprise moreover requires both an awareness of a potential enemy's technology and the secret development of one's own technologies. From the literature, we know that "surprise" is an integral part of Soviet naval art. It has been recognized that the ALFA's speed is 50% greater than initially estimated, and it was initially credited with a titanium hull. And, the noise level of the AKULA was observed to have achieved a quieting level not expected until near the turn of the century while the "abandoned" Soviet SS-NX-13 , a homing ballistic missile for use against carriers, might have proved an unexpected weapon.

The Soviet Union has been successful in developing Western basic research. U.S. Navy laboratories produced: the first work on gasification for drag reduction; the first work in bionics as a tool to gain insight into improving underwater performance; the first work in coatings to reduce drag on underwater vehicles; and the first proposition for magnetohydrodynamics for submarine propulsion. While these programs have received only desultory interest in the United States, they spawned major research efforts in the Soviet Union. It is apparent that technologies considered unfit for U.S. needs and those of her allies may be responsive to the needs of navies with different strategies/objectives.

Summary

Emerging technologies are increasing the potential for submarines to contribute to more aspects of national policy of many countries than was possible in the recent past. Similarly, a dynamic national policy can be a stimulant for advances in submarine technology regardless of the size of the host country. Counter-terrorism, low intensity conflicts, and local wars, as well as global conflict situations demand more advanced submarine technical capabilities. While the demands of policy foster new submarine technology, emerging technologies also can increase the breadth of policy options. Innovation and imagination are necessary to continue this process and to ensure that the full potential of the submarine is realized. The dynamics of technology demand that warfare systems continue to improve if they are to remain viable. Long term basic research programs are the "seed corn" of future warfare systems and hence must be aggressively supported at national levels. The improvements in submarine speed, depth, and stealth, which are discussed in foreign literature as being currently attainable, are the result of many years of intense and continued efforts. Since countries can have unique requirements, it is apparent that all must be involved to some degree in research to ensure that specific needs are satisfied. At the very least, the submarine consumer must investigate the offerings of multiple suppliers since no one country has the edge in every aspect of emerging submarine technology.

K. J. Moore

THE SUBMARINES OF HAWAII THROUGH WW II

Hawaii and particularly Pearl Harbor have played a key role in the 20th Century by providing a home and base for U.S. submarines which continues to this day.

Earlier, in 1874, King Kalakaua had given the United States exclusive rights for a coaling station at Pearl Harbor and on November 9, 1887, Pearl Harbor was formally ceded to the

United States. Queen Liliuokalani is alleged to have said, "This is a mistake."

The first Navy ships of any kind to be assigned to Hawaii were four submarines, the F-1, F-2, F-3 and F-4. They arrived in 1914 with the mission of coastal defense. They were based at the foot of Richards Street at what was known as Flat Iron Pier. As a Class of submarines, they had an unfortunate history. On march 25, 1915, the F-4 foundered off Honolulu in 305 feet of water and all hands, 21 men, were lost -- the greatest U.S. Navy disaster since the sinking of the MAINE in 1899.

The Navy was determined to bring F-4 to the surface and establish the cause of her loss. She was finally surfaced on August 29, 1915, five months after sinking, and was docked in Honolulu. Investigators found that battery acid from leaky cells had worked its way into the lead lined covering of the hull in the battery compartment and eaten away the hull, which collapsed when she dove. There was no opportunity to save the boat or any of her crew.

The three remaining F-Class boats were relieved in November, 1915, by four K-Class submarines and a tender, the ALERT. (Two years later the F-1 collided with the F-3 and sank off the California Coast.) These K-Class boats were the first naval vessels expected to be permanently assigned to Pearl Harbor as their home base. Their temporary base was established at Kuahua Island in Pearl Harbor -- no longer an island. (From dredging and land fill, the island was connected to the shoreline early in 1942 and became an integral part of the land on which the Naval Supply Center was built.)

When the U.S. entered World War I, the decision was made to reassign the K-Class boats to the Atlantic. On October 31, 1917, they departed Pearl Harbor for their new home at Key West, Florida.

As we know, Germany had imposed no limitations on employment of her submarines in World War I, (or in World War II). Submarines to them were far from the pure coastal defense vehicles we originally planned them to be. The German U-Boats cut the life line to Great Britain and her allies by sinking merchant ships without warning, to prevent supplies of all kinds getting to, particularly the British Isles.

The submarine had profoundly altered the conduct of war at sea.

Our national morality at the time of Germany's unrestricted submarine warfare campaign was such that we deplored this indiscriminate sinking of merchant ships without warning and without providing safety for the crews. President Wilson made our position known to the Kaiser on several occasions without success.

Finally, on February 4, 1917, Germany ordered and announced all-out attacks by U-Boats on merchant ships, i.e. unrestricted submarine warfare. As a result of this action, President Wilson broke diplomatic relations with Germany and three weeks later ordered the arming of our merchant ships. On February 26, 1917, at the peak of the U-Boat campaign, the President asked Congress to declare war on Germany.

In preparation for the Paris Peace Conference of 1919 following World War I, the Navy had circulated a position paper for President Wilson which proposed that "all submarines in the world should be destroyed and their possession by any power forbidden. They serve no useful purpose in peacetime. They are inferior to surface craft in time of war, except in their ability to treacherously attack merchant ships. Civilization demands that war be placed on a higher plain and confined to combatant ships. So long as the submarine exists it will be used in the stress of war to attack neutral trade."

Great Britain came to Paris with a similar proposal. Neither the position of the United States nor that of the British was seriously considered by the other allies. Their proposals were actually lost in the prolonged hassle over what to do with captured German ships -- destroy them or distribute them among the allies.

Hawaii moreover was without submarines until June 25, 1919, when, to quote the Honolulu Star Bulletin, "The first unit of the new naval defense of these islands, consisting of the mother ship, BEAVER, and six submarines of R-Type, will make Hawaii this afternoon and will be berthed near the drydock at Pearl Harbor. The six boats form the advance guard of boats of the type to come here for permanent duty."

When the crew went ashore all they found were two finger piers that had been constructed at Quarry Point, the site of what was to become the permanent SubBase. Shortly after bedding down in tents, the enlisted forces of the boats began clearing away cactus, rocks and kiawi for temporary buildings. Living conditions were sparse to say the least. In August, 1919, a building constructed from World War I wooden huts removed from a U.S. base in Queenstown, Ireland, was reassembled as the first structure at the base.

On October 20, 1919, Navy Secretary Daniels, after a visit to Pearl Harbor in the battleship NEW YORK, recommended to the President and Congress that a first class naval base capable of taking care of the entire U.S. Fleet in time of war be developed immediately at Pearl Harbor. Among his recommendations was included an appropriation of over one million dollars for a complete submarine base.

From that time until the present, the Submarine Base has continued to expand and modernize to meet the demands of more new, more sophisticated and capable submarines. The Base was a vital element in support of the many boats which came to Pearl Harbor for support during World War II. How thankful we should be that in the 1920's and particularly the depression years of the 1930's responsible officials in Washington, including the Congress, had the foresight to build such a base. In the intervening years since World War II, this facility has kept pace with the advanced technology introduced into our modern submarine forces. I have in mind such items as nuclear power, the multitude of electronics and computer equipment, satellite communications transmitting and receiving equipment, stronger, heavier and more high-yield metals for hull construction which permit greater operating depths, quieter operations, special "smart" weapons like the Mark 48 wire-guided and target-seeking torpedoes, Harpoon and Tomahawk missiles configured for anti-ship or shore bombardment -- just to name a few.

When President Harding came into office in 1921, he was determined to achieve a limitation in armaments. He called for an international conference, known as the Washington Conference on Limitation of Armaments, to be held in Washington, D.C., in 1921-1922. During this conference, abolishing the submarine was again one of the major problems.

Great Britain once more proposed submarines be abolished. This time she was all alone. The French saw these crafts as a possible solution to their nation's continuing quest for an inexpensive counter to Britain's overwhelming power at sea. The Japanese and the Italians saw a strategic need for the submarine. Naval opinion in the United States had changed -- we had no intention of giving up our submarines.

At the convening time of the conference, all participants, except Great Britain, had plans to strengthen their submarine forces. The conference agreements were thus limited to halting the armaments race in capital ships. Some restrictions, however, on submarine attacks on merchant ships were agreed to.

There is one more pertinent observation concerning the Washington Conference. Japan, who had seized the Micronesian Islands as part of her bounty for joining the allies in the war, proposed that the United States "agree not to increase the fortification of naval bases at Guam, the Philippines and Hawaii." I wonder what she had in mind as early as 1922. This was the first of at least three exact proposals made by the Japanese at Washington in 1922, at London again in 1930 and on December 7, 1941. Admiral Nomura made the same proposal to Secretary of State Hull about 1300 hours, Washington time, when attacks on all three places had already commenced or were about to.

It is interesting to recall a related protest to the United States when the Hawaiian Detachment of the U.S. Fleet was formed in early 1940. Several cruisers, destroyers and support ships were permanently assigned to Hawaii. On May 27, 1940, the Japanese Consul General in Hawaii had the gall to object to the formation of this Detachment and to homeporting those ships in Hawaii.

From the end of World War I to the attack on Pearl Harbor, there was a period of changing philosophy and further development of our undersea craft. The coastal defense mission was abandoned because of the number of boats required to defend our long mainland coastlines and those of our possessions in the Caribbean and the Pacific.

Still thinking of our national morality concerning the sinking of merchant ships, the U.S. built in the ten-year period, 1920-

30, big long range submarines which mounted fairly large caliber guns, 4, 5 and 6-inchers, for commerce raiding -- having always in mind our obligation from the Washington Conference to provide safety for crews of merchant ships. In addition, these boats carried a large number of torpedoes (36) to attack enemy battleships, cruisers and aircraft carriers. We built five of these big boats, up to 4,000 tons. I served my first four years of submarine duty in the NAUTILUS based at Pearl Harbor -- the last of these large craft. In July, 1941, I was transferred to the DOPLHIN, also based at Pearl Harbor, as Executive Officer. The DOLPHIN was much smaller, about half the size of the NAUTILUS. It had been built in the 1932 era and was designed as the first stage in building smaller but more capable boats. From 1930 to 1935, new construction submarines were completed at a slightly increased rate of five per year following carefully calculated improvements.

Although the Navy is criticized in history for being caught unaware on that infamous Sunday morning of December 7, 1941, I can only tell you that in submarines we were already making defensive war patrols.

For example, DOLPHIN departed Pearl Harbor in early July, 1941, under secret orders, not to be opened until we were out of sight of land. The orders directed us to go to Midway Island and conduct a submerged patrol to the south but in close proximity to the island and remain absolutely undetected. Another submarine, the NARWHAL, would be patrolling to the north. Neither boat was to have any contact with Midway. We got our first taste of being submerged all day every day for 30 days in a row as was so common after World War II began.

We returned to Pearl Harbor in early September for rest, recreation and replenishment. On the patrol we neither saw nor heard -- I'm speaking of sonar -- anything of a suspicious nature, having in mind all of the time the proximity of the Micronesian atolls.

In early October, we sailed again on a similar mission to Wake Island -- DOLPHIN to the south, NARWHAL to the north. On one particular day during the patrol, we were alerted to be especially careful not to be sighted. It seems that Admiral Nomura, a Japanese emissary, was enroute to

Washington via PANAM to deliver the Japanese final response to negotiations which had been going on for some time between our two countries. We were close enough as his plane landed for refueling to see it with all curtains closed.

In late November, we were relieved at Wake by another pair of submarines and returned to Pearl Harbor arriving on Friday, December 5th. The DOLPHIN was scheduled for a much needed overhaul so we immediately began preparing to enter the Navy Yard.

When the attack came that Sunday morning, we were of course involved immediately in trying to shoot down enemy airplanes. We fired at those which came close but still too far away for our .30 caliber machine guns, service rifles and .45 caliber pistols. When the attacks finally subsided, we began putting the boat back together again -- undoing our Navy Yard preparations. It was recognized that we would soon be going on patrol again.

I should note at this point that within hours of the attack, President Roosevelt sent a message directing us to "conduct unrestricted submarine warfare against the Japanese." Our national morality on this matter suddenly evaporated into thin air with this treacherous attack by the Japanese.

On Christmas eve, after dark, we departed for a patrol area in the Marshall Islands. We were to reconnoiter four atolls -- Jaluit, Wotje, Arno and Kwajalein -- and report back to headquarters what we observed including defenses and in particular any shipping present in the lagoons. We saw some ships at Jaluit but none underway at sea that we could attack.

As a result of our reports and those of three other submarines with the same mission as ours at other atolls, Admiral Nimitz sent Admiral Halsey and his aircraft carriers to attack those sites where shipping had been seen.

In late February, 1942, upon return from the patrol in the Marshall Islands, I was detached form the DOLPHIN and sent to New London, Connecticut, as Executive Officer of the new submarine AMBERJACK. What a thrill to move from the poor decrepit broken down DOLPHIN to a brand new boat, which had the new reliable high speed diesel engines, electric drive installation, air conditioning, electric distillers, plenty of battery water and fresh water for everybody (a Godsend, no more 42 days without a bath), radars (more than a Godsend, a miracle), ice cream freezers (what a dream and space for the mix!). We had it made! This was the standard design Fleet Boat we had heard so much about! Moreover, we had seen the submarine mission change from being a scout for our battleships, cruisers, aircraft and troop transports and with a theoretical mission to attack only large enemy combatant ships to a mission calling for the sinking of any and all Japanese ships, combatants of all kinds, and merchant ships of any size or type (except hospital ships) wherever found. In addition, we stood ready on lifeguard stations to rescue any downed U.S. and allied aviators from air strikes against Japanese ships, bases and facilities all over the Western Pacific.

Normally, we operated as lone wolves in a given area where surface ships could not go; our presence usually becoming known when we attacked a ship or convoy. We did, however, in 1944, begin operating in "wolf packs" of 2 or 3 submarines, the senior skipper of the 3 being designated as the wolf pack Commander. The idea of wolf packs originated with the Germans, but by 1944 we were introducing new submarines into the force at a rate of 5 per month and could afford to concentrate our resources in the forward areas. As Nimitz moved into the Central Pacific (Guam, Saipan, Iwo Jima and Okinawa) and MacArthur into the Philippines and Okinawa, our submarine operating areas, heretofore inaccessible to surface ships, became within reach of our aircraft and allied warships.

In many respects, the war against shipping for our submarines pretty well ended about January, 1945. Relatively few ships remained to carry oil, food and other needed cargo to Japan from the South Pacific. Ships which tried to move anywhere were in great jeopardy and few, if any, got through as the record shows.

It's no wonder the Japanese said after the war that they thought the East and South China Seas' shipping lanes were paved with American submarine periscopes.

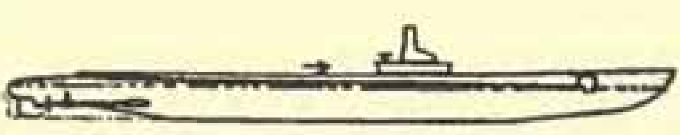
As our forces moved closer and closer to Japan and ships to attack became scarce, submarines gladly took on the mission of patrolling on lifeguard stations near the scene of an air strike to recover any downed aviators. All in all we picked up 511 flyers. We had actually been doing lifeguard duty at any time the opportunity permitted from the very beginning of the war. One day, in July, 1944, my college roommate picked up 22 naval aviators who had been shot down during the strikes on the Japanese bastion at Truk. My boat recovered 12 Army aviators whose B-29 had been badly damaged in an air strike over Japan. The flyers knew where a lifeguard submarine was located and when in trouble tried to head for that spot to bail out.

While quoting some statistics, I should add that Japan lost over 10 million tons of shipping during the war, 51 percent sunk by submarines alone. She lost 201 combatant ships, 29 percent to submarine attacks.

Immediately following the end of the war, there was of course a massive standdown of all military forces. Most of our newer submarines were put in mothballs. All of the older ones were scrapped. We began modernizing the newer ones which remained in the active force, installing snorkels, high capacity batteries and streamlined hulls. Some of these were based at Pearl Harbor from then until today.

In 1946, a national decision was made, however, to manufacture a nuclear power plant and install it in a new submarine. The name selected was USS NAUTILUS, since we were in effect nearly creating the mythical submarine of Jules Verne's science fiction novel.

Admiral Bernard D. Clarey, USN(Ret.)



RANGE BY TRIANGULATION

Triangulation is a well established method for determining the range to a contact based on bearing information from multiple sources. The theory is simple; bearings on a contact are plugged into a trigonometric formula which accounts for array geometry (i.e., distance between arrays) with the net result being the contact's range (Figure 1).

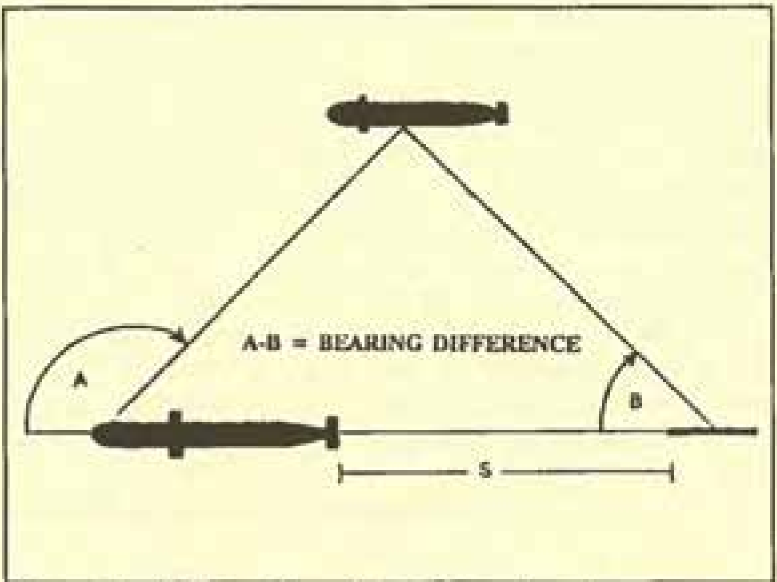


Figure 1. Triangulation Range Geometry

This can be a useful complement to other range information. The primary advantage of triangulation ranging is time. While most other techniques require multiple legs, contact may be triangulated in the time it takes to process the sonar data. With detection and counterdetection ranges growing ever closer, this time factor becomes even more critical; seconds could make the difference.

This was the primary motivation for the creation of the triangulation rangefinder (Fig.2) It affords the fire control party the most rapid means of calculating triangulation range. Using readily available bearing information, anyone can complete this task in approximately ten seconds.

Example:
Spherical array relative bearings on contact = 040°
Spherical array/towed array bearing difference = 2°
Range = 12.5 KYD

Point of Intersection
(for a towed array scope of 2100 ft.)

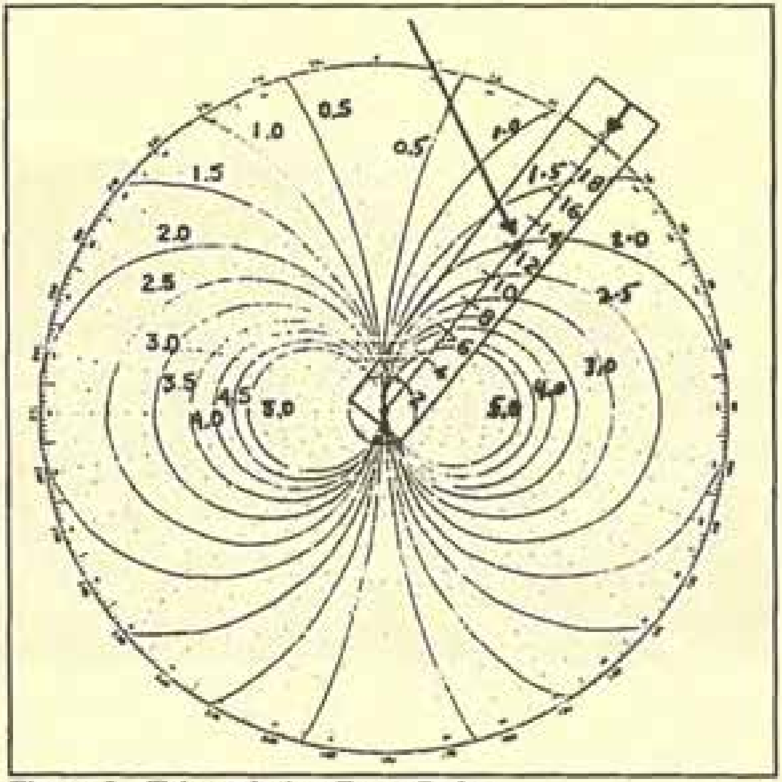


Figure 2. Triangulation Rangefinder

To use the rangefinder:

1. Place the moveable pointer to the hull mounted array's relative bearing.
2. Find the intersection of the pointer with the applicable line of constant bearing difference (i.e. difference between the two bearing sources).
3. Read the range directly off the moveable pointer scale (at the point of intersection).

It should be noted that the limitations normally associated with triangulating a contact (i.e. bow/stern bearing and long ranges) still exist; the rangefinder merely gives the fire control party the ability to calculate the range, probably less accurately, but more expeditiously.

Robert F. Gazdzinski

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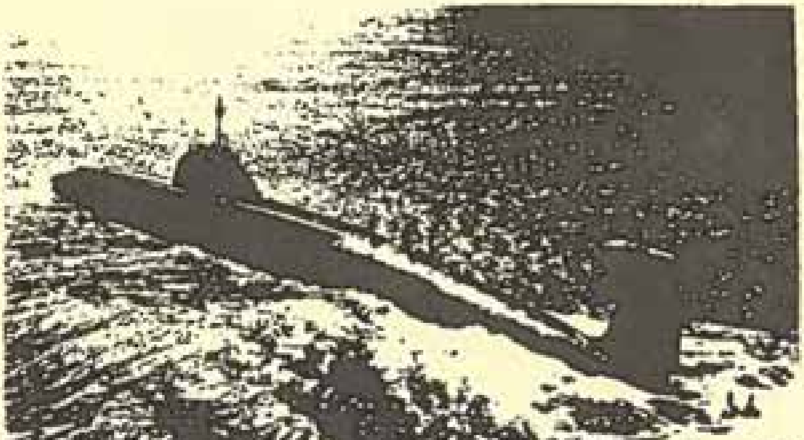
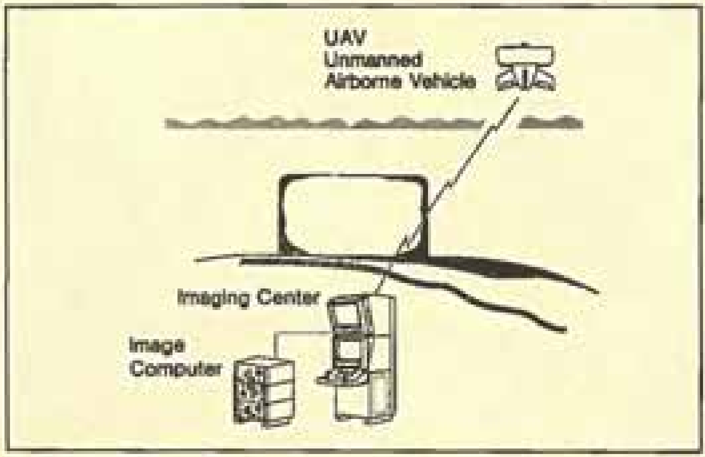


Extending the Submarine Commander's Vision



Kollmorgen continues to extend the mission of the U.S. Navy's submarines by exploring the feasibility of integrating the imaging center with off-board sensors such as the UAV-Unmanned Airborne Vehicle, providing:

- Reconnaissance and surveillance of OTH sea targets, coastal areas, harbors and inland areas.
- OTH identification and targeting for sub-launched missile systems.
- Battle damage assessment.
- Surgical engagement.

KOLLMORGEN

AN AIRBORNE UNDERSEAS WEAPON SYSTEM

Because of the limited range of both surface and subsurface Naval ASW systems, it would appear that the tactical effectiveness of the Navy ASW mission could be greatly enhanced by a weapon system which consisted of vertical take off and landing (VTOL) transport type "mother" aircraft which would be able to deliver to any given ASW area a combined capability for detection, localization, classification and kill. A small 100 knot deep-diving (6,000 ft.) winged two-man submarine (which would be light enough for airborne delivery yet would contain suitable detection and armament equipment) could be flown out to a deployment area where it would be launched into the ocean by the mother plane. At this point, the submarine could elect to either perform a short patrol of up to 2 days or to immediately begin neutralizing action against a possible enemy in that area. In either case, the mother aircraft would be available for pick-up at any time at a predetermined rendezvous. The mother aircraft would also have an all-weather pick-up and launch capability combined with comprehensive long-range communications as well as an air-underwater communication link with its underwater vehicle.

The VTOL Airborne Delivery Vehicle

This type of aircraft is being developed (as represented by the V-22 OSPREY) and would be capable of lifting a 12,000 pound payload over a range of 1,000 miles at a cruise speed of 350 knots. The description of this vehicle need not be duplicated here.

The Winged Pulse-Power Submarine

Studies show that it is possible to build a two-man winged submarine with a detection and attack capability within the weight and size restrictions imposed by a VTOL carrier aircraft. Past experience has indicated that its two-man crew carried within a five foot diameter pressure sphere is the minimum possible for the vehicle to satisfactorily perform its mission.

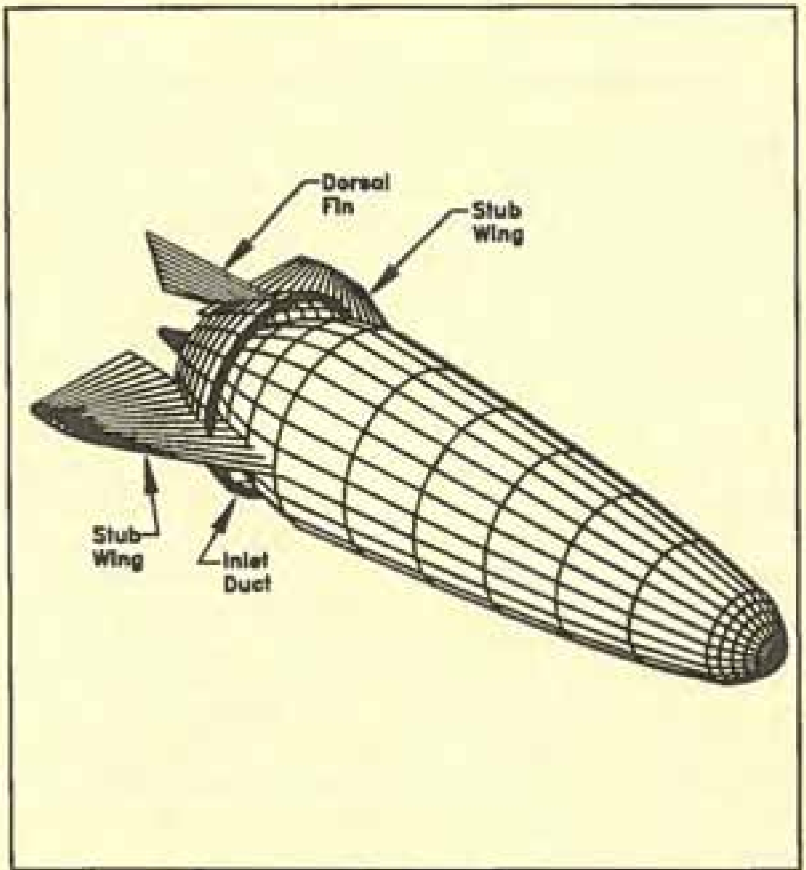


Figure 1. Pulse-Powered Submarine

These requirements establish the following approximate boundary conditions for the Pulse-Power Submarine

Length:	20 feet
Width:	5 feet
Weight:	12,000 lbs. max. at launch, 10,000 lbs at recovery
Speed:	100 knots
Depth:	6,000 feet
Endurance:	2 days

In addition, it is desirable to have:

a) Positive buoyancy at all times
b) A weapon's payload of underwater rockets
c) Sensitive detection and communications capabilities

Because of the very wide speed range and the flexible mission capabilities of this vehicle, an additional auxiliary power-plant is indicated to provide electric power for low-speed secondary propulsion and the electronic gear.

The Sub's Propulsion

Minimum drag considerations for high-speed underwater flight dictate a body of revolution type hull with a maximum length to diameter ratio in the range of 7 to 8. Using the known shape of the SSN 585 SKIPJACK class submarine, operating in fully turbulent flow, the power required for the Pulse-Power Submarine is shown in Figure 2 over its operating speed range. Obviously, it is desirable to avoid power-absorbing cavitation effects and, accordingly an operational envelope can be derived within which the Pulse Power Submarine can safely maneuver free of cavitation.

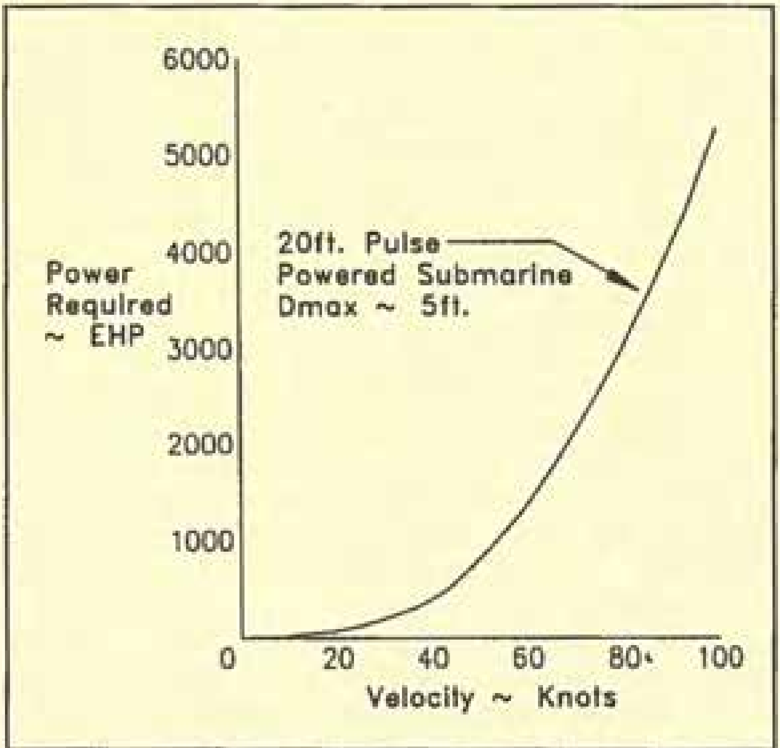


Figure 2. Equivalent Horsepower - Required vs. forward Velocity

It is apparent from Figure 2 and the power equation, that, assuming completely attached flow, the power required for any given speed is directly proportional to the wetted area of the vehicle. Since the extreme depth requirement dictates a series of maximum strength/weight ratio spherical shells for enclosing the electronic gear, crew, and auxiliary powerplant, a significant saving in overall length and wetted area is accomplished when all these functions are enclosed within three spherical shells as shown in Fig. 3.

The short tail of this configuration will normally lead to a high pressure drag addition to the wetted area friction drag. However, a suitably chosen powerplant will create a positive pressure gradient on the aft portion of the hull such that the water flow remains attached at all points, thus removing the pressure drag and allowing a large reduction in power. The solid curve of Figure 2 describes the power required of this shape with its propulsion driven boundary layer control.

Results of the mass flow entrainment possibilities of pulsed ejectors are sufficiently encouraging (with 100% entrainment attained) to enable their use as an underwater propulsion device with unique characteristics. The very large mass flow entrainment achieved by the pulsed ejectors allows this device -- in a suitable array -- to create the desired pressure gradient for efficient attachment of the aft-end water flow. In addition the pulsed propulsion system is a rugged lightweight thrust producer which will require no lubrication and can be built to take the heavy loads of high-speed underwater flight.

A very important characteristic of this pulsed propulsion system is that it can operate over a range of frequencies with high amplitudes of sound energy. This might well be used as an active sonar transducer for acoustic tracking and homing during the high-speed attack phase of the mission. In this manner the submarine can avoid carrying a bulky and power-absorbing active sonar transducer.

Since the high speed of this vehicle will only be used for a short period of time, a sufficient quantity of lithium water-reactive fuel can be carried to run the propulsion system with complete control including throttling, shut down and restart capabilities. Because this is an open cycle system with water containing the oxidizer, the propulsion system operates

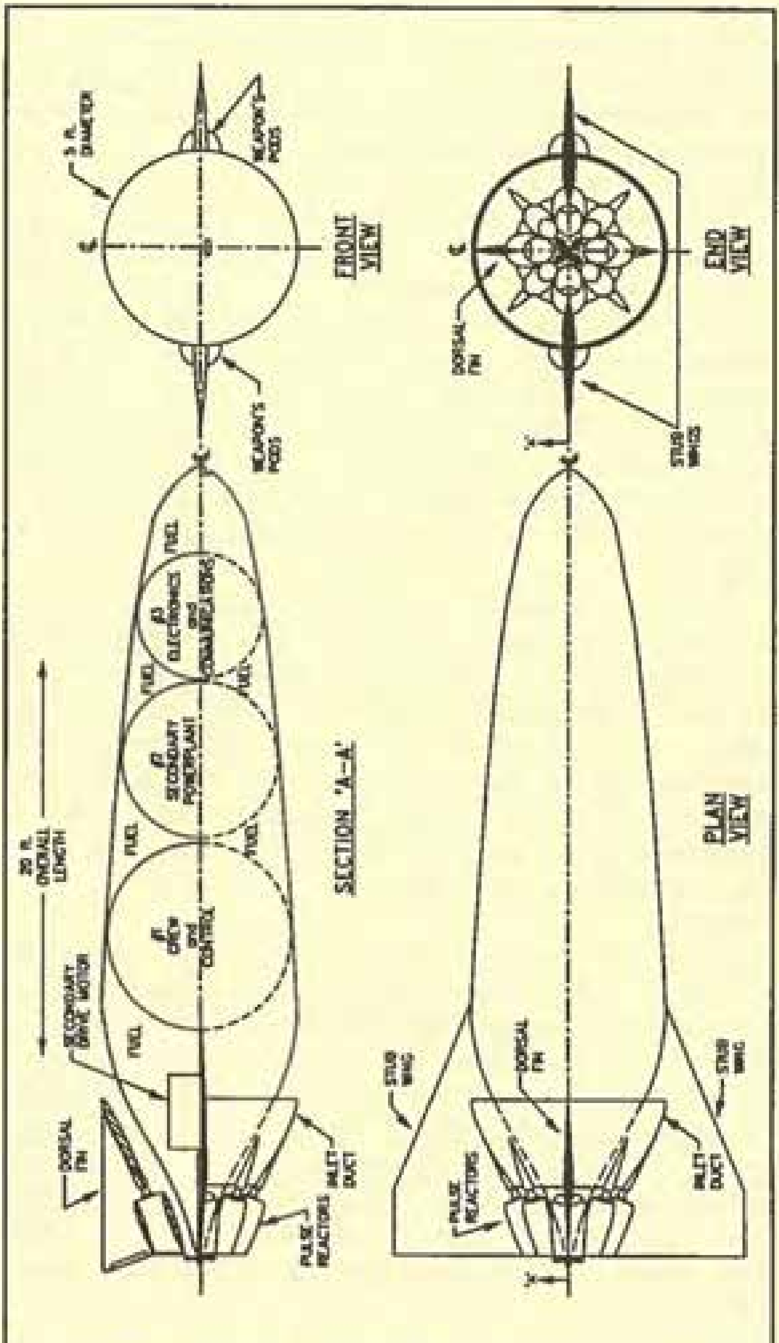


Figure 3. Winged Vehicle - General Arrangement

independently of external pressures and will function equally well at any depth as long as cavitation is avoided.

Figure 3 shows the arrangement of the pulsed ejectors at the submarine's stern to provide a positive pressure gradient and prevent turbulent separation.

Secondary Propulsion

In order to provide noiseless, long endurance auxiliary propulsion for extended underwater reconnaissance where hovering and 2-3 kt. speeds would be required, a closed Rankine cycle steam turbine system is employed. Using the heat released from an annular surface burner fueled by a lithium-water reaction, this cycle provides a simple lightweight powerplant. Since the ocean is a virtually infinite heat sink, the spent steam can be efficiently condensed through radiators mounted in the stub wings to a quite low temperature; the deeper and colder the water, the more efficient will the cycle become.

The steam turbine drives a high-frequency alternator which, in turn, supplies constant frequency high voltage power to a solid-state voltage regulator for the electronic system and also to a small water-cooled variable frequency propeller drive motor which will allow a 0-12 knot speed range with a maximum power output of about 30 horsepower (note, separation drag will be high at these low speeds with the pulsed propulsion off, but this is of little consequence since the power level is quite low).

Structure

Techniques exist for building strong light-weight solid-propellant rocket casings using filament wound reinforced plastics. Similarly light, high strength spherical shells can be produced for underwater operation at extreme depths. In particular a boron-based fiber with a composite tensile modulus of elasticity of approximately 33 x 10^6 psi and a composite specific gravity of something less than 2.0 provides a significant breakthrough for shell structure performance. A comparison with a solid shell of Alclad 75S aluminum, shows for a 6,000-foot maximum depth capability and a five foot diameter sphere:

	E_{ten}	Wall thickness Required	Weight of Sphere
Aluminum	10×10^6	.884 in.	1001 lbs.
Boron filament wound	33×10^6	.501 in.	398 lbs.

Utilizing the optimum strength characteristics of the spherical shell, the hull is divided into the three basic pressure spheres:

#1 Sphere - Crew and control
#2 Sphere - Secondary powerplant
#3 Sphere - Electronics and communication

In order to minimize the weight still further, the outer hull is a non-pressure structure and the space between the three pressure spheres is filled with flexible fuel bags. In this manner, as fuel is consumed, the hull is flooded with sea water through a bow opening which also serves to pressurize the fuel tanks.

However, the hull filament wound impregnated plastic structure has sufficient strength to withstand the very high dynamic loads at 100 kts. (= 28,400 psf) and can carry the control wings which are mounted on aluminum forgings encircling the crew sphere.

The pulsers, of aluminum alloy, have their thrust loads taken out through a sub-frame attached to the main structure around the crew sphere.

The weapon's payload is carried in pods under the control wings. These rocket weapons would be solid-fuel propelled water-to-water rockets with a conventional warhead, and operate over a maximum range of 200 yards.

<u>Stability and Control</u>

The ability to hover and maintain station at very low speeds as well as the ability to fly at speeds up to 100 kts., dictates that wind tunnel tests will be required to fully establish the positioning and optimum shape of the stub wings and control surfaces.

The design provides for a maximum positive buoyant force of 2550 lbs. decreasing to 1350 lbs. as fuel is expended and the fuel cells are flooded with sea water.

Since positive buoyancy is maintained at all times, the stub wings are required to develop sufficient "negative" lift for the submarine to hold station at any given depth. With a wing area of 24 $ft.^2$ a minimum speed of approximately 6 kts. is required to hold depth in the fully fueled condition. This requires approximately 5 SHP from the secondary propeller propulsion.

The control surfaces are capable of maneuvering the submarine under water in the same manner as a conventional fighter aircraft in the air.

Air-to-Underwater Communications Link

The requirements of this weapon system are that the submarine be able to transmit information from any depth down to 6,000 feet to the air-sea interface from which it can be relayed either to the "mother" aircraft or to a surface ship.

By equipping this vehicle with sensitive passive sonar and echo ranging equipment it is possible to conduct an extended undersea reconnaissance -- picking any thermal layer desired -- to effectively pinpoint an enemy submarine. A laser operating in the blue or green spectrum should be quite effective for distances up to 2-3 miles.

The "mother" plane can drop a pattern of small floating laser-buoys (for receiving, decoding the underwater vehicle's laser signal and then transmitting this information via radio frequency to surface vessels or the "mother" aircraft). The underwater submarine located near this laser buoy pattern could transmit vertically by laser beam to the nearest buoy, and have one of its many channels reflecting back from the buoy for an automatic lock-on to the buoy during the transmission time period.

Assuming a transmitting depth of 5,000 ft. and an attenuation of 10^{-2} DB per yard (see Figure 4), it is apparent that over a slant range of 6,380 ft., (i.e. the laser buoy is 2,000 ft. laterally from the winged Pulse-Power Submarine) there is a power attenuation of only 17 DB. With the very high power density at one frequency radiating billions of times as much energy as an equivalent area of the sun's surface, the laser would appear to be ideally suited for short range underwater communication.

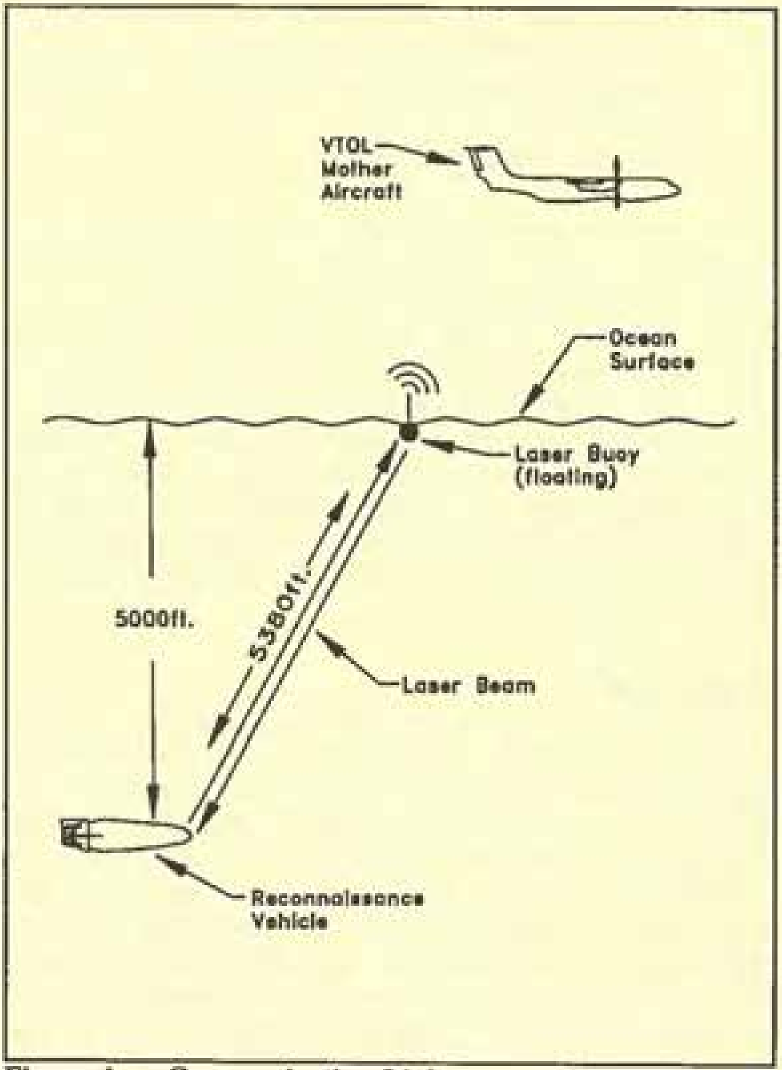


Figure 4. Communication Link

Launch and Recovery

The launch and subsequent recovery of the submarine requires a system that successfully overcomes several major problems, including:

1. Operations during high seas, requiring lift of as much as 100 ft.

2. Attachment of recovery harness to submarine during turbulent conditions of both sea and air.
3. Providing for lateral stability of submarine during launch and recovery.
4. Design for minimum weight.

The solution proposed provides the ability to operate in all weather conditions, while at the same time, requires a minimum amount of complex machinery and weight.

The submarine is lowered and raised by means of lifting cables attached to a recovery harness which is attached to the submarine. A telescoping stabilizer bar is attached between the lifting harness and the airplane, providing for lateral control and also limiting longitudinal swing. This stabilizer bar serves also to guide the lifting harness into position for attachment to the submarine during the recovery phase of the operation. Figure 5 shows the system partially extended for launch or recovery.

Lifting Harness

The harness is a rigid member which can be guided into position for recovery of the submarine. During the recovery operation a large 4-foot diameter wire loop is attached to the front of the harness. This loop will be guided by a crewman, through control of the stabilizer bar, until it connects with an extended hook on the submarine. Upon this contact the hook will be drawn into the submarine, or moved along it, moving the lifting harness into position for the lift. With the front of the rigid harness secured, the rear of the harness will move into position and with a similar but smaller cable ring attach the rear support cable to the dorsal fin. With the harness firmly attached front and rear, the lift can begin.

The stabilizer bar provides lateral stability to the harness at all times, with and without the submarine attached. Stability is extremely important, for yawing of a large mass suspended below the airplane would cause difficulty with the aircraft's control and stability.

Second, the stabilizer bar, of aluminum tubing, consists of four to seven sleeves depending upon the location of the attachment point. Since the lower end of the bar is

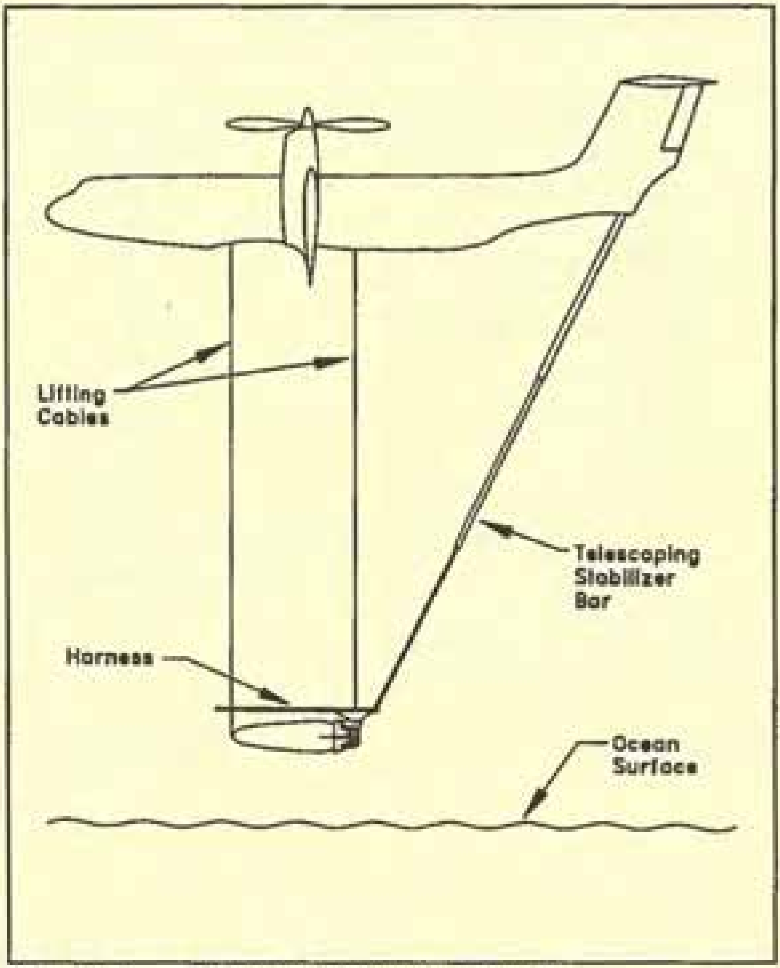


Figure 5. Launch and Recovery System

permanently attached to the lifting harness and will raise and lower with that harness, it is necessary to make this a hydraulically extensible or retractable boom. Locking sleeves grooved and keyed to prevent axial rotation prevent any unwanted movement of the lower end of the bar.

Using the above outlined method, submarine launch and recovery appears quite feasible even under adverse conditions of sea and air.

Pulse-Power Submarine Specifications

Weights:

Fuel (slurry or paste)	4,400 lbs.
Sphere shells	928
Body (1/2 in. wall)_	962
Pulse reactors	1,900
Auxiliary powerplant	500
Crew and Gear	900
Electronic equipment	500
Laser system	300
Wing structure	1,210
Weapons (4 rockets)	400
Maximum Gross Weight	12,000 lbs.
Empty Weight (less fuel and crew)	7,000 lbs.
Displacement	14,550 lbs.

Fuel Available: 30 minutes @ 100 kts.
2 hours @ 60 kts.

February 1963 *Henry E. Payne III*

■

DISCUSSIONS

SUBMARINE OFFICERS: NOT "NUKES"

"He's a Nuke!" The phrase is often cynically applied to the reputed stereotypical engineering-oriented nuclear trained officer. It expresses what is one of the popularized problems with the submarine community -- its perception as an organization overly concerned with nuclear plant safety. The belief that this emphasis comes at the expense of tactical prowess fosters the perception of submarine officers as expert technicians but only adequate tacticians.

First, is the perception accurate? Claims that the U.S. submariner is excessively engineering oriented are refuted by professional opinion to the contrary. Tom Clancy, author of "The Hunt for Red October" suggests in a recent editorial that the U.S. Navy concentrates on engineering instead of tactical development. His thoughts echo those of some naval officers who speak from experience of the disparity in emphasis between tactics and nuclear training. Commonly cited is the disparity between shipboard preparation for Tactical Readiness Examinations and the seemingly all-important Operational Reactor Safeguards Examination (ORSE). Other incriminating factors include the dedicated schooling and interview process for submarine Engineer Officer qualification, and the implicit requirement of command-track officers to have served a tour as Engineer.

Who is right? To the young Engineering Officer of the Watch standing watch in maneuvering and preparing his engineering division for the grueling ORSE board, there is decidedly too much emphasis on engineering. To him, the engineering department training, engineering seminars, and around the clock drills are forever preempting the more fun and more important, "front end" challenges of shiphandling and weapons employment. To non-submariners, there is conflicting evidence that suggests that submariners represent the elite of a sophisticated and capable Navy, while also suggesting the Navy would do well to more closely pattern its submarine officer training after that of the Royal Navy.

There is no definitive answer to an issue over which reasonable people can disagree. Although the ongoing professional dialogue has allowed a productive airing of differing views, it is hard to support sweeping changes to a system that has developed uniquely impressive operational capabilities and an unblemished submarine nuclear safety record.

What, if anything, should be done? Let's get back to the original issue of perception: that within the Navy, and increasingly in other circles, submarine officers are seen as engineering "machines" deficient in undersea warfare. Although the accuracy of the perception will remain in dispute as long as nuclear power remains on submarines, the presence of the perception is real and should be addressed.

Source

Why does the perception of submariner officers as being engineering-biased exist? First, because our submarines are powered by nuclear reactors. No one can dispute the tremendous tactical advantage this affords a submarine. Nuclear power makes our subs uniquely capable of carrying out the forward-oriented missions of our Maritime Strategy, including the crucial anti-SSBN mission performed under the ice only by nuclear submarines. The engineering that so perfectly complements the U.S. submarine's missions presents a potential for dire operational and political consequences. To carry out the warfighting missions safely and responsibly, the force must develop officers with complete confidence in their submarine's capabilities. Officers deployed in forward areas on independent missions must be completely capable of maintaining their ship in top warfighting condition. The submarine must be kept mission capable without the support of tenders and shore based repair facilities heavily relied upon by other naval elements with different missions. When the required engineering training encourages the type of aggressive shipfighting borne of knowledge and confidence, it enhances the submarine's exciting role. When this same training fosters an exceedingly risk adverse attitude, it compromises wartime effectiveness, and becomes a tactical handicap. Most submarine officers can look proudly on the high operational readiness their boats have earned through special operations and other tactically rewarding deployments. The engineering-first perception, though, is perpetuated by a minority of submarines in the fleet that establish engineering as of top priority.

Second, the perception exists because we in the submarine force perpetuate it through action, inaction, and oversight. The traditional "Silent Service" unwillingness to publicize even routine operations skews non-submariners' interpretations of what submarining is all about. Within the community, shipboard priorities on some submarines misdirect the needed focus on warfighting. The shipboard training program, for instance, that religiously requires the entire wardroom to attend all engineering-related training, but leaves weapons and operations training to respective departmental personnel, encourages the perception and fosters its development into reality. Again, submarine skippers stressing engineering at the expense of tactical prowess are in the minority, but are numerous enough to give the perception unwarranted credibility.

An area affecting perception is submarine officer accessions. In the Naval Academy and NROTC Units, the percentage of male Navy midshipmen volunteering for submarine duty has declined over the last five years. Surveys show that, among other reasons, the perception of junior officers spending their tours isolated in nuclear-related work is responsible for turning many candidates away. With the Navy's most powerful, sophisticated, and sensitive equipment operating at both ends of the submarine, the emphasis has to be clear: warfighting first, engineering expertise necessary.

To illustrate the problem, consider a first class midshipman at the Naval Academy and see how he perceives the submarine community. After several years' exposure to the various warfare communities, this young man can discuss his career options with officers from: Aviation Warfare, Marine Corps, Surface Warfare, and, pointedly, Nuclear Power. Sure, most Nuclear Power Officers are submariners with valuable operational experience, but their designation as NPO on some official instructions suggests an engineering emphasis that is counterproductive. The need for one individual to coordinate all nuclear accessions (submarine and nuclear surface ship) is questionable anyway. It certainly doesn't warrant the preemption of Submarine Warfare Officer as the submarine representative's acknowledged title.

To continue, consider the midshipmen who have decided to take the requisite interviews for accession into submarines; He will go to Naval Reactors, respond to a battery of engineering-related interviews from NR staff, and finally be asked some broader personal questions to determine his motivation toward the nuclear power and, we hope, submarine program. One can argue that the questions asked by the design engineers implicitly determine a candidate's submarine officer potential as well as his potential as an engineering watch officer. The fact remains that this nuclear hurdle is clearly the substantive criteria which future officers must satisfy to get subs. The conclusion is clear in the minds of many: if you're a good "nuke", you'll make it in subs. The matter is extrapolated by Clancy and others to include officers at all levels in the submarine community.

How to make it better? Simple measures include refocusing the accession programs and renaming billets in the community to emphasize the development of complete submarine warfare officers as opposed to nuclear-trained officers. Reestablishing the commitment to warfare expertise means providing a submarine officer accession channel distinct from a surface officer, nuclear-trained channel. It also means that a midshipman will go on a submarine cruise, instead of being detailed to a nuclear cruiser, and will talk to the Submarine Warfare Officer instead of the Nuclear Programs Manager. Naval Reactors should maintain centralized control of the intense engineering training so crucial to the submariner's warfare specialty. The process will start, though, with Submarine Officer interviews, as opposed to Nuclear Power interviews. The interview material can be supplemented, not replaced, with material geared toward the selection of capable warfare officers, not explicitly nuclear-trained officers. The distinction serves to promote the well-roundedness of submarine officer expertise and dispel the myth of submariners as simply undersea engineers.

Some will argue that there is no perception problem. They probably have read material proclaiming the submariner as the

Navy's elite, but haven't seen the accession statistics for the submarine program and the reasons given for not entering the program. The absolute numbers, which show an improvement this year, belie the steady decline in the percentage of volunteers from recent graduating classes.

Others will acknowledge a perception problem, but say "so what?" They will argue that we have a job to do, and outsiders' perceptions of our capability are inconsequential. Their point is a good one. There should be no dispute about the relative importance of our perception among non-submariners and submariners alike and our acknowledged ability. However, the submarine force is losing competent and dedicated officers to other communities partly because of a perceived imbalance in the system. In the eyes of young midshipmen, perception becomes reality.

Finally, still others will agree that there is a problem but argue that the costs of fixing it exceed the benefits. Certainly the widely held perception must be addressed. The officers defending the country aboard submarines -- in maneuvering or in the attack center -- deserve to be recognized as true professionals in their warfare specialty, and not as the tactically deficient "nuclear engineers" so commonly perceived.

LT Kenneth M. Perry, USN

"GETTING COMFORTABLE IN SUBMARINES"

The compartment bill or evolution checklist is an invaluable aid in assuring the safety of the submarine and crew. Regardless of how many times we have participated in any evolution we must always use a check list or bill.

We can never be entirely sure that everything has been done correctly. The horror stories that come from everyday evolutions are frightening, considering that most of the mistakes could have been avoided.

It boggles the mind to think that the people involved were so aware of procedure and had done the evolution many times before, yet assumed they remembered exactly what they were supposed to do, while forgetting an important detail -- and disaster struck.

We as professional submariners have the need to consider all the potential ramifications of everything we do. This is especially difficult when we become careless through repetition. A lackadaisical attitude is the seed of disaster. Blowing sanitaries becomes more of a "pain in the neck" than the potentially hazardous evolution it can be. Confidence through repetition and not following the bill can lead to a missed valve, and with it a little mess, embarrassment, and being disqualified for a watch. But what often gets overlooked is that it could have been more serious. Everyday evolutions are usually harmless, but add inattention to detail with electricity, compressed air, or hydraulic pressure, and you have a life threatening situation.

Submariners are in an inherently dangerous environment. There is no escaping the problem. Every day we put our lives in the hands of our shipmates. We hope the C.O. feels certain, when the officer of the deck wakes him up to ask permission to go to periscope depth that the nearest contact is indeed not a threat to ship safety. We also hope that a strange noise was properly assessed by the machinery lower watch as "Nothing to worry about!" And we hope that the duty cook put only enough shortening in the deep fat fryer to avoid a fire.

Don't take everyday evolutions for granted just because they have been done a million times before. We will do them a million times again, but this does not take away from the fact that an evolution is still potentially dangerous.

We must take to our bunks at the end of our day trusting our shipmates and confident they will be professional enough to use the proper procedures. Because, gentlemen, that is all we have; trust, confidence, and prayer -- that we won't make one more dive than a surfacing.

MS2(SS) Benjamin W. Davies, USN

What's The Word From Westinghouse On Naval Submarine Systems?

Fathom.

Westinghouse has committed a significant force of its scientists and engineers to help fathom the needs of the U.S. Navy's nuclear submarine fleet.

Some of the successes include missile launching and handling systems, which have been installed on every Navy fleet ballistic missile submarine. And we developed a system that vertically launches Tomahawk cruise missiles from attack submarines.

We are currently manufacturing the quietest main propulsion system in a submarine for the Los Angeles class and we're developing an even quieter system for the future Seawolf.

Westinghouse has a long and distinguished history in torpedo development. Dating back to the MK 18 and MK 28, during World War II, when we produced more than 10,000 units. Recently, we helped develop, and now manufacture, the MK 48 ADCAP and the MK 50 lightweight torpedos, the fleet's standard.

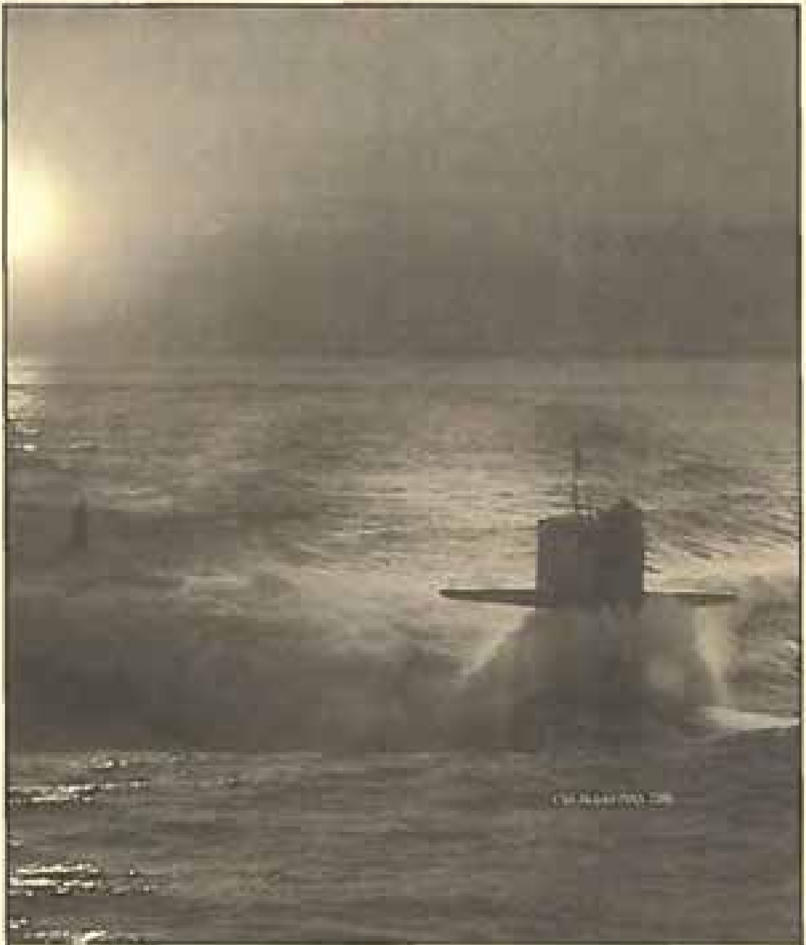
And our state-of-the-art technology in fiber optics, underwater vehicles, and sonar systems assists Navy submarines in rapidly localizing enemy threats.

Additionally, Westinghouse instrumentation and control systems are installed on virtually all nuclear submarines.

At any level, Westinghouse is helping to fathom the requirements of the U.S. Navy's nuclear submarine fleet.

You have our word on it.

You can be sure . . . If it's Westinghouse



TORPEDO EVASION: A GAMES APPROACH

(*Somewhere in the Northern Pacific:*)

Sonar to Conn:
"Hold new sonar contact, designated Sierra Two, bearing 073, no aural classification."

OOD to Captain:
"Sonar reports new contact, designated Sierra Two."

Sonar to Conn:
"Sierra Two classified as possible close-aboard submarine. I've got steam noise."

OOD to Captain:
"Have commenced active sonar search. Currently hold no active sonar contacts. Sonar is classifying Sierra Two as possible submarine. Am assigning passive tracker, bringing the ship left -- Helm; left degrees rudder, steady course 340."

Captain to OOD:
"Take that rudder off, you'll give our position away."

Sonar: "I hold planes' transients, bearing 250. Possible submarine."

OOD: "Ready weapon in tube two. Captain, I'm making weapon ready, tube two, probable submarine off my port hand."

Captain: "Captain has the conn. Status of making weapon ready?"

Fire Control:
"Weapon ready, tube two."

Captain: "Fire tube two."

Sonar: "Conn; we've got launch transients, bearing 065. Torpedo in the water, bearing 065."

Fire Control:
"Captain; Weapon ready, tube one".

Captain: "All ahead flank. Helm; Left full rudder, steady course 300. What's his bearing now?"

Sonar: We've lost track Sierra Two. All we hold is the incoming weapon."

It is possible that no environment so severely imposes the 'fog of war' as the undersea battleground for SSN versus SSN engagements. Information, real time information, and the ability to exploit the data will ultimately determine the outcome of any engagement.

The particular problem of torpdeo evasion is a complicated one, made all the more so by the extraordinary pressures of submerged combat. What to do with the submarine, how to employ the counterfire weapon, when and should the unit under attack attempt to re-engage? These are all questions the submarine's Commanding Officer must answer within seconds of commencing battle.

This problem can be examined through the use of an idealized engagement scenario. An imaginary aggressor has at his disposal a very simple weapon -- a torpedo of unlimited endurance. It acquires and homes on its target by active acoustic transmissions. It relies on its acoustic returns to effect search, localization, and terminal homing. The torpedo is also gifted with the ability to home irrespective of target evasive maneuvers. It has only one flaw. The acoustic environment being what it is, the possibility exists that before acquiring the target the weapon may begin homing on a false target -- possibly a decoy. Further, the weapon can terminally home on only one target. That is, once homing begins, whether on the target or on a false return, the weapon is locked in and unable to disengage.

At this point a bit of underwater acoustics is in order. If an active emitter is operating at a frequency of, say 100 KHz, then there will exist significant reverberations at and around that frequency. These reverberation sources include the ocean bottom, the surface, waves, biologics, eddies and currents, and many others. The performance of a processor whose task is to recognize the returns from a contact which are valid, will be degraded by the reverberations. If, however, the returns are shifted in frequency away from the emitter frequency, discriminating valid returns from false contacts becomes an easier task.

The typical mechanism for evaluating return frequency shifts is the well known doppler effect. That is, if the contact of interest is closing or opening in range, the active returns will be shifted up or down in frequency in direct proportion to the range rate of closure or opening. This "doppler shift of convenience" proves to be a great aid in avoiding false contact returns.

The torpedo described above has given the user of the weapon a simple tool, i.e., it may be designed to filter out that frequency region most affected by active reverberations. In doing so, it has in effect decreased its probability of false contact acquisition. There is of course a downside tradeoff. In filtering out the frequency region in and around the emitter's center frequency it has made itself blind to zero doppler (little or no opening or closing range rate) targets. Thus, the Commanding Officer who uses this hypothetical weapon opts to have it either filter out near-zero doppler returns or process the entire spectrum of incoming data.

The evader in this simple problem has a choice of two evasion gambits. Once alerted to the incoming weapon he may either evade away (good doppler) or across the line of sight (no doppler) of the incoming weapon.

Having described this rather idealized scenario, we are faced with developing an optimal strategy for both the aggressor and the evader.

Which strategy would you employ if you were the aggressor? The evader?

The simple game described above may be generalized as follows. Two players, operating to achieve diametrically opposed goals, play under a very rigid set of conditions. While the rules and possible strategies are known to both players, the option actually chosen by either player is unknown to the other.

Option 1 for player I, the aggressor, is to employ active doppler filters (doppler enhancement) in his torpedo; Option 2 is not to employ these filters (no doppler enhancement). Option 1 for player II (evader) is to evade away; option 2 is to evade across the line of sight of the torpedo.

What we would like to do is decide on an optimal strategy for both players -- recalling that the hypothetical torpedo has infinite range. The mathematics for this engagement of a homing torpedo versus an evading target shows:

PLAYER I AGGRESSOR STRATEGY	PLAYER II EVASION STRATEGY 1	2
1	1.0	0.0
2	0.9	0.7

This shows that with doppler enhancement used, the evader running away is always hit, but without doppler enhancement the evader running away will be hit only 90% of the time. On the other hand, when doppler is depended on a crossing evader has zero doppler and no chance of being hit. Player II, the evader, will never choose evasion option 1 -- to evade away. Doing so guarantees that at a minimum the probability of being hit is 0.9. If, on the other hand,, option 2 is selected, you (evader) are certain that at worst the probability of being hit is 0.7. It may even be zero if player I chooses doppler fliters.

Now consider the game from player I's point of view. He is trying to maximize the hit probability of his torpedo. For the game depicted it is clear that he will always choose option 2 (no doppler enhancement).

In summary, the game reduces to the following: Player I, the aggressor, should always choose no doppler enhancement, while player II, the evader, should always choose to evade across the line of sight. This particular class of zero sum game is called stable. The value of the game is said to be 0.7.

Generally, the solution to such games is a probability distribution. That is, player I should choose option 1, X% of the time and option 2, Y% of the time. Likewise for player II. In this special case, player I chooses option 1 0.0% of the time and option 2 100% of the time. Likewise, player 2 chooses option 1, 0.0% of the time and option 2, 100% of the time.

Now lets assume that the probability of false contacts increases with the distance run by the torpedo when doppler enhancement is not selected. Thus, if player II chooses to evade away, the total active torpedo run will be greater than the total torpedo run for evasion across the line of sight.

Moreover, for the simple case proposed, the probability of a torpedo hit, given no doppler enhancement, is greater for torpedo evasion across the line of sight than it is for an evasion in the line of sight.

We have arrived at a point where we can solve a more realistic formulation of the doppler enhanced torpedo evasion problem. The aggressor has opted to engage the evader at a range of five Kyds. The weapon has an operating speed of 50 knots. The evader has a speed of 30 knots. We assume a value of 0.10%/Kyd for the probability of false contacts. Having determined run of the torpedo, if player I chooses no doppler enhancement and player II chooses to evade away then:

PLAYER I AGGRESSOR STRATEGY	PLAYER II EVASION STRATEGY 1	2
1	1.0	0.0
2	0.29	0.61

What does this solution tell us about the very simple evasion problem described? First, it is clear from the results that there is no simgle correct strategy for either the aggressor or the evader. In fact, the aggressor should shoot with doppler enhancement selected 24% of the time and without doppler enhancement 76% of the time. The evader should evade away 46% of the time and across 54% of the time. In the final analysis the aggressor has a 46% chance of successfully engaging the evader.

Or we might consider the results from the viewpoint of the enemy force commander. He has at his disposal 100 SSNs. At some particular moment all come under simultaneous attack. If his unit commanders all choose to evade away and the aggressors all employ doppler enhanced weapons, then the force commander expects to lose all his assets. This is the scenario where the aggressor is aware of enemy force doctrine and attacks to exploit that knowledge. If however, the enemy unit commanders are instructed to draw a card at random from a deck numbered one to 100, and act according to the evasion rules found above, then the enemy force commander will expect to lose only 46 units. While there is an element of the ridiculous in carrying out the optimal solution, it is clear that for the hypothesized scenario a mixed strategy will clearly result in fewer loses than a single strategy.

Questions are raised by these results: first, of course, how valid is the model employed? Clearly many factors have been left out. For instance, current weapons do not have an unlimited endurance. Nor are they able to be accurately steered onto the target in all instances. The evader modeled is also deficient -- his ability to evade outside the torpedo's acoustic cone has been discounted. How does the employment of torpedo countermeasures affect the false contact model proposed? There are many other shortcomings.

However, the reader should also remember that the scenario was kept simple, but a careful look at the problem reveals that, for the situation modeled, the ordering of the payoff matrix is probably correct. That is, while the numbers used might not be exact, the order in which they appear makes some logical sense. If the ordering is correct then the reader can convince himself that the optimal strategy will always be a mixed strategy. That is, there is no one attack or evasion strategy which is best. Best is always some combination of the two!

There are many interesting tactical questions related to this model. At what depth should torpedo evasion take place? (Clearly it depends on where the aggressor has placed his weapon). If the aggressor knows, for instance, that tactical dogma for the enemy is to evade deep, then shouldn't all torpedoes be placed below the thermal layer? And if all weapons are placed below the thermal layer, shouldn't there be a certain percentage of the time when the evader should go shallow?

Tactical decision making is best done by man, not by machine. The subtleties of each particular engagement do not lend themselves to mathematical modeling or optimization. For instance, do we factor in the Commanding Officer's knowledge of the particular enemy commander's reaction to an attack?

Just as dangerous, however, is unthinking adherence to tactical dogma. An exercise like the one just completed above, forces submariners to examine the tradeoffs affected by the various options available. The cost of adhering to "the right solution" is lost ships and lost lives.

While certainly no panacea, the examination of various tactical desisions under the game rules described above will clearly enhance the commander's understanding of the situation.

P. Kevin Peppe

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MEETING THE FITNESS NEEDS OF THE SUBMARINE SAILOR

The ability of a warship to carry out its missions is directly related to the capability of her crew to stand alert watches, to properly react to unexpected circumstances, and to demonstrate these traits on a daily basis -- on long deployments. This is certainly true on a submarine. Every watch on an underway submarine plays an important part in meeting the mission of the submarine. With dwindling acoustic advantage and faster torpedoes, a mental or physical lapse of even one crew member on watch during wartime might spell disaster for the submarine. Even in peacetime missions, the rigors of a three-section watch bill combined with the many training, administrative, and maintenance duties of a submarine crew make it tough to stand a proper watch.

It is generally accepted that human beings function with more stamina, efficiency, and accuracy in a demanding environment if they are in good physical condition. Recognizing this, a submarine watch stander performs better at his station if he keeps his body in the same good working order as he keeps his mind. Thus, one would expect the submarine force to maintain the highest standards for physical fitness. Submariners after all, claim to be an elite group of highly trained professionals -- a claim that is valid, only if we maintain both our minds and bodies in the best condition possible.

However, if one were to examine the individuals who make up our submarine force today, it would be discovered that this could not be further from the truth. One of the first things noticed on a quick personnel inspection is the large number of overweight sailors -- with "pot bellies," popular among even the youngest crew members. The crew as a whole seems to suffer from too little exercise and too many runs to the ice cream machine. What seems absurd is that many of these sailors, both enlisted and officers report aboard their first submarine in this condition. All have passed the minimum Navy standards for body fat and physical fitness, but the standards are anything but rigid and are not a true minimum for physical fitness. For example: one must go 1.5 miles in 15 minutes -- that's only six miles per hour, little more than walking speed. Also, if one's neck is proportionately as fat as his waistline, he will measure less than the 22% body fat minimum. In fact, the records of the Submarine Command's Fitness Coordinator show that few submarine crew members score in the "excellent" or "outstanding' categories while far too many only meet the minimum standards for a "satisfactory."

A "fitness" inspection of the submarine force also reveals a large number of sailors who smoke. During underways, cigarette smoke literally permeates the air -- tasking the scrubbers and burners, and making it uncomfortable for non-smokers. In the close confines of a submarine, cigarettes affect the health not only of the smoker but also the crew members who work around smokers. The public is aware that cigarette smoking is a health hazard, but it still continues to remain a health problem among sailors. Of course, many of the smokers onboard submarines already had the habit before they reported aboard -- while some acquired it during their basic training.

Despite relatively low physical fitness standards, submarine crews have for years been conducting successful peacetime submarine deployments without crew members failing physically.

Yet are we prepared for the physical efforts that will be required to fight a modern submarine battle? We have put too much emphasis on the mental aspects of submarine warfare and have probably underestimated the physical demands. It should be recalled that in World War II, submarine attacks often required the crew to stay awake for many hours and exhaustion resulted in many fighting problems. Also that only the superb fitness of a few crew members was instrumental in "saving the boat" during battle. Today, submarine warfare is undergoing a transition in which the expected time between enemy detection and torpedo firing is becoming shorter and shorter. Submarine warfare is beginning to take on characteristics similar to "dog fighting" in air battles. Should war break out, SSNs could be found in melee warfare -- in which quick reaction, concentrated effort and putting the weapon on target first should determine the survivor. Murphy's Law indicates that such a battle would occur at the end of a long and stressful watch. The submarine crew most physically and mentally alert should hold a distinct edge. (It should be recalled moreover how Frank Leahy, the football coach at Notre Dame during the 1940s said "Fatigue makes cowards out of all of us.")

Certainly damage control efforts greatly tax a submarine crew's physical reactions and endurance and may be critical in determining the ultimate survivor in sub against sub engagements.

The Navy has done little to physically prepare the submarine sailor for a transition to war. With a work day that is already too full in port, there is not a regimented, command-supported daily physical fitness program for all hands onboard submarines, and the physical readiness of the sailor at sea is scarcely considered when designing U.S. submarines or preparing them for long underways. The crew must fend for itself to stay physically fit. Submarine training and operations however are far better oriented to provide mental fitness.

To help solve the physical readiness problem, following basic training, with new recruits filtered through one or more service schools before entering the fleet, physical fitness programs in each one of these schools could help ensure submariners with improved physical readiness. Such programs should establish better physical standards and educate submariners to maintain these standards. (A physical fitness session could easily be added at the beginning or at the end of the daily classroom schedule.) The fitness program should include an education on maintaining oneself in good physical condition during both underway and in port periods. Being especially tough on new recruits during the service school period should establish good habits and high physical standards before a recruit ever reaches his first submarine. Submarine officers might also be expected to establish nothing less than the highest personal standards for physical fitness and to actively set the example for the rest of the crew.

To follow through on this program, fitness equipment including stationary bicycles and rowing machines should be added to the list of required equipment onboard all submarines. At present, it takes a few crew members who are fitness enthusiasts to purchase their own equipment and get permission from the Commanding Officer to carry such equipment on board. Most portable exercise machines can be easily stored for quick use. During an underway period, fifteen to twenty minutes of rowing on a portable rowing machine or pedaling on a stationary bike along with several rounds of push-ups and sit-ups is all that would be required to maintain a good standard of physical fitness, if done on a daily basis. Skipping an occasional meal should also help keep a crew member slim and more fit.

The submarine force is being short changed by not maintaining high standards of physical readiness for her submarine officers and men. There is thus a need to take positive steps to correct the crew's physical deficiencies.

Lieutenant W. J. Flynn, USN

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REMARKS BY VADM LAWSON P. RAMAGE, USN(RET.)

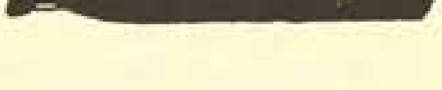
(at SubTraFac dedication of Ramage Hall
2 June 1989)

"On occasions like this I am always reminded that the man who is singled out for recognition has been supported by numerous officers and men of his commands, and they too, deserve recognition by association.

"In my case, I'd like to cite my Torpedo Officer (LT) Frank Allcorn. It was Frank's imagination and initiative that made it possible for us to reload torpedoes while in action. It was the secret of our success, and no question about it.

"In the case of our war patrol on the PARCHE, (*for which VADM Ramage received the Congressional Medal of Honor*) we quickly got in and sank two ships, completely unloading the forward tubes. But we still had work to do. There was still a big transport to be looked into. The problem was that we had to close to short range, and swing the stern tubes to bear, in order to be sure that we could get hits with the slow running electric torpedoes. We had more than our hands full. After two attempts to reach a suitable attack position, it had to be aborted because of enemy gunfire. About that time, Frank Allcorn came to the bridge and requested permission to reload two torpedoes forward. This, at that time, was considered complete heresy. It had never been attempted or even considered before because of the dangers involved. But he assured me that he had the bunks all cleared out of the forward torpedo room and the crew was standing by, ready to go to work. And on that basis, I gave him my permission. And within a short time, we had two reloads ready to fire and were able to drive straight in and get the third ship with no difficulty, leaving the escorts completely confused and bewildered.

"I cite this example because I want to emphasize the importance of imagination and initiative as essential to complete success, not only in combat, but in our everyday endeavors. I would like to suggest that these two watchwords become the criteria of this new training command, and that they will leave a mark on all those who pass through these doors.... Throughout my career, the two watchwords that I have cited -- imagination and initiative -- are certainly essential to good submarine operations."



HULL PROTECTION AGAINST UNDERWATER PRESSURE TRANSIENTS

The possibility of providing over-pressure protection to a submarine hull from an underwater explosion is well worth exploring. A finned design, it is observed, causes an incoming transient pressure wave to strike a submarine pressure hull at two different times due to the different speeds of sound in the fin and in seawater. The pressure wave interferes with itself, thus reducing the peak intensity of the incoming pressure wave when it impacts the submarine pressure hull. By causing a 50 microsecond "shifting" of the incoming pressure wave, the finned design proposed here causes a peak pressure of 61% of the original impacting peak pressure -- resulting in a reduction of 39%. This result hinges on the fins being of such close spacing that the effect of an impacting pressure transient is spread over the fin's base area and half of each adjacent water channel. Thus, a submarine hull covered with .1 meter long fins of steel can provide a passive means of reducing pressure wave transients on submarine pressure hulls due to underwater explosions. The reduced peak pressure results in increased survivability of the submarine, reduced lethal radius of enemy weapons, (reduced active sonar returns) and increased difficulty in conducting anti-submarine warfare against a submarine equipped with such a finned surface. (If not practical for large submarines, midgets might benefit.)

When a submarine is subjected to a pressure transient due to a nearby underwater explosion, it is this peak pressure which collapses the hull. If the pressure transient is spread over a longer time, then the peak pressure experienced would be reduced and the chances of survival for the submarine and crew improved.

In tests conducted by Woods Hole Oceanographic Institution for the U.S. Navy, the pressure profile due to an underwater explosion was recorded, the result of which is magnified in Figure 1.

The main points to note in the pressure profile are the short duration of the pressure transient (100 microseconds) and the even shorter duration of the main pressure excursion

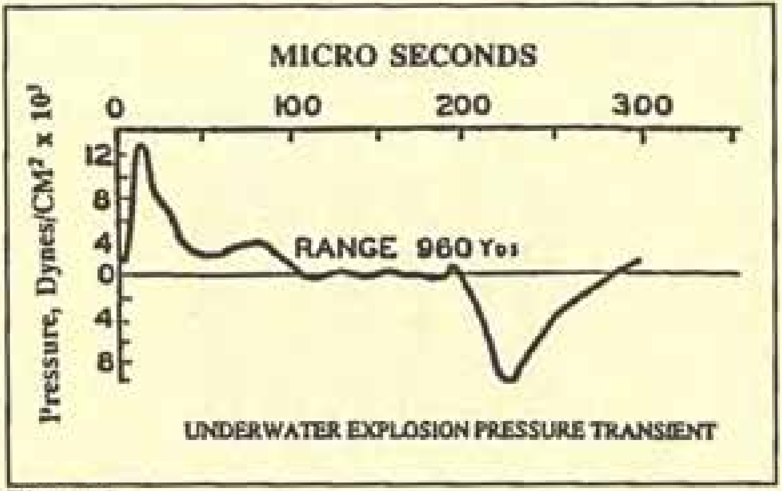


Figure 1.

(50 microseconds). The reduced pressure wave (seen as a pressure reduction below zero) that occurs at 200 microseconds after the initial transient response is the reflection of the pressure wave from the surface of the ocean and thus cannot be used to destructively interfere with the initial pressure transient.

If the initial pressure transient wavefront were to impact a submarine pressure hull at two times that are 50 microseconds apart, the effect of the transient is spread out. How does the pressure transient become split into two waves 50 microseconds apart? The different velocities of sound in different materials allows this to be done.

Figure 2 shows a very finely spaced fin arrangement (like the fins on an automobile radiator, only much more closely spaced). If this spacing is sufficiently small, a pressure transient in a fin impacting the submarine hull will affect an area of the hull immediately around the base of the area of the fin. If the base area of all the fins is equal to the base area of all the seawater channels, then the local intensity of the pressure transient will be halved due to the effect being spread over twice the area of the fin base (the base area of the fin and half the area of the two adjacent water channels.)

The speed of a pressure wave in a metal fin is much greater than the speed of the same pressure wave in seawater! This results in the pressure wave in the fin "racing ahead" of the

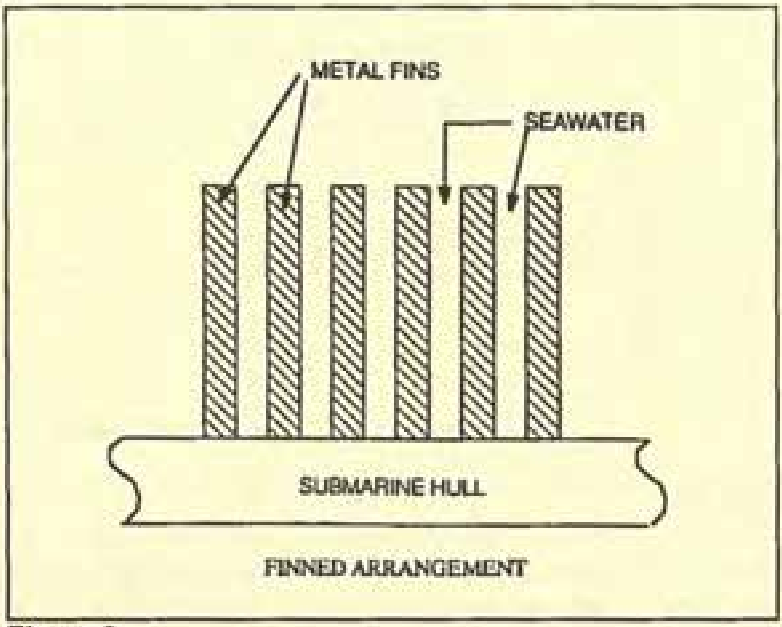


Figure 2.

same pressure wave in the seawater channel.

If the length of the fins were such that the pressure wavefront in the fins impacted the hull 50 microseconds before the same pressure wavefront in the seawater channel impacted the hull, the pressure felt by the hull would be a superposition of the two pressure wavefronts, as shown in Figure 3. The local intensity of the pressure transient will be halved due to the effect being spread over twice the area of the fin base.

Figure 3 shows that by splitting the pressure transient into two waves 50 microseconds apart, the peak pressure experienced by the averaged acoustic wave was $8x10^{-3}$ dynes/cm^2, whereas the initial peak pressure was $13x10^{-3}$ dynes/cm^2. Thus the peak pressure is reduced 39% by splitting up the pressure transient!

How long should the fins be in order to cause a 50 microsecond separation of the wavefronts? The velocities of sound in pertinent materials shows:

seawater	1531 (m/sec)
mild steel	5960 (m/sec)

Distance sound travels in seawater in 50 microseconds is .0766 meters.

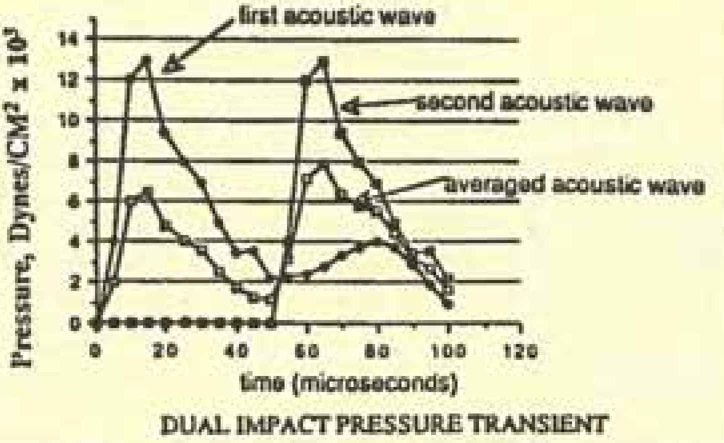


Figure 3.

The velocity difference between steel and seawater is 4429 m/sec. Time for wavefront in steel fin to get .0766m ahead of the same wavefront in seawater is 17.3 microseconds, calling for a steel fin .1 meters long to obtain a 50 microsecond separation between incoming pressure waves.

Summarizing, by using a steel finned arrangement of modest height (.1 meter) we can cause an incoming pressure wave to interfere with itself and produce a 39% reduction in the peak pressure experienced by the impacted surface. This result hinges on the fins being of such close spacing that the effect of an impacting pressure transient is spread over the fin's base area and half of each adjacent water channel.

The above concept can also be applied to the reduction of a submarine hull's echo return due to an active sonar search by an opposing platform -- by tailoring the length of the fins to cause destructive interference at the pressure hull surface causing an active sonar "ping" to be attenuated.

Jamie Hogan

[Ed. Note: This concept won an award for "technical excellence" in a student competition at San Diego State University.]

■

SMITHSONIAN SUBMARINE EXHIBIT

The Armed Forces History Division at the Smithsonian has asked the NSL for assistance in setting up their new Armed Forces Exhibit. This will be a rather modest exhibit and the submarine portion will be just a part of the overall Armed Forces display. A script has been prepared by the Smithsonian staff to tell the story of the development of the submarine in the United States Navy, from its first appearance in the Revolutionary War, through various stages to the present day nuclear submarines.

We will be assisting the Smithsonian by going over the text that they have prepared and advising of any technical inaccuracies, omissions or corrections which we believe would make a stronger and more complete description of the development of the submarine in the U. S.The museum has some models with which to provide a visual impact, but they are in need of others.

The purpose of this item in the Submarine Review is to send out a call for information about models which the membership might have or about which you might have some information and which would be available for temporary or permanent use by the Smithsonian. The donors or loaners would be identified and recognized by the museum as having contributed to the display through their gifts or the loaning of the item to the museum.

The NSL would like to develop a list of the models or items of historical interest concerning submarines which may exist (with their description, scale, location, availability, etc). This would enable the League to coordinate the use of the items, should their owners make them available for this current endeavor or the future more comprehensive endeavors contemplated by the NSL.

Initially, we are looking for the following models:

Turtle (Bushnell's)
R-Boat
Fleet Type
Guppy
Albacore
Nautilus
Skipjack
Permit
Sturgeon
Los Angeles
Ohio

As mentioned above, this display at the Smithsonian is a modest effort, but it does move toward filling a void in the history presented by the Smithsonian. We, the NSL, are also considering a future endeavor to develop a more comprehensive museum, dedicated to submarines and undersea warfare. To do this in cooperation with the Smithsonian would be the ideal way to reach the greatest number of our citizens with information about submarines, their technical development and their vital contribution to the defense of our nation. More on this will be forthcoming in future editions of the Review, as ideas are formulated into a plan of action.

Please write or call NSL headquarters with your information at:

Naval Submarine League
P.O.Box 1146
Annandale, VA 22003
Tel: (703) 256-0891

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IN REMEMBRANCE

Captain Robert J. O'Malia, USN(Ret.)
CRM(SS) Merrill P. Edson, USN(Ret.)

NAVAL SUBMARINE LEAGUE
Balance Sheet at March 31, 1989

Assets:		
Cash	$ 65,836.02	
Short term investments	155,000.00	
Furniture, equipment and software (net of depreciation)	24,055.86	
Prepaid expenses	3,710.54	
Total Assets		$248,602.42
Liabilities and Fund Balance:		
Current Liabilities:		
Deferred membership dues and contributions	$ 45,045.53	
Deferred advertising	12,500.00	
Total current liabilities		$ 57,545.53
Long Term Liabilities:		
Deferred membership dues and contributions	$ 37,963.65	
Total Liabilities		$ 95,509.18
Fund Balance		$153,093.24
Total Liabilities and Fund Balance		$248,602.42

Statement of Activity and Changes in Fund Balance for the year ended March 31, 1989

Revenues:		
Contributions/Corporate Support	$170,658.45	
Dues	24,876.25	
Symposium	76,188.51	
SubTech Symposium	20,000.00	
Interest	12,264.25	
Advertisements	24,460.00	
Other	2,651.10	
Total Revenues		$331,098.56
Expenses:		
Awards and grants	$ 4,164.75	
Operations	140,844.91	
Publishing	57,948.01	
Meeting "A"	5,921.99	
Symposium	77,342.72	
Chapter support	1,832.95	
Total Expenses		$288,055.33
Excess of revenues over expenses		43,043.23
Fund balance, beginning of year		110,050.01
Fund balance, end of year		$153,093.24

THE HUMAN-POWERED SUBMARINE RACE

[*Ed. Note: This letter provides additional details concerning the submarine race which was described in the July issue of the REVIEW.*]

On 23 June, the First International Human Powered Submarine Race was held off Palm Beach, Florida. Eighteen 2-man submarines were on hand to compete on race day. They represented universities and industry. The entries, in order of their assigned hull numbers, were: 1 - Tennessee Technological University/IMAGINEERING, Inc., 2 - University of New Hampshire, 4 - Lockheed, 5 - Sub Human Project, 6 - Benthos, 7 - Innerspace Corp, 8 - U.S. Naval Academy, 9 - MIT, 10 - Florida Institute of Technology, 11 - Sea Scapes Aquariums, Inc., 12 - David Taylor Research Center, 13 - Applied Physics Laboratory-University of Washington, 14 - Florida Atlantic University, 15 - University of California-Santa Barbara, 16,17,18 - Cal Poly (3 entries) and 19 Florida International University.

The rules were oriented mainly toward safety considerations. Briefly, they were as follows: Subs were to be flooded, with two persons on board with SCUBA air sufficient to complete a one kilometer course. There was one person for power, the other to navigate. No stored power was allowed. Subs had two pounds positive buoyancy and towed a surface buoy. These rules allowed for considerable innovation and resulted in a great diversity of ideas. Awards were made based upon three criteria: speed, cost and innovation with the grand prize being $5,000. It was a "fun" event with a real competitive spirit all around. A cooperative air prevailed since there was a sharing of talent (and spare parts) amongst the various teams both before and during race time.

The original idea was to have a series of single elimination races between paired subs as a result of their timed 100 meter time trials. The poor weather experienced ultimately reduced the competition to running the 100 meters individually. This was no mean feat. Only eight of the entries were able to do it successfully. The main problem was that the currents were variable with strong shear components. Those attempting to run during the 2.5 knot window were generally less successful than those lucky enough to run during times when the current was a knot or less. The major contributing factor, however, was the realistic training time the various teams were able to put in prior to race date. The Naval Academy team was head and shoulders above the rest of the subs in this regard. It clearly showed as the midshipmen walked away with the honors. Others had a variety of technical problems such as controllability, visibility and breakdowns which precluded their finishing the run or even getting off the starting line.

The course was about 200 meters off the beach with its main axis running north and south. The 100 meter portion was near the shore where the depth was between six and seven meters. The task was to run this portion southward against the current through the starting point after the sub had been pointed in the right direction and given the starting signal. Two navy divers were stationed ahead of the starting buoy and their task was to position each sub near the bottom and get them started south. A surface boat followed each sub along the route for safety and two divers were at the finish to help the crews exit. Bottom markers were laid out every six meters with highly visible vertical members. It would seem a trivial task to complete such a run -- but not so. Variable bottom currents conspired against those whose designs were lacking in adequate control and at least one crew backed out because of sea sickness. Bottom contact was a frequent occurrence as was screw entanglement with buoy lines. Few entries, other than the Naval Academy's had adequate screw protection, and this proved to be a costly omission for many of the subs and not to be repeated by the entries in '91. MIT's screw was bent double at the starting buoy line. Provision for adequate visibility, especially downward and forward was a must and several subs lost their way shortly off the start line. The University of New Hampshire entry was practically all plexiglass as was Cal Gongwer's Innerspace Corp entry while others were severely limited in adequate visibility. Underwater visibility varied between 4 and about 12 meters, depending upon current and cloud cover.

Although other entries had higher top speed than the Midshipmen's entry, Navy's overall ranking was first because of their scoring in other judged categories.

Well done NAVY!!! See you again at the starting line in '91.

Ted Haselton

■

DEPTH CHARGE DAMAGE - A QUESTION OF SIZE

In "The Menace of the Midgets" in the April, 1989 edition of the SUBMARINE REVIEW, it was noted that small submarines were not as likely to be damaged by depth charges since the whip effect is effective primarily on the larger submarines. I wonder if this can be extended further to very large submarines, such as the Soviet TYPHOON. The double-hulled construction of submarines is thought to render them less vulnerable to damage, but would this be offset by the submarine's much larger size? I would be interested if some smart engineer had the answer to this.

Wiley Livingston

■

HISTORY OF REGULUS I and II

I am in the process of researching and writing the history of the Regulus I and II guided missile submarine program. What I would like is for former Regulus I and II crew members interested in being interviewed to contact me.

I have been able to find only scant information concerning the history of the design of these weapons, typical launch procedures, operations of the various submarines for both the Regulus I and II or as the system was retired, the disposition of the various submarines other than conversion to troop carriers. I feel that a comprehensive history of the Regulus program would be a valuable addition to the evolution of the strategic (nuclear) forces of the U.S. Navy.

David K. Stumpf, Ph.D

■

IS THE SUBMARINE REVIEW A MAGAZINE FOR THE SUBMARINE PROFESSION?

Current submariners apparently feel that Tom Clancy's allegations that nuclear power safety comes first on our submarines rather than the submarine's warfighting capability is a bad rap from a "writer of fiction".

They also seem to feel that there is a public perception that a large number of the skippers of our nuclear submarines overemphasize the importance of nuclear power for their career enhancement. But this perception, they feel, is wrong because basically our "nukes" are superb warfighting submarine professionals -- and "warriors" to boot.

If this be true, the submariners aboard our nuclear submarines should have a high interest in their profession -- one which deals with the art of submarining. They should therefore be steady readers of THE SUBMARINE REVIEW, a quarterly which is the only publication slanted toward their profession and its betterment. However the question arises whether our submariners read THE SUBMARINE REVIEW.

The SUBMARINE REVIEW needs the interest and participation of all submariners and deserves their attention and support. The Naval Submarine League and THE SUBMARINE REVIEW exist mainly to support the active duty submariner and the submarines upon which they serve.

Ironweed

BLOOD FOR AARON THOMAS

There is hope that Aaron Thomas can win in his battle for survival! He has been able to visit his grandmother in South Carolina, and is camping with his father and younger brother this week.

Due to a series of events, Ross and I will be out of the country for several months. Chief Spatz, Blood Donor Services, National Naval Medical Center (NNMC), Bethesda, MD, has accepted administering our present list of some 60 volunteers for Aaron's bank of blood donors. His telephone number is 301-295-1737.

Aaron needs whole blood, Type "A". He also needs platelets. Therefore, it is important to have a large pool of donors. This is where your name on a list is important. In case of critical need you may be called individually. Blood type is immaterial for platelet donations. This is highly desirable in Aaron's case, as he needs a constant source of platelets.

Those wishing to be donors for whole blood or platelets, contact the Pheresis Clinic, (301) 295-2105. The clinic uses an appointment system. The procedure for whole blood requires about one half-hour while the procedure for platelets requires about two hours.

In Aaron's name, we thank all prospective and actual blood donors to date, and applaud how the submariners look out for their own!

Helen J. Williams

[*Ed. note: This is a follow-up letter to one that appeared in the January 1989 issue of the REVIEW. Aaron Thomas is the nine year old son of FTBCS(SS) Edward J. and Theresa Thomas. He has leukemia. Ross and Helen Williams have volunteered to act as coordinators with the Blood Bank and the Thomas family.*]

■

IN THE NEWS

o The Washington Post of 18 July reported that a Soviet submarine of the ALFA-class had surfaced 30 miles north of Kola Bay, pouring white smoke out of its conning tower. Norwegian observers believed the sub had a fire on board. The Soviet explanation of this incident was that a "reactor's emergency warnings were activated" causing the sub to shift to its batteries, but that a short circuit caused a further shift to the diesel engines "which caused the exhaust." With a Soviet ship as escort "the submarine headed to home base under its own power."

o Navy Times reports that two serious cracks in the SSN TOPEKA were found during its construction "forcing Electric Boat to replace part of the submarine's steel hull."

The cracks on the outer hull were discovered during sand blasting operations. "Construction of the TOPEKA (SSN 754), ordered by the Navy in 1983, was begun on January 22, 1988, and she is to be commissioned September 30, 1989."

- <u>NAVY NEWS & Undersea Technology</u> of 1 May reported that "during this Spring's budget battles, the Navy offered to give up two future TRIDENT missile submarines and one SSN-21, to meet President Bush's budget target." But that, Defense Secretary Cheney had "rejected the submarine sacrifice and instead cut one 688-class submarine from the procurement for the next two years."

  In an additional article, it is reported that the House Seapower Subcommittee had "questioned the need to build one TRIDENT submarine per year." Chairman Charles Bennett said, "when we started the TRIDENT program, people talked about six ships, then 10, now it's 18. There's got to be a limit somewhere. This is stealing money from other things." Yet, another member of the subcommittee in a letter to the President said, "In a post-START environment, we'll have too many missiles on too few boats." But Chairman Bennett said, "To produce things we don't need and not things we do, is idiotic. The present (building) rate exceeds the numbers of TRIDENTs we need."
- <u>Defense News</u> of 24 July 1989, summarized the Soviet's trends in production of military systems in Mr. Gorbachev's so-called "glasnost" era -- relative to U.S. programs. "Soviet production of submarines decreased from ten in 1983 to nine in 1988 while the U.S. was averaging five per year over the same period. Since Gorbachev came to power the Soviets have produced 34 submarines, the U.S. 15, and the gap will almost certainly increase over the next few years." Then, during Gorbachev's tenure and despite Soviet emphasis on nuclear arms control, the Soviets have produced 450 ICBMs while the U.S. produced only 56. "The Soviet production of long range sea-launched cruise missiles has increased from 150 in 1983 to 300 in 1988 while production of U.S. missiles went from 40 to 280. The Soviet production of short range cruise missiles was 800 in 1988 as compared to a U.S. production of 400. Such disparities raise serious

questions about the long-term impact of the resulting gap on Western security. The West needs to be far more cautious about Mr. Gorbachev and glasnost than it has been to date."

- o NAVY NEWS & Undersea Technology of 19 June reports on a study, "Submarine Warfare in the Arctic: Option or Illusion?" by Mark Sakitt of Brookhaven National Laboratory. In this study Sakitt says: "The Arctic naval game seems to be one in which the defenders, the Soviets, can dominate." If U.S. SSNs try to destroy Soviet SSBNs, "the U.S. forces must remain passive in their sonar tactics since any information about their presence will lead to coordinated attacks from the numerically superior Soviet forces. The Soviets have the option of using active sonar with low-value targets supplying the signals. Given this asymmetry, noisemakers can tilt the scales in favor of the active searchers by reducing the ranges at which passive sonar can be effective for U.S. SSNs." Sakitt also sees the Soviet mining of the northern and western approaches to the Barent Sea as giving Soviet SSBNs a distinct defense advantage.
- o The Washington Post of 17 August has an article by George C. Wilson on setbacks to two major military weapons. He describes the TRIDENT II missile tests, noting that in the first three firings at sea there had been two failures causing the operational deployment of this weapon to be delayed past the originally scheduled December 1989 date. The second failure on 15 August was believed to be due to a malfunctioning of the steering nozzle -- as it had been in the first failure. In the land tests there have been 16 out of 18 successful firings. It was noted that "the House Armed Service Committee has cited the D-5 as a model development program."
- o NAVY NEWS & Undersea Technology of 12 June tells of a study, "Implications of Advancing Technology for Naval Warfare in the 21st Century," done by the Naval Studies Board of the National Academy of Sciences. This "Navy 21 Study" made some interesting recommendations for submarines and their weapons; "A large number of missiles must be acquired for a full inventory in case of a 'come as

you are' war;" "Acquisition must begin for a new class of submarine equipped with a large number of missiles;" "R and D should be concentrated on, for example, unmanned underwater vehicles, and smart torpedoes and mines."

The study calls for development of a new class of American submarine, a missile-carrier or SSGN. It should be armed with "several hundred long-range missiles for land attack, anti-air warfare, anti-satellite missions, anti-ship strikes, and even launch of satellites."

Strategic submarines (SSBNs) will be increasingly important for nuclear deterrence, because land-based systems will be increasingly vulnerable. He said strategic ASW "won't catch up enough to make SSBNs vulnerable although security around ports needs to be solved. It needs a lot of attention."

Because satellites can monitor ship movements "in almost real time, there won't be any non-combat zone," especially if tactical ballistic missiles are developed.

If the Navy proceeds as the study outlines, a longer fraction of the budget should go to space systems for battle management command, control, communications and intelligence.

o A note in the 21 May NAVY NEWS & Undersea Technology says that twice in two years, new nuclear submarines have had to return to port for repairs to their reduction gears. In late May the HELENA (SSN 725) was towed back to Pearl Harbor because of reduction gear failure, and in June 1987 the NEVADA (SSBN 733) had to return to port after "emergency repairs were performed at sea on its reduction gears." The actual cause of these failures has not been pinpointed.

o Defense News of 19 June tells of a fiber-optic magnetic field sensor that could be used in sonobuoys to possibly double their detection range of submarines. It would also give sonobuoys a dual-detection capability. This magnetic anomaly detection system is a good fall-back system for use against low-level submarine sounds. The magnetic field sensor "is not without problems since temperature changes tend to create too much noise in the system."

o PATROL of 23 June records that the USS NEWPORT

News (SSN 750) on 3 June was the latest addition to the U.S. Submarine Fleet. When it was commissioned it became the 99th SSN addition to the Fleet.

- o The Washington Post of 12 July, in an article by Andy Rose, tells of a tabulation of 42 collisions world-wide involving U.S. submarines, since 1983. Information obtained from the Navy in accordance with Freedom of Information Act requests, identified "five incidents involving fishing boats that were dragged or sunk;" "Submarines collided with other Navy ships at least 28 times -- including five with other submarines, one with a destroyer and 15 with Navy tugboats; an additional 13 collisions involved "objects" such as mooring buoys, piers and markers. This story was developed after the SSN HOUSTON on 14 June snagged the towing cable of the tug BARCONA off Long Beach, and pulled it under.
- o A book review of *Sabotage at Black Tom* by Robert L. Benson tells of the German submarine assists of German saboteurs in America before the entry of the U.S. into World War I. On Sunday, 30 July 1916, shortly after midnight, the saboteurs blew up the munitions depot of Black Tom Island which faced the Statue of Liberty at New York's harbor entrance. "Thirteen huge warehouses were leveled and six piers destroyed. These assaults on neutral America (perhaps as many as 200 acts of sabotage were committed against factories, ships, bridges and canals) were combined with covert operations designed to embroil the United States with Mexico and led to the U.S. declaration of war against Germany."
- o On 16 July a fire broke out on an ALFA-class sub off Norway and a Soviet tug proceeded to tow it back to port. It was the third time in less than four months that a Soviet nuclear submarine had been involved in an incident off Norway. In April, the MIKE-class submarine had caught fire and sank in the Norwegian Sea, and on 26 June an ECHO-2 class missile sub caught on fire and leaked small amounts of radiation. However, "water tests conducted by Norway showed no significant traces of radiation."
- o NAVY TIMES of 10 July tabulates the selection opportunity of submariners and other unrestricted line officers to the rank of Commander. 81 out of the 99

LCDRs in the zone were selected for Commander for an 81% selection opportunity -- which is far better than for other unrestricted line officers. The aviators had a 59.9% selection opportunity and the surface officers had a 61.9% opportunity. In addition, one submarine LCDR above the zone and 12 below the zone were selected.

o Defense News of 3 July tells of Navy research work at the Navy research center at Annapolis on a "front wheel-drive propulsion system for the next generation of submarines. The system pulls the sub through the water rather than pushing it. Captain Charles Graham, in charge of the project says: "What we want to do is put a pod up forward with a propeller facing forward so a rich hydrodynamic flow comes right into the propellers, thus reducing the cavitation. The system may be tested by the middle of the next decade, according to the researchers involved.

o NAVY NEWS & Undersea Technology of 24 April tells of Robert Moore's testimony to the Congress on DARPA's advanced research projects and recommendations as to how to maintain the superiority of U.S. submarines over those of the Soviets. In his 11-page statement he lists six specific ASW areas in which his agency is working to enhance American capabilities: as to passive acoustic arrays, "we think that large two dimensional arrays may buy back a portion of the performance that we stand to lose;" on active sonar, he commented, "we have developed a new theory pertaining to ocean noise for a cost effective technology for very powerful low-frequency active sources;" DARPA has "begun to test a new non-acoustic ASW system which has high potential." Moore notes that DARPA is developing: automated acoustic detection technology which adequately processes the environmental and shipping noises; "smart" processors with neutral nets to automatically detect non traditional signals; DARPA is asking $28m to develop unmanned undersea vehicles; and a final project for automated contact prosecution which should involve aerial delivery of an ASW weapon with autonomous re-localization of a submarine at the end of flight. An additional research project approved by DARPA for the SSN-21 was composites for the propulsor. Moore says, "That gives us a significant noise reduction, as well as eliminates about 30% of the mass in the aft end of the submarine."

o At the dedication of Ramage Hall, Submarine Training Facility, Norfolk, June 2, 1989, Vice Admiral Roger F. Bacon, USN, Commander Submarine Force U.S. Atlantic Fleet, had the following remarks:

> What makes a submarine? "Despite a massive technological evolution, many of the fundamental principles of submarine warfare forged in the fire of combat ... have clearly stood the test of time: principles like remaining undetected, shooting first, maintaining propulsion, knowing your boat, and how to fight 'hurt'. Now, as then, we recognize that it takes men -- the crew -- to master those principles, to make a submarine come alive: men who possess the technical skill and courage to operate for days, weeks and months on their own; men who can confront the hazards of the deep willingly, with trust in their own skill and in the excellence of their people and their ship."

■

BOOK REPORTS

SILENT CHASE

By Steve and Yogi Kaufman, Thomasson-Grant, Inc., Charlottesville, VA. 160 pages. Forward by Tom Clancy.
ISBN: 0-934-738-38-6

The Chinese proverb, "one picture is worth more than 10,000 words" aptly fits the description of this color-photo treatise. It is a fine tribute to our present submarine force and to the men and women who man and support the submarines. The framing, lighting, color quality and definitive exposures surpass any still-photographers' works this reviewer has seen.

Many volumes have been written about the exploits of captains, their submarines and crews. Both world wars have been covered by fiction and non-fiction authors and photographers, depicting life aboard most sub types since the days of the "pigboat." None have brought home to the reader with more realism and accuracy the modern submariner, as shown in this elegant work. The slices of life featured by this father and son team point up their creative talents and the well planned and directed "shoots" undertaken.

With 30 years of sub service under his belt, Vice Admiral Robert Y. "Yogi" Kaufman, USN(Ret.) was able to tap navy contacts heretofore untouched, so the public could see firsthand what life is like as a submariner. Now a prolific natural history photographer, he and his son Steve, an outdoors photographer, took one year and thousands of shots to produce the dramatic results in this book.

Photo sessions take the reader across the Atlantic to bases in Holy Loch and La Maddalena; to New London and Groton; south to Norfolk, Charleston and Kings Bay; to homeports in San Diego and Pearl Harbor; and up the west coast to the Trident facility in Bangor. Major sections of the book deal with "Attack Subs" and "Missile Subs." The mix of exterior and interior shots is well balanced. Other visuals highlight DSRVs, TACAMO, Diver Special Ops, VLF Station, Maryland, Explosive Handling Wharf and Magnetic Silencing Facility, Bangor, and one of our remaining diesel boats, USS Blueback.

The text has been written in the first person and is interspersed with the photographic shots. You'll read the reflections by a CO, XO, COB, Torpedoman, Quartermaster, Sonarman, Weapons Officer, Cook and others. Their observations make for interesting and informative reading.

In his introduction, Yogi Kaufman relates how he came to choose a career in the Navy. It boiled down to seeing three navy films: "Flirtation Walk," "Shipmates Forever" and "Navy Blue and Gold." If the Chinese proverb about a picture being worth 10,000 words is correct, the Submarine Service will reap many a future recruiting benefit. This book should prove to be the inducement for a lot of young men to join the ranks, as were those Hollywood features for the Admiral.

With all those extra shots Yogi, how about a sequel?

Larry Blair

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TORPEDO JUNCTION

by Homer H. Hickman, Jr.
Naval Institute Press, Annapolis, MD
ISBN: 0-87021-758-5

This narrative description of the U-Boat war off the East Coast of America in 1942 is told in a fast moving style that captures the essence of the battle from all points of view. Mr. Hickman has traced the plan and the execution of Admiral Doenitz's effective interdiction of the vital sea lanes along the east coast of North America and the Gulf of Mexico in such a manner as to put the reader right into the fray. His exhaustive research into the records kept by all parties involved is evidenced by the detail of the encounters between the U-Boats and their victims and between the U-Boats and their opposition. Much to the joy of the German submarine crews and the High Command, the opposition was found to be nil in the earlier stages of this daring war carried out by a handful of submarines, in an arena of seemingly unending targets.

The reader finds himself engulfed in the emotion of the encounters, feeling the exhileration of the U-Boat commanders as they managed to attack and sink ship after ship, by torpedo and gunfire, and come away unscathed; and also feeling the frustration of the U. S. Navy and Coast Guard officers and men who were unable to stop the destruction of our merchant fleet and the allied ships which sailed the coastal waters. One finds himself at once in the cramped spaces of the U-Boat calculating the attack and on the bridge of a small but gallant Coast Guard cutter, battling the unrelenting seas in an all but futile attempt to locate the enemy, lurking below.

This is the story of those ships at sea; the submarines bent on destruction of the shipping so vital to the allied war effort, and the American and British counterforce, such as it was. It is the story of the men who manned those ships, on both sides of the contest. And it is the story of the leaders who sent the combatants to sea to fight the battle. The author has not only searched the records of this period, to bring the facts to light, but he has also interviewed many of the actual participants - from the admirals to the radiomen, from the seamen to the masters of the ships that were the victims of the relentless undersea menace, some of whose operators were also interviewed. The politics of war are shown as well as the battles. One witnesses, through the telling of this history, the frustration of Rear Admiral Adolphus Andrews as he was given a job to do with few assets with which to carry it out. But we also see the determination of this same admiral to fight for the forces necessary and the final victory that comes when the forces are eventually brought to bear.

For some, this saga of the war at sea, the ships, the names, the locations such as Hatteras, will stir memories of that war and their own experiences. For others, it will provide a vivid history of the havoc wrought by the U-Boat and tragic loss of ship and life that resulted during this period in the 'American Shooting Gallery'.

G. L. Graveson, Jr.
Captain, USN(Ret.)

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MEMBERSHIP STATUS

	Current	Last Review	Year Ago
Active Duty	918	934	918
Others	2883	2897	2774
Life	166	169	158
Student	25	23	31
Foreign	52	54	39
Honorary	20	14	10
Total	4064	4091	3930

HAVE YOU GOTTEN 2 NEW MEMBERS FOR 1989?

NAVAL SUBMARINE LEAGUE
HONOR ROLL

BENEFACTORS

1. ARC PROFESSIONAL SERV GRP, DEFENSE SYS
2. AT&T
3. ADVANCED TECHNOLOGY
4. ALLIED-SIGNAL, ELECTRODYNAMICS DIVISION
5. AMERICAN SYSTEMS CORPORATION
6. ANADAC, INC.
7. ANALYSIS & TECHNOLOGY, INC.
8. APPLIED MATHEMATICS, INC.
9. ARGOSYSTEMS, INC.
10. ARGO-TECH CORPORATION
11. ARGUS RESEARCH CORPORATION
12. BBN SYSTEMS & TECHNOLOGIES CORPORATION
13. BABCOCK AND WILCOX COMPANY
14. BATTELLE MEMORIAL INSTITUTE
15. BELL AEROSPACE TEXTRON
16. BENDIX OCEANICS DIVISION
17. BIRD-JOHNSON COMPANY
18. BOEING AEROSPACE COMPANY
19. BOOZ-ALLEN & HAMILTON, INC.
20. CAE/LINK TACTICAL SIMULATION
21. COMPUTER SCIENCES CORPORATION
22. CONTEL FEDERAL SYSTEMS
23. CORTANA CORPORATION
24. DAEDALEAN, INC.
25. DATATAPE, INC.
26. EDO CORPORATION
27. EG&G SEALOL ENGINEERED PRODUCTS DIV
28. EG&G WASCI
29. ELECTRIC BOAT DIV OF GENERAL DYNAMICS
30. ELIZABETH S. HOOPER FOUNDATION
31. ESSEX CORPORATION
32. FMC CORPORATION
33. FOSTER-MILLER, INC.
34. GE AEROSPACE
35. GE GOV'T ELECTRONIC SYSTEMS DIVISION

36. GENERAL DYNAMICS/UNDERSEA WARFARE CTR
37. GENERAL ELECTRIC MARINE & DEFENSE FSO
38. GENERAL PHYSICS CORPORATION
39. GLOBAL ASSOCIATES, LTD.
40. GNB INDUSTRIAL BATTERY COMPANY
41. GTE GOVERNMENT SYSTEMS CORPORATION
42. HAZELTINE CORPORATION
43. HONEYWELL, INC.
44. HUGHES AIRCRAFT COMPANY
45. HYDROACOUSTICS, INC.
46. IBM CORPORATION
47. IMI-TECH CORPORATION
48. INTEGRATED SYSTEMS ANALYSTS
49. INTERSTATE ELECTRONICS CORPORATION
50. JAYCOR
51. KAMAN AEROSPACE CORPORATION
52. KOLLMORGEN CORP ELECTRO-OPTICAL DIV
53. LIBRASCOPE CORPORATION
54. LOCKHEED CORPORATION
55. LORAL CONTROL SYSTEMS
56. LORAL SYSTEMS GROUP
57. L. Q. MOFFITT, INC.
58. MAGNETIC BEARINGS, INC.
59. MARTIN MARIETTA BALTIMORE AEROSPACE
60. NATIONAL FORGE COMPANY
61. NEWPORT NEWS SHIPBUILDING
62. NOISE CANCELLATION TECHNOLOGIES
63. NORTHROP CORPORATION
64. PACIFIC FLEET SUBMARINE MEMORIAL ASSOC.
65. PEAT MARWICK MAIN & COMPANY
66. PLANNING SYSTEMS INC.
67. PRESEARCH INCORPORATED
68. PURVIS SYSTEMS INCORPORATED
69. QUADRAX CORPORATION
70. RADIX SYSTEMS INCORPORATED
71. RAYTHEON COMPANY SUBMARINE SIGNAL DIV.
72. RES OPERATIONS, PHYSICAL DYNAMICS INC.
73. RIX INDUSTRIES
74. ROCKETDYNE DIVISION/ROCKWELL INT'L.
75. ROCKWELL INTERNATIONAL CORPORATION