THE SUBMARINE REVIEW
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PAGE

FEATURES

ARTICLES

REFLECTIONS

BOOK REVIEW

A Quarterly Publication of the Naval Submarine League

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EDITOR'S COMMENTS

This October '96 issue of THE SUBMARINE REVIEW tries to reach a broad range of interests, from the geo-political-military, through the Euro-scientific and the combined-historical to logistic-financial. In all of that hyphenation, of course, are issues of real concern which are addressed from viewpoints perhaps not as familiar to our readers as the way we normally approach subjects of concern.

The features section has two pieces by Admirals who are, or have been, the highest ranking submarine officers in their respective Navy. Their words represent high-level interest in, and fundamental policy for, the subjects they discuss; therefore, they warrant close reading to get the full meaning. Admiral Carl Trost pays a tribute to retiring Admiral Bruce DeMars, and to the importance of his work over the past eight years. Admiral Gorbunov of the Russian Navy pays a tribute to the history of his service over the past 300 years, and also defines the goals for the future of the Russian Navy and its submarines.

Rear Admiral Ed Giambastiani's presentation to the Annual Naval Submarine League Symposium in June is one of the features and it also addresses the future of US submarines, in both broad terms and specifics. In addition, Captain Mike Feely, the Submarine Detailer, reports on the status of several issues impacting on the officers operating those submarines. Three copies of each issue of this magazine go to each ship and activity of the Submarine Force. About seventy copies reach the Naval Academy and each NROTC unit gets one. Every submarine officer, and each prospective submariner, therefore has the opportunity to read the latest about pay and promotion.

This issue carries the second part of Jerry Razmus' article on SSBN security and the program which is the model for force evaluation and improvement. As the World War Two veterans and history buffs read Jerry's accounting of this latter-day success story, they may well harken back to the days of Admiral King's Tenth Fleet when his Chief of Staff, Admiral Low, from one room ran the intelligence, operations, evaluations, and developments for the Atlantic battle against the U-Boats. As to the submarine operations of that war, do not miss the tale of FLIER, and how what one does not know can really hurt. There is also Dick Boyle's piece about a great torpedo shot by a British skipper in the Mediterranean campaign. One wonders if, with the advent of very sophisticated torpedoes and fire control systems, the quick response bow-and arrow snap shot remains the mark of a combat ready submarine. Perhaps some of the Commanding Officers of today's finest would care to comment.

Air Independent Propulsion is certainly a submarine subject much discussed in terms of what it bodes for the future. We have Hans Saeger's presentation of the German view which centers on a diesel engine-fuel cell combination, and we can compare that with Pelle Stenberg's Swedish side of the story with Stirling engine plants. There are many issues of development and support to be resolved before deciding which is the better concept, but it is certain that practical air-independent submarine propulsion--of some power capability--is just around the corner. What that will mean for future "Desert Shield/Storm" overseas movements should become obvious to all those who wish to keep advanced ASW on the back burner.

Last, but not least, there is a review of the latest Jane's Fighting Ships done by the staff of **THE SUBMARINE REVIEW**. The emphasis, of course, is on submarines and what the order of battle numbers tell us about were the world is going and who is driving the trends.

Jim Hay

FROM THE PRESIDENT

During the last July Fourth weekend SEAWOLF completed her first sea trials with exceptional results; and Admiral DeMars was effusive in his praise for the performance of both the ship and the crew. The following is quoted from a letter he wrote:

> "This sophisticated ship represents an enormously complex and long term undertaking. Design characteristics were approved and initial design work started 13 years ago. Nuclear propulsion plant component fabrication began in 1987 and ship construction commenced in 1989.
>
> The importance of SEAWOLF transcends the three-ship class. While these ships will add significantly to our nation's undersea superiority, the technology developed for SEAWOLF is even more important. These advances—including stealth, propulsion plant power density and combat system capability—have moved our submarine

technology to a new level. This investment continues to pay off with its incorporation into the New Attack Submarine."

In early September, USS CHEYENNE (SSN 773) was commissioned. It was the last of the 688 class (in this case 688I) to be built by Newport News which, at this time, has no submarine under construction. At Electric Boat there are still one 688I and one Trident under construction; EB also is the builder for the three authorized Seawolf class submarines.

On the other side of the equation, since 1990, 34 attack submarines have been decommissioned and by the end of 1997 14 additional will be retired.

The fact is, the number of operating attack submarines will, in the next three years, drop below the Bottom-Up Review level of 55 which was derived just three years ago. As this publication is printed, the 1997 Authorization and Appropriations Bills are being completed and the program which has been under discussion over the last two years, possibly four *prototype* submarines starting in 1998 and then a decision on a new class (with many opportunities for mis-step and *mischief* 'tween here and there), is still extant.

As we strive to understand these actions, attempt to ensure that all the NSL members are fully cognizant of the facts and ramifications, and support the Submarine Force in an educated way, this publication, the symposia (classified in May at APL, and unclassified in June in the Washington area), and the chapters will promulgate the latest information we can assimilate.

An unusual but fascinating article which Jim Hay has received for this edition commemorates the Russian Navy's 300th birthday. It was written by the senior submarine officer in the Russian Navy. I commend it to you.

In the next edition we will attempt to have the best interpretation possible of the Congressional actions both from the Bills, hopefully signed by the President, and from the various *reports* which are promulgated by the two Appropriations Committees, the two Authorizations Committees, and the two Conference Committees. These reports will usually have more impact and information than the Bills themselves.

The next several years are critical to our Defense Department, our Navy and our Force. I strongly encourage your informed participation.

Dan Cooper

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A TRIBUTE TO ADMIRAL DEMARS AND NAVAL REACTORS

Remarks at the Annual Symposium June 6, 1996

by ADM C.A.H. Trost, USN(Ret.)
Former CNO
Past Chairman of the Board
Naval Submarine League

I have an opportunity this evening to recognize another one of our members and his achievements over the years. We had an opportunity earlier today to pay tribute to Admiral Mike Boorda, our recently departed CNO, for his very strong support and active interest in the submarine program before Congress these past several years. We also have a chance to recognize the fact that COMSUBLANT, Vice Admiral George Emery, is attending his last of these functions as an Active Duty Naval Officer. He will be relieved shortly and will be retiring. We hope we don't lose you, George, as a strong and active supportive member, which you certainly have been.

My real purpose tonight is to say just a few words about Admiral Bruce Demars. Bruce will retire in October of this year after eight years of service in the NR organization. I never know exactly what the right title is, but it's either Division of Nuclear Reactors, or Director of Nuclear Propulsion, or whatever. But he presides over the organization and he has done so, very successfully, since 1988.

Bruce, I went to the stats. When you took over, and I was still on active duty, there were five nuclear powered aircraft carriers, including one with eight reactors, there were nine nuclear powered cruisers, 97 attack submarines, and 36 missile submarines. I counted that up in my mind and that's about 167 reactors. Now based on your most recent testimony to the Congress, we are down to only 130 operating naval nuclear plants. That doesn't include any of those which are in the shipyard not yet commissioned or authorized and not yet built.

To put that in perspective, for those of you who may not be familiar with it, there are 109 reactors operating commercially in the United States. So the number that are under Bruce's control, and are his responsibility, exceeds by 20 percent those in operation in commercial service in this country.

Bruce's responsibility matches the combined total of power generating reactors in France, the United Kingdom, and Japan; the three countries who have the largest proportion of their electricity governed by nuclear power. Again putting it in perspective, during this time Bruce has seen us reach a milestone of 4600 reactor years of operation by nuclear propulsion plants owned and operated by the Navy. All of the commercial plants in the world have operated just about that amount of time. We have never had an accident or incident in the Navy which threatened the health of the crew or the general public in this country or anywhere else in the world. Why? Because this organization, headed by Bruce for almost eight years, and by Admiral Ken McKee, one of our members, and before them headed by that gentleman whom you've heard of as Hyman George Rickover for the balance of the roughly half century that we're talking about, has always had as its hallmark *excellence*. Excellence in technical design, excellence in construction, excellence in testing, excellence in operation based on excellence in training and demanding it from the people in our business. People say it's too tough, too demanding, too expensive. This guy's too powerful. He is responsible for all of this and he controls it. I know we have a propensity in this country to tear down things that work, but here is something that really works.

Now think of the consequences. Can you imagine how many ports we could enter, our own or foreign, if we have a serious accident with one of our nuclear propelled ships. It would be a disaster from that perspective, or the perspective of readiness of the United States Navy to meet its requirements and its responsibilities around the world. It would also very possibly be very negative with its impact on people, whether they were within eight feet or in the vicinity, regardless of nationality, who might be affected by it. **We can't afford it, our hallmark is safety. We have to continue our demands for excellence.**

Someone said in the aftermath of Mike Boorda's death, and I'm sure he'd disagree with it, that we are too demanding. I would agree that *zero defects* has its place and there are places where you don't want it. This is one place, ladies and gentlemen, where we want it to continue, and it has to, and it has been under Bruce's leadership.

I have also read, over the last couple of months, several articles that annoyed me, and because I can't write very well, I don't write letters to the editor as often as I would like. Besides, they don't usually print my letters. But I have seen a lot of things that said here, once again, is the time for change. I saw this once before, because I'm getting to be an old man, in terms of age, and not otherwise, I saw it when Admiral Rickover was being retired. I saw it when it was time for Kin McKee, who had decided to step down, to be relieved, and we nominated Bruce. People said we have got to downgrade this organization because there is a four star who works for a three star at NAVSEA and that doesn't make sense. Of course, he was also working for a Cabinet Member, and he also worked directly for the CNO, the Secretary of Navy, the Secretary of Defense, and Congress thinks he works for them. But, that's not quite good enough. Some say we have to downgrade his office because it's too independent.

A group of us yesterday morning on the Hill heard that one of the dangers is that Naval Reactors runs the submarine program. Bruce, I don't believe thinks so. If I had thought, while I was on active duty, he thought that, I would have slapped him down. He runs the Naval Nuclear Propulsion Program, but he provides the expertise from many years of operational experience to the naval submarine force, and to the CNO and the program.

I have spoken too long, so I'll wrap it up, and say, simply, "Let's not destroy that which has proven its capability, that which is dedicated to excellence, and that which is dedicated to the safety, today and tomorrow, of everyone in the Navy and outside."

Bruce, a job well done—thank you. ■

<u>ISR '96</u>

The International Human-Powered Submarines Races (ISR) Organization announces the first engineering workshop for contestants and other students interested in participating in submarine races or learning more about them. The workshop will be held December 14-15, 1996 at Carderock, Maryland. Contact: Nancy R. Hussey, ISR/FURE, P.O. Box 1569, Solomons, MD 2068; (410) 326-6896.

THE SUBMARINE FLEET OF RUSSIA: ITS PAST, PRESENT AND FUTURE

by ADM Alexander V. Gorbunov
Deputy Commander-in-Chief of the Navy
Chief of the Department of
Combat Training of the Navy

In the history of Russia as a European and world power, its Navy has always taken an important and appreciable place. In the present day complicated situation in Russia, the 300th anniversary of our Navy bids us once again to reconsider its history and present condition in order to determine the optimum trends of its development, training and application in the first half of the 21st century without repeating past mistakes.

The geopolitical, geostrategic and geoeconomic situation of Russia, with its coasts washed by 12 seas, with more than 70 percent of our state frontiers passing through sea waters and with a coastline of about 100,000 kilometers, with the most important and the most prospective part of national economics being the rich natural resources of the seas and continental shelf, definitely put our country into the number of the world's greatest sea powers.

The first to understand this was the famous reformer of Russia, Peter the Great, who, 300 years ago, on the 20th of October 1696, founded the Russian fleet. Only after victories over its strategic enemies on the Black and the Baltic Seas, gained under the personal participation of Peter the Great, was Russia recognized in Europe as a great power (empire), and Peter the Great was considered to be an emperor. With his genius and his efforts a powerful state was created, a strong fleet founded, and glorious traditions laid, on the basis of which Russia's fleet has gained the greatest number of victories among all other fleets of the world. Our Navy still sticks to these traditions and its mottos are: Motherland, Fortitude, Honor.

The first Russian submarine project was submitted to Peter the Great in 1718 by the peasant Efim Niconov, and in 1723-1732 it was constructed. This trend in the construction of Russia's Navy got its further development only in the first half of the 19th century, after the successful experiences of the American engineers Bushnell and Fulton, when the Russian military engineer Karl Shilder became engaged with it.

But the first submarine with a mechanical engine in Russia was constructed and tested in 1863-1866 in the Baltic plant by engineer Ivan Alexandrovskiy. By 1874 he had created and tested a self-propelled torpedo for his submarine. S. Dzhevetskiy was the first in Russia to design, construct and test a submarine with an electrical engine in 1876-1879. And, in 1879-1881, 50 submarines were constructed under his last project.

In 1900-1903 under I. Bubnov's and M. Beklemeshev's project the first combat submarine DOLPHIN, with above-water and underwater movement engines, was constructed. This submarine was armed with two torpedoes and a machine gun and could travel 60 miles at a speed of 5 knots in a submerged condition, and 1000 miles at a speed of 7 knots in the surfaced condition. In 1904 DOLPHIN was in the Baltic fleet, and then was carried by railway to the Far East. During the war with Japan, six various types of submarines were constructed in Russia. Part of the submarine fleet was engaged in combat operations.

On the 19th of March 1906 a decree was signed by Emperor Nikolay the Second for the creation of submarine forces for Russia as a part of the Baltic fleet, with the first formation of submarines situated in Libava. In all, during the period of 1900-1917, 95 submarines were laid down and constructed in Russia.

In the course of the First World War of 1914-1918, Russian submarines were widely engaged in combat operations against Germany's Navy on the Baltic Sea. After the end of the Civil War Soviet Russia had only 9 submarines fit for further employment. Having drawn the right conclusions from the results of sea fights of the First World War, in which about 6000 ships were sunk by submarines (while only 217 ships were sunk by surface ships), Soviet naval science of the 1920s and 1930s considered the submarine force to be one of the main arms of the Soviet Navy. Within the period of 20 years before the beginning of the Second World War, the Russian Navy, which had been destroyed during the Civil War, was reconstituted on the new technological basis. By the Spring of 1941 it was formed of 1000 combatant ships and vessels, including 3 battleships, 7 cruisers, 59 destroyers, and so on. The quantity of submarines in the Russian navy exceeded the quantity of submarines in the navies of any country of that time. The Soviet Union had 218 submarines, Germany-165, Italy-93, Japan-63, USA and Great Britain together had 168 submarines. And Soviet submarines of classes S and K were quite up-to-date, submarines of class K were considered to be the fastest and to have the strongest armament in the world. The realization of the leading role of submarine forces in other navies occurred in the course of the war: Germany constructed 1131 submarines, the US Navy and the Royal Navy had 463 submarines.

Submarine forces of the Soviet Navy by June of 1941 had the following disposition: the Northern Sea Fleet-15 submarines; the Baltic Fleet-68; the Black Sea Fleet-44; the Pacific Fleet-91; with the objective of braking the enemy's sea communications. In evaluating the war potential of the Soviet Navy of that time it is necessary to note the negative influence of the lack of connection between the fleets and theatres of war, the very low possibility for maneuvers between theatres of war and the capability of the Navy to conduct combat operations only in inland waters because of the lack of aircraft carriers, and an insufficient number of ocean submarines and big ships.

It was possible for the German Navy to increase its power on the Baltic Sea, as well as on the Northern Sea and on the Black Sea, because Germany had in its hands straits and coasts along which it used to carry out strategic shipping, especially on the Baltic and the Barents Seas. The German Navy gained a lot of advantages from this situation in the initial stages of the war.

The Soviet Navy was the only armed service which was not taken unawares by the sudden enemy aggression on the 22nd of June 1941. By order of the Navy Commander-in-Chief Admiral N. Kuznetsov, all fleets were given the alarm in proper time and could in, an organized way, repel the first attacks of the enemy. In the first half of the 22nd of June, 15 submarines of the Baltic, Northern and Black Seas occupied combat positions.

In the course of the war from the very beginning up to the end on the 2nd of September 1945, Soviet sailors, as well as submariners, never retreated. In all of their combat they showed a high level of battle training, fortitude, courage and bravery, according to the best historic traditions of the Russian Navy.

Submarines of the Northern Sea Fleet laid mines at the entrances to the enemy's ports, destroyed enemy transport and combatant ships in and near ports using torpedoes and artillery fire, and operated independently on the seas protecting allied convoys in our zones.

But in spite of replenishment of the fleet by new submarines it still did not have enough forces. According to the Navy Commander-in-Chief's decision in 1943 five submarines from the Pacific

Fleet arrived in the Northern Sea Fleet, having traveled 17,000 miles through the Pacific and Atlantic Oceans.

To raise the effectiveness of combat operations in 1944 submariners, instead of acting in the sea positions, began to use submarines to make up *beetled* (over Norway coast) *screens* in cooperation with torpedo boats and the fleet's attack aviation using air reconnaissance data. During the war submarines of the Northern Sea Fleet made over 300 combat patrols and destroyed about 250 enemy transport and combatant ships. In these operations the fleet lost 22 submarines.

On the Black Sea combat operations of the Soviet submarines were directed against enemy sea shipping near the Romanian coast, and to blockade the Bosporus. After the occupation of the Crimea and the blockading of Sevastopol, the Black Sea Fleet's submarines were transferred to the Caucasus ports. From there they delivered ammunitions, nourishment and fuel to the beleaguered Sevastopol, taking wounded away from the city.

In 1943-1944 the activity of the Black Sea Fleet's submarine forces was directed toward breaking near and remote communications of the enemy, and to prevent the enemy's evacuation. Fulfilling these missions, our forces annihilated more than 42,000 fascists near the Caucasus coast. During the years of the war, submarines of the Black Sea Fleet made over 200 combat patrols and destroyed over 100 enemy transport and combatant ships. In these operations the fleet lost 27 submarines.

The Baltic Sea Fleet's submarines conducted their combat operations in most unfavorable conditions. By the end of August 1941 the fleet had lost almost all its naval bases including the main base in Tallinn. The submarines forces had to be based only in Leningrad and Kronstadt, having the very straitened and shallow eastern part of the Gulf of Finland for deployment.

Submarines of the Baltic Sea Fleet acted against enemy communications near Swedish coasts and laid mines near enemy naval bases. The resistance of the enemy in the Baltic Sea was very powerful. Antisubmarine warfare in the Gulf of Finland consisted of 66,542 mines of various types, a lot of antisubmarine nets were set and about 150 fascist ships and vessels conducted combat operations. In these conditions, submarines of the Baltic Fleet in 1941-1942, made more than 110 combat patrols, destroyed about 80 enemy transport and combatant ships, having complicated considerably German strategic sea shipping on the

Baltic Sea. But, during the first 18 months of the war, the Baltic Fleet lost 40 submarines because of mines and antisubmarine obstructions, and the Navy Commander-in-Chief N. Kuznetsov temporarily prohibited them from going out to sea.

The Baltic Sea submarines resumed combat operations in September 1944 from the ports of defeated Finland. During the eight months before the end of the war they destroyed 72 enemy transport and combatant ships. The most glorious victories were gained by the submarine LEMBIT under command of Captain of the Second Rank A. Matiyasevich—25 victories included 22 transport and combatant ships destroyed by him personally, and the submarine S-13 under command of Captain of the Third Rank A. Marinesko, who in January 1945 in one cruise, destroyed the fascist military transport ship WILLIAM GUSTLOV of 25,484 tons and then the transport ship GENERAL VON STEUBEN of 14,660 tons. These ships carried 10,000 fascists including 3000 submariners. This allowed S-13 to take first place in the Soviet Navy in the total displacement of destroyed enemy ships.

The results of the war confirmed the correctness of the Soviet military scientists' prognosis: submarine forces as well as aviation had become the main armed services of the Navy. Aviation destroyed 55 percent of all ships sunk of Germany and its allies in the East Front, and submarines sank about 33 percent of all annihilated ships.

In our seas the enemy lost 48 submarines; our Navy-95, with most being lost in the initial period of the war, 1941-1942, which was most unfavorable for our country. Total losses of the German submarine fleet in this war were 768 submarines, that is 64.5 percent of their total quantity. Our losses amounted to 35.2 percent (including 54 submarines constructed during the war). And these figures show higher combat skills of the captains and crews of our submarines.

These experiences of the war showed the necessity of providing global combat support of submarines by other armed services of the Navy, first of all by surface ships and aviation. In the whole, the Soviet Navy and its submarine forces honorably fulfilled their tasks in the Great Patriotic War and proved their capability to defend the sea frontiers of our country.

Global geopolitical differences between the USA and USSR, creation of NATO in 1949 and, in response to it, creation of WTO (the Warsaw Treaty Organization) in 1955 led to the Cold War and escalation of the armaments race. Taking into account our considerable lack of submarines (in 1945 the USA and GB had 463 submarines; the USSR-172 or 37 percent) the Soviet Union had constructed by the late '50s 265 conventional-electrical submarines of the first after-war generation.

For the purpose of protecting its communications and defending 12 seas which surrounded the USSR, part of which were closed sea theatres of operations, the Soviet Union continued to construct conventional-electrical submarines. After 1958 more than 120 submarines of this type (project 641-Foxtrot class, project 641B-Tango class and project 877-Kilo class) were constructed for the Navy and for export.

But yet from the early '50s, on the basis of the latest achievements of science and engineering, it became clear that the main and most prospective trend of development of the submarine forces was in the design and construction of nuclear powered submarines. In September 1952, a decision was taken to design the first nuclear powered submarine (called NOVEMBER) in the Soviet Union. In September 1955 it was laid down in Severodvinsk, and in 1958 it was delivered to the Navy. By 1964 12 more submarines were constructed and delivered to the Navy.

The introduction of nuclear technology in the construction of the Soviet Navy led to the appearance of three classes of nuclear powered submarines: strategic (SSBN), attack (SSGN) and multipurpose (SSN). The USSR was the only country to create three classes of combat nuclear powered submarines at a time. A characteristic feature of the period in which nuclear powered submarine fleets were formed was that the United States, after long research and construction of eight nuclear powered submarine projects, chose in the early '60s two main projects, while the Soviet Union constructed 11 different projects of nuclear powered submarines up to the early '80s. That large number of submarine classes greatly complicated the operations and performance of the force.

During 1961-1970 the USA constructed 78 nuclear powered submarines (including 41 SSBNs which carried up to 70 percent of the American strategic nuclear offensive potential) and the Soviet Union began to construct nuclear powered submarines of the second generation. By 1974 the biggest series was created in the history of nuclear powered submarine construction: an SSBN series of 34 nuclear powered submarines of project 667A (Yankee class) which in its further modifications (Delta-1, Delta-2, Delta-3 and Delta-4) amounted to 77 submarines by 1990.

The period from the middle '60s up to the early '80s is considered to be the Golden Age of the Soviet military ship construction. The USSR Navy successfully developed the process to attain military parity with the US Navy. That became possible due to an increase in the quantity of the ships. All this contributed considerably to the maintenance of international stability.

In this period the US Navy constantly had about 24-25 (of 41) SSBN on combat patrolling in the open seas. It means that the efficiency of the operational employment was about 0.6. Besides that, up to 20-25 multipurpose submarines (SSN) constantly were in the open seas. In total they took 210-230 cruises per year. Lack of a systematic character in the Soviet Navy construction and the low developed infrastructure of the Navy resulted in an efficiency of the operational employment of our submarines of half that and we could maintain parity in the seas only by having two times as many submarines.

In the early '80s we managed to overcome the technological lag and to considerably improve the characteristics of our submarines. The third stage in the history of Russia's nuclear powered submarine fleet was marked by the appearance of a new type SSBN (Typhoon) in 1981. Six submarines of the class were constructed up to 1989. At the same time seven Delta-4 SSBNs, which had the same range of fire, were constructed.

Besides that, from 1980 up to the present time the SSGN Oscar class (with 24 SLCM Granit) is being constructed. At the same time, along with the third modification of the nuclear powered multipurpose submarine Victor-3, from the middle '80s SSNs of the new projects Sierra and Akula, with quite similar characteristics, are being constructed. The experience of combat patrolling of submarines of this type during the last few years shows that former shortcomings of Soviet nuclear ship construction, such as high noisiness, are basically eliminated. In 1993 an SSN of a new generation, SEVERODVINSK, was laid down.

The composition of the Soviet submarine fleet met the requirements determined by Soviet military doctrine. Our Navy was in all important zones of the world and had operational and tactical contacts with ships and forces of the US Navy and NATO. Our ships and sailors were not inferior to American ships and sailors. In the early '90s, the senselessness of political and military opposition between the USSR and the USA, WTO and NATO, became clear. That's why START I and START II were signed in 1990 and 1993, and according to those treaties the quantity of SSBNs in the Russian Navy is to be reduced from 62 to 25, and the quantity of SSBNs in the American Navy is to be reduced from 36 to 14.

But global changes which had occurred in the world after the end of the Cold War, and had reduced considerably the threat of worldwide nuclear war, did not reduce the danger for the world community in whole, and for many states in particular. A new danger is represented by local and regional armed conflicts of different scale and intensity, which will be the most probable method of resolving ethnic, religious, economic, territorial and other disputes between states. This is confirmed by the developments in the Caucasus, on the south borders of the former Soviet Union, in the Middle and Far East, in Yugoslavia and so on. Most of these hot points are situated near Russia's borders.

The policy conducted during the last decade by our leadership on the basis of *new political thinking for our country and the whole world* did not lead to the expected stabilization of the international situation. On the contrary, the situation became more complicated and tense. Unilateral self-dissolution of the WTO did not cause the dissolution of NATO. According to the specialists' estimations the number of countries possessing nuclear armament and means of its delivery will increase to 20-25 in 2003. The struggle between world powers for economic and political influence worldwide and regionally, for possession of sources of raw materials and so on, shows that the transition to the 21st century will not be quiet and serene.

Analysis of the condition and prospects of development of the NATO navies, and those of other countries, for the next 20-25 years shows that all these countries continue to strengthen and improve naval components of their armed forces. Construction of up-to-date ships and submarines (including nuclear powered attack submarines in the USA, France, Great Britain and China; submarines armed with SLCM (Submarine Launched Ballistic Missile); and nuclear powered aircraft carriers in the USA and France) will increase considerably the combat potential of these countries in the beginning of the 21st century.

Analyzing the condition and destination of our Navy during the last 10 years, it is easy to understand that, being reduced by half, it was, and remains, destined to conduct defensive sea operations: about 60 percent of its ships are the ships of local seas and only about 15 percent are the ships of open seas.

If the disintegration processes on the territory of the former Soviet Union will not be stopped, if insufficient providing for the Navy of money, ship repair, men, fuel, materiel and so on, will be continued, we, according to some estimations, in 2000 will not have more than 7-10 SSBNs with limited periods of employment, 15-20 SSNs and 10-12 conventional submarines. On the Baltic Sea we will be two to three times weaker than Sweden and five times weaker than Germany; on the Black Sea we will be two times weaker than Turkey and if we lose Sevastopol, the main naval base of the Black Sea Fleet, five to seven times. In the Far East our Pacific Fleet has three times less ships than Japan (Japan and the Pacific Fleet have an equal number of torpedo submarines, but Japan has to protect its 1000 mile zone and we have the shortest distance from Vladivostok to the Chukotski Peninsula of 2500 miles). In total our combat potential is comparable with potentials of Great Britain or France. But it is necessary to take into account that our sea frontiers are 15-20 times longer and our economic sea zone and continental shelf are considerably wider, so it is easy to understand that we have less possibilities to protect both our frontiers and our national interests at sea.

If Russia has not the naval power able to restrain the hostile intentions of others and to decrease the appetites of its neighbors, in the complicated, multipolar and dynamic situation on the Baltic and Black Seas, it will be 200-300 years behind other countries in the geostrategical aspect. Then, similar events will occur in the Far East.

So, appraising geostrategical, geopolitical and economic conditions of Russia on the threshold of the third millennium, we can come to a conclusion that the Navy continues to be one of the most effective instruments of the state policy oriented to secure constant economic and foreign policy interests of Russia. In the view of its national security and significance, the role of this instrument will increase.

According to the adopted "Principal Propositions of Russia's Military Doctrine" the Navy, in the composition of armed forces, is tasked to secure sovereignty, territorial integrity and other vital interests of the Russian Federation. The priority mission of the Navy and other services of the armed forces, side by side with political, diplomatic, economic and other activities, **is prevention of war and military conflicts**, repulse of probable aggression, covering of the country's objects, forces and troops from ocean and sea directions, infliction of defeat on enemy forces, creation of conditions for cessation of hostilities at the earliest possible stage and concluding of peace on conditions meeting Russia's interests. Besides that, the Russian Navy can conduct peacekeeping operations under the direction of the UN Security Council or according to the international obligations of the Russian Federation.

Modelling opposing combat systems at sea is necessary to take into consideration the navies of neighbor countries. This is done by proceeding from the constant national interests of these countries, declared by them, (which do not coincide with our interests and which even contradict them), from the policy of the blocs they participate in, from the condition and perspectives of development of the navies as well as from real and planned employment of their navies in the time of peace and war.

With the purpose of fulfulling the armed forces' and the Navy's priority mission—**prevention of war** as part of forces of nuclear deterrence, maintaining strategical stability in a dynamic, multipolar and changing world, we must retain as a traditional component of our Navy—naval forces of a nuclear deterrent which have some advantages over strategic missile forces and strategic aviation.

With the aim of providing safe and secure functioning of these naval forces of a nuclear deterrent, in any conditions, as well as with the creation and maintenance of such an operational regime which will prevent the enemy from unleashing military conflicts, the Russian Navy must have in its structure **general purpose forces**.

The basis of the **general purpose forces are submarine forces**, which are the principal component of the Navy's attack potential and are the most universal, mobile and powerful armed service able to fight with any kind of sea enemy. Surface ships, naval reconnaissance aviation, naval missile aviation, and naval antisubmarine aviation under the conditions of defensive doctrine, must become the main means of gaining supremacy in the near seas and of repelling an enemy's aggression, in cooperation with submarines and other armed services.

Analysis of the experience of combat operations in the Persian Gulf shows that massed fire destruction of the terrain targets from sea is realized by means of highly precise missile (SLCM) and air assault from submarines, surface ships, including deck aviation of the attack aircraft carriers, and by air attack forces form a distance up to 2500 kilometers.

Nuclear powered submarines are the very forces most efficiently capable of counteracting enemy naval forces carrying SLCM before they reach the open-fire line. They can create and maintain unfavorable conditions for the enemy, prevent missile assault against Russia and defeat the enemy after the beginning of the combat operations.

To provide secure combat activity of our naval forces of a nuclear deterrent, and fulfill missions of our general purpose forces, our Navy must have not less than 70 SSNs (50 of them being ready for action). Only half of our submarines meet this requirement. To retain this modern arm of the Navy it is necessary to construct a big series—about 30-40 SSN of a new type. Also our military science and industry must raise effectiveness, combat steadiness and vitality of submarines and surface ships by means of theoretical, constructive, technological and information support. Taking into consideration the physical and geographical peculiarities of our sea theatres of war and the geostrategical situation of Russia, it is expedient to have in the composition of our general purpose forces up to 30 up-to-date conventional-electrical, relatively inexpensive submarines (with 20-25 of them being ready for action) which will be sufficiently able to fulfill the same missions in the near sea zone on the Baltic, Black and Japan Seas.

Diminution of the quantity of submarines (less than 70 SSNs and 30 SSs) would prejudice, checked by combat experience, the strategic and operational conceptions of successfully conducting modern war at sea under the terms of Russia's military defensive doctrine.

Analyzing surface forces, it is necessary to consider aircraft carriers of the Navy. The main destination of aircraft carriers of our Navy is to ensure combat steadiness. First of all in antisubmarine warfare and antiaircraft defense of operational forces of the Northern Sea Fleet and the Pacific Fleet while these forces fulfill the above mentioned missions of the general purpose forces.

Without such assistance at the lines from where the enemy will open fire against Russia, such powerful, multipurpose and mobile part of our Navy as submarines forces will suffer unwarranted and inadmissible losses before the beginning of combat operations and in the initial stage of it, that it will not be able to fulfill its missions in a proper way. The presence of the aircraft carriers in the composition of the operational forces of the Navy increases the effectiveness of submarine actions 150-200 percent, and decreases considerably the risk of losses.

So, by 2010-2015 it will be necessary to have the Navy composed of about 300 up-to-date ready for action ships (up to 85 submarines, up to 95 warships and up to 120 combatant vessels and near sea ships). It will be one third the quantity of 1990 but will improve 2.5 to 3 times the total combat potential for conducting defensive operations at sea. This quantity will allow the Russian Navy to keep parity with the forces of the US Navy, NATO, and other countries and blocs of the 21st century in the principal sea zones and regions in order to securely fulfill the missions of Prevention of Military Conflicts and Safeguarding of Peace and Stability at Sea.

Present temporary difficulties, mostly of an economic character, overshadow the acuteness of the situation and prospects of solving the problem of safeguarding Russia's interests at sea, but if we do not see it in proper perspective and do not find the way to resolve this problem, in 1-2 years we will lose the most technological part of our shipbuilding industry, in 5-6 years we will lose the Navy. And it will take us not 10-15 but 30-40 years to revive it, with all the ensuring irreversible negative geostrategical, geopolitical and economic consequences.

To give a clear idea about the condition and prospects for solution of the strategic task of revival of Russia's Navy, the author considered only one, the most tangible and visible, part of it—the ships and submarines. It is necessary to adopt a State program of revival of the Navy with stages of 10-15 years and 20-25 years. We think that, concerning ships, the program should include three levels: what, when and how it is necessary to save from the present composition of the Navy with the aim to form a combat main body of the Russia's future Navy; construction of new ships to substitute obsolete ones, ensuring the secure fulfillment of the missions of protection of Russia's vital interests at sea; as well as participation in peacekeeping operations of the UN in the interests of world community in the main regions of the world for 20-25 years.

A country which is weak in world policy and economy can safely be ignored and its opinion usually is not taken into consideration. Russia must have a powerful Navy to save its traditional place of a great sea power to have prospects for its development in the 21st century as a strong, prospective and democratic state.

Admiral Gorbunov Alexandr Vasilievich was born on October 4, 1940 in Dzerzinsky and attended the Pacific Naval College and the Naval Academy.

Admiral Gorbunov began his service in the Pacific Fleet as a submarine torpedo group commander and continued as the commander of a submarine mine department and then as the 1st mate.

In the Northern Fleet from 1973 until 1987 he acted as 1st mate of a nuclear submarine, nuclear submarine Commander, Deputy Commander of the ships operational division and nuclear submarine Division Commander.

In the Black Sea Fleet from 1987 until 1990, he was the 1st Deputy Commander of the Flotilla and Commander of the operational squadron.

On the Main Naval Staff from 1990 until 1992, Admiral Gorbunov was the 1st Deputy Commander of the Combat Training Department and from 1992 to the present he has been the Deputy Commander-in-Chief of the Navy for Combat Training and Chief of the Navy Combat Training Department.


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THE FUTURE OF OUR SUBMARINES
Remarks at the Annual Symposium June 5, 1996

by RADM E.P. Giambastiani, USN
Director
Submarine Warfare Division
June 5, 1996

It is an honor and pleasure for me to be here today. I've been here many times before, but this is my first on this side of the lectern. I hope I can convey why I and the N87 staff are optimistic about the future.

You just heard Jerry Ellis talk about the Pacific Submarine Force and the many challenges he faces. While I don't have any operational submarines under my direction—of course, I'm not counting my fleet of desk models in the Pentagon—I do have three more days in my job than he does. So, I will try to use that additional experience in sharing my perspective from inside the beltway on the future of your submarines.

I'm not going to just give you a laundry list of programs today, except to tell you that we have had to do some restructuring—make some tough choices,including cancellations and, basically, we had to find money where it didn't exist. And believe me, my young guys, and those on the TYCOM staffs, did a great job of finding money.

This morning I'm going to talk about several areas. First, while the nature of the challenge has changed in the last 5 years, control of the seas—or in our parlance, *sea control*—remains as fundamental to national security as it was when the Phoenicians introduced the first fighting ships in 700 BC. Second, the future security environment demands expeditionary response, which places a higher premium on naval forces; third, to improve our margin of acoustic superiority, we must modernize our 688s; and fourth, the value of stealth has never been higher. Finally, I'll try to tie these concepts to some of our program initiatives designed to enhance our capabilities in today's security environment and that of tomorrow.

One could argue that the end of the Cold War has really been a return to history. The rigidity of bi-polarity and nuclear deterrence during the cold war brought stability, whether intended or not, and stifled regional hegemony. But that was more of an aberration than a norm when viewed in the context of conflict throughout history. Consider the roots of the war in Bosnia which dates back at least 500 years to the Ottoman Empire.

Let me discuss the nature of today's challenge, and why sea control is so essential. As Admiral Mike Cramer, the Director of Naval Intelligence, stated in his latest publication of worldwide submarine challenges, these challenges come in three categories. First is the technological pacing of Russia's submarine force; second is the investments by China in new submarine capabilities for the next century; and third, other countries of concern which are acquiring submarines and capable weapons systems at a remarkable rate. These countries want to obtain relatively low cost, high leverage solutions like mines, anti-ship cruise missiles, diesel submarines, or weapons of mass destruction.

World demographics continuously evolve; today's neutrals may be tomorrow's adversaries. Although each group is motivated differently, one constant remains—we still have and will always have nations which seek to gain access to the sea. There will always be those who want to impose regional sea denial. With about three quarters of the earth's surface covered with water, and 90 percent of the material required to support any U.S. led military campaign arriving by sea, the fundamental truth remains that the seas are a lifeline through which prosperity flows. Our status as a world leader dictates that we must continue to hold a clear advantage in sea control. We cannot abrogate this responsibility.

Nations with advanced capability diesel submarines, available on the open market, whether originally intended for defensive measure or not, can restrict commerce in a strategic choke point by the mere perception of their presence. With at least two dozen of these choke points around the world, threats of closure of one or more would have an adverse effect on the global economy.

More and more nations realize the value of a submarine's undetected presence. Their ability to conduct anti-shipping missions, both actively and passively is well understood and has been proven in combat time and again. An advanced capability submarine operated by a nation with hostile intent is a serious threat to U.S. and Allied naval forces, so undersea superiority remains key to our nation's security.

When a crisis erupts and the President asks "Where's the nearest carrier?", a submarine is already on station and probably has been for sometime. Most of you recognize the contributions forward deployed submarines make in the clandestine collection of intelligence and surveillance of potential adversaries. Their ability to respond rapidly—undetected, and to operate for long periods without a logistics tail in hostile areas—**discriminate them from all other platforms.**

We have submarines around the globe, around the clock. Today, of the 78 SSNs, 33 are underway—18 of which are forward deployed—and they are covertly collecting where the action is—ready to respond if a crisis is brewing or erupts.

As you know, the last several years have seen continued tasking of these forces around the globe. The realities of lowering defense budgets have forced us to do more with less.

Our force structure is declining at the same rate as the rest of the Navy but declining none the less; and while the new attack submarine will bring enormous capabilities, it will not enter the force in sufficient numbers until well into the next century.

In fact the 688 class attack submarine will still comprise 60 percent of the force in 2015. The argument that we need to do more with less really boils down to the fact that we need to do better with less, and that's why modernizing the 688 is one of our highest priorities.

The introduction of commercial off-the-shelf technologies (COTS) into submarine systems—sonar, fire control and communications being most noteworthy—has provided the opportunity to change the way we approach modernization. **We must get capability to the fleet as fast as the commercial sector gets it to your home!**

Last year we began an effort to study how we could improve our margin of acoustic superiority. As many of you know, you can make gains in two areas: acoustic stealth, which is expensive and very hard to change once the design is locked in, and sensors and processing in the sonar area.

SEAWOLF and the NSSN improve the stealth part of the equation. SEAWOLF will become the quietest submarine in the world when it goes to sea for the first time. And, for the first time in our submarine development history with the new attack submarine, we have maintained acoustic quieting in a smaller hull. **This is a big deal.** We are on the right track with our new platforms, but that does not help the 688. Here, you have to work on the electronics side.

We are working very hard to regain dB or improve our detection capability of other platforms through improvements in processing and new algorithms. We reviewed the problem in detail and are developing a commercial solution. **The Submarine Force requirements are clear affordable systems that stay ahead of the threat.**

We will need that improved margin of superiority as we move into the future security environment. Why? Because the value of stealth is so much greater. The trend in almost all of the services' weapons delivery systems is to stealthy or unmanned platforms. The Army wants the Commanche helicopter, and the Air Force is even looking at a future unmanned combat aircraft. In fact, radar cross sections and infrared signatures are for today's ship designers what armor was to yesterday's. Other services are making huge investments to achieve what is inherent in a submarine--stealth. Stealth leverages the soft kill and alters the attack equation.

The first bomb dropped on Baghdad was from an F-117A stealth fighter which was well inside Iraqi radar coverage. Simultaneously Tomahawk cruise missile strikes were taking place. The F-117s and Tomahawks systematically created gaps in the Iraqi radar coverage and in the command and control network to pave the way for non-stealthy aircraft. The first wave of attacks included 30 F-117s and 54 TLAMs. Within the first 5 minutes, nearly 20 air defense, C3, electrical and leadership nodes had been struck in Baghdad. All of this was done to create a less dangerous environment for the non-stealthy aircraft which still only flew to the outskirts of the city but they would be used to deliver the bulk of the ordnance on the ground forces.

This concept of achieving air superiority is well understood, and the consequences of failure is inculcated in all of our senior military commanders. The same cannot be said, however, for achieving undersea superiority which, in my view, is a completely analogous concept.

Achieving undersea superiority is a much more complex and challenging problem--stealthy, mobile targets veiled in the oceans' shadow require significant investment in time and resources to eliminate. The consequences of failure in achieving undersea superiority are disastrous and not as well understood nor appreciated by those outside the Submarine Force and the Navy. They are assumed away.

But threats from undersea are not the only challenge that our expeditionary naval forces will face in the future. The threat to naval forces from land based weapons systems, linked to space based and air breathing sensors, is real. In fact, Mr. Andy Marshall, the Director of Net Assessment in the Office of the Secretary of Defense, has commissioned a review of how a future adversary might attempt to deny the U.S. Navy access to the sea—from ashore. He calls this the Anti-Navy.

The Anti-Navy is a predominantly land based response to a classically-styled surface combatant force, capable of denying an enemy use of wide sea areas. A successful Anti-Navy is a force which has solved today's targeting problem: identifying and tracking mobile platforms from over-the-horizon, in a potentially high background clutter environment. It is land based because that is cheaper than procuring and maintaining a sea-going force capable of controlling the same size area.

So why is Andy Marshall studying the Anti-Navy? Because he is not a friend of ours? No, Andy has a long history of being a supporter of the Navy. He is studying it, because future trends in sensors, weapons, communications, and computing power, of technologies which can be purchased on the open market, are leading to an environment where, *if I can sense you, I can kill you*.

Technology is making life on the ocean more difficult. In this environment, stealth is the enabler; and submarines become the enabler for the enabling force, our Navy and Marine Corps team. In this future, stealthy platforms will prepare and dominate the battlespace.

We have many initiatives in this area, and I will talk briefly about several of them. We are working hard to enhance our core competencies by extending our battlespace horizon under the sea and in the air.

But first, let me recount a lesson from history, back to the battle of Midway 54 years ago today—a battle where submarines were remarkably ineffectual.

Of the 25 submarines in the area between Hawaii and Midway, only 12 got into a position to intercept any Japanese forces. And of those 12, only one, USS NAUTILUS, managed to get a score. It sank an aircraft carrier which had been slowed to 2 knots by dive bombers. But Midway served as a pivotal point in the evolution of submarine success in the war. It was determined that the primary reason for submarine frustration at Midway was the lack of a search radar for night tracking. The SJ radar, the first directional radar used by the undersea force, was installed on most of the submarines within a few months. In fact in August of 1942, just two months after Midway, USS HADDOCK sank two merchants through a new tactic: night time radar approach.

HADDOCK's first patrol may be remembered as an historic episode in submarining and an important turning point in the Pacific war. Search radar expanded the horizon of submarine warfare by many leagues, and its successful introduction dated the beginning of the end for thousands of tons of Japanese shipping which, in pre-radar days, might have reached their intended destination.

So, as radar brought a new dimension of warfare to the World War II boats, unmanned aerial vehicles and unmanned undersea vehicles introduce a new dimension into today's submarines: a clandestine reach through the surf zone into the enemy's backyard. These modern versions of the telescoping spyglass will deliver precision information to the submarine commander, which can in turn be relayed to the battlegroup and joint task force commanders; and these new systems are not just pie in the sky.

In fact, just this past weekend, in the Southern California operating areas, USS CHICAGO controlled a Predator UAV and used its video downlink to deploy and direct special operations forces to destroy a high value target. Major General Ken Israel, Director of the Defense Airborne Reconnaissance Office, flew out to ride CHICAGO, so he could see this with his own eyes.

This was his first exposure to a submarine, and he's in on the ground floor of this powerful future capability. **The Submarine Force is in the 21st century.**

Let me describe the scenario, the submarine, with SEALs embarked, is conducting all-sensor surveillance off an adversary's coastal island. Onboard sensors indicate the presence of a target of high interest to the joint task force commander, COMTHIRDFLT, located 3000 miles away. The submarine commander requests operational control of a Predator UAV to support real-time planning and execution of a SOF mission against the newly discovered Silkworm missile site. The tasking is to monitor the site and support precision aircraft strike should the missile battery be prepared for launch.

In this demonstration, the submarine had control of Predator for 26 hours, 9 hours continuously at one point, out to a range of

104 miles. The theoretical range, based on signal strength, is considerably further. Truly this is the world's tallest periscope.

The future looks bright for the unmanned undersea vehicles. We are developing a self-propelled vehicle that can be launched and recovered from a torpedo tube. It will be fiber optically connected to the ship and able to pass data from forward and side looking sonars, providing a real time display miles ahead of the ship.

Initially, we looked at using this system for mine reconnaissance, but advances in power sources for longer dwell times outside of the submarine and potential for autonomous operation with pre-programmed mission packages, provide the gateway for the UUV to be of immense assistance in other submarine operations.

We are currently working with the Surface Warfare Division to adapt the Army's Tactical Missile System, or ATACMS, for use aboard both surface combatants and submarines. ATACMS does not compete with Tomahawk; they are completely complementary. Used for different target sets, ATACMS adds a different kind of arrow to our quiver. We are also pursuing the prosecution and elimination of the deep and hardened target set. This is a real challenge, and we are meeting it head on. Fielding this capability will enable us to engage a well entrenched enemy, and may even be of use as we attempt to devalue weapons of mass destruction. We will be pursuing this through an advanced concept technology demonstration led by the Strategic Systems Program Office, in concert with the Army.

While at times, inside the beltway, the future looks grim with the budget deliberations we face, I am excited about the future. There is reason for optimism about where we are going. We have great Submarine Force people inside the beltway. There are some advanced technology demonstration proposals that look like they will make the cut—one of them will attempt to demonstrate a towed array design that will provide an order of magnitude reduction in production costs and at least a 50 percent or more reduction in volume compared to conventional thin line array technology. That is just a snapshot of some initiatives we have going on.

I do want to leave you with a few thoughts. Remember that sea control is an essential element to our national security. Although I did not spend much time discussing ASW, that is still the primary mission of our submarines. Submarine success in that area is critical to keeping the sea lanes open.

Secondly, the key to improving our margin of acoustic superiority through modernization of our 688 fleet is a near term priority, while moving forward with SEAWOLF and the new attack submarine. Finally, remember that the future security requirements demand that expeditionary forces and submarines use stealth to defeat the Anti-Navy.

THRESHER/SCORPION MEMORIAL

A memorial is being designed and built for those lost at sea as a result of the accidents aboard USS THRESHER and USS SCORPION. The U.S. Naval Academy Class of 1950 has contracted to construct this memorial which will be located in Nimitz Library at the Naval Academy. The memorial will be a compliment to the Dr. Thomas O. Paine Memorial Collection of submarine literature which will be housed in the Special Collections portion of the Library. The Paine Collection is reputed to be the largest collection of its type in the world and is finding its rightful home at the U.S. Naval Academy. The memorial is a glass relief depicting the oceans' depth with silhouettes of the two vessels on perpetual patrol. This will be supplemented by displays related to each ship. Donations to this memorial will be gratefully accepted by the U.S. Naval Academy Alumni Association, P.O. Box 64978, Baltimore, MD 21264-4978.

SUBMARINE OFFICERS RECEIVING STRONG SUPPORT

by CAPT Mike Feeley, USN
Head Submarine Detailer, BUPERS

Last quarter's **SUBMARINE REVIEW** described various submarine related issues being considered by the Congress, mainly related to ship construction and procurement. I thought there might similarly be interest in the support we are receiving at the highest levels within the Navy and on the Hill for our people programs. While there are numerous examples I could cite, I will limit my discussion here to three recent and significant changes.

The spot promotion program allows for the temporary promotion of lieutenants to lieutenant commander while they fill key conventional and nuclear engineering billets. The program is necessary to help overcome shortfalls of qualified lieutenant commanders, and provides appropriate authority, recognition and compensation commensurate with the job. The program has been authorized in its current form since 1975, when it was modified from a similar Viet Nam era authorization.

Because of its unique nature within the Department of Defense, the spot promotion program has been authorized in several year increments, and periodically reexamined for renewal. This year, the 1997 Defense Authorization Bill, awaiting passage, will make the authority permanent. Congress has agreed that officers serving in these few critical billets need to be lieutenant commanders, and has acknowledged our necessity to sometimes assign top lieutenants. This decision was made following our thorough review of various alternatives, including major changes to career paths, a special bonus, and greater use of below zone promotions. Our study concluded that spot promotions remain the most efficient and economical solution to put the best officers in the job while properly compensating them. Navy leadership concurred in our findings. The Secretary of Defense whole heartedly agreed, and Congress voted to make spot promotion authority permanent!

Another issue receiving strong support is Nuclear Officer Incentive Pay (NOIP). NOIP provides additional compensation to attract, retain and compensate nuclear trained officers. The program was first established in 1969 and was last adjusted in 1987. NOIP rates were held constant through the post Cold War drawdown to aid in retaining high quality officers.

With the end of the drawdown in sight, we conducted a review of retention programs needed for the future. This study examined future requirements for nuclear trained officers and past retention behavior in response to bonus level changes. The total costs of accessing excess officers to compensate for low retention were compared to the costs of limiting accessions to meet junior officer requirements and paying bonuses to achieve required retention. This analysis concluded that the most efficient and economical strategy will be to retain the current NOIP structure while adjusting the bonus rates to overcome the erosion of inflation since the last rate increase in 1987.

In his forwarding endorsement to Congress, SECNAV showed his very strong support for our nuclear trained officers by directing that the NOIP rates be immediately raised to their legislative maximums to encourage an increase in junior officer retention required as we emerge from the draw down. He also stated his intention to recommend to Congress higher legislated rates to provide him with added flexibility should retention trends indicate the need.

Funding for the increased NOIP rates was provided for FY97, and programmed into the budget for FY98 and beyond. The revision to the implementing instruction to raise the bonus rates gained final approval on 12 August 1996, and is now in effect. The following table summarizes this change:

Bonus Provision	Former Rates	New Rates
Nuclear Accession Bonus	\$6,000	\$8,000
Nuclear Continuation Pay[1]	\$10,000/yr	\$12,000/yr
Annual Incentive Bonus[2]		
Unrestricted Line Officers	\$7,200/yr	\$10,000/yr
Limited Duty Officers	\$3,600/yr	\$4,500/yr

[1] Nuclear Continuation Pay is paid to qualified officers for agreements to remain on active duty for periods of three, four or five years beyond their existing service obligation, up to a maximum of 26 years of commissioned service.

[2] Nuclear Annual Incentive Bonus is paid to qualified officers for each year of continued nuclear service beyond their initial service obligation, when not under a continuation pay agreement. Eligibility continues to retirement, or promotion to flag rank.

We have submitted draft legislation for the FY98 Defense Authorization Bill which proposes higher bonus maximums.

The third issue of interest is the recent change to the obligated service requirement for attending the Naval Postgraduate School in Monterey. Federal regulations and Department of Defense policy require officers to accrue additional obligated service for attending fully funded postgraduate education. Three years additional obligation is earned for the first year of schooling, and thereafter at a one for one rate. Navy policy additionally required this obligated service to be completed on a consecutive basis with other pre-existing obligated service. This policy had the unintended effect of precluding potentially career oriented nuclear trained officers from access to the Continuation Pay described above during the period of time they were fulfilling their postgraduate school obligation. Many of our officers were reluctant to attend Monterey because of this unintended financial burden.

When this conflict was identified to Navy leadership, they enthusiastically agreed that the obligated service requirement should be concurrent vice consecutive, and immediately revised it. This new policy now meets the dual needs of ensuring officers remain on active duty to fill subsequent assignments related to their advanced education, and attracting nuclear-trained officers towards advanced education and a Navy career.

In this era of fiscal constraint, this strong backing is both welcomed and appropriate. Today's submarine officers remain highly motivated, technically competent, and well respected. Through initiatives such as these, we can offer the support and compensation to offset the sacrifices they and their families must make. Our leaders know this, and their actions reflect it. ■

*** IN REMEMBRANCE ***

CAPT Luciano P. Montanaro, USN(Ret.)

CAPT Richard A. Ryzow, USN(Ret.)

SSBN SECURITY
Part 2

by Jerry Razmus

This second installment of the discussion of the SSBN Security Program describes the projects which comprise the program to convey the breadth and depth of the research directed toward understanding potential pre-launch vulnerabilities of the SSBN force. It touches briefly on the spin-off SSBN Survivability and SSN Security Programs.

Mr. Razmus has spent 35 years in SLBM and SSBN test, evaluation and assessment. He began his career at The Johns Hopkins University/Applied Physics Laboratory where he performed SSBN assessments. He was also technical advisor to COMSUBLANT and CINCLANT. He is a plank owner in the SSBN Security Program and contributed to establishing its philosophy, objectives and management plan.

Mr. Razmus continues to contribute to the SSBN Security Program as an independent consultant to JHU/APL.

Elements of the Program

The 1968 Foster Memorandum referred to in the previous article *[Editor's Note: See the April 1996 issue of* ***THE SUBMARINE REVIEW****, p. 25]* stimulated the Navy to formulate and implement the SSBN Security Program. Initially the program was named the SSBN Defense Program because an *SSBN Survivability* program as suggested in the memorandum had a specific connotation in the PPBS. That is, survivability referred to the ability of a platform or weapon system to survive hostile engagements and continue to perform. The Navy did not want a program that aimed solely at the SSBN's ability to survive engagements, but rather one that maintained and enhanced the at-sea SSBN's ability to avoid engagements by its immunity to detection. Some Navy officials believed *Defense* also created the wrong impression so the program was eventually named the SSBN Security Program with the principal objective of maintaining the covert mobility of SSBNs.

While many familiar with SSBN security think of the program as the research and advanced technology development efforts of the SSBN Security Technology Program, the Navy, in fact, created a comprehensive set of programs to address SSBN security issues. The SSBN Security Program included: The SSBN Security Technology Program (SSTP), The SSBN Tactical Development Program (STDP), an all-source intelligence program, and a series of countermeasure development and deployment programs. Later, in 1986, as the potential of various detection technologies was thoroughly understood, the SSBN Survivability Program was created to develop and demonstrate countermeasure technology deemed prudent to have available if ever needed. Each of these projects contributed to comprehensive understanding and mitigation of potential vulnerabilities of SSBNs—both near and far term. The countermeasures developed and deployed remain classified and therefore are not discussed herein.

The SSBN Security Technology Program

Because the Dr. Foster Memorandum established the *charter* and provided guidance to the Navy on program execution of the SSTP it is reproduced here in its entirety.

16 October 1968

MEMORANDUM FOR THE ASSISTANT SECRETARY OF THE NAVY (R&D)

SUBJECT: SSBN Survivability

In view of the Soviet buildup of submarine capability in terms of both quantity and advancing technology, I believe it prudent to take those actions which will ensure the continuing survivability of our SSBN force well into the future. Toward this end, I am considering formulation of a separate and new line item in the FY 70 R&D budget on SSBN survivability. The basic objective of such an endeavor would be to develop all relevant technologies, on a continuing basis, to ensure the long term survivability of the present FBM force as well as providing the technological base for any future sea-based systems such as ULMS. *(Editor's note: ULMS, the Undersea Launched Missile System was the 1968 STRAT-X Study proposal for the next generation strategic weapon system. ULMS became the Trident system.)*

My rationale for considering a separate line item, as opposed to doing the work as part of the ASW efforts, is generally as follows. Although the technologies involved are admittedly similar, I believe that if the same people were working both the offense and defense problems there might be a tendency to gravitate to one position to the detriment of the other.

With SSBN survivability a separate line item, pursued in part by different personnel than ASW, the competition that would naturally evolve should bring forth the best efforts in both activities.

Relative to the potential SSBN survivability line item, I would like to have your views on the subject, including a list of specific tasks that you believe should be pursued in such an activity. It is preferable that such a listing not be prioritized. After my review of these specific tasks, I would then like to get together with you to mutually establish the substance and priorities for such a program. The potential problem that you outlined in your note can be addressed at that time as can the nomenclature for a new line item.

John S. Foster, Jr.

After several iterations on program content and priorities the SSBN Security Technology Program was initiated in FY 70. The specific guidance on program execution resulted in the Navy assigning the program to the Strategic Systems Project Office (SSPO), and SSPO selecting the Johns Hopkins University/Applied Physics Laboratory (JHU/APL) as the prime contractor. Both of these organizations were selected because of their reputations for technical excellence, their demonstrated ability to manage large and complex technical programs, their intimate knowledge of the technical and operational details of the FBM program, and their lack of any previous ASW research work (DDR&E demanded a fresh look at the problem). In 1983 Navy program management was shifted to the Office of the Chief of Naval Operations, where it is administered within the Security and Technology Branch of the Submarine Warfare Directorate (OPNAV N875). While JHU/APL remains the principal contractor, an original program policy of obtaining the best talent available to pursue the research projects, whether from industry, academia, Navy laboratories or national laboratories remains in effect.

The SSBN Security Technology Program was formulated as a non-acquisition R&D program with the objectives of: (1) developing understanding of operational techniques and potentially exploitable physical phenomena associated with SSBN operations that would permit accurate assessment of any potential threat to the FBM force and, (2) developing techniques, countermeasures, and advanced technology that would ensure the survivability of the force against such threats. Thus the program is logically comprised of two major activities, force security assessment and technology research and development. The technology research and development activity is *physics based*, that is its objective is to understand the limits on the ASW utility of any submarine observable phenomenon imposed by the laws of physics, not those imposed by current technology limitations. Neither is the program driven by intelligence information. Intelligence, however, does provide an additional input for project selection and prioritization. The force security assessment project evaluates the implications of advanced technology (both detection and countermeasure technology) as well as current threats. The top-level assessment results were discussed in the previous **SUBMARINE REVIEW** article SSBN Security so the discussion here will concentrate on the technology research element.

Although the detailed organization of the program has varied over the years as the major thrusts changed, the program throughout its history has maintained a three element division for planning and execution. Those elements are, Acoustic Technology, Non-acoustic Technology and Operations Security. The Operations Security element includes the force security assessment activity as well as technical assistance to fleet SSBN security projects such as the STDP, the Port Egress Task Force and the SSBN Continuity of Operations Project (SCOOP).

The program philosophy is to systematically explore all submarine-generated phenomena and the potential exploitability of those phenomena over the entire range of submarine operating conditions and the environments in which they operate. No investigation of a promising technology is considered to be complete until it is demonstrated full-scale, at sea. To that end, the program developed a structured process for selection and pursuit of specific research projects. That process is a series of tasks that collectively constitute a research activity, start to finish. Those tasks are:

- Phenomenology Description
- Concept Development - Hypotheses
- Sensor Development - Laboratory/Field Tests

- Signal Model - Data Collection and Analysis
- Noise Model - Data Collection and Analysis
- Detection Algorithms - Signal Processing
- At-Sea Tests - Plan/Execute/Analyze
- Performance Prediction - Probability of Detection/False Alarm Rate
- Operating Characteristics - Environment/Depth/Speed/Habits /Tactics
- Countermeasure Concepts - Tactics/System Hardware Development
- Fleet Guidance/Tactical Exercises/Naval Material Development

The process ensures thorough and rigorous examination of each technology selected and provides necessary *off-ramps* as the activity proceeds. As anyone who has attempted to probe the oceans secrets knows, the ocean does not give them up easily. So some of the SSTP research activities have had a life span 10 years or more, encompassing a series of major at-sea experiments. Therefore, the single purpose, stable management and stable funding the SSBN Security Technology Program has experienced have been absolutely essential ingredients to program success. Because of the cost of at-sea experiments and the complexity of the experimental sensors and data acquisition systems involved, pursuit of joint research projects with SPAWAR, NAVSEA, ARPA and Navy Labs has been an equally important contributor to success. In the course of the program it has employed the services of over 150 industrial contractors, universities and laboratories, taking advantage of their specialized expertise.

The easiest way to describe the nature of the research activities of the program over the past 26 years is to present a list of program accomplishments. While many of the program research results remain classified, the following unclassified list amply conveys the scope of activity and the return the nation has received on the SSTP research investment.

SSTP ACCOMPLISHMENTS

Passive Acoustics

Steady State Detection

First to develop and demonstrate FFT technology for real-time multi-channel beamforming and signal processing.

Developed and demonstrated techniques for measuring and compensating for long towed array deviations from straightness.

Measured in-situ signal coherence across a very long towed array. Results showed achievable gains significantly greater than had been predicted.

Demonstrated that by capitalizing on low frequency ambient noise anisotropy substantial gains over conventional array gain could be achieved.

First evaluation of submarine detectability in the 0.01 to 1 Hz frequency region.

Transient Detection

Quantified detectability of SSBN specific transient evolutions.

First demonstrated the potential for automated transient detection at low false alarm rates.

Acoustic Signatures

Determined physical mechanisms responsible for hull SWATHs.

Developed a physical explanation for the low frequency shaft related noise (LFSRN) phenomenon.

Active Acoustics

Low Frequency

First tests of very long range, low frequency active acoustics.

Developed explosive source technology used in target strength measurement.

Conducted first full scale measurements of low frequency target strength.

Conducted first tests of low frequency active barrier concepts.

Conducted first tests of low frequency active in shallow water.

Developed first low frequency active intercept receiver.

Developed first tactical decision aid for low frequency acoustics.

First demonstration of low frequency active bistatic receiver.

High Frequency

Designed an advanced technology high frequency, high resolution trailing sonar for countermeasure evaluation and assessment.

Developed active sonar detection avoidance, evasion and break-trail tactics.

Radar

Mast Detection

Developed first validated models of radar mast detection.

Demonstrated in-situ radar detectability of submarine periscopes and masts.

Floating Wire Detection

Quantified radar detectability of floating wire antenna which led to changes in the operational utilization of the antenna.

Developed radar intercept receiver wholly contained within the floating wire.

Hydrodynamics

Employed theoretical studies, tow tank experiments and in-situ full scale experiments to develop submarine induced hydrodynamic signature generation, propagation, and decay models.

Validated the models with in-situ full scale experimental data.

Quantified detectability of submarine hydrodynamic wake.

Employed submarine ejected dye trails to quantify potential of submarine wake trailing.

Performed first two-dimensional high resolution measurements of ocean microstructure.

Electromagnetics

Airborne

Conducted first scientific mapping of geologic noise spectra using aircraft.

Conducted first flight demonstration of superconducting magnetometer.

Performed first in-air measurements of ELFE signature.

Conducted first active magnetohydrodynamics experiments.

Fixed

Developed and conducted first tests with fixed electromagnetic barrier sensors.

Demonstrated significant noise cancellation possible using fixed sensors.

Signatures

Conducted first DC and AC electromagnetic signature measurements on fully submerged submarines with fixed high sensitivity sensors.

Demonstrated technical feasibility of reducing submarine MAD signatures through closed loop degaussing.

Infrared

Developed first millidegree sensitivity, absolute temperature, scanning, airborne radiometer.

Identified previously observed IR submarine scars as manifestations of the sail plane vortex wake.

Demonstrated that submarine induced internal waves do not produce detectable IR signatures.

Optics

Passive

Developed first low light level imaging system for bioluminescence detection.

Developed first quantified bioluminescence detection model.

Developed self-monitoring countermeasure system for bioluminescence.

Conducted investigation of optical detectability of communications buoy.

Developed communications buoy optical detection countermeasure.

Active

Developed first airborne digital lidar system.

Demonstrated potential of lidar for hull detection.

Developed quantified detection model for submarine hull.

Developed and demonstrated submarine hull mounted lidar intercept receiver.

Environment

First use of AXBT sensors deployed in fields to determine the three dimensional characteristics of the ocean environment.

Program was a leader in quantifying the importance of ocean environmental measurements to acoustic and non-acoustic detection concepts resulting in:

Establishment of SSBN Security Program Environmental Data Base, a large collection of raw and averaged acoustic and non-acoustic environmental data unique in its variety and world wide distribution.

Developed a methodology for specification of environmental measurements requirements. Used to provide specific direction to NAVOCEANO for use in designing surveys.

Developed detailed Strategic Area Notebooks which provide a unique global assessment of submarine detectability based on environmental data in each of the SSBN patrol areas.

Developed techniques and published guidance for tactical utilization of oceanography.

<u>Tactical Decision Aids</u>

Developed the first tactical decision aid for topographic noise stripping on a PC.

Initiated the first development of an expert system tactical decision aid for submarines which was subsequently transitioned to the ARPA Signature Management Program.

Developed and demonstrated the capability to directly receive and display satellite imagery of environmental parameters on the Navy desktop computer.

Developed the first tactical decision aid for low frequency active acoustics.

In addition to the tangible results listed, the SSTP has become the Navy leadership resource in submarine stealth technology, ASW science and technology, and full-scale, at-sea experiment design and execution. It is the Navy's storehouse of knowledge and data in all submarine detectability phenomena, ocean environment characterization, and SSBN operations and habits characterization. And, it has developed and maintains assessment models for all plausible anti-SSBN ASW employment tactics including, open ocean search, trail from port, surveillance assisted search, area bombardment and tagging.

The SSTP continues its research activities today albeit with substantially reduced funding.

<u>The SSBN Tactics Development Project</u>

At the time the SSTP was being structured, the Chief of Naval

Operations was concerned about the security of the SSBN force from an operational standpoint. Based on the facts that the Soviet submarine force was improving at a rapid rate and that any advanced technology developed would not reach the fleet for 5 to 10 years, the CNO directed COMSUBLANT and COMSUBPAC to establish an SSBN Tactical Development Program. In order to insure that the SSTP and STDP were coordinated, SSPO was directed to provide funding and technical support to the STDP and to establish direct liaison with the Force Commanders.

The STDP was managed by the Force Commanders until 1980 when management was transferred to Commander, Submarine Development Squadron TWELVE. Sonalysts has been, and remains the principal support contractor to the STDP. The program employs analysis, simulation, gaming and exercises to develop SSBN security related tactics and to ensure SSBN operational security. The STDP developed the SSBN Security Manual which ultimately was incorporated in the NWP series.

SSBN tactics were developed and published for contact avoidance, evasion, break-trail, countermeasure employment, port egress, transient signature and other patrol habits management, and guidance was promulgated for control of SSBN maneuver induced observables. Just as in the projects of the SSTP, the tactics development projects are not considered complete until they are demonstrated and refined in at-sea exercises. Thus a major element of the STDP is the Security Exercise Project or SECEX.

The SECEX project is comprised of three types of exercises: Tactical SECEXs, Scientific SECEXs and Forward Area SECEXs. Tactical SECEXs are those employed to demonstrate and refine the specific tactics developed by the STDP. Scientific SECEXs are joint efforts with the SSTP to demonstrate and evaluate the advanced technology developed by the SSTP in a tactical environment. Forward area SECEXs are employed on a random basis in statistically significant numbers to confirm the security of SSBNs on patrol.

The STDP contributed to and conducted joint exercises with the Port Egress Task Force and the SCOOP Task Force. The program has annual multi-day performance review and planning sessions that are chaired by the Force Commanders' staff and include Development Squadron TWELVE commander and staff, Submarine Groups NINE and TEN staff, SSTP staff, SSP staff, CINCSTRAT staff and appropriate contractors. The STDP continues today, also with reduced funding and therefore reduced level of activity.

The All-Source Intelligence Program

Coincident with the formulation of the STDP, the Naval Intelligence Command was tasked to create an SSBN Security intelligence assessment program. The program was highly classified and access was strictly limited, with a specific need-to-know basis. The program employed all sources of intelligence data to determine and evaluate any Soviet reaction to SSBN operations. Special focus was placed on Soviet submarine, MPA, AGI and AGOR activities. Each SSBN patrol track was reconstructed and searched for coincidence with any Soviet platform. Any even remotely possible coincidence was researched in great detail and an assessment was made and reported to the VCNO, the Director of Submarine Warfare, the Director of SSPO and the Program Manager and Technical Director of the SSTP. The program discovered attempts of Soviet anti-SSBN operations but uncovered no Soviet successes throughout the duration of the Cold War. With the collapse of the Soviet Union the program was terminated.

SSBN Survivability Program

The SSBN Survivability Program is a non-acquisition program with the objective to identify and develop prototype technology to enhance SSBN survivability in a hostile environment. It selects from the SSBN Security Program (or elsewhere) countermeasure concepts for prototype technology development and demonstration. The countermeasure concept selection process is keyed to the assessments performed in the SSBN Security program. Priority therefore is established by the assessed severity of potential threat and an estimate of the time required by an adversary to field such a threat. The countermeasure concept feasibility is demonstrated at sea employing the prototype technology and, when successful, the requisite documentation for transition to full scale engineering development is prepared.

SSN Security Program

The end of the Cold War brought a dramatic change in emphasis in SSN missions and with that change a requirement to reassess potential SSN vulnerabilities. The emphasis on operations in the littoral in support of the land battle increased the importance of understanding the potential vulnerability of SSNs to short range, shallow water detection systems. Since the SSBN Security Technology and Survivability Programs had developed knowledge and a technology base for all potential submarine observables, the Navy decided to establish a specific effort to apply those to assessment of SSNs in the new missions context. The SSN Security Program was therefore established in 1991 with a charter and approach similar to the SSBN program and employing the same technical management and performing organizations. The SSN Security Program is able to perform assessments with a relatively low level of funding only because of its leveraging off the SSBN Security Technology and Survivability Programs.

Summary

When the Assured Destruction deterrence policy elevated the importance of prelaunch survivability of strategic weapons systems, the Navy responded with a comprehensive program to ensure that characteristic of the SLBM force as well as to ensure the confidence our national security decision makers had in that characteristic of the SLBM force. Prelaunch survivability of SSBNs was considered so important to our nation's deterrent posture that the Defense Science Board, the JASONS, the Central Intelligence Agency and the Office of the Secretary of Defense were tasked at various times during the last 25 years to independently evaluate aspects of SSBN security. To the credit of the Navy's SSBN Security Program, none of its conclusions were ever refuted by those independent assessments. The net assessment remains that our SLBM force is secure now and into the foreseeable future. That assessment is made confidently because of the technical and tactical enhancements deployed and the thorough and rigorous investigations of all potential ASW technologies conducted by the SSBN Security Program.

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THE SUBMARINE REVIEW

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

Articles for this publication will be accepted on any subject closely related to submarine matters. Their length should be a maximum of about 2500 words. The content of articles is of first importance in their selection for the **REVIEW**. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the **REVIEW**.

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

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

CHINA: THE NEXT GREAT NAVAL POWER?

by LT Donald W. Wolfgang, USN

The winning essay of the Submarine Advanced Officer's Course in February of 1996.

Lieutenant Wolfgang enlisted in the Navy in 1982 and completed nuclear power training before being selected for NROTC at the University of Michigan. He again went through nuclear power training and qualified in TECUMSEH. He is currently Navigator in LOUISIANA (SSBN 743).

With the end of the Cold War, the U.S. finds itself in a precarious situation in regard to its relations with the Peoples Republic of China (PRC). Prior to the collapse of the Soviet Union, the U.S. and China maintained rather cold relations as a balance-of-power approach. The logic behind this type of association was a strategic counterweight to Soviet military power. Since the collapse of the Soviet Union as a superpower, the necessity for this type of arrangement is no longer viable. The ensuing American foreign policy approach towards China can be described as "constructive engagement".[1] This is based upon the belief it is better to have some sort of relationship rather than becoming estranged and not be able to exercise any influence on political and economic change currently in progress in China. This essay looks at these changes and their possible consequences for the United States.

In order for any nation to be considered a military power, it must meet three basic criteria. These criteria include the following:

- The weapon platforms must be capable; long range platforms must be present in order for power projection to be a viable option as a nation's strategy.
- The military must be well trained, proficient at operating all the above platforms in order to use them to their fullest capability.
- The military must have the financial backing of the nation. Included in this category is the national infrastructure to support

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[1] Monte R. Bullard," U.S.-China Relations: The Strategic Calculus", Parameters, Summer 1993, pg. 86.

the repair and maintenance of the aforementioned weapons platforms.

The primary focus of this essay is the final point. This is the starting point for any nation wishing to become a more viable military power. Without first establishing a means to support the military, both financially and materially, the military will not be able to sustain its operations. It is this area in which the PRC has made leaps and bounds towards advancing its military power. First, reformation has created a burgeoning economy in China. Second, technological advancement has significantly improved the PRC's capacity to sustain its military weapon systems and improve its war fighting capability.

Economic Reforms

In 1978 a reform movement was started by Den Xiaoping. He wanted the Chinese economy, until then a slave of Soviet principles of central planning, state ownership and import substitution, to be reformed and opened to the outside world.[2]

The first major reform was to shift from a state run agricultural system to private market controlled farms. This was accomplished by freeing prices of food, thus creating a market economy in food items. The ground work had been laid for sustained growth and created a surplus of rural savings. This surplus would become extremely important as a launching point for the second phase of reforms.

The idea behind the second set of reforms which occurred in the mid 1980s was again to decentralize control; however, industry became the emphasis vice agriculture. Along the way, a shift from the heavily agricultural based rural areas to more industrial based would also be accomplished. Throughout the rural areas, local government-controlled industries have started to crop up and now make up a major portion of the rural industrial base. These entities are referred to as Township and Village Enterprises (TVEs).[3]

Finally, four *Special Economic Zones* were created to test the

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[2] The Economist, "When China Wakes, A Survey of China", 28 Nov. 1992, pg. 6.

[3] Ibid, pg. 12.

virtues of an *open door* policy for foreign trade. The central government previously maintained monopolistic control over all trade with foreign entities. These zones were set up in strategic locations, three surrounding Hong Kong in the Guangdong province and one across the straits from Taiwan in the Fujian province.[4] These centers have served as focus points for foreign investment into the nation as well as a source of trade export and import. As with the other reforms, the open door policy swept the nation. Since 1980, the dollar value of China's trade has grown by more than 12 percent per year. This is twice as fast as the rest of the world. Foreign trade has become one of the primary catalysts for the growth of the Chinese economy.

The three reforms have resulted in the fastest growing economy in the world. Since 1978, real GNP has grown by an average of almost 9 percent a year. In 1994, China's economy was four times the size it was in 1978.[5] This makes China the third largest economy in the world, behind only Japan and the United States. Foreign trade, foreign investment, food production and manufacturing have all grown at tremendous rates as a result of these reforms. Most importantly, a means has been provided from which technological advancements and further industrialization can occur. In other words, those who have money will spend it!

Technological Advancements

For hundreds of years before the late 19th century, China was the most advanced civilization in the world. Then for much of the first half of the 20th century China was mired in continuous social reform.[6] As a result, China lagged significantly behind its western and Japanese counterparts both economically and technologically. When China's economy began to burgeon, technological importation became a paramount interest within the nation. The lure of a market consisting of 1.2 billion people has many countries and corporations *licking their chops* at the prospect of

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[4] The Economist, pg. 7.

[5] Ibid, pgs. 3, 4.

[6] Gerald Segal, "The Coming Confrontation Between China and Japan", World Policy Journal, vol. X, no. 2. pg. 28.

doing business in China. Thus, countries such as Japan, Hong Kong, Taiwan, Russia, Israel and even the U.S. have jumped on the band wagon of China trade.

China's industries, and to an even greater extent, China's government, have used rather overt methods for their technology acquisition. They have a four-tiered scheme based on the principle of ultimately achieving self-sufficiency in production.[7] The scheme is as follows:

- Try everything possible to steal the secrets of industry or to purchase single items and then produce those items indigenously through reverse engineering.
- Encourage joint ventures in which foreign firms supply blueprints to China and allow access to the secrets of production.
- Establish co-production with foreign firms, allowing the firm to supply some of the components, this allowed some withholding of secrets from China.
- Then lastly if all else fails, purchase the equipment outright.

Most of the overt acts have occurred within the defense industries; thus, the major concern looked at in trade considerations is that this trade is bolstering the military effectiveness of the Peoples Liberation Army (PLA).

One of the most interesting developments to occur during China's drive for advancing technology has been the means by which the PLA has advanced itself. A complex military-industrial network has developed over the past couple of decades.[8] These industries are owned and manned by the military, control is via the Central Military Commission (CMC), directly or indirectly, via the State Council, with significant direction from the CMC. The CMC can be most closely related to our own Joint Chiefs of Staff. The primary function of these industries is to export and import goods between China and foreign nations. Exporting of goods produced within the industries is the source of funds used to import foreign weapons systems for use by the PLA. Since the PLA is permitted to keep its own profits it has expanded its manufactures from simple weapons to other goods such as pig

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[7] "US-China Relations: The Strategic Calculus", pgs. 93-94.

[8] John Pomfret, "China's Army Now Major U.S. Arms Merchant, Washington Post, 4 Mar. 1993, pg. 11.

iron, basketballs, bicycles, car jacks, silk jackets, and even negligees.[9] Along the way many military officers have raised their own standards of living as well as padded a few bank accounts.

One of the major strategies currently used by these import-export companies is to buy small U.S. defense firms to get grassroots control of advanced technology. As of March 1993, seven different states in the U.S. contained companies which were owned and operated directly from the Chinese military-industrial network.[10] Wendy Frieman, a Chinese specialist for the Virginia based think-tank Science Application International Corporation, stated,

> "The Chinese military is pretty much doing anything it can to make money...so they can buy things primarily the U.S. won't sell them. Opening businesses in the U.S. gives the defense firms a window into the U.S.."

The Chinese military has also purchased firms in Germany, the United Arab Emirates, Singapore and Hong Kong. Again the aim of these acquisitions is to arm the PLA with the most modern weapons technology they can get their hands on.

China's spending on defense is the second largest in the Asian Pacific region, only Japan spends more.[11] One must temper these *official* figures with the belief that a great portion of the dollars spent on defense are hidden within the military-industrial network. Consequently, China may in fact spend almost three times the official figure indicated by the State.

As a precursor to modernization, China reduced its force strength from four million to three million in the 1980s. This allowed more room in the budget to purchase advanced technology weapons systems. Several avenues have been used for these purchases. Outright buying, co-production, licensing, and joint commissions have all had a part in the technology acquisition. Among many outright purchases China has acquired four Kilo

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[9] Ibid, pg. 1.

[10] Ibid, pg. 11.

[11] Institute for National Strategic Studies, "Strategic Assessment 1995", pg. 22.

class submarines[12], 72 SU-27 long range fighters, 440 T-72M main battle tanks, and a long range Early Warning system all from Russia.[13] China is taking advantage of economic woes in Russia to advance its own military capability.

China is also using *offset* type agreements in its modernization efforts. With a purchase of 24 MIG-31 fighters from Russia, China licensed the production of 200 more indigenously.[14] This requires the transfer of both the blueprints for the planes and the production technology used to build them. Co-production type contracts were used to purchase Israeli air-refueling capability and a radar system for its J-8II fighter aircraft. These two particular deals did not please U.S. officials since some of the technology originated in the U.S. While the U.S. was not pleased with these results, it too has begun to encourage trade with China.

For the past several years, officials in both countries have been trying to work out two deals for technology transfer. One would allow the sale of seven satellites to China, the other would allow the sale of a Cray Supercomputer.[15] The technology supported by these sales is meteorological prediction and communications. While neither are directly linked to the military, both supply technology which could be converted into military applications at future dates. These deals now appear to be ready to get off the ground since the two countries have been able to come to agreement on several trade issues.[16] Purchasing capital assets has not been the only means by which China has advanced its technology base.

Within the past few years China has successfully recruited

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[12] Kathy Chen, "China Buys Russian Submarines, Raising Tension Level in Region", Wall Street Journal, 9 Feb. 1995, pg. 1.

[13] William Branigin, "As China Builds Arsenal and Bases, Asians Wary...", Washington Post, 31 Mar. 1993, pg. 5.

[14] Ibid, pg. 11.

[15] Elaine Sciolino, "U.S. Will Court China in a Sale of Big Computer", New York Times, 19 Nov. 1993, pg. 1.

[16] Helen Cooper and Kathy Chen, "China Averts Trade War with U.S. ...", Wall Street Journal, 27 Feb. 1995, pg. A3.

Russian weapons systems experts to upgrade its nuclear and ballistic missile programs.[17] The Chinese media has claimed that as many as 3000 former Soviet experts are now working for the government. Some of the experts are even contributing via electronic mail vice moving to China. Still another means by which China seeks to better itself is by the use of joint commissions.

In October of 1994, Secretary of Defense William Perry and General Ding Henaggo, minister for China's State Commission for Science, Technology and Industry for National Defense (COSTIND), met to establish a joint commission on military conversion.[18] The two governments desire the commission serve as a means by which technology can be shared and joint ventures between U.S. and Chinese business can be accommodated.

Whether for military modernization or for increased industrial capability, China is currently engaged in a massive effort to acquire modern technology. This endeavor has resulted in a very entrepreneurial minded military leadership, tremendous gains in foreign trade and investment, as well as the purchasing of many foreign firms by China. Since relations with China and the U.S. have never been much better than mutual distrust but acceptance nonetheless, the question should be asked, "How do these ongoing efforts affect our relationship with China"?

Implications for the U.S. Navy

China has taken tremendous steps towards providing the financial and material backing necessary for a viable power projection military force. They have even begun to purchase, or build indigenously, many power projection weapon platforms. While very few of these weapon platforms are directly related to a naval force, with the exception of the Kilo submarines, the technological background has been laid for China to start producing a much more significant naval presence. Combined with the currently existing weapons such as their nuclear attack subs and

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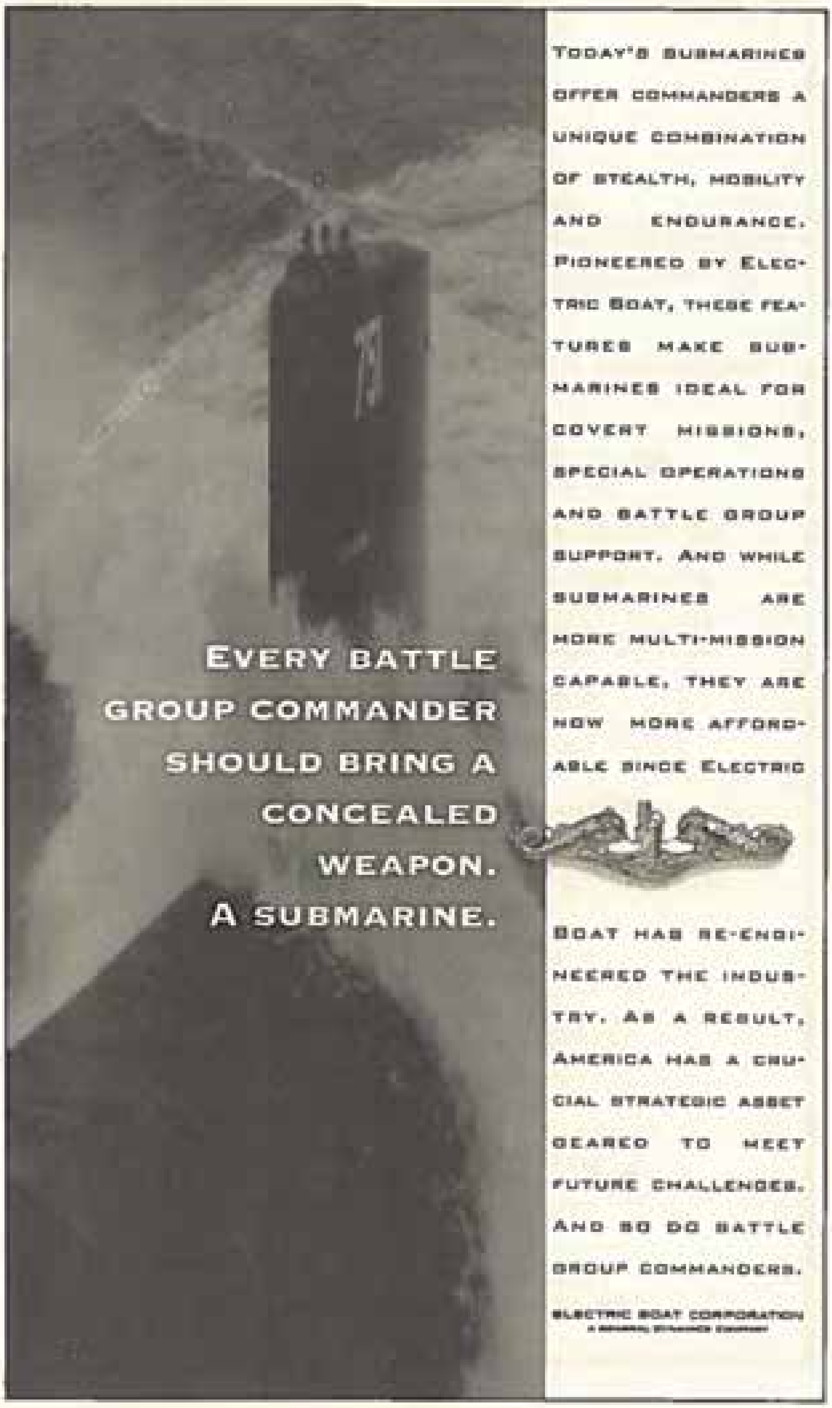
[17] John J. Fialka, "U.S. Fears China's Success in Skimming Cream of Weapons Experts from Russia", Wall Street Journal, 14 Oct. 1993, pg. 12.

[18] Richard C. Barnard and Barbara Opall, "U.S., China Resume Ties", Defense News, July 11-17, 1994, pg. 21.

ballistic missiles, China has become a serious player in the Pacific region.

There has been much interest by China's neighboring countries over the increasingly blue water capabilities of the PLA. China has already made public its desire to extend its control of the sea out to 1000 miles from shore. Certainly, one of their primary concerns is the acquisition of several island chains in the South China Sea which are believed to be rich in oil and other minerals. Most of the island chains in question are claimed by several different nations in the region, thus a concern for regional stability. In order to soothe the anxieties of many Asian nations, the U.S. will have to maintain somewhat of a presence in the East and South Asian areas. This should include a presence on the Korean peninsula, in Japan, and especially by maintaining a credible naval force for power projection and showing of the flag.

Finally, any U.S. naval forces operating in the South and East China Seas as well as the Sea of Japan will certainly come into contact with Chinese naval assets as they increase their sea going capabilities. As the infrastructure for a formidable navy is being built, and the platforms the PLA is purchasing, and building indigenously, are indeed much better than they have ever had; all that will hold back the Chinese naval presence is training and proficiency at operating their platforms. They are not likely to take this area lightly given their desire to expand their presence throughout the China Sea regions. ■


EVERY BATTLE GROUP COMMANDER SHOULD BRING A CONCEALED WEAPON. A SUBMARINE.
TODAY'S SUBMARINES OFFER COMMANDERS A UNIQUE COMBINATION OF STEALTH, MOBILITY AND ENDURANCE. PIONEERED BY ELECTRIC BOAT, THESE FEATURES MAKE SUBMARINES IDEAL FOR COVERT MISSIONS, SPECIAL OPERATIONS AND BATTLE GROUP SUPPORT. AND WHILE SUBMARINES ARE MORE MULTI-MISSION CAPABLE, THEY ARE NOW MORE AFFORDABLE SINCE ELECTRIC BOAT HAS RE-ENGINEERED THE INDUSTRY. AS A RESULT, AMERICA HAS A CRUCIAL STRATEGIC ASSET GEARED TO MEET FUTURE CHALLENGES. AND SO DO BATTLE GROUP COMMANDERS.
ELECTRIC BOAT CORPORATION

ETHICS, THE NAVY, AND THE SUBMARINE FLEET

by MIDN 1/Chris S. Garvin
NROTC
Rensselaer Polytechnic Institute

We hold as axiomatic that a naval officer be a person of integrity, of moral character, and of honor. In the undersea world of the nuclear submarine, daily pressure focusses and illuminates character flaws like a magnifying lens. In this world, it is imperative that the ethics of the leader be beyond question. Theodore Rockwell illustrates the submariner's unique perspective as he discusses recruiting submarine captains: "...Calvert quickly adopted the submariner's clear understanding that his life was very much dependent on...his shipmates...He was sure no other service forged such bonds..."[1]

But why? Why does the subject of ethics matter? After all, "...no [leader] ever yet lacked legitimate reasons with which to color his want of good faith..."[2] James Stockdale, Medal of Honor awardee, discusses integrity and ethics in his foreword to Ethics for the Junior Officer. He reminds us that the word "integrity" originated from the concept of unity, and that it is through unity, through comradeship, that battles are won and wars decided. Truly, integrity is the Navy's business.[3]

And as illustrated above, integrity is even more so the business of the submariner.

Knowing how important ethics and a *moral compass* are, we must be concerned with the future of our Submarine Force officers. This concern comes from the moral decline of American society that has driven a complementary decay in the moral quality of officer accessions. A submarine force can only be as good as its men; its men can only be as good as the Navy's officer corps; and that officer corps can only be as good as society.

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[1] Theodore Rockwell, The Rickover Effect: How One Man Can Make a Difference. Annapolis, MD: Naval Institute Press, 1992, p. 107.

[2] Machiavelli, The Prince. New York: Pocket Books, 1963, p. 77.

[3] Writing in Ethics for the Junior Officer. Annapolis, MD: Naval Institute Press, 1994, pp. ix-x.

I won't try to explain *why* there has been American cultural erosion since World War II—there simply isn't room to list the causes. Pundits, from George F. Will to Mike Royko, have blamed everything from Dr. Spock to Donahue. Books, like James Q. Wilson's The Moral Sense, have been written on the topic. I won't explain why this problem exists, but I will illustrate that it exists. And it exists painfully close to the Navy's home.

In the past decade we've had the Tailhook debacle—where members of the officer corps not only misbehaved, but as a group disguised their complicity, bringing further discredit on what are supposed to be America's paladins.

The U.S. Naval Academy, where "...American values are alive and well..."[4] gave us two prominent scandals: the Electrical Engineering exam-cheating ring and, most recently, a group of midshipmen dealing LSD—a potent hallucinogen.

Examples of sexual harassment, misconduct, and poor moral judgement can be found from top to bottom in today's Navy. There have been delays in recent flag officer promotions for exactly those reasons. Amorality in naval leadership has made headlines in recent months. And submariners, a group virtually untouched by Tailhook's infamy, have been shamed by the actions of a few miscreants.

How can naval leaders expect subordinates to do the right thing when they themselves do not occupy the moral high ground? "...Before continuing to pummel American youth for their lack of moral virtues—and by inference, extolling those of their elders—we might ponder the degree to which those elders (or seniors) are responsible...".[5]

The preceding is not meant to libel the Navy. A strong majority of officers set a fine moral example. Nevertheless, here are the facts:

- We necessarily have a very high ethical standard for naval officers.
- A small fraction of serving officers aren't up to those

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[4] ADM Charles R. Larson, USN, "Service Academies—Critical to Our Future", Proceedings, October 1995.

[5] MGEN J.D. Lynch, USMC(Ret.), "Fish Rot from the Head", Proceedings, February, 1995.

standards.

- A larger fraction of potential officers don't meet those standards.

How, then, do we solve this problem? Can we escape the *garbage in, garbage out* paradigm that condemns the naval service to the same moral mediocrity as American society? And if so, how do we do it?

We must start with officer training programs. A universal standard must be established, based on the Navy's core values: Honor, Commitment, and Courage. Then we must train to those standards. Leadership and immorality must be shown to be incongruous. ROTC programs should adopt the Naval Academy's *Character Development Program*, "...a four year, integrated process in which basic American values and those of the Navy and Marine Corps are strengthened and reinforced...".[4] Future officers must understand the need for moral courage both in and out of uniform, and see that *situational ethics* is an oxymoron.

You can't teach honor—that's not what I advocate. But you can strengthen moral sense, through frank discussion, reading, and discourse. ROTC and OCS must shift the focus from their traditional drilling in pomp and circumstance to the strengthening and reinforcing of moral courage and the honor concept.

Officer accessions must act as a filter, removing dishonorable and unethical candidates before they enter the service. To this end, policy should facilitate removal of undesirables. We can no longer allow any exceptions to the code of honorable conduct. Those who fail to act ethically must no longer be merely *counseled* by upperclassmen—they must be eliminated as future officers. There is no room for second chances—this is the Navy's future.

In a similar vein, commissioned officers cannot be allowed to act without honor. We must no longer give the appearance that politics dictates policy and punishment, and that the dishonorable are merely *slapped on the wrist*. We must send the message down the chain of command that naval officers are held to higher moral standards. This is stern stuff, but necessary—commissioned service truly is not a job; it is an exacting subordination of self to country, and it requires **character**.

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[4] ADM Charles R. Larson, USN, "Service Academies—Critical to Our Future", Proceedings, October 1995.

Even more so, submarining requires character. No profession depends more on teamwork, cohesion, and integrity than that of the nuclear submariner. The responsibilities are uncountable—reactor safety, personnel safety, crew well-being—and the demands are myriad. Thus, the men selected must be culled from the finest in society. Honor and integrity must be inculcated in these men from the beginning of their naval training. If we improve the moral quality of officer accessions, we will improve the quality of the submarine officer corps. If we fail to take ameliorative steps toward the problem of ethical decline, we risk not only the future of the Submarine Force, but the future of the naval service. ■

REUNIONS

USS NARWHAL (SSN 671) will hold a crew reunion in Virginia Beach, Virginia on 25-27 October 1996. Please contact:

Steve Stone
P.O. Box 1175
Pascagoula, MS 39568-1175
(601) 769-5603 (W)
(334) 865-4402 (H)
E-mail: Narwhal@juno.com

USS PIPER (SS 409) will hold a reunion on the 30th anniversary of her decommissioning, 20-24 August 1997. Please contact:

Frank Whitly P.N.C.
U.S. SubVets, Inc.
87 Oak Street
Middleboro, MA 02346
(508) 946-5274

GERMAN SUBMARINE TECHNOLOGY

by Hans Saeger
Howaldtswerke-DeutscheWerft AG (HDW)

This paper was presented at the Submarine Technology Symposium jointly sponsored by the Naval Submarine League and the Applied Physics Laboratory of The Johns Hopkins University in May of this year.

This paper addresses the German submarine technology and its evolution during the last 35 years. It concentrates on features integrated in the new submarine class 212 for the navies of Germany and Italy, like hydrogen/oxygen storage and energy generation by fuel cells, signature minimization, permanent magnet propeller motor, water ram weapon expulsion system, etc. The paper comments on the submarine-related maturity/suitability of different air independent energy systems and the competitive situation of submarine designers and builders in Europe. It ends with information about the German submarine class 212 development, design, and construction costs.

Historical Background

The rearmament of the German armed forces, started in 1955, was subject to several political and technical conditions agreed upon between the Allies and Germany before that date and modified in the years thereafter and until the reunification happened. The conditions that were the origin of and reason for technologies and industrial structures and capabilities observed today in Germany have, to a large extent, been forgotten on both sides of the Atlantic.

The German Ministry of Defense (MOD) was not allowed to operate and control organizations, departments, institutes, or companies for research, development, design, and construction of arms of any kind, including, of course, submarines. All such work had to be subcontracted by the MOD's purchasing department, which had to be exclusively manned with civilian governmental employees, to private industry.

For submarine-related research and development (R&D), Ingenieurkontor Luebeck (IKL) was founded and operated by Professor Ulrich Gabler, who had experienced several war missions on submarines during WWII as a chief engineer before he was called into the then naval design offices at Berlin for the design of the next types of submarines. Right up to today, the privately owned office of IKL performs R&D and design work for all classes of German submarines for the MOD.

In 1969, the German MOD contracted Howaldtswerke-Deutsch Werft AG (HDW) as the lead yard/prime contractor for the turnkey program of 18 units of the class 206 submarines for the Federal German Navy (FGN). This program included not only the detailed design work, purchasing, and construction, but also the operation of up to four submarines in parallel during sea trials until the contractually specified performances of each boat and all its subsystems, including electronics and weapons had been proven at sea—culminating in several scenarios of torpedo firing exercises. Shipyards' own crews accumulated driving experience and fed this experience back into the design offices of the same company, thus creating the unmatched technical maturity of the class 209 design.

The industrial capability of delivering submarines under agreed specifications for the overall weapon system became attractive to several nations and navies that could not establish or maintain a full submarine R&D and detailed design capacity of their own.

Other conditions accompanying the rearmament phase had a significant influence on the development and the performance of German-designed submarines. Most significant was the tonnage limitation to 450, then 1000, then 1800 tons standard, which is no longer in effect today. However, of broader influence on submarine design was the allocation of the Baltic Sea and the Baltic approaches as the operational area of the FGN. The average depth of 40 and the maximum depth of 90 meters triggered not only the nickname *flooded meadow* for this area, but also developments deemed useful today in regard to littoral warfare requirements.

Nuclear propulsion was not allowed for German submarines in those early days when everybody believed that the dream of submariners would become reality and remain affordable.

Resulting Submarine Design Particularities

The optimization of a fighting machine of small tonnage, allowed to be called a submarine (but only of 450 tons max), resulted in design principles best characterized by:

- Doubled use of spaces on board: for example, the living space was used also as a torpedo-reloading space and there was the *hot bunk* system (17 bunks for 23 crew); and
- Deletion of any weight allocated for functions that did not add to the fighting capability: as an example, the deletion of the torpedo loading hatch or the hull-mounted instead of deck-mounted fixation of heavy but shockproof equipment.

The necessary weight optimization also required the pressure hull to be designed and built to be as light as possible. The calculation methods applied had to be test verified. Consequently, the principle of scale 1:1 testing was also applied to a complete hull of a class 205 submarine within a worldwide unique pressure dock of the naval arsenal at Kiel. This collapse test had to prove that buckling of plates and instability of frames occur at the same outer load and that calculation methods and tolerances are in conformity with reality.

For coastal submarines, a shock and collision resistant steel with sufficient elasticity is the preferred choice. Mechanized production of high yield (HY) 100 hulls has been tested, but the application in designs offered is deferred until a customer insists on this material for his pressure hull.

All weight remaining within the maximum tonnage limitation after satisfying the requirements of sensors, data processing, man-machine interfaces, communications, weapons, propulsion, living conditions, etc. was used for energy storage and stability ballast. The German designs had between 16 and 24 percent of their surface weight in the form of *active ballast* which means battery. International submarine designs built so far achieve at the most half or two-thirds of this.

Not only the overall designer's consideration of battery weight but also the battery manufacturer's achievements in Whrs per Kg, or liter, of a lead-acid battery add to the performance/endurance/speedhotel power, etc., of a submarine. Today, with the introduction of various forms of energy storage and production for the power demand during deep submerged operation, using the power-per-ton ratio seems to be a more adequate way to compare the parametrical overall deep submerged energy content of different submarine designs. For instance, the British UPHOLDER and the Dutch WALRUS both are capable of about 5 kWhrs per ton while the German 205/206/207/209 classes do about 9kWhrs/ton.

The maximum energy made available onboard has never relieved the submarine design engineer nor the subcontractors in their joint task of minimizing the required energy consumption for mobility, data acquisition and processing, living, etc., or, in other words, finding continuously more efficient and even multiple ways to use energy in its different forms and temperature levels. A most welcome side effect is the minimization of thermal effects in the water.

Signature Minimization

For about 30 years the most important operational area of German submarines has been the Baltic Sea. These waters are shallow and dominated on the surface and in the air by the Eastern opponent, more than suitable for mines with any kind of fuses and for bottom-moored acoustic sensors. Besides radiated noise, color selection, radar cross-section of the hoistable installations, sonar cross-section, etc., the magnetic signature of the boats was an additional and unique requirement of the German Navy. This feature of a magnetic design and construction has been transferred to the class 212.

Technology Applied Today

The new class 212 is being built for the navies of Germany and Italy (Figure 1). The definition of the class 212, in U.S. Navy terms—the concept design, was finalized in July 1992. The construction contract, which includes in Germany the detailed design, was expected to be accepted in early 1993. The reshuffling of the federal budget due to reunification consequences delayed the signature of the contract to 1994 and the effective date of the contract to 1995.

The class 212 mission priorities are antisurface, antisub, and reconnaissance. These required a drastic increase in passive sensor ranges since surface targets as well as submarines have reduced their radiated noise levels significantly during the last decade. While passive detection ranges have more than doubled compared to submarines built a couple of years ago, the own noise radiation under comparable speed is now only a fraction of what it was. The 212 will displace approximately 1200 tons and be 56 meters in length. The power plant is a hybrid AIP fuel-cell plant with a diesel generator-battery base. Sonars will be an optimized flank array and a towed array. The propulsion motor is a permanent magnet motor with a low noise propeller.

The boat, as under construction contract today, has pressure hull diameters of 7 and 5.7 meters.

Newly developed components of the boat are mainly the proton exchange membrane (PEM) fuel cell system, the permanent magnet propulsion motor (PMM), the towed array with low frequency detection and classification, several features of the combat management systems, and the torpedo launching system.

The hydrogen/oxygen fuel cell system was at sea on the class 205 submarine U1 during trials in 1988 and 1989. HDW gave a briefing to NATO attachés in March 1989 about the results. The inherent safety of this system, the fully automatic operation, and the refueling from local suppliers of industrial gases in Norway and Scotland was proven during the sea trial period. The fuel cell used in the system at that time was an alkaline type fuel cell. In the meantime, the development of the PEM fuel cell has been completed. Its low temperature level and high efficiency, together with the potential of air breathing (replacement of charging diesels depends how fast costs can be brought down), made this type of fuel cell attractive for submarine application. An oxygen/hydrogen-consuming PEM fuel cell manufactured by Siemens will be installed on the class 212 submarines. In our hydrogen lab at HDW, hydrogen/air breathing PEM fuel cells made by Ballard in Canada are also being tested and prepared for submarine use.

The oxygen is stored in two liquid oxygen tanks under the superstructure while the hydrogen is absorbed by metal-hydride, consisting of a mixture of titanium and ferrum with several additional ingredients, which is in hard-mounted tubes fixed around the pressure hull. The direct chemo-electrical energy conversion process has a high efficiency rate. The waste heat is partially used for releasing the absorbed hydrogen from the storage pipes in gaseous form.

The prototype of the permanent magnet propeller-motor has been driving a naval trial vessel since 1989. The availability of more powerful solid state switches triggered a redesign phase that was completed at the end of 1992. The low rpms and high efficiency of this PM are achieved over the full speed range without mechanical switches and generation of transient noises.

The Hydraulic Water Ram system consists of a piston in a water-filled tube pulled back by hydraulic force. The water column is led to one of three weapon tubes. The prototype of the torpedo launching system was fitted into a towable section and operated during sea trials for shock and noise tests. It is a hydraulic water ram system that accelerates the weapon to be launched in the quietest way and allows weapon launches even if the boat is bottomed. The class 212 submarine has two water ram systems and six weapon tubes in total.

Other Design Features

The overall design of the submarine has been organized in a modular structure, both for technical reasons and for cost-efficient production. The CIC with its control consoles, etc. is arranged on a deck that is elastically connected to the pressure hull. Other electronic cabinets and complete storerooms, etc. are suspended under this deck without any uncontrolled noise-transferring contact to the hull.

Special emphasis was also given to the small but unavoidable noise of auxiliary engines, such as air conditioning, pumps, etc. They have all been fitted together in the encapsulated engine room, and their fittings and connections were optimized in regard to structure and airborne noise transfer to and through the pressure hull. Measurements were performed at sea on the engine room aft section of the submarine with critical equipment actually operating. The hull-mounted heavy hydrogen storage tanks were represented by corresponding weights.

Besides the noise signature, emphasis has also been given to minimizing the magnetic signature. The pressure hull is built of 1.3964 steel, an austenitic magnetic and non-corrosive steel. The final compensation of a still remaining small magnetic effect (despite stray field-reducing design and magnetic materials used throughout) will require only a few kW, while for a boat of comparable size built of HY80 nearly 100kW would be consumed continuously without achieving the same signature reduction.

Class 209

Subsystems developed for the class 212 can also be adapted for integration into other submarines, for example into class 209 boats. The submarine class 209 has outnumbered every other non-nuclear submarine family in the western world, with 50 units contracted by 11 different navies. These boats have been continuously updated upon availability of platform improvements or of new sensors and weapons. Even an increasing number of U.S.

suppliers is considering these boats as a potential market for their products.

It has been investigated to which extent an improved performance in deep submerged range could be achieved by adding the fuel cell system in a section with relevant storage capacities of liquid oxygen (LOX) and hydrogen stored in a metal hydride.

The deep submergence cruising range can be extended to more than 2,000 nautical miles.

Also technical solutions introduced on the last copies of the class 209 have found their way, after further improvement, into the class 212. An elastically mounted frame is the foundation for the four diesel-generator sets of a class 209 and the auxiliary equipments. All together they are moved on the frame into the empty pressure hull.

Cooperation with Italy

The specified performances and signatures of the class 212 design made available via government to government channels have attracted the Italian Navy with the result that the national development of their S-90 project was stopped last summer. A Memorandum of Understanding (MOU) between the MODs of Italy and Germany was signed in April of this year. A corresponding industrial cooperation agreement between Fincantieri and the German Submarine Consortium (GSC) has been adopted, ensuring the identical configuration of these class 212 submarines of Italy and Germany.

This cooperation has already resulted in a few changes to the original design of the class 212, such as increased diving depth, lockout for command teams, and a docking facility for a deep submergence rescue vehicle (DSRV).

Both countries will have advantages and will save on non-recurring costs.

Technology Trends and Competition

There is a surplus of capacities in Europe for the development and construction of submarines. However, the necessary turnover of about two submarines per year which would allow maintaining up-to-date R&D activities at the prime contractor and specialized subcontractor level is not achieved anywhere—the industrial base of a single country is export-dependent.

Since Europe cannot afford several parallel submarine developments for its own national defense purposes, in October 1994 during the international naval exhibition Euronaval in Paris, the GSC, with HDW as the lead yard, presented a derivative of the class 212 design, the EuroSub, for follow-on-construction by European NATO members for their own national needs. However, the national specialization in certain weapon systems and the overall reduction in European industrial defense capacities will require time during which export dependencies of the industrial base will continue to exist.

The Race for Increased Non-Nuclear Energy Density

Different air independent energy storage and conversion systems are presently under development (Table 1).

Outer-air-independent thermodynamic energy transformation processes are used onboard and at sea: the Swedish Navy added to the submarine class A19 (export designation T96) two units each of the Stirling engine, consuming desulphurized diesel and oxygen. The next class of Swedish submarines has been planned with fuel cells onboard. In France, the Mesmer turbine system (a derivate of nuclear power plant elements) is under development to go onboard the Agosta 90 class submarines for Pakistan sometime after 2003. The companies Rotterdamse Droogdockmaatschapeij, Netherlands, and Vickers in England are cooperating and trying to export their Moray class submarine design with a closed cycle diesel engine for air independent power generation. It is remarkable that the Dutch Moray and the French Scorpene submarine designs are partially and, respectively, totally funded by the relevant governments, although no national requirements have been announced.

The optimal results, considering all naval submarine performance and signature requirements, are expected to result from the fuel cell system. The energy amount carried onboard will increase another couple of times with the integration of reformers producing the hydrogen for the fuel cells out of methanol on board. In this technology area, commercially used fuel cells will drive down the prices and we will see applications on commercial vessels for clean energy generation in harbors. The same units will replace the charging generators carried onboard our submarines today.

Russia

The most interesting competitor in the international market is Russia. Any price is all right if paid in hard currency. But not only the relatively old Kilo is for sale; also the single hull, cheaper to produce, Amur class submarines (of a tonnage between 950 and 1850 tons) show interesting features. Fuel cell systems have been tested at sea and will be integrated on the Amur class.

Summary

Particular features and technologies applied in weapon systems and submarines have their reason and origin in sometimes forgotten political and/or economical circumstances. It seems worthwhile to stop the daily routine business from time to time and recheck the validity for today of reasons established yesteryear. Therefore my paper began with a short recollection of conditions under which the development of German submarine technology started.

The industrial base is eroding and the defense budgets are too short to ensure the survival of desired capabilities and comfortable capacities—this is heard in many counties. Economic considerations other than military ones very often form the basis for decisions.

[Hans Saeger was born in 1938 in Gelsenkirchen, Germany. He completed studies in electronics at the Technical University in Aachen, earning a Diplom-Ingenieur (Engineering Diploma). From 1964 to 1971, he saw active military service as an electronics officer in DD 183, and in electronics and weapons for naval Air Wing 1. He served several months from 1973 to 1984 as a reserve system officer for submarines. From 1971 to today he has been involved in torpedo development; as head of various departments in the naval shipbuilding division of HDW; and finally as director of the naval division of HDW.]

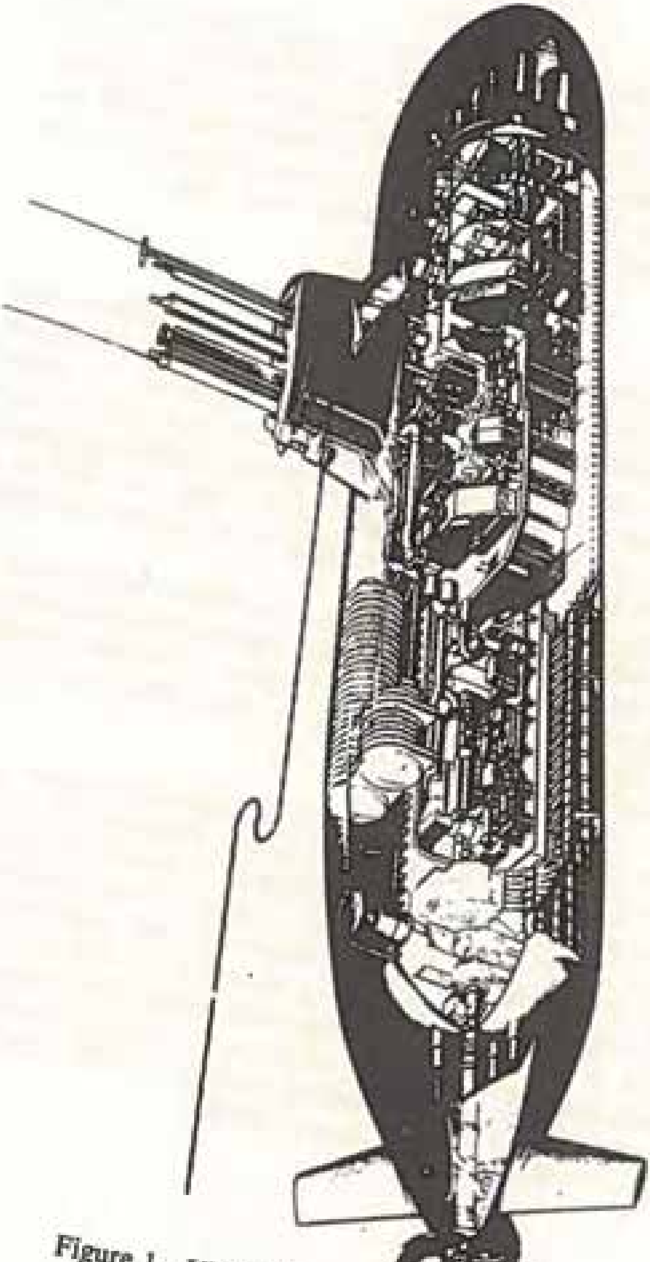

Figure 1. Uboote Klasse 212

Table 1. Current Technical Position of AIP

					Signatures	
	Status of development	Energy conversion	Maximum temperature	Efficiency	Noise	Heat
Fuel cell	submarine proven	direct/ no moving parts	80°C	approx. 70%	noiseless	low/closed loop
Closed cycle diesel engine	submarine proven	indirect/ combustion	>400°C	approx. 30%	noise reduction expense	cooling water exchange
Stirling engine	submarine proven	indirect/ combustion	>750°C	approx. 30%	noise reduction expense	cooling water exchange
MESMA	not submarine proven	indirect/ combusiton	>700°C	approx. 25%	noise reduction expense	cooling water exchange

AIP—THE SWEDISH WAY

by Pelle Stenberg
Kockums AB

Let it be said from the very beginning that the nuclear propelled submarine is the ultimate underwater vehicle, in particular when it comes to sustained mobility and endurance in the stealthy ocean depths. No other underwater vehicle can even come close to any of these performances, whatever sophistication of conventional plants are developed, including any non-nuclear Air Independent Propulsion (AIP) systems, whatever energy converter and energy storage they may use.

Although the deep ocean depth constitutes the classical environment for deep diving and fast SSNs, today's submarine warfare is also a matter of operations in the so-called littorals. From a U.S. Navy perspective, these littorals can be virtually anywhere in the world and they may have to be reached covertly and in a hurry, an ideal task indeed for the large SSN.

However, one can perhaps see a certain paradox here, in that the large SSN is indeed unrivalled for the transit but it may be less ideal for at least some operations upon arrival. This potential problem, however, is not the subject of this paper. It is mentioned here merely to point out that for a country like Sweden, the littorals are nearby and Sweden can therefore make very good use of non-nuclear submarines, particularly so if they are fitted with AIP.

Seen in the historic perspective, once the art of submerging in a controlled fashion was ensured for the early primitive boats, efforts to improve underwater endurance became a high priority. These efforts were significantly accelerated during various conflicts involving submarines. During WWII for instance, advancements of the airborne radar effectively, and forever, drove submarines away from the surface. The weaknesses of submarines requiring periods of surface running to charge the batteries with air consuming diesel engines were exploited to the fullest, with quite staggering losses as the result. Attempts to lower the catastrophic casualty rates by introducing innovative designs were certainly done. However, as is well known they came too late to have any influence on the outcome of the conflict.

One design, and perhaps the most well-known, aimed at presenting a smaller target when recharging, by arranging the diesel engine air induction through a mast, hoistable from the submerged submarine. Other efforts were made to increase the submerged endurance by improving battery capacity and also by installing more of them.

Although these measures meant improvements in battery technology and larger boats, there were also initiatives for other and less weight and volume consuming ways of providing AIP, namely to carry certain reactants and process these in a suitable energy converter into power for sustained underwater running.

It is these kinds of concepts which today are coming to full operational maturity in order to augment the combat efficiency and the survivability of modern non-nuclear submarines. The Swedish concept which deploys Stirling cycle heat engines as energy converters reached this maturity in 1989 and is now a standard feature in the Swedish submarines of A19 Gotland class. The system is fitted in the compartment just aft of the pressure tight bulkhead which divides the hull into two compartments. The upper level contains the engine-generator modules whereas the oxygen tanks are fitted in the lower level. The installation is capable of providing several hundred hours of low speed submerged running, more than four times the energy stored in the ordinary battery.

AIP systems, whether currently in use or under development have one thing in common; they significantly increase the submerged endurance which was previously entirely decided by the size of battery installation.

As long as the submerged endurance was purely depending on the battery, it was natural to focus development efforts to improve the specific energy content of the battery itself (or in some cases shift to other battery types than the common lead acid type). Consequently, such developments have very successfully been carried out and the post WWII years have seen quite dramatic improvements in this area. Today a state-of-the-art lead—acid battery cell will yield more than twice the energy than a cell of the same weight 50 years ago.

Further increases in battery energy density are possible, but one can suspect that the efforts to do so will be increasingly difficult and expensive the closer one comes to any technical limit. In these circumstances the most obvious solution might be just to install more battery to achieve better endurance. This, however, will quickly drive boat size to unacceptable levels, hence the search for an alternative and smaller power system to provide energy for the submerged running, i.e., a system of much higher energy density than even the most modern lead acid battery. This search which started already during WWII carried on quite strongly and reached a fundamental milestone when nuclear propulsion for submarines came of age with NAUTILUS.

Sweden was one of several countries which modeled their post WWII first and second generation submarines on the German late-war Type XXI, a submarine with substantially more and better batteries than previous types and therefore with very good underwater performance. A third post WWII Swedish submarine generation was developed for the Swedish Navy in the early 1960s. The development included investigations and tests to explore whether an AIP system could be included in that design. The technology studies for that purpose were based on previous foreign trials with diesel engines run in a closed cycle. This required a system in which the exhausts were scrubbed of CO_2 and recirculated to the induction side where fresh oxygen was injected to make up a combustible mixture. The oxygen had to be carried onboard, as for instance high test peroxide.

The Swedish program reached the stage of full scale testing in a land based facility but was eventually terminated because of uncertainties in technology as well as costs. The submarine project was then established as a pure conventional design of which five were delivered by Kockums between 1968 and 1972.

At that time another technology was already under investigation as a future potential submarine power generation system, namely a system utilizing fuel cells. These devices convert energy in a direct chemical process between two reactants, normally oxygen and hydrogen. Again the system had reached an advanced testing stage in a land based facility but again the program had to be terminated because of uncertainties in technology and costs. The levels of ambition in both these programs were high; the respective installation was aimed at providing power at all running modes, i.e. the traditional diesel/battery system was to be completely replaced.

Modern AIP Concepts

Towards the end of the 1970s, the ambition had been reduced and the *add on* concept was identified. In such a concept the AIP system was to be configured in a separate autonomous hull module which could be inserted into existing submarines and new construction projects alike. The add on module would constitute a compact storage of significant amounts of energy and a conversion system to augment and complement the battery in order to extend the submerged endurance at low patrol speeds.

From a technical point of view the system would provide an alternative power source to the battery for running at silent speeds and consequently, from a tactical point of view, it had to display the same low noise signatures. It was assessed that stretching an existing submarine by 15 to 20 percent to accommodate the AIP module would not have any notable impact on the original performance, particularly in view of the much better—a factor of 4 to 5—submerged endurance which would be the result.

Obviously, when incorporating a module in a new submarine design all proper provisions could be taken from the outset of design work.

The Stirling Solution

Studies to identify the most suitable energy converter for the Swedish system were completed in the early 1980s. Given the usual constraints in available resources and a desired target time for introduction into naval service of the new system, the studies conclusively pointed to the Stirling cycle heat engine as being the best candidate.

Most elements of the engine itself were at that time defined under other programs and the principles for heat creation by combusting fuel and pure oxygen at an overpressure—a key feature of the underwater engine—were established. Additionally, the high efficiency of the Stirling engine, the efficiency in storing oxygen as liquified oxygen (LOX) and utilization of fuel oil as the fuel promised an installation of high energy density. Furthermore, the prospects of achieving excellent balancing of the rotating parts and the mode of continuous combustion, all indicated that stringent noise emission requirements also could be met.

The development program for the full system was commenced in 1982 with a series of rig testing which eventually produced the power unit, i.e. the engine with its overpressure combustion chamber and the electrical generator together with appropriate control systems.

In parallel, studies and various testing to establish safe handling procedures and storage arrangements for the LOX were conducted. Since the first system was to be retrofitted, although as a permanent installation, to an existing submarine, the added hull module containing the system had to be totally autonomous and weight compensated to fit inside the original submarine trim polygon.

The Battery Boat Dilemma

Advances in battery technology, together with opportunities to carry more battery have in some cases stretched the submerged endurance of battery submarines towards the 100 hour mark. The recharge must then commence. However, the interval between recharging will normally be less because of the tactical wisdom of avoiding complete discharge in order to retain a *tactical reserve* of around 50 percent.

The fitting of an additional energy supply for the submerged running, but as a much denser package than bulky batteries, is what AIP in this context is all about.

A normal AIP installation of this kind will give the submarine commanding officer several hundred hours submerged at low speed running during the patrol from this system alone. And on top of that, another hundred hours from a fully charged battery.

A theoretical and stereotype mode of utilizing this capability is for the AIP submarine to start patrolling in his dedicated area on the AIP system and with the battery fully charged. The AIP running will not permit any battery discharge. Oxygen is of course consumed instead, up to a point—let's say a day or two—when a target is engaged requiring power flexibility, hence the AIP plant is shut down and the battery is engaged until the target is eliminated. The submarine then goes back to the AIP mode until the next target opportunity. And so on, until the oxygen is consumed. The rate of battery discharge is slowed down and the submarine has been in the operational area for many days; it has eliminated a number of targets and it has remained air independent and stealthy during the whole period.

The Swedish System

The major elements of the Swedish system are the Stirling engine generator sets, the LOX storage and handling system, auxiliaries and the control system. The fuel storage and handling system is integrated with the bunkering and tankage system for the diesel engines. The Stirling engine is the energy converter in the AIP plant. It converts heat from combustion of oxygen and fuel into mechanical work through a thermodynamic cycle carrying the name of the person, Robert Stirling, who was first with its practical application. Characteristic for this cycle in its ideal shape are the four steps:

1-2 isothermal compression (on the cold side)
2-3 constant volume displacement (from cold to hot side)
3-4 isothermal expansion (of the heated working gas)
4-1 Constant volume displacement (from hot to cold side)

The working gas, i.e. the gas contained inside the engine and the heater, is helium. The heat collection part is located inside a separate combustion chamber to collect heat for the cycle, the heat being created by continuous combustion in the chamber of fuel and oxygen. The cycle creates movements of the pistons which in turn rotate a crank-shaft which then drives the electrical generator to provide the electrical power. The actual engine has four cylinders and pistons. The cylinder pressure curve is sinusoidal and smooth and the engine is furthermore meticulously balanced and fitted to a double elastic mounting arrangement. Consequently, the resulting vibration levels and noise signatures are extremely low.

During operation it is run at a constant speed of 2000 rpm and can develop up to 75 kW. A total system of four units could easily support even a large submarine at slow speeds and including the hotel load.

The combustion chamber is an integral part of the engine unit although the combustion is external to the engine itself, the created heat being transferred to the working gas inside the engine across the heater pipes connected to the cylinder tops.

There are two prominent features of the combustion chamber arrangement. One is the technique to control the combustion temperature, given that the reactants provided are fuel and pure oxygen and the other provides the ability to discharge the combustion products—carbon dioxide, water and some excess oxygen—straight overboard against the diving pressure. The combustion flame temperature is controlled by diluting the incoming pure oxygen to a mixture suitable to provide a gas temperature of

1800C (and an average temperature of 750C at the heater tube walls). The diluting substance is the combustion gas itself, part of which is being recirculated for this purpose and injected into the incoming oxygen. Recirculation is achieved without moving parts but rather through the creation of a static pressure drop at the points of the inrushing oxygen, which will bring parts of the combustion products to that point.

The overboard discharge of the exhaust is achieved by conducting the combustion at an overpressure corresponding to a certain diving depth. On the reactant side, this is facilitated by allowing and controlling an overpressure in the oxygen supply tank. The fuel is injected by traditional fuel oil pumps.

The combustion chamber itself is a pressure vessel on top of the engine unit and the exhaust discharge line ends in a non-return valve set to the maximum diving pressure and a discharge disperser into the outgoing system cooling water flow.

LOX is a daily industrial commodity in many countries and techniques, technologies and procedures for its storage and handling are well established. However, the inclusion of such storage etc. into a military submarine with mission times of several weeks requires specific considerations. Firstly, the thermal insulation needs to be superb to avoid losses caused by heat leakage and secondly, it has to be structurally aligned with safety requirements for the submarine as a whole. The typical Swedish installation comprises two tanks, each of stainless steel and with outer and inner structures separated by high vacuum multilayer insulation. The tanks are fitted inboard, resiliently connected to the hull structure for shock protection. The inside tank pressures are kept at a constant level to allow for direct supply to the combustion chamber inlets. This holding pressure is obtained by evaporating LOX and feeding it to the top of the tanks. Oxygen to the combustion chamber is taken from the tank bottom as LOX and brought into gaseous phase in an evaporator. Heat for this process is taken from the Stirling engine fresh water cooling system.

Swedish AIP Status

As a result of the pioneering efforts in this particular AIP technology in Sweden, the Swedish Navy is currently the only western navy to routinely operate any kind of a complete AIP system in non-nuclear military submarines.

The complete installation in the submarine NÄCKEN in 1989 and a number of successful patrols to follow, paved the way for the incorporation of this capability into the three submarines of A19 Gotland class.

These submarines were contracted in the early 1990s. The lead submarine conducted acceptance sea trials and was delivered to the fleet in mid 1996 and the second of the class commenced sea trials in July this year after being launched only five months earlier. The third unit will be launched in September *[Ed. Note: After **THE SUBMARINE REVIEW** goes to print.]* and goes on sea acceptance trails early 1997.

The control of the AIP system is integrated, as a small panel, with the overall propulsion control console. The starting and shutting down of the system is a push-button operation. The console contains all means for controlling and monitoring the entire propulsion plant, i.e. diesel-generator sets, the main propulsion motor and the AIP system. It also provides monitoring of the main battery as well as control and monitoring of all valves associated with the propulsion plant. Indeed conditions, etc. of all platform systems can be called up on the screens.

These truly state-of-the-art submarines with their unique propulsion system will be in service with the fleet for the next 25 to 30 years. The current AIP system and its capability is presently fully defined.

Naturally, there are also ways identified by which further enhancements can be achieved. These would range from parametric changes to the engine itself and the system to installation trade offs between the conventional plant and the AIP plant. In all cases the result will yield further improvements of the submerged endurance, which is most certainly the way ahead for non-nuclear submarines.

It is also with great interest one is looking forward to the introduction in operational submarines of AIP systems using alternative energy conversion devices, reportedly in 1999 (France) and 2003 (Germany). The pioneering work in the AIP field conducted in Sweden currently forms the very peak of a long and proud submarine tradition in that country. The momentum of the development is considerable and a long lasting competitiveness is projected. ■

THE GREAT TORPEDO SCANDAL, 1941-43

by Frederick J. Milford

Naval rearmament, which began in the mid 1930s, and WWII had dramatic impact on U.S. torpedo programs. Three of the most significant changes were the enormously increased requirement for torpedoes, the urgent need for new torpedo types and the first use of U.S. torpedoes against enemy vessels. The increased requirement was satisfied by expanding government facilities, the Newport Torpedo Station (NTS-Newport) was enlarged, the Alexandria Torpedo Station was reopened[1] and Keyport Torpedo Station began assembling torpedoes, and by initiating civilian production. Total production between 1939 and 1945, almost 60,000 torpedoes, was about equally divided between the torpedo stations and contractors. Mk 14 torpedoes were, however, in such short supply in 1942 that some fleet boats loaded out with Mk 10 torpedoes or even Mk 15s in the after tubes.[2] New types of torpedoes are discussed in Part Three of this series. Firing warshots was an almost totally new experience for the U.S. Navy. It seems probable that the number of warshots fired against enemy vessels in December 1941 was larger than the total number

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[1] The Newport monopoly on the torpedo business had a significant effect on the development of torpedoes. The extent of the monopoly and efforts to preserve it are illustrated by opposition to the reopening of Alexandria, which was accomplished in the face of demands from New England politicians and labor leaders that Newport be expanded. Resuming torpedo work at Alexandria expeditiously was possible only because when it was closed in 1923 it had been incorporated into the Washington Navy Yard. Consequently, the torpedo station could be reopened without an Act of Congress.

[2] This was mentioned by ADM B.A. Clarey in a recent interview with John DeVirgilio and confirmed by RADM M.H. Rindskopf who also supplied key parts of the following material. Mk 15 torpedoes were too long to be loaded through hatches or stowed in the torpedo rooms. They were also too long for either the forward or longer aft torpedo tubes. They were modified, probably by using shorter warheads, and loaded into the aft tubes through the muzzle doors. USS DRUM (SS 228) sailed so loaded on her second war patrol from Pearl Harbor in July 1942. All four Mk 15s were fired.

of warshot torpedoes fired for any purpose[3]—in the entire past history of the U.S. Navy. Perhaps not surprisingly, this intensive use of torpedoes revealed shortcomings that had been previously obscured, especially in the new service torpedoes and particularly in the Mk 14.

The trio of new service torpedoes, Mk 13, Mk 14 and Mk 15, which represented the bulk of the U.S. Navy torpedo development in the 1930s were on the one hand excellent weapons and had long service lives—the Mk 13 remained in service until 1950, the Mk 14 was a valuable service weapon until 1980 and Mk 15 served as long as 21 inch torpedoes remained on destroyers. On the other hand they all had significant problems that were only fixed after wartime use began. The Mk 14, which was the principal submarine weapon, was plagued with defects that vitiated its use as a weapon until mid 1943. The conflict between the shore establishment and the operating forces over these problems was a very significant and much discussed factor in U.S. submarine operations during WWII.

The Great Torpedo Scandal

The Great Torpedo Scandal[4] emerged and peaked between December 1941 and August 1943, but some of its roots went back

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[3] This, of course, means self propelled torpedoes and excludes spar and towed devices. Apparently, only 11 torpedoes were fired by U.S. forces against enemy vessels prior to WWII (AL boats against U-boats). *[Editor's Note: The USN L class was designated AL while overseas in WWI to distinguish them from the British L class.]* The number of warheads used in training and test and evaluation was very small. U.S. submarines made 54 war patrols in December 1941 and fired 66 torpedoes at enemy targets, quite possibly more warheads than had been fired in the entire previous history of the U.S. Navy.

[4] At least three MA theses have been written about the problems of the Mk 14 torpedo (Ingram (1978), Shireman (1991) and Hoeril (1991)); the problem was noted by Morison and is discussed at length in Theodore Roscoe, "United States Submarine Operations in World War II", Annapolis: Naval Institute Press, 1949; Clay Blair, Jr., "Silent Victory: The U.S. Submarine War Against Japan", Philadelphia and New York: J.B. Lippincott, 1975; and Edwyn Gray, "The Devil's Device: Robert Whitehead and the History of the Torpedo" (Revised Edition), Annapolis: USNI Press, 1991. David E. Cohen has written a paper on the subject, "The Mk.XIV Torpedo: Lessons for Today", Naval History, Vol. 6, No. 4, Winter 1992, pp. 34-36.

25 years. It involved primarily the Mk 14[5] and three distinct problems, depth control, the magnetic influence exploder[6] and the contact exploder, whose effects collectively eroded the performance of the torpedoes. The scandal was not that there were problems in what was then a relatively new weapon, but rather the refusal by the ordnance establishment to verify the problems quickly and make appropriate alterations. The fact that after 25 years of service the Mk 10 had newly discovered depth control problems adds weight to the characterization of the collection of problems and responses as a scandal. These comments should, however, be mitigated a little by the fact that each of the Mk 14 problems obscured the next. Although BuOrd did not identify the final problem, contact exploder malfunction when a torpedo running at high speed struck the target at 90 degrees, their response, once the difficulty had been identified, was notably prompt. It spite of the promptness of BuOrd's response, by the time it reached Pearl Harbor a number of relatively simple solutions to the problem had been proposed, and modifications had already been designed and implemented. This was, however, almost two years after the United States entered WWII.

Torpedo Depth Control

The first of the U.S. torpedo problems was deep running which was a frequent torpedo problem in various navies beginning at least as early as WWI. The problem, however, was not always

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[5] Criticism of the destroyer launched Mk 15 is almost nonexistent. This is strange because the principal differences between the Mk 14 and the Mk 15 were in the size of the warhead, the fuel load, three speed vice two speed and slightly slower high speed, 45.0 k vice 46.3 k. One might speculate that it is even more difficult to distinguish misses from duds in a high speed destroyer attack than it is in a more measured submarine attack. The Mk 13 was a slower speed torpedo so it did not have the contact exploder problem and it used the Mk 4 exploder which did not have the magnetic influence feature.

[6] Properly, the exploder is the entire Mk 6 assembly. It has an influence feature and a contact feature. This leads to awkward verbiage so we refer to the magnetic influence exploder and the contact exploder. Both are parts of the Exploder Mk 6, which weighs approximately 90 pounds, and some elements of the exploder function in both modes. The exploder also contains important safety features.

due to the same sort of defect.[7] There are at least four distinct kinds of problems that impact depth control:

1. Differences between calibration shots and service/warshots
   a. Torpedo weight or balance changed in converting to warshots, for example, warheads that were heavier than calibration heads.
   b. Calibration firings failed to simulate service launch conditions, for example, calibration firings from barges or surface vessels rather than submerged torpedo tubes, and/or calibration shot launch speeds, i.e., the speed at which the torpedo leaves the tube, and accelerations during launch different from service conditions.
2. Design or manufacturing defects causing changes in calibration after proofing or effectively causing calibration to change with time or environment, for example, sensing water pressure where flow corrections were large, or depth spring fatigue, or leaky castings, etc.
3. Erroneous calibration: failure to check against an absolute standard, for example, total reliance on hydrostatic depth measurement and failure to use nets, soft targets or other sensing systems to establish true depth.
3. Inadequate understanding of the technology involved, for example, failure to recognize the importance of hydrodynamic flow in sensing the pressure at the skin of a fast torpedo; lack of understanding of the feedback loop and depth control dynamics.[8]

Amazingly, U.S. torpedoes, especially the Mk 14, demonstrat-

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[7] Some indication of the bewildering set of problems experienced by other navies can be found in CDR Richard Compton-Hall, RN(Ret.), "Submarines and the War at Sea, 1914-1918", London: Macmillan, 1992; Karl Doenitz, "Memoirs: Ten Years and Twenty Days", Annapolis: U.S. Naval Institute Press, 1990; and Cajus Bekker (pseudonym for H.D. Berenbrok), "Hitler's Naval War", Garden City, NY: Doubleday, 1974.

[8] The Summary Technical Report of Division 6 of NDRC, "Torpedo Studies", Vol. 21, Washington: NDRC, 1946, p. 15, contains the following revealing comment: "The principal result of the study of depth-keeping is the development of a theory ... there is no longer any excuse for the laborious production of depth mechanism that cannot be expected to operate at all."

ed that most of these possibilities could, in fact, occur.

Depth control problems with U.S. torpedoes were suspected by NTS-Newport and BuOrd even before the United States entered WWII. On 5 January 1942 BuOrd, based on earlier (1941) testing, advised that the Mk 10 torpedo, which had entered service in 1915, and was still used in S class submarines, ran four feet deeper than set.[9] NTS-Newport tests on the Mk 14 torpedo in October 1941 had been interpreted as indication that it too ran four feet deeper than set, but this was not reported to the submarine commands at that time. War patrol experience led to fleet suspicions that the torpedoes ran deep and these thoughts were communicated to BuOrd. In response to a direct order from the Chief of the Bureau of Ordnance, additional NTS-Newport tests in February-March 1942 *confirmed* the four foot error for the Mk 14. Rear Admiral William H. Blandy, Chief of BuOrd, notified Rear Admiral Thomas Withers, Jr., COMSUBPAC, of the problem in a letter dated 30 March 1942, but general notification to the submarine forces was not made until BuOrd issued BuOrd Circular Letter T-174 dated 29 April 1942. The language in correspondence between Withers and Blandy indicate that Newport and BuOrd believed that the four foot error in Mk 14 depth was due to calibrating torpedoes with test heads that were lighter than the warhead. This would cause torpedoes with warheads to run deep both because of increased weight and a most heavy trim. The Mk 14 depth control problem was, however, much more severe than the four feet acknowledged by NTS-Newport.

In a mood of desperation, the operating forces made their own depth determinations, using fishnets for depth measurement, at Frenchman's Bay in Australia on 20 June 1942. These measurements indicated that the depth errors were probably more like 11 feet.[10] BuOrd and NTS-Newport criticized the methodology and were reluctant to accept the results of the Frenchman's Bay firings

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[9] Roscoe, p. 253.

[10] More detail can be found in any of the references cited above. Blair discusses the situation on p. 275 ff. It is not clear whether or not the 11 foot error included the error due to changing from exercise heads to warheads. It is, however, interesting that BuOrd/NTS-Newport criticized the Frenchman's Bay experiments on the basis of "improper torpedo trim conditions" (quoted in Blair, p. 276).

and it was not until August of 1942, after intervention by the CNO, Admiral Ernest J. King, that they re-investigated and agreed that there was a 10 foot depth error in the Mk 14 system. Interim instructions for fixing the problem were issued very quickly and kits to effect an official alteration were distributed in late 1942. As near as we have been able to determine, there were two independent problems: trim change due to warheads heavier than calibration heads and sensing the water pressure at a point where the velocity head was significant and consequently the measured pressure was low. The fix for the latter moved the pressure sensing port to the interior of the free-flooding midbody where the pressure was close to the true hydrostatic pressure and so reflected the true depth. The modified torpedoes were identified by the suffix A added to the Mod with the most famous being Mk 14 Mod 3A.

Since the hydrodynamic problem has seldom been explained in readily accessible documents, we give a brief summary here. The pressure along the length of a torpedo varies because the velocity of the water relative to the surface varies. The pressure at the nose is higher than the hydrostatic pressure, which is proportional to depth, by an amount proportional to the square of the torpedoes speed. This corresponds to a depth of 39 feet of seawater for a torpedo moving at 30 knots or 88 feet for a 45 knot speed. As the measuring point is moved back along the skin of the torpedo the pressure decreases rapidly and becomes substantially less than the hydrostatic pressure. The pressure subsequently rises but remains slightly less than the hydrostatic pressure along most of the cylindrical section. Finally along the conical afterbody the pressure again drops and then rises though, since the actual flow is not streamline, not to the values found at the nose. The critical point is that the pressure at the skin of a torpedo is generally different from the hydrostatic pressure corresponding to the torpedo's depth. The deviation is substantial in the nose and tail cone regions. A depth error due to the measurement of the wrong pressure would, of course, be detected in any calibration process that used an absolute depth measurement for reference. Unfortunately the Torpedo Station used a depth and roll record which determined depth by measuring the water pressure and was thus subject to the same kind of error as the depth gear. Furthermore, the depth and roll recorder was placed in the test head at a point where the hydrodynamic pressure was less than the hydrostatic pressure by almost the same amount as at the location, in the afterbody, of the sensing port for the depth gear. Thus both the recorder and the depth gear sensed essentially the same pressure, though not the hydrostatic pressure, and the torpedo appeared to be running at the set depth. The depth engine, however, responded to the lower pressure by adjusting the horizontal rudders to correct this *error* and the torpedo ran deep. The hydrodynamic theory needed to understand this problem was readily available in the 1930s but most design engineers were quite probably not acquainted with it. In consequence, it was assumed that since the depth recorder showed the correct depth, the torpedo was running at the correct depth. There are other insidious aspects to this problem. One of these is that a depth recorder checked against depth by static immersion in water to various depths or in a pressurized tank of water reads correctly since the error described above is due to hydrodynamic flow. Further the error is proportional to the square of the torpedo speed and is thus almost twice as important for a 46 knot torpedo as it is for a 33 knot torpedo. None of these comments, however, justify or excuse the failure to use an absolute standard to verify the results obtained with the depth and roll recorder or the obdurate resistance to complaints from the operating forces.

The operational aspects of the depth control problem have been recounted many times.[11] The Mk 10 problem, which was probably dominated by the error caused by the change from exercise heads to warheads, was handled by simply setting the torpedo to run at a shallower depth and this procedure was implemented in January 1942, over 25 years after the weapon entered service. The Mk 14 problem required both a calibration modification and a modification to sense water pressure in the midships section and the latter was implemented beginning in the last half of 1943.

The Magnetic Influence Exploder

The second problem with the Mk 14 torpedo was the erratic performance of the magnetic influence feature of the Mk 6 exploder. Magnetic influence exploders had great appeal as

[11] Roscoe, p. 253; Morison Vol. IV, P. 221 in particular; Blair, pp. 169-170, 198; John David Hoerl, "Torpedoes and the Gun Club", unpublished MA Thesis, VPI and State University, 1991, pp. 9-15.

proximity fuzes for torpedoes offering the possibility of detonating the warheads under the vulnerable bottoms of warships. This potential advantage led most of the major navies to attempt to develop such exploders and generally these first attempts were not successful in service use.

The basic idea of a magnetic influence exploder is to sense either the field due to permanent magnetization of a ship's hull or the perturbation of the earth's magnetic field caused by the large quantity of relatively high permeability ferrous metal in the ship's structure. This is a sound and workable idea, but early simple attempts did not take adequate account of the nature of the perturbation. The Mk 6 device in particular relied on the variation of the horizontal component of the magnetic field as the torpedo approached the target. This field variation induced a voltage in a sensing coil. The voltage triggered a thyratron which discharged a capacitor through a solenoid. The solenoid, in turn, operated a lever that displaced the inertia ring thus triggering the mechanical exploder. This complex arrangement was presumably designed so that an exploder, Mk 5, withouth the magnetic influence portion, but otherwise identical to the Mk 6 exploder could be produced and issued to the fleet in peacetime. Security was apparently the overall motivation for this convoluted approach.

The perturbation of the earth's field by a ship naturally depends on the inclination of the earth's field to the horizontal. This inclination varies from 0 at the magnetic equator to 90 degrees at the magnetic poles. At NTS-Newport it is about 60 degrees. Regardless of the inclination of the earth's field, a ship, because of the ferrous metal in its structure, causes both horizontal and vertical perturbations of the earth's field which vary with distance and direction from the ship. The closer the earth's field is to vertical the greater the **rate of chance** of the horizontal perturbation field with distance and the closer to a point directly below the keel the maximum rate of change occurs. Thus a device that senses the rate of change of the horizontal component of the perturbed field works best where the earth's magnetic field has a large vertical component. Unfortunately, a device that works well at high magnetic latitudes may not work at all well where the earth's field is nearly horizontal. Thus, the performance of a simple magnetic influence exploder is significantly dependent on the latitude at which it is operated.

Exactly this problem affected the magnetic exploders developed by the Royal Navy, the German Navy and the U.S. Navy. The

Royal Navy quickly abandoned magnetic influence devices and relied on contact exploders. The German Navy provided a sensitivity adjustment that would, in principle, compensate for changes in latitude. This was unsatisfactory and it too was abandoned fairly quickly.[12] The BuOrd/NTS-Newport response was first denial that there was a problem, then a complicated set of instructions for setting the exploders for different latitudes.

The magnetic influence exploder was unquestionably responsible for sinking some, perhaps even a large fraction, of the 1.4 million gross registry tons of Japanese merchant ships sunk by submarines between December 1941 and August 1943. Reports from submarine commanding officers of apparent magnetic influence exploder failure, mainly duds and prematures, finally led to CINCPAC ordering the disabling of the magnetic influence feature on 24 June 1943. COMSUBSOWESTPAC reluctantly followed suit in December 1943.[13] CINCPAC's order was issued 18 months after Jacobs, on SARGO's first war patrol, ordered the deactivation of the magnetic influence portion of the Mk 6 exploders in his torpedoes and incidentally got into considerable difficulty for doing so. Magnetic influence exploders were not used by U.S. Navy submarines through the balance of WWII.

The Impact Exploder

Once the depth problem had been fixed and the magnetic influence feature of the Mk 6 exploder deactivated, it came the turn of the impact exploder to demonstrate its merit. Unfortunately the initial result was a plethora of duds, solid hits on targets without warhead detonations.[14] This problem was suspected

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[12] Successful magnetic exploders have, of course, subsequently been developed by many organizations.

[13] COMSUBSOWESTPAC (Christie) issued the deactivation order in response to an order he had received from the new Commander, Seventh Fleet (Kincaid). Blair, p. 504. Christie had been heavily involved in the development of the Mk 6 exploder at Newport and was reluctant to see it abandoned.

[14] Two of the best documented patrols that suffered duds were WAHOO—5 (April 1943) and TINOSA—2 (July 1943). The first of these is reported in O'Kane "Wahoo" and the second in Shireman "The Sixteenth Torpedo" unpublished MA thesis, U of Wisconsin, 1991.

earlier, but it was not until the other two problems had been eliminated that there was unequivocal evidence of a problem with the impact exploder. This difficulty was a further frustration for the operating forces,but fortunately it was quickly diagnosed. The key to the problem was again the increased speed of Mk 14.[15] The impact portion of the Mk 6 exploder was exactly the same as that which had been used in the Mk 4 and Mk 5 exploders. The Mk 4 worked entirely satisfactorily in the 33.5 knot Mk 13 torpedo. What was overlooked was that in going from 33.5 knots to 46.3 knots the inertial forces involved in striking the target at normal incidence were almost doubled. These greatly increased inertial forces were sufficient to bend the vertical pins that guided the firing pin block. The displacement was sometimes enough to cause the firing pins to miss the percussion caps, resulting in a dud. In cases of oblique hits, the forces were smaller and the impact exploder more often operated properly. Several war patrols, especially those cited above, convinced COMSUBPAC, Vice Admiral Charles Lockwood, that there was a problem and he again resorted to experiment. Firings at a cliff in Hawaii demonstrated that some torpedoes did not detonate when they hit the cliff. A rather risky disassembly of a dud revealed the distortion of the guide pins. It was a simple solution to make aluminum alloy (rather than steel) firing pin blocks and lighten them as much as possible thus reducing the inertial forces to a level that did not distort the guide pins. Another solution was to use an electrical detonator and a ball switch to fire the warhead. This too was relatively easy to implement and soon became standard.

Once these and other less significant problems were solved, the Mk 14 torpedo became a reliable and important weapon. After WWII, it was modified to accommodate electrical fire control settings, gyro angle, depth and speed, and as Mk 14 Mod 5 remained in service until 1980.

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[15] The literature on the Mk 13, Mk 14 and Mk 15 torpedoes focusses strongly on the Mk 14 and says almost nothing about either the Mk 13 or the Mk 15. This is understandable in the case of the Mk 13 since it was a slower torpedo and consequently had a smaller depth error and not major problem with the contact exploder. In the case of the destroyer launched Mk 15, which was a few feet longer than the Mk 14 and carried a larger warhead, but otherwise nearly identical to the Mk 14, I have found no references to unequivocal torpedo failures. This may be because during a destroyer torpedo attack things are too hectic to permit a careful evaluation of torpedo performance.

How and Why

It is worth asking how these three problems might have come about and presented such a refractory situation early in WWII. It is easy to identify several contributing factors, but it is unlikely that any one of them alone was the deciding factor. One of first factors was the economy. These torpedoes were developed during the Great Depression: the total U.S. Navy budget from 1923 through 1934 averaged less than $350M per year and total personnel stood at about 110,000. In that environment a torpedo was valued at around $10,000 (about the same as a fighter aircraft airframe complete except for engine) and destroying one in testing was a risk that only the fearless were willing to run. The result was that testing and proofing were done in such a way as to avoid risk of damage either to expensive torpedoes or scarce targets. As is often the case, constrained testing failed to reveal certain critical problems. It is, however, difficult not to believe that deep running, in particular, should have been discovered. There were well documented reports of German and British problems during WWI. It appears also that impact exploders were not tested in high speed torpedoes or at least not tested in impacts of well simulated warheads with hard targets. Such tests were undoubtedly omitted in an effort to avoid destroying useful materiel, exploders in particular, and perhaps further justified by the fact that the exploder performed satisfactorily in lower speed tests and by its primary role as a back up to the magnetic influence exploder. Thus we conclude that with respect to these two problems, depth control and the impact exploder, the poor state of Navy finances and the concomitant lack of realistic testing probably played a significant role.

Another aspect of the situation was the almost total isolation of NTS-Newport from the larger U.S. technical and engineering community especially after 1923 when the station secured a monopoly on torpedo development and production. Political and labor interests in keeping jobs in New England probably encouraged the isolation. The net result seems to have been a lack of expansion of the scientific basis for torpedo technology at Newport at a time when dramatic changes in engineering were taking place elsewhere. No one was thinking about torpedoes from different perspectives and asking hard questions about design details. The isolation was exacerbated, especially in the case of the Mk 6 exploder, by draconian security, which in some cases even excluded the operating forces from full knowledge of the weapons they were expected to us. In this isolated environment, NTS-Newport developed an arrogant *we are the torpedo experts* attitude and when problems began to arise, the response was denial—*there is nothing wrong with the torpedoes*—with the result that problems were identified and fixed slowly.

Perhaps not surprisingly a very strong polarization developed between the operating forces and the torpedo shore establishment. The operating forces resented their exclusion from the torpedo development cycle and flaunted their successes in proving that there were problems with the Mk 14 torpedo. These strongly expressed opinions of the men of the operating forces did not tend to improve relations with NTS-Newport. The operating forces also tended to exaggerate their contributions to the solution of the problems and deprecate those of NTS-Newport. A distinguished and truly great submariner recently wrote: "So by the beginning of September 1943, the operating submariners had detected and solved three serious defects in the Mark XIV torpedo: its faulty depth setting, skittish magnetic exploder and sluggish firing pin. All three problems had been solved by the operating forces in their tenders and bases, without help from Newport or Washington."[16] This is certainly an overstatement, but what is most significant is that though written over 50 years after the events, it still reflects the intense polarization that existed between the operating forces and the torpedo shore establishment.

This spectrum of problems was not unique to the U.S. torpedo establishment. Almost the same set, defective depth control, unsatisfactory and untested magnetic exploder and a contact exploder that did not work at certain striking angles, occurred in the German Navy and many of the responses of the shore establishment to the problems were also the same. The situation is discussed in considerable detail by Doenitz in his memoirs.[17] The German Navy's problems were closed out, however, with four senior officers being tried by court martial, on the order of

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[16] James F. Calvert, "Silent Running: My Years on a World War II Attack Submarine", New York: John Wiley, 1995, pp. 96-97.

[17] Karl Doenitz, "Memoirs: Ten Years and Twenty Days", Annapolis: U.S. Naval Institute Press, 1990. The bulk of the discussion of torpedo failures is contained in Chapter 7 and Appendix 3.

Grand Admiral Eric Raeder, found guilty and punished.

Lest there be any implication that the entire U.S. Navy or even all of BuOrd was functioning in isolation, we note that at about the same time early experiments with what became radar were being conducted at the Naval Research Laboratory (only about 350 miles southwest of Newport). In 1937 complete disclosure of the state of radar development was made to the Army Signal Corps and Bell Telephone Laboratories. Radio Corporation of America was brought into the fold in 1938.[18] The contrast of this approach to the Newport approach is nothing if not striking. BuOrd itself in the development of range keepers for surface fire control, in a comparably secret endeavor roughly contemporaneous with the Mk 14 development, co-opted Ford Instrument, ARMA and Sperry to assist with the development. A later dramatically contrasting development program was the development of the Mk 24 Mine (Torpedo) between December 1941 and May 1943, which is discussed in a subsequent part of this series.

This takes the story of U.S. Navy torpedoes through the beginning of WWII. As the United States became involved in the war, it became apparent that new kinds of torpedoes would be useful and a multitude of programs to develop improved weapons for submarines, surface vessels and aircraft were initiated. The idea that torpedoes could be significant ASW weapons also evolved and was elaborated with considerable success. The wartime developments and the post war development of U.S. Navy torpedoes are discussed in the third part of this series. ■

[18] L.S. Howeth, "History of Communications-Electronics in the United States Navy", Washington: GPO, 1963, Chapter XXXVIII, and chronology pp. 540-41.

TO SINK AND SWIM: THE USS FLIER

by Eugene D. McGee

Eugene D. McGee is a 1981 graduate of Duke University (Mechanical Engineering) and a 1983 graduate of Emory University (Marketing). He is currently a manager with AT&T Submarine Systems Incorporated and a manager for the all-volunteer International Submarine Races.

The surfaced World War II submarine USS FLIER (SS 250) picked her way on the dark moonless night of August 13, 1944 through Balabac Strait in the Philippine Islands with a combination of SJ radar ranges and visual fixes on Comiran and Balabac Islands. The crew on the bridge were anticipating their upcoming engagement with a Japanese convoy—but this was not to be. Off Comiran Island, at approximately 2200, FLIER struck a mine somewhere forward on the starboard side. Diesel fuel, water and debris rained down on the bridge while yells and screams came from below. Air rushed out of the conning tower hatch (propelling some crewmen through the hatch) and in 20-30 seconds, with FLIER still making 15 knots, she sank in water approximately 180 to 600 feet deep. At least 15 men of her 86 man crew now found themselves in the water without life jackets and far from land and facing a swim for their lives.[1]

USS FLIER was a Gato class fleet submarine commissioned at Electric Boat, New London, Connecticut, in October 1943. Her first and only Commanding Officer was Commander John D. Crowley who had graduated from the U.S. Naval Academy in 1931 and had previously commanded the S-28.

FLIER sailed to Pearl Harbor via the Panama Canal and enroute dodged a friendly merchant ship that fired 13 shells at her.[2] She departed Hawaii on January 12, 1944 for her first war patrol. Arriving at Midway to top off her fuel tanks, she ran aground while negotiating a treacherous channel and fighting an 8

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[1] Captain J.D. Crowley, unpublished paper "Story of Men Against the Sea is told by Sub Skipper", p.1.

[2] Clay Blair Jr., Silent Victory, The U.S. Submarine War Against Japan. Philadelphia: J.B. Lippincott Company, 1975, p. 564.

knot cross current. With the submarine hard aground and damaged, the submarine rescue ship USS MACAW (ASR 11) attempted salvage but it too ran aground. FLIER crewmen Waite Daggy and James Cahl went topside to secure some lines only to have waves throw and injure Daggy against the four-inch gun and sweep Cahl overboard and drown him.[3] Cahl's body was recovered the following day and he was buried at sea.[4] FLIER was later hauled off and towed to Hawaii and later proceeded back to Mare Island for permanent repairs. MACAW was not so fortunate—she sank on February 13, 1944, taking her commanding officer and four of her crew with her.

The repaired FLIER departed from Pearl Harbor for a patrol in Iwo Jima and Philippines waters and between June 4, 1944 and June 23, 1944 she attacked six ships in three different convoys.[5] These attacks sank at least the 10,000 ton naval transport HAKUSAN MARU and the 5,838 ton cargo ship BELGIUM MARU.[6] FLIER then proceeded to Fremantle, Australia and Commander Crowley was awarded the Navy Cross for the first patrol.[7]

FLIER departed from Fremantle, Australia on August 2, 1944, for her second war patrol with orders to proceed via Balabac Strait to the South China Sea and Indochina. Enroute, an Ultra message on a southbound Japanese convoy in the South China Sea was received and as a result, speed was increased and the bridge watch doubled as the ship threaded its way through Balabac Strait.[8] After the mine strike and the submarine's sinking, nearby Comiran beckoned to the desperate survivors as the closest island to swim to—but with a Japanese garrison believed to be on the island,

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[3] Earl R. Baumgart, letter dated January 26, 1994.

[4] Ibid.

[5] Blair, op. cit., p. 613.

[6] John D. Alden, U.S. Submarine Attacks During World War II. Annapolis: Naval Institute Press, 1989, pp. 104, 106, 108.

[7] Crowley, op. cit., p. 1.

[8] Ibid, p. 1.

Commander Crowley decided that the group should head north. Only 8 men survived the 12 mile swim to Byan Island (most of them in 17-1/2 hours) some with the assistance of a floating palm tree, currents and the moonrise.[9] [10] A lean-to was constructed on the island for temporary shelter. On August 15, 45 hours after the sinking, a mysterious explosion was observed in the direction of FLIER.

The group made a seven by four foot raft and despite the thirst, lack of food, blistering sunburn, insect bites, Japanese aircraft patrols, poor clothing and coral cuts, island hopped in search of food and water with the raft until reaching Bugsuk Island.[11] On Bugsuk, the FLIER survivors found an abandoned village and quenched their thirst with water from a cistern and coconuts.

Shortly thereafter, friendly guerrillas of the Bolo Battalion of Bugsuk Island appeared armed with a mixture of rifles, blow guns and bolos. They told the survivors not to drink water from the cistern since it had been poisoned. (One man did become ill for the night.)[12]

These guerrillas later told the survivors of the loss on July 26, 1944, of USS ROBALO (SS 273).[13] A post war account states she sank as a result of striking a mine "...two miles off the western coast of Palawan Island..." while returning from a patrol

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[9] The eight survivors were: Commander John D. Crowley, Lieutenant James W. Liddell, Jr., Ensign Alvin E. Jackson, Jr., Arthur G. Howell, Donald P. Tremaine, Wesley B. Miller, James D. Russo and Earl R. Baumgart.

[10] At the first USS FLIER reunion held on September 28, 1994 in Annapolis, Maryland, it was determined by the five survivors attending that the group landed on Byan Island, not Mantangule Island as noted in the wartime report.

[11] Crowley, op. cit., pp. 1, 2, 3, 4.

[12] Alvin E. Jacobson, Jr., unpublished paper, p. 16.

[13] Crowley, op. cit. p. 5.

in the South China Sea.[14] The guerrillas in fact told the FLIER survivors that the survivors of ROBALO landed on Comiran Island and were captured by the Japanese. These ROBALO survivors did not survive the war. (A total of 81 men were lost as a result of the sinking of ROBALO.)

The guerrillas and survivors left the area since Japanese troops were expected shortly. They hiked overland to a sailboat that took the party to Brookes Point, Palawan Island. Enroute, they had to evade a Japanese launch. The group was introduced to a team of U.S. Army coast watchers most likely part of the guerilla-trained 978th Signal Service Company.[15] An Army radio was utilized to arrange evacuation by USS REDFIN (SS 272).

REDFIN evaded a small Japanese Maru and despite communications difficulties, rendezvoused on August 31, 1944 with the eight FLIER survivors along with nine other people in two small local boats provided by the guerrillas.[16] REDFIN off-loaded guerilla supplies and with the survivors safely on board, attempted to attack with deck guns the small Japanese Maru but was thwarted by shallow water.

The survivors were taken to Australia where they eventually recuperated from their ordeal and went on to other assignments. An investigation was held on the loss of ROBALO and FLIER and Balabac Strait was declared to be off limits to future U.S. submarines during the war due to the danger of mines.[17]

While post-war records show I-123 mined Balabac Strait on December 6, 1941, it was most likely some of the 600 Type 93 Model 1 deep sea contact mines laid by IJN TSUGARU in late

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[14] Naval History Division, Office of the Chief of Naval Operations, United States Submarine Losses—World War II. Washington DC: U.S. Government Printing Office, 1963, pp. 100, 101.

[15] George Raynor Thompson and Dixie R. Harris, United States Army in World War II—The Signal Corps: The Outcome (Mid-1943 through 1945). Washington, DC: U.S. Government Printing Office, 1966, p. 273.

[16] REDFIN had been patrolling west of Balabac Strait and apparently proceeded eastward back through the strait to effect the rescue.

[17] Blair, op. cit., p. 691.

March 1944 that sank FLIER and ROBALO.[18] The mines were capable of being laid in water depths up to 3500 feet and with a case that could be set as deep as 230 feet.[19] It would appear that Japanese mines could be laid in water far deeper than the U.S. Navy estimated at the time, possibly explaining the losses of other U.S. fleet submarines during the war. (A similar analogy can be drawn from the underestimation of the range capabilities of the Japanese Long Lance torpedo that caused the loss of many U.S. Navy ships in the Solomons.)[20] As an example, the description of the loss of USS ALBACORE to a mine states: "...because of the danger of mineable water, she was ordered to stay outside of waters less than (600 feet) deep".[21] In fact, Japanese mines could be laid in water 2900 feet deeper than that.

As a side note, IJN TSUGARU was sunk by USS DARTER (SS 227) on June 29, 1944 off Morotai Island in the Molucca Sea—720 miles from Balabac Strait.[22] Hence, the IJN TSUGARU was already sunk by the time her mines sank ROBALO and FLIER. (USS DARTER later came to grief on a charted reef off the western shore of Palawan.) ■

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[18] Teruaki Kawano, Japanese Military History Department, letter dated December 19, 1993.

[19] Operational Archives, U.S. Naval Technical Mission to Japan 1945-1946. Washington, DC: U.S. Naval History Division, 1989, Reel JM-200-D, Report Number 0-04, Japanese Mines.

[20] Samuel Eliot Morison, The Two-Ocean War: A Short History of the United States Navy in the Second World War. New York: Ballantine Books, 1963, p. 233.

[21] Naval History Division, Submarine Losses, p. 122.

[22] Alden, op. cit., p. 110

WANKLYN VERSUS GARIBALDI
28 July 1941

by Richard Boyle
Line Drawings by David Hill

UPHOLDER was commanded by M. David Wanklyn in the Med during a period of feverish activity when Italian and German ships were attempting to supply Rommel in North Africa. UPHOLDER was part of the Tenth Submarine Flotilla (Malta) commanded by the legendary Captain G.W.G (*Shrimp*) Simpson. Wanklyn's attack against the Italian cruiser GARIBALDI on 28 July 1941 stands out as one of the most extraordinary moments in the history of submarine warfare.

UPHOLDER was a U class submarine, the *smallest and slowest*[1] in the Royal Navy. Her basic characteristics were:

Length	197 ft
Beam	16 ft
Surf Disp	540 LT
Subm Disp	730 LT
Surf Speed	11.8 knots (design)
Subm Speed	9 knots
Range (Surf)	4100 nm @ 10 knots
Range (Subm)	170 nm @ 2.5 knots
Test Depth	200 ft
Armament	Six 21 inch bow torpedo tubes. Two external. Four internal. Total load: 10 torpedoes
Complement	31 total

Although painfully slow (actual top speed seldom more than 10.5 knots on the surface[2]), UPHOLDER was ideally suited to the Med. Patrols out of her home base at Malta were often very short. Targets could be within reach on the first day underway, and patrols were sometimes over in four days or so, limited by torpedo carrying capacity.

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[1] G.W.G. Simpson, *Periscope View*. London: MacMillan, 1972, p. 112.

[2] Alastair Mars, *British Submarines at War 1939-1945*. Annapolis: Naval Institute Press, 1971, footnote, p. 132.

British torpedo gyros could only be set at 0°, and it was necessary to lead the target by aiming the submarine as shown in a typical firing triangle (Figure 1). In Royal Navy parlance, the lead angle was known as *Director Angle (DA)*. A thumb rule for attacking merchant ships in the Med was: "The DA is always 10°."[3] Indeed, if calculated for a target speed of 7.5 knots, torpedo speed 44 knots, and angle on the bow of 90°, we get 9.8°.

Multiple torpedo spreads were often created by firing all torpedoes down a *hosepipe* course with firing interval calculated from a special slide rule. In order to avoid countermining, the interval had to be at least five seconds. Inputs to the slide rule included torpedo spacing in fractions of target length versus target speed.

On the evening of 28 July 1941, UPHOLDER was on patrol submerged NW of the island of Maretimmo (off the NW coast of Sicily). It was her 11th war patrol. Excerpts from the patrol report tell the story. The Firing Triangle and Torpedo Hosepipe are shown in Figures 2 and 3.

"28th July

1941 Sighted two cruisers and two...destroyers to southward steering 355 degrees. Assumed speed of 22 knots. The cruisers maintained a steady course while the destroyers zigzagged on either bow...

1950 ASDIC gave 230 revs which equals 28 knots. This put the director angle up to 46 degrees and the leading cruiser had already been missed.

1951 Fired full salvo of 4-35 knot torpedoes at rear ship [GARIBALDI] in position 38-04 N 11-57 E using a 12 second interval at a range of 4000 yards.

1955 Two heavy explosions at exactly 12 seconds interval. Retired to the Northeast at 150 feet.

1957-2046 Depth charge attack by one destroyer while the other apparently guarded the wreck with an occasional charge. In all 38 depth charges were recorded, some being fairly close during the first 15 minutes. On one occasion the destroyer passed right overhead at a very high speed: but had just finished dropping a

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[3] John Coote, *Submariner*. New York: W.W. Norton, 1991, p. 176.

stick of charges."[4]

Wanklyn had one minute after learning that target speed was 28 knots, to aim the ship with a huge DA and let go his salvo. The attack was in effect a long range snap shot.

The two explosions are not explained, because there was only one hit, on the starboard side of the forecastle forward of A Turret.[5] GARIBALDI was seriously damaged, but was escorted to Palermo and ultimately to a drydock in Naples.

David Wanklyn was a shy, quiet and modest gentleman. "He had a brilliant mathematical brain which suited him perfectly, however fraught the situation was; and, above all, he had the knack of inspiring his crew into being a cut above average."[6] He was the leading British ace of World War II having sunk 101,999 tons of merchant shipping, two submarines and a destroyer.

During UPHOLDER's 14th patrol Wanklyn sank the liner CONTE ROSSO (17,879 tons) and was subsequently awarded the Victoria Cross, Britain's highest award for valor. UPHOLDER failed to return from her 25th patrol. She was sunk off Tripoli on 14 April 1942, a victim of enemy depth charges. Wanklyn and his crew had made the supreme sacrifice at a time when the war in the Med was not going well for the Allies. In the final analysis, Malta survived and the Tenth Flotilla submarines sank or damaged more than a million tons of merchant shipping. This contribution was instrumental in returning total control of the Med to the Allies. ■

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[4] ADM 199 1154. HMS UPHOLDER Patrol Report Number 11, 19th July - 31st July 1941, dated 5th August 1941.

[5] Personal communication, Dr. Achille Rastelli, 12 December 1988.

[6] Richard Compton-Hall, *The Underwater War 1939-1945*. Poole: Blandford Press, 1982, p. 83.

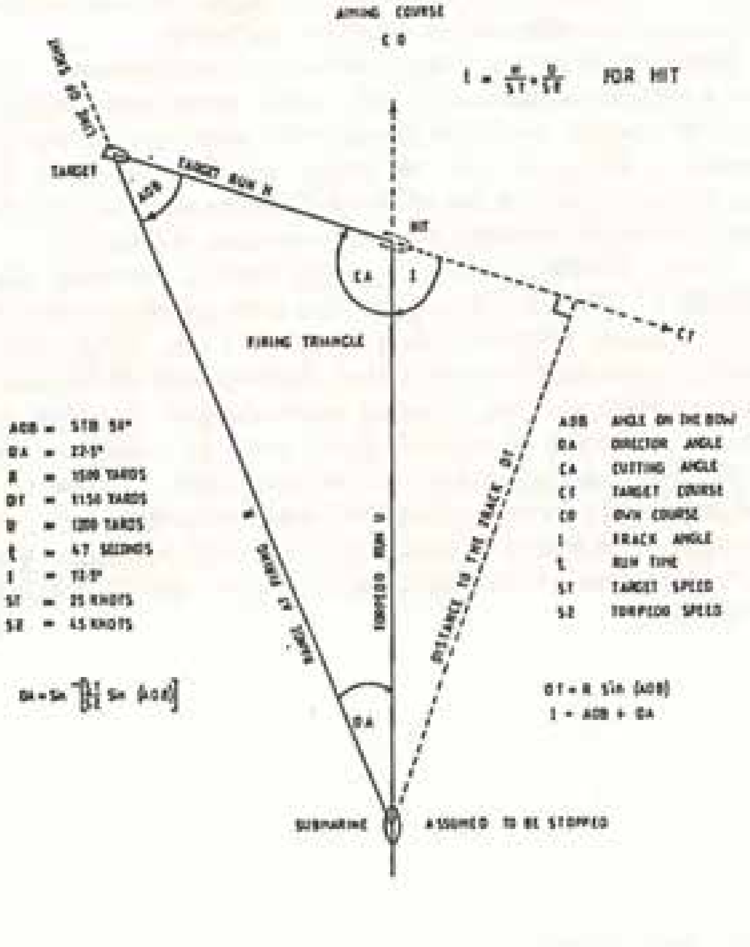
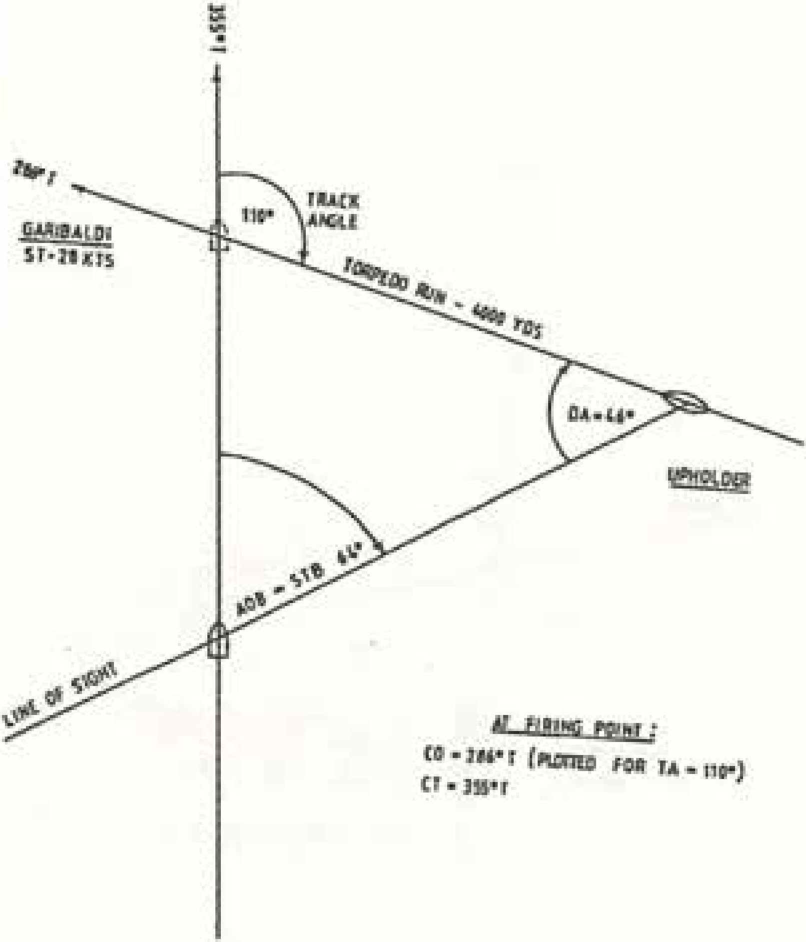

AIMING COURSE
C O
FOR HIT
TARGET
TARGET RUN H
AOB
HIT
CA
I
C T
FIRING TRIANGLE
TORPEDO RUN U
DISTANCE TO THE TRACK DT
DA
SUBMARINE
ASSUMED TO BE STOPPED
R = 1500 YARDS
DT = 1150 YARDS
U = 1200 YARDS
t = 47 SECONDS
ST = 25 KNOTS
SE = 45 KNOTS
AOB ANGLE ON THE BOW
DA DIRECTOR ANGLE
CA CUTTING ANGLE
CT TARGET COURSE
CO OWN COURSE
I TRACK ANGLE
t RUN TIME
ST TARGET SPEED
SE TORPEDO SPEED
DT = R SIN (AOB)
I = AOB + DA

Figure 1



AOB = STB 64°

$$DA = \sin^{-1}\left[\frac{ST}{SZ}\sin 64°\right] = 45.975°$$

Figure 2

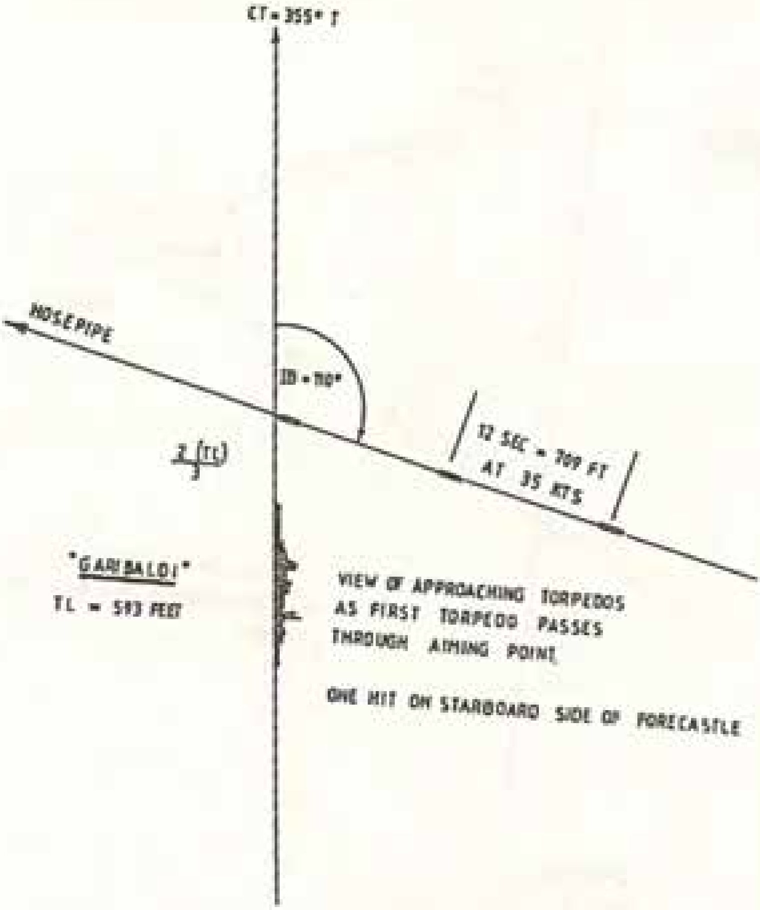

CT = 355° T
HOSEPIPE
ID = 110°
12 SEC = 709 FT
AT 35 KTS
2/3 (TL)
"GARIBALDI"
TL = 593 FEET
VIEW OF APPROACHING TORPEDOS
AS FIRST TORPEDO PASSES
THROUGH AIMING POINT
ONE HIT ON STARBOARD SIDE OF FORECASTLE

Figure 3


Newport News Shipbuilding
WE BUILD MORE THAN SHIPS.
WE BUILD PARTNERSHIPS.
TENNECO

A SHIPBUILDER'S PERSPECTIVE OF LOGISTICS

by James E. Turner, Jr.

Adapted from Mr. Turner's presentation to the Naval Logistics Conference, Hershey, Pennsylvania on October 31, 1995.

We at Electric Boat have been supporting *Tomorrow's Navy* since the year 1900, when John Holland delivered the first submarine to the Navy. Ninety-five years—and over 300 submarines later—we are hard at work supporting *Tomorrow's Navy* with Trident, SEAWOLF and the New Attack Submarine.

Before getting into logistics, it might be useful to define the term. Let's start with the Joint Chiefs of Staff definition of logistics as, "The science of planning and carrying out the movement and maintenance of forces."[1] The military historian, Professor Stanley Falk, provides an expansive definition stating, "In its broader sense, it has been called the economics of warfare" and includes "practically everything related to military activities besides strategy and tactics".[2] In essence then, the three basic elements of warfare come down to strategy, tactics and logistics.

Logistics itself can be considered at the strategic or tactical level. The Civil War provides several examples. At the tactical level, Confederate General Nathan Beford Forrest was known for his ability to "Git thar fustest with the mostest men".[3] While that's a great sound bite, those weren't exactly Forrest's words. General Forrest was known as "one of the Civil War's most industrious gatherers and conservers of every military resource, from rifles to hogs".[4] Forrest's actual statement was simple and direct, "I just got there first with the most men."[5] That's a good way to describe logistics at the tactical level.

At the strategic level stood General Grant. Grant was convinced that "the Union had wasted its greatest strategic advantage—its larger resources of manpower and material".[6] Grant's strategy was to use "all the Federal armies in concert to apply a simultaneous and relentless pressure to leverage the power of the industrial North in a way never before seen in war".[7] General Grant's successful campaign was nothing less than logistics on the grand scale.

Indeed, the combination of the North's factories, railroads, steamships and the telegraph with the manpower of Grant's armies was revolutionary. But this strategic application of logistics has only recently been recognized as a *revolution in military affairs*. Interestingly, the important elements of Grant's revolution came from the private sector; they were not products of the public shipyards and arsenals. I believe there is a lesson there.

Since I have recently managed a shipyard that builds submarines, my focus is on submarine logistics; but, my message applies to military platforms in general. And, I'll limit my remarks to submarine acquisition. Modernization, repair and overhaul could be the topic for another article.

First—before discussing where we are headed—a little review of submarine logistics in the past.

Ever since World War I, independent operations have been fundamental to submarine warfare. Submarines sailed independently, transited to their mission area, and at the end of their patrol, returned to port—all without outside support. There was no underway replenishment—no COD delivery of critical repair parts. The submariner had to take it with him or go without. This demanding operational concept required submarines to be designed for reliability and endurance. And it placed great importance on proper provisioning.

A few may remember that submarines were classified as *ships without a central storeroom*. Until the early 1960s they had no Supply Corps officer or storekeeper. Spare parts, as they were called then, were issued directly to the departments as they were received. As you can imagine, inventory control wasn't very good.

Submarine logistics were managed independently by different bureaus—BUSHIPS, BUORD, BUSANDA, BUMED—and each generated its own allowance lists. Production of technical manuals, maintenance routines and operating procedures was fragmented among the Bureaus, the type commander and the ship's force. Again, the results weren't great.

When it came to new construction, the basic responsibility of the shipbuilder was to deliver a well-built submarine per the Navy specifications. Shipbuilder involvement with initial provisioning and maintenance was limited.

If this sounds like an uncoordinated approach to submarine logistics, you're right! It worked because the ships were sturdy and relatively simple, and a lot of Navy people labored hard to make it work.

The 1960s brought several major changes. First, nuclear power replaced diesel power. Second, submarine-launched ballistic missiles were introduced. Third, the complexity of nuclear power and strategic missiles brought private industry into the submarine business on a full time basis. Fourth, the loss of THRESHER led to the SUBSAFE program. And finally, a 1964 DOD directive mandated Integrated Logistic Support (ILS) for systems and equipment.[8] Together, these changes had a profound impact on shipbuilder involvement in submarine logistics—with positive and lasting results.

The size and complexity of submarines had taken a step change. The integration of submarine logistics followed close behind, as the old ways were inadequate. Naval Reactors and the Strategic Systems Program Office led the way in developing military-industrial teams that set new standards for solid engineering and sound management.

At this time, for the shipbuilder, logistics was not a contractual element of design and construction. However, the submarine designers provided for important factors like:

- providing access to equipment for maintenance
- selecting equipment that would pass through a 30 inch hatch, and
- developing system and equipment operating manuals.

By the 1970s, these and other improvements were formally brought together with the SSN 688 and Trident SSBN programs. Trident was the first submarine class acquired under a comprehensive program that integrated the ship's design, weapons, provisioning, maintenance, repair, training and basing over the life of the ship.

Trident program requirements called for higher ship availability and lower life-cycle cost. That meant longer patrols, shorter refit periods and less time in shipyard overhaul. Higher ship availability demanded greater reliability and better maintainability. Lower life-cycle cost required a comprehensive management system. All of this required the ship designer, the shipbuilder, key contractors and the Navy—working together—to consider the entire life of the ship—from design to disposition. This team effort was a new way of doing business.

Typical aspects of this integrated approach at EB were:

- initiating a formal logistics program concurrent with ship design

- designing 60 inch diameter logistics hatches for rapid provisioning and equipment replacement
- developing the concept of incremental overhauls
- providing design support to Trident training and refit facilities, and
- assisting the Navy in managing alterations and maintenance.

We all know that this new approach worked. The Trident program has been a tremendous success. Electric Boat has delivered 17 Trident submarines, each one better than the last. And to illustrate how important process improvements in ship construction can be, the 17th Trident was built with less than 50 percent of the man-hours required to build the first ship of the class.

The Trident integrated logistics system has continued to mature in the 15 years since USS OHIO was commissioned. Maintenance routines have been fine tuned to eliminate unnecessary work. ILS has moved into the digital age as computers and CD ROMs have replaced paper COSALs and punched tapes. The mature Trident ILS now serves as a stepping stone to the future, as EB explores an expanded planning yard concept and the potential to support Navy regional maintenance. And, the Trident logistics system provides a baseline for the New Attack Submarine.

Thus, we have seen the development of integrated logistics, from diesel boats to the Trident program. We have also seen a great increase in the participation of industry in the submarine logistics process. The integration of the public and private sectors has paid off handsomely. The readiness and reliability of the United States Submarine Force are the envy of the world's navies—including our own.

I suspect that you all know what comes next. Just about the time that our hard work on integrated logistics was really getting results, the Cold War ended. We were all grateful that four decades of deadly confrontation were over. But—we were suddenly faced with a changed world.

The changes of the post Cold War era have impacted every element of the defense establishment. Military budgets and forces were cut; major defense programs were terminated; bases are being closed; and the defense industry is being rationalized. These changes have been tough—especially on our people—in and out of uniform.

Let me explain how General Dynamics faced these changes. First, at the corporate level, we quickly recognized there was significant over-capacity in the defense industry. Major rationalization was urgently required.

Therefore, we took prompt action to establish a *critical mass* by selling, or buying, businesses that were not first or second in their defense market sector. After a series of transactions, we are concentrating on our core products—armored vehicles at the Land Systems Division, submarines at Electric Boat, and now, surface warships at Bath Iron Works. This proved to be a successful strategy for General Dynamics, for our stockholders, and for the Department of Defense.

At the production level, Electric Boat faced major problems. Attack submarine force levels were cut by 45 percent, and the Trident program was limited to 18 ships. We were caught at a high building rate, but with the future workload headed toward zero.

Let me give you some numbers. In 1992 there were 13 submarines under construction at Electric Boat. By the end of 1996 there will be three, including SSN 23, the third and final Seawolf. In 1992 Electric Boat employed 22,000 workers. Today we have 10,000, and we're headed toward 6 or 7,000 by the end of the decade.

The challenges we faced went far beyond reducing the size of the work force. We determined that to remain competitive, we must reengineer the company to build submarines at one-half ship per year, as efficiently as we had built three or four per year. Otherwise, our submarines would be unaffordable.

It became evident that radical action was required. Simply shrinking in place was not enough. With the help of a consulting firm we undertook a top-to-bottom reengineering of the company. Every facet of the business was examined: organization, work practices, facilities, pay and benefits, overhead. We looked at every opportunity to drive out costs; and then set specific targets for cost reduction.

I'm proud to say that the targets are being hit, and Electric Boat is moving confidently ahead. Based on our reengineering, EB has already reduced the forward-pricing rates charged to the government. In fact, I was so confident of our results that I told the Senate Armed Services Committee in May 1995, that I would sign a contract to build the New Attack Submarine for the same rates that we charged in 1989, at our peak workload, corrected only for inflation.

Now, let me give you a specific example of our action. One key element in our drive for affordability is the single-shipyard, design/build approach being used on the lead New Attack Submarine.

Traditionally, the Navy contracts with a shipbuilder to design a submarine that meets the Navy's operational requirements. Separate contracts are then awarded to one or more shipbuilders to construct the submarines to the Navy's design. Inevitably, some defects in the design are encountered during construction. Defect correction involves the designer, the builders, and the Navy. This results in delay, change orders, claims against the Navy, and considerable cost growth. Today, this is unacceptable.

The design/build concept places sole responsibility for the design and construction of the lead submarine directly on the shipbuilder. The design/build approach to the New Attack Submarine is being implemented through Integrated Product and Process Development teams. We call them design/build teams. These teams are made up of designers, engineers, construction and maintenance personnel, logisticians, and representatives from key suppliers and the Navy. Working together, the design/build teams are designing a submarine that meets the Navy's military requirements, is producible at least cost, and is less costly to maintain over its service life.

With design/build, logistics is an integral part of the New Attack Submarine design process from the very beginning. This is vitally important if we are to control the cost of ownership of weapon systems with service lives of 30 years or more. And, with lifetime operating and logistics costs exceeding the purchase price, it is essential to attack these costs up front—during the design. Otherwise, the Navy will be unable to afford the fleet it needs.

Looking back over this brief survey of submarine logistics, I'd say that we have come a long way from the days of submarines without storekeepers or integrated allowance lists! From my perspective, the steady increase in the involvement of the private sector has been an important factor. With the design/build process as an example, I see this trend toward privatization continuing in the future, and expanding into modernization, maintenance and repair.

There are three messages that I would like to leave with you today. First, Navy-industry cooperation works. The Trident program is a great example. Design/build is another. Second, life-cycle costs and logistics must be an integral element of platform design. And third, increased privatization of life-cycle support functions is necessary to affordability. We should be planning for it now. ■

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7. Ibid.

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CONTROLLING C^3I SYSTEM LIFE CYCLE COSTS

by CDR Tom Belke, USNR
and CAPT Tim Oliver, USN(Ret.)

The increased usage of commercial electronics in new DoD C^3I systems has resulted in the need for adopting new methods of controlling system life cycle costs. High tech defense systems are facing *upgrade or else* situations due to the high price of obsolescence brought about by the rising cost of custom made electronics components and the fast pace of computer technology. Generally, these supportability upgrades now contain a high percentage of commercial-off-the-shelf (COTS) components.

Rising Life Cycle Costs

Traditional military procurement has followed the path of military development optimization for mission requirements. Because nonmilitary applications were limited, the cost of development was absorbed in the process. As a result of the ongoing reduction in defense spending, the Government has looked to new ways to maintain tactical capability while continuing to operate within declining budgets. The Government is, therefore, turning to the commercial world and its products to satisfy both goals. This is being accomplished by two methods: through the use of equipment with other applications whose general purpose can meet military objectives, and, by utilizing the faster development times being experienced for commercial electronic products. New system designs focus on affordability while leveraging and consolidating existing and future subsystems into a cohesive program. Use of Open Systems Architecture (OSA) is leading to the establishment of standard, commercially accepted interfaces for new or modified DoD electronics. In order to reduce recurring and life cycle costs, legacy system life cycle approaches now focus on transitioning current combat system hardware and software into COTS products.

Upgrade or Else

The rapid pace of obsolescence in commercial electronics means more frequent upgrades are required for long term supportability. Because the Government does not significantly influence the design of COTS products, the life cycle maintenance and modernization philosophy needs to be considered when selecting each item. A challenge in the COTS arena is the relatively short time available to acquire and field COTS equipment before obsolescence. This *upgrade or else* stance leaves little time for a traditional maintenance strategy.

Nontraditional Support Approaches

Innovative and nontraditional support approaches are required for new acquisitions because of shortened schedules, technology driven configuration changes, and greatly extended requirements for service life. Several areas exist where system support will be affected by the broad use of COTS products and where traditional Navy maintenance and support concepts may not be effective. These areas are:

System design. Newly designed electronic systems will not be so much a large, fully integrated system as they will be a federation of reasonably independent subsystems. As a result, the prime contractor will function as an integrator and as a designer for these subsystems. Likewise, the Program Manager's Office (PMO) will be more involved in coordination among the subsystem Participating Managers (PARM) and have less independence. Interface definition will require major effort and constant attention. Due to COTS product volatility, the system design phase will continue throughout system life requiring a life cycle designer.

Configuration management. The PMO will have less control over the configuration of a COTS-based system than it had previously because COTS product evolution will be driven by commercial market pressures rather than government design. Instead of specifying the desired design, the PMO must accept and adapt what is available. As a result, configuration management must be more flexible and more functional. Configuration status accounting must be faster and more accurate to provide configuration data for logistics, maintenance, and upgrade.

Life cycle estimating. COTS products will have a much shorter life cycle than a MIL-SPEC system. Reasonably accurate estimating of a COTS product life cycle length is important for budgeting and planning of periodic supportability upgrades for the system. Accurate estimates will require a constant awareness of the progress of the commercial marketplace.

Maintenance philosophy. The traditional Navy three-level maintenance system will be hard to adapt to COTS products. Few COTS products should be repaired by organic resources and many will be cheaper to replace than to repair. Documentation and test equipment will be inferior to previous standards in that it will not be as comprehensive, nor will it be tailored to the military environment. The prime contractor should develop a new maintenance philosophy as the system is designed and built. This should include a system maintenance manual that specifies the level of repair and disposition of failed components of the COTS products.

Supply Support. Form, fit, and function spare and replacement parts may vary from vendor to vendor, and perhaps lot to lot from the same vendor. To ensure that new parts function in the system, testing will be required at levels far exceeding the levels needed previously, and parts interchangeability must be accurately specified.

Controlling System Life Cycle Costs

Since the cost profile of a system is determined near the beginning of the life cycle, new strategies need to be considered early on. The primary points of this recommended life cycle strategy are:

- Defined maintenance and modernization evaluation criteria
- COTS-compatible configuration management plan
- COTS knowledgeable In-Service Engineering Agent (ISEA)
- Integrated testbed for hardware and software evaluations.

Maintenance and modernization evaluation criteria. Ongoing market assessments, based upon maintenance and modernization evaluation criteria, are essential to ensure system supportability and continued satisfactory performance of the system in the out years. Because COTS life cycles are frequently only a fraction of the system life cycle, a series of supportability upgrades must be planned and budgeted. Well-defined maintenance and modernization evaluation criteria are critical to make this upgrade strategy work.

The expected service life of COTS hardware and software products varies from product to product, but COTS products are normally expected to be supportable for one generation after the original equipment manufacturer (OEM) delivers the product (typically 5 to 10 years). This is important to remember because the OEM, rather than the PMO, is likely to repair failed products. A two-level maintenance approach will likely be necessary. Operator-level maintenance should consist of troubleshooting to the lowest replaceable unit (LRU). Defective components should be discarded or returned to the intermediate maintenance and repair activity for repair. Repairs should take advantage of the commercial service, repair, and spare parts distribution systems that support the equipment, which should have been identified during the market investigation. Near the end of the supported product life, the fielded failure rate of a product needs to be reviewed. As a result, appropriate actions need to be taken to ensure spares are available until the product is replaced during a supportability upgrade.

<u>COTS-compatible configuration management plan</u>. The success of COTS supportability depends on the success of the COTS-based program's configuration management (CM) plan. The goal of a CM plan for a system composed of many COTS products is to maintain an accurate record of the configuration of each existing subsystem and component. Although this goal is similar to the traditional CM goal, COTS CM will be more dynamic and will be a more functional role than an administrative one. A COTS-based system will be undergoing constant change and evolution. Many system configurations will exist in parallel. Spare parts and maintenance support will depend on accurate documentation and knowledge of each system's configuration.

<u>COTS knowledgeable In-Service Engineering Agent (ISEA)</u>. An important aspect of COTS equipment life cycle support is the selection of the ISEA. The ISEA will be the activity that applies a systematic evaluation approach for determining appropriate repair and replacement items. Because of the ISEA's involved role in both the system development and life cycle management, careful consideration should be given to what activity is selected as the system ISEA. After the prime contractor develops and builds the system, the ISEA operates an Integrated Test Facility (ITF). This ITF should be used for the certification phase throughout the system life.

Integrated testbed for hardware and software evaluations. The ITF is a key element in successful COTS equipment employment and support. It will be used to perform product evaluations during the initial selection and subsequent system or subsystem upgrades. The facility will provide the PMO insight into the capabilities of any given product to meet the system requirements. It implements a *fly-before-buy* philosophy that has been successful in many other military programs with extensive equipment procurement production. The ITF should be used throughout the life cycle of the system or subsystems to (1) evaluate new or replacement products; (2) conduct operational tests simulating a mission environment; and (3) certify the correct operation of any products that have changed since the last time they were procured or repaired. Because the PMO will have less control over changes to COTS products, the ITF is the mechanism to ensure the correct operation of a changed product before purchasing a large quantity.

COTS Supportability is the Key

Since a growing percentage of new and legacy C^3I electronics systems is made up of COTS, implementation of a cohesive approach toward COTS supportability is the key to controlling system life cycle costs. Faced with an *upgrade or else* proposition to avoid wholesale system obsolescence, more systems are incorporating large amounts of COTS products. The long term implications of incorporating more of these commercial products into defense requires new innovative and cost effective approaches to ensure DoD systems remain viable. ■

ON DECOMMISSIONING USS SUNFISH (SSN 649)

by EM1(SS) Aaron Fitzsimmons, USN

August 28th 1996 marked the end of an era. USS SUNFISH (SSN 649) decommissioned and started the voyage to Bremerton, Washington for inactivation. Although 27 years young, SUNFISH has seen long and hard duty to the fleet. More and more long hours each day were going to maintenance and upkeep of the boat, but instead of opting for the *quick fix*, the crew of USS SUNFISH came through for lasting repairs and preservation, putting 100 percent effort into everything they did.

It's getting harder to find the right parts for the right job on these older boats. It's getting harder to chip away the years of paint, and lay down a new layer. It's getting harder to keep the edge on a boat that is slated for inactivation, but through perseverance, pride in our ship, and a continuous training program that prepared both junior and senior sailors for follow-on tours to other submarines and shore commands, USS SUNFISH shone through and made the best deal out of the hand dealt.

USS SUNFISH has a long and proud history. Coming full circle during her lifespan, SUNFISH made her maiden deployment to the Mediterranean, and ended with another deployment there, with Rear Admiral Mies from Group 8 in Naples riding the boat. Admiral Mies did his junior officer tour on board and was present on 13 February 1996 for SUNFISH's historic 1000th dive. A feat that few commissioned submarines hope to accomplish, SUNFISH and her crew completed a safe dive, and as Admiral Mies said, "...Another safe surface."

USS SUNFISH was commissioned on 15 March 1969 at the Quincy Division of General Dynamics. From that point on, the spirit of SUNFISH has shined in every ocean in the world. The early part of the '70s was spent conducting various deployments and services for the fleet along with earning her first Meritorious Unit Commendation. Completing an overhaul in 1973, SUNFISH returned to Charleston and the period of June to December 1974 marked the first deployment to the Mediterranean. SUNFISH's first Battle Efficiency E was awarded for 1976 along with her second Meritorious Unit Commendation. In February 1977, she left again for the Mediterranean, returning to Charleston in June.

In January of 1978, SUNFISH left Charleston for Pascagoula, Mississippi for her second overhaul, completed in February of

1980. In August 1981 SUNFISH again left for the Mediterranean returning in January 1982. This highly successful deployment netted SUNFISH the Navy Unit Commendation, The Battle Efficiency E, and her first Anti-Submarine Warfare A. SUNFISH then saw four deployments to the Atlantic from 1982 to 1986, receiving her third and fourth Meritorious Unit Commendations. After numerous tactics and training exercises, SUNFISH was awarded her second Anti-Submarine A for 1987.

January of 1988 brought USS SUNFISH to Norfolk where she continued her proud history; she began her third overhaul in May 1988 at Norfolk Naval Shipyard and returned to the fleet in 1990 for a deployment to the Atlantic. Then in late 1991, she deployed to the Mediterranean for the third time. In 1993 SUNFISH provided services to the fleet and spent the remainder of the year in Newport News Shipbuilding for an extensive Selective Restricted Availability. January of 1994 took SUNFISH to the Caribbean Sea for a deployment, returning in March. In August of 1994, she deployed with a joint task force to Haiti and performed flawlessly earning the Armed Forces Expeditionary Medal. Her fourth and final deployment to the Mediterranean began in November 1995 and completed in March 1996 with the 1000th dive. SUNFISH earned the Armed Forces Service Medal for her efforts there. July 1996 brought SUNFISH her final inspections prior to making the second homeport change to Bremerton.

Crew attitudes regarding decommissioning the boat varied. When all seemed to be working fine the notion of a few years more service to the fleet wasn't out of the question. Most resolved themselves for a difficult yard period in a place that few have been. Many looked forward to the chance of going around to the West Coast and making their follow-on tours with Pacific Fleet submarines. Others left wives, kids and homes on the East Coast hoping for a quick return when the crew melted away during the yard period. Either way the officers and crew of USS SUNFISH continued to go the extra mile and made their time on SUNFISH effective and meaningful.

SUNFISH kept charging until the deactivation ceremony, then took her *can-do* attitude with her to the West Coast and performed the decommissioning safely in all aspects and phases. USS SUNFISH leaves a proud history behind her as the older makes way for the newer. It's a history that past and present crewmembers challenge the rest of the Force to match. ■

A SPECIAL BLESSING

by CAPT Sherman G. Alexander, USN(Ret.)

While serving as Commanding Officer of the Recruit Training Command, Great Lakes, and as the senior submariner present at Great Lakes, I was the Chairman of the Great Lakes Submarine Birthday Ball held on 24 April 1982. That weekend, Bob Fountain (then Rear Admiral and Assistant Deputy Commander for ASW and Undersea Warfare (SEA06B)) served double duty as the Recruit Graduation Reviewing Officer, and joined the 200 or so active duty and retired submariners as the Guest of Honor at the Birthday Ball. I had requested Chaplain Owen Melody, LT CHC USNR, to present an appropriate blessing. His evocative invocation got our attention and our festivities off to an inspirational start!

O God, it's rumored that you're a little upset with submariners. They have the annoying habit of topping some of your finest efforts.

*You walked on the water. **They found a way to walk under it.** You divided the Red Sea amid noise and clamor, leaving behind a gaping wide trench. **They divide the sea silently, leaving behind no trace at all.** Then, in one of your finest hours, when you were really on a roll, you took the first submariner, Jonah, submerged him in the sea for three days in the belly of a whale, and then dramatically let him live to tell the tale. **Now, these showoffs submerge themselves in their steel fish for months at a time, and without batting an eye, come home, hale and hearty.***

They're a determined lot, Lord. I can undersand your being testy: no one likes to be upstaged. But, in your heart of hearts, I know you like their style. We are grateful for them in the Navy and I know that you are too. The world is a better place, a freer place for what they do. They are the silent sentinels around the world. Bless those serving on lonely patrols this evening; unite us in spirit with them. And, on this, their birthday, grant these submariners your most special blessing. Amen. ■

DEFENSE TECHNICAL INFORMATION CENTER

The Defense Technical Information Center (DTIC) is presenting its Annual Users Meeting and Training Conference on 4-7 November 1996 at the DoubleTree Hotel, Arlington, VA. The theme of the conference **Meeting the Challenges of Changing Technology**, reflects DTIC's goal to assist our customer community in meeting tomorrow's challenges by providing the most relevant information in the most appropriate format as quickly as possible.

This meeting provides an opportunity to explore in detail new developments at DTIC and throughout the federal information network. We are particularly pleased that this year we are able to offer a number of speakers and exhibitors from other federal agencies as well as from the Department of Defense. All of the presentations will address the most current issues effecting the research, development and acquisition communities. Not only will these speakers acquaint you with the latest policy and operational developments, but they will also provide you with practical details on valuable and diverse domestic and foreign information resources, security issues, the World Wide Web, copyright and the storage and dissemination of electronic documents. The popular SGML class is again being offered as well.

Changing technologies present exciting new challenges—DTIC'96 promises to provide the tools to expand your horizons to meet these challenges! Check out the conference information on our homepage at http://www.dtic.mil. For further information, please contact Ms. Julia Foscue at (703) 767-8236 or by e-mail at jfoscue@dtic.mil for further information.

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Barbara J. Ettner
CAPT M.R. Lenci, USN(Ret.)

MK 16 AND MK 23 TORPEDOES

2 August 1996

This concerns a recent article in the July **REVIEW**, pp. 94-99, *Post WWII Torpedoes 1945-1959*. Your facts concerning the Mk 16 and Mk 23 torpedoes are wrong:

1. No Mk 16 torpedoes were outloaded on war patrol against Japan during WWII.
2. The Mark 23 was a high speed only version of the Mk 14, not the Mk 24. It was used interchangeably with the Mk 14-3A during the last 18 months of WWII. For example, my own personal records show that two of the 14 torpedoes that I fired during the sixth war patrol of POGY (SS 266) were Mark 23s. One of them sank the I-183 off the Bungo Suido in late April 1944.

The reason the Mk 23 was produced, and used in large numbers, was because experience had proved that the low speed feature of the Mk 14 was totally useless:

- To get hits, you needed to have a torpedo run of 2000 yards or less
- Use of low speed almost guaranteed detection and evasion.

Very truly yours,
Rear Admiral Ralph M. Metcalf, USN(Ret.)
14150 Douglass Lane
Saratoga, CA 95070

An Offer by LING's Museum

I am proud to offer a special contest to your subscribers. The New Jersey Naval and Maritime Museum is starting the construction phase of our new museum. We have designed the exterior of the building, but saved the interior displays for the public to design. We want to know what they want to see.

As a representative of the Board of Trustees, I would like to offer free lifetime admission to the museum and USS LING (SS 297) for anybody that enters this contest. We did not want a contest where there is only one winner. When it comes to preserving history, we are all winners. All we ask is that all designs stay within one story in height, and that the displays include the following motifs:

a. Naval History of New Jersey:
   ex. Washington crossing Delaware, Hindenburgh, etc.
b. Maritime History of New Jersey:
   ex. Port Authority, Troop embarkation of WWI and II, etc.
c. New Jersey Aquatic Life and Environment:
   ex. fresh and salt water animals and surroundings, etc.
d. Famous New Jersey Sailors and Ships:
   ex. Admiral Bull Halsey, USS NEW JERSEY
e. John Holland and Submarine History:
   ex. USS LING, design and development, etc.
f. Native and early New Jersey residents use of the water:
   ex. Lenepe Indians, Dutch and English settlers, etc.

Please have all entries sent to: New Jersey Naval and Maritime Museum, P.O. Box 395, Hackensack, NJ 07601-0395. Please call me if you have any questions about this contest (201) 328-3458. All entries must be received by December 15, 1996 to be eligible.

Sincerely,

R.J. Pellegrino

Director, Public Relations and Acquisitions

A FREMANTLE MEMORIAL

July 3, 1996

Under the heading Submarine Memorials/Museums, NSL may care to log a submarine project soon to get underway *down under*. Associate Professor John Penrose of Australia's Curtin University terms the ambitious project "Maritime History Display, Incorporating a Submarine". His words are found in the forward to Lynne Cairns' text Fremantle's Secret Fleets, published in 1995.

On a recent Space Available trip *down under*, I visited the area at South Wharf, Swan River, Fremantle, West Australia.

The nearby Maritime Museum, among other maritime artifacts, displays a hugh bronze plate inscribed with all the U.S. boat names that ever put to sea out of Fremantle, I was advised that any questions regarding the above construction should be directed to: Mr. Peter Horobin MBE, Level 33, AIDC Tower, 201 Kent Street, Sydney N.S.W. 2000, Australia. Phone (02) 235-5023 or (041) 991-4964, Fax (02) 251-4440.

M.F. Schaffer

NAVAL WAR COLLEGE AND SUBMARINE STUDIES

As you requested, here is the list of the holders of the Naval War College's **Charles A. Lockwood Chair of Submarine Warfare:**

Captain William K. Yates	1970-July 1973
Captain Robert B. Connelly	July 1973-November 1977
Captain Richard T. Wright	November 1977-June 1978
Commander Thomas Nolan	June 1978-July 1979
Commander Christopher O. Nichols	July 1979-July 1981
Captain David H. Boyd	July 1981-July 1982
Captain Timothy E. Somes	July 1982-August 1985
Captain Robert G. Loewenthal	August 1985-June 1987
Captain Edward Alexander	June 1987-June 1991
Captain Richard H. Hartman	June 1991-June 1994
Captain George W. Jackson	June 1994-Present

You may receive a correction or two on the dates but don't believe it if you hear from the War College since their records are in error (they don't list me as a holder).

Sincerely,
Robert B. Connelly
CAPT, USN(Ret.)
169 America Way
Jamestown, RI 02835

A NEW TORPEDO BOOK

Tom Pellick suggested that I send you a note regarding my new book, Hellions of the Deep: The Development of Torpedoes in World War II, which has just been published by Penn State Press.

Hellions of the Deep tells the dramatic story of how Navy planners threw aside the careful procedures of peacetime science and initiated *radical research* to win the war. Numerous interviews were conducted over a 20 year period with scientists, engineers, physicists, submarine skippers, and Navy bureaucrats, all involved in the development of advanced weapons technology.

Dr. Harvey M. Sapolsky of MIT said about the book, "The U.S. Navy's failure to provide its submarines with effective torpedoes was one of the great near disasters of the Second World War. Gannon offers us a finely crafted, thoroughly informative study of the failure and the successful technical effort to develop winning weapons for the fleet."

It can be ordered from Penn State Press, (800) 326-9180, (Fax (814) 863-1408), 820 N. University Drive, University Park, PA 16802. The cost is $28.50, and is a Military Book Club Alternate Selection. If you ask for the **RG96 discount**, the price will be reduced by 20 percent.

Robert Gannon

BOOK REVIEW

JANE'S FIGHTING SHIPS 1996-97

Ed. Captain Richard Sharpe, OBE, RN
Jane's Information Group, Ltd.
Coulsdon, Surry, UK 1996
ISBN 0-7106-1355-5

Reviewed by CAPT George Graveson, USN(Ret.)
and CAPT James C. Hay, USN(Ret.)

In his introduction to the 1996-97 edition of Jane's Fighting Ships, Captain Richard Sharpe, RN provides a comprehensive view of the world's navies. He addresses each nation's naval power (or in some cases aspiration for a naval presence) not only by numbers and types of ships, but also from the political and economic points of view. He comments upon the needs and aspirations of nations and the collective efforts perceived by two or more nations to provide for their common naval presence. Captain Sharpe describes the world's maritime situation today, in contrast to that of Cold War days. He makes this clear in his discussion of each country's vulnerabilities and their dependence upon some amount of naval power to defend against real or perceived potential threats.

The economic realities in societies today, with many struggling to gain or maintain social improvements, put pressure upon defense needs and force greater interdependence among nations to support their navies. These dependencies result in new alliances between the countries who have the capacity to build ships and those who do not, at present, have that capability.

Captain Sharpe leads into his commentary on the world's fighting ships by pointing out that the world is facing an increasingly tenuous future, with proliferation of weapons of mass destruction, and the means to deliver them across continents, in the hands of aggressive regimes headed by unstable leaders. This puts pressure on those nations who have the ability to maintain the balance, and are willing to take the steps necessary to contain any rogue action. He points out that, contrary to the views of vociferous environmentalists and their willing supporters in the press, "*nuclear power has been the defining factor in the conduct of military affairs since the first bomb brought a premature end to the war in the Pacific in 1945 and so saved thousands of lives*". Today, with the Cold War behind us, "*the massive arsenals of* *nuclear weapons it generated are slowly being negotiated down to more sensible levels... the overall percentage of strategic weapons carried by submarines is steadily rising, and the navies which deploy them are more than ever determined to increase their effectiveness.*" Captain Sharpe goes on to describe the programs of the United States, the United Kingdom, Russia, France, and China, for sea-borne weapons and their submarine delivery systems. He states: "*Every one of these five countries has therefore recently reaffirmed its commitment to submarine-launched ballistic missiles with nuclear warheads, even though the cold war ended seven years ago. For whatever reason, and whether you agree with it or not, it is a unanimous vote of confidence in the continuing strategic significance and invulnerability of these weapons and of the nuclear-powered submarines as the preferred platform.*" He argues that this sea-launched deterrent system is "*the greatest force for peace in the last half century.*"

Captain Sharpe stresses the importance of nuclear-powered submarines and speaks of nuclear power as revolutionizing naval warfare. He decries those who initiate scare stories about the dangers of nuclear power plants and sees it a great pity that responsible nuclear design authorities don't do more to "*publicly ridicule some of the more hysterical claims of potential Armageddon.*"

This commentary on navies and naval power emphasizes the importance of the United States Navy as a force for peace. He notes that the rest of the world looks to the United States to maintain its naval strength and to be there (as it was during the recent Mainland China-Taiwan situation) to intervene if necessary. The rest of the world is very much aware of the U.S. Five Year Defense Plan and how it impacts the U.S. Navy and by extension world maritime commerce and world peace.

With respect to Russia, the emphasis continues to be on nuclear submarines. Surface ship production is almost at a halt. Although their fleet is smaller and continues to be reduced in number, they continue to build new, highly capable submarines. These newer submarines are at sea, and their surface navy centered around carrier borne air power provides a formidable force.

Captain Sharpe paints a rather gloomy picture of the UK Navy, fraught with economic problems and a management culture which neither understands or supports the fighting effectiveness of the Navy.

The rest of the Europeans seem to be caught up in struggle between those who see the Western European Union (WEU) as the military arm of the European Union and those who continue toward their own independent military forces, including their own navies. But there is no lack of submarine building. Germany, The Netherlands, Sweden, France, Italy, are all building non-nuclear submarines, albeit most for other countries in and outside of Europe. The old rivalries and disputes continue, giving another dimension to the international scene, and complicating the tenuous balance of power that effects world stability. In the Indian Ocean and The Gulf, in Pacific Asia and the China Seas and in the rest of the world, the attempts at cooperation between and among nations play against nationalistic objectives and expansionism and contribute to instability.

Captain Sharp's astute assessment of the global political situation provides insight concerning the factors that impact upon the navies of the world. This introduction to the latest edition of Jane's leaves no doubt in the minds of its readers that the world of today is far from stable and that the U.S. Navy's maritime strength is crucial to the maintenance of peace in a very uncertain world society. As a distinguished submarine officer in the Royal Navy, his insights on worldwide naval affairs are knowledgeable, and his frustration with those who do not understand the basics of naval power is understandable. It is in the details of Jane's Fighting Ships country by country accounting, however, that the full impact of submarine importance to post Cold War security affairs become obvious.

The first point to notice is that its submarine force is the lead entry for each of the 46 nations (of the 166 listed) having such a capability. That *pride of place* says volumes about the important place of submarines in today's navies. Recognition of the submarine have-to-have-not fraction is followed closely by also understanding something about the other 120 countries. The obvious first cut is on the basis of wealth. The almost as obvious next cut is on the basis of need, with those like Mexico, Morocco, and Saudi Arabia either having no critical maritime problem or a strong friendly ally who can take care of any which might arise. Among the nations currently without submarines, the most plausible argument for them can be made in the case of rogue states like Iraq and Burma.

The next noteworthy point, naturally, is that the five nuclear powers; USA, France, Britain, Russia and China, are also the five most powerful submarine operating nations—both in quantity and quality. Each has strategic ballistic missile firing submarines and each has nuclear powered attack submarines. It is appropriate to rank them as *Submarine World Powers*. The section on Russia proves the point of submarine emphasis which Captain Sharpe comments on in his forward to this edition. Their naval order of battle for major combatants (frigates and larger) is over one-half comprised of submarines.

One can debate the *World Submarine Power* point about China, of course, but when that country is looked at with the next tier of *Submarine Regional Powers*; India, Germany and Japan, some interesting developments can be noted from Jane's. The individual country sections tell us that China, India, Germany and Japan each has made a significant commitment to their undersea warfare capability. Their submarine forces are relatively large, comprising respectively; 54 percent, 31 percent, 57 percent and 22 percent of their sea-going combatant strength.

The real interest, however, is in the notes which Jane's carries about the ongoing submarine building program which each is conducting. China is developing both a new class of SSBN and a new class of SSN, the later with Russian design and technical assistance. India is also working on a nuclear project around which they plan to build a 6000 ton SSN, probably very much like the SEVERODVINSK. Germany, of course, is building four new Type 212 U-Boats with a diesel-fuel cell propulsion plant. Japan is constructing four Improved Harushio SSs, of 2700 tons. There is a possibility of follow-ons to them having an air independent capability.

The building programs in Australia and Sweden have been discussed in these pages at length, and Jane's takes due note of them with several excellent pictures of the lead ship in each class. In addition to the orders of battle and ship descriptions for the *World, Regional and Local Submarine Powers*, there are also several items noted by Jane's for countries seeking to raise their naval status. Singapore, after some consideration, has joined the submarine club by purchasing a 1968-vintage, 1100 ton Swedish boat, and in April of 1996 sent 40 men to Sweden to begin their training. Brazil's progress in building a 2800 ton SSN is noted in that section of the book, as is their current force expansion of two more 209s and two improved 209s to be an intermediate step to their SSN. In addition, Jane's notes that Malaysia has been at the point of ordering several submarines since at least 1990 and has been having its people trained in Pakistan, India and Australia. ■

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