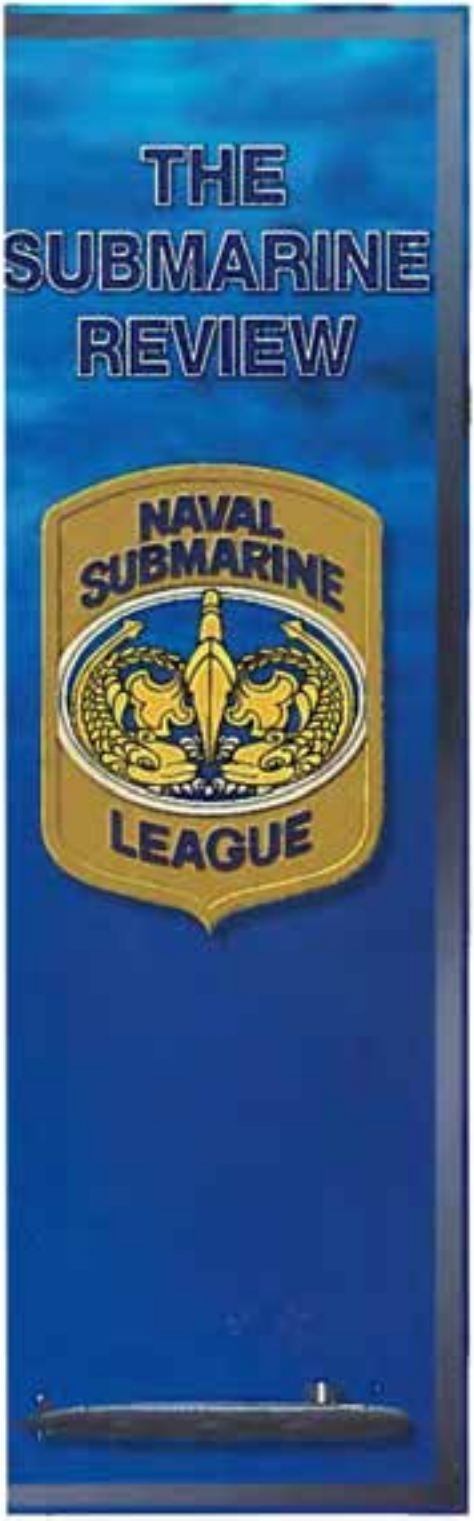

JANUARY 2006

PAGE

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EDITOR'S COMMENTS

The subjects of the three FEATURES in this issue are among the most important to the submarine community; certainly because they address the future of U.S. submarines and how we get there, and probably because they are so little understood. Considered together, they illustrate the need for American submarine advocates to understand fully the rather sophisticated political-military issues involved, and to take every opportunity to expound and explain the need for competent American submarines in a credible American force.

The first FEATURE, Mr. Joe Buff's Will China Rule the Waves?, describes what the pol-mil commentators call *the emergence of a peer competitor*. Of course, this is not the first time that specter of Chinese military, as well as economic, potential has been expressed. What is new and critical to appreciate in Joe Buff's article is his particularization of that *threat* in submarine terms. His assessment of the *Taiwan Question* in mainland strategy also is not new, although it is rarely seen in the popular western press. The potential effects of that strategy, however, are outlined here to competent American submarines in a credible American force indicate the political-military implications for East Asia, the Pacific area and the U.S. homeland.

In getting those "competent American submarines in a credible American force" the obvious issue usually raised is the *acquisition cost* of each submarine. Very rarely is the *cost issue* discussed as total cost of a force to the Nation in terms of *life cycle costs* or even *acquisition costs relative to other air, land and sea forces* or, more importantly, as a *total cost/total benefit* value assessment. What does come up often in discussions about the building of submarines has to do with *getting more for less*. As the second of our FEATURES, Mr. Mark Henry, a submarine design expert recently retired from NavSea, has given us a Brief Lesson on Submarine Design with a view toward putting reality into policy and press considerations of the inter-relations of hull, ship characteristics and military capabilities. Incidentally, for a very instructive picture of just how complex, time consuming and permanent the submarine design process is see

Mark's answer to Dr. George Sviatov's question about America's chief submarine designers in the DISCUSSIONS section.

Our third FEATURE is by CAPT Bill Norris and is titled The Transatlantic Divide. Bill Norris is a former SSN skipper and has commented often in these pages about nuclear armed force issues and the place of the Submarine Force with respect to those issues. His current piece is a general political-military view of the future facing America's more Euro-Centric vital and security concerns.

VADM Chuck Munns, as Commander Naval Submarine Forces, has observed in several of his commentaries that the Submarine Force is a potent arm of US national security across the entire time-conflict spectrum. That is, it has very significant combat power in big wars and small ones and the crises which can grow into wars; and in peacetime it has the deterrence to cause any potential aggressor reflection on the wisdom of his actions. Also in peacetime, which is most of the time in the life of any force, submarines can perform missions of Intelligence, Surveillance and Reconnaissance with endurance and reactive potential. This ***full spectrum coverage***, coupled with the very cost factors to which so many object, argues for ***multi-mission capability and worldwide characteristics*** in every SSN we build. This is the "competent American submarine" called for by the Joe Buff piece, put together by the Mark Henry design lesson, and the need for which can be read into Bill Norris's description of where Europe is going in the defense of freedom. The part about the need for "a credible American force" may also be seen in Joe Buff's words about the difference in focus required for the Chinese submarines compared to the worldwide nature of US submarine taskings, and there Bill Norris gives us a lot to think about.

Go forth, expound and explain–Jim Hay

FROM THE PRESIDENT

2006 will get off to a great start for the Submarine Force! USS OHIO (SSGN 726) will re-enter the fleet in early February. She will bring capabilities to the Joint Forces only dreamed about a few years ago. The tenacity of the Force overcame many obstacles to make SSGN a reality. To all that contributed to the effort, a hearty "Well Done"!

For USS VIRGINIA (SSN 724) continues to demonstrate outstanding capabilities. Barely out of the ways she has completed her first deployment. USS JIMMY CARTER (SSN 23) is on station in her new home port in Bangor, WA. The Navy is moving forward to balance strategic and attack submarine assets to best meet the needs of national defense. The major challenge remains the submarine build rate. Building one submarine per year will not sustain the Submarine Force. The need for submarines continues to grow. It is our collective task to encourage elected officials to support the people who man, maintain and build the Submarine Force. Nuclear submarines are capital ships that will cause any potential enemy to pause. Not every platform can make that claim.

Your Naval Submarine League completed a full and profitable year. All services were provided within budget. The League's financial status is improving. The Executive Committee has voted to restart the grants this year.

New leadership has been added to the NSL governing boards. In 2005 Mr. John Casey, President of Electric Boat, Dr. David Stanford, recently retired from SAIC and a former member of the Advisory Council, Mr. Mike Feeley, of Lockheed Martin Undersea Systems, and RADM Joe Henry, Secretary of the League, joined the Board of Directors. Mr. Phil Lantz, President of Planning and Analysis, Inc., Mr. Chuck Mayer, Vice President of American Superconductor Corp. and CAPT Dave Cooper, the Vice Chairman of the Submarine Centennial Committee joined the Advisory Council.

The slate of major events for 2006 is looking great! The Corporate Benefactors Recognition Days are 31 January-1 February 2006. This event provides a day and a half of briefings and opportunities for the Corporate Benefactors to meet with the active duty leader-

ship. The agenda features Admiral Donald, Director, Naval Reactors and Vice Admiral Munns, Commander Naval Submarine Forces along with briefings from key members of the Submarine Force leadership. Senator Chris Dodd (D- CT) is the invited breakfast speaker and Admiral Mike Mullen, Chief of Naval Operations, is the invited luncheon speaker. This event is designed to thank the Corporate Benefactors for their support of your League.

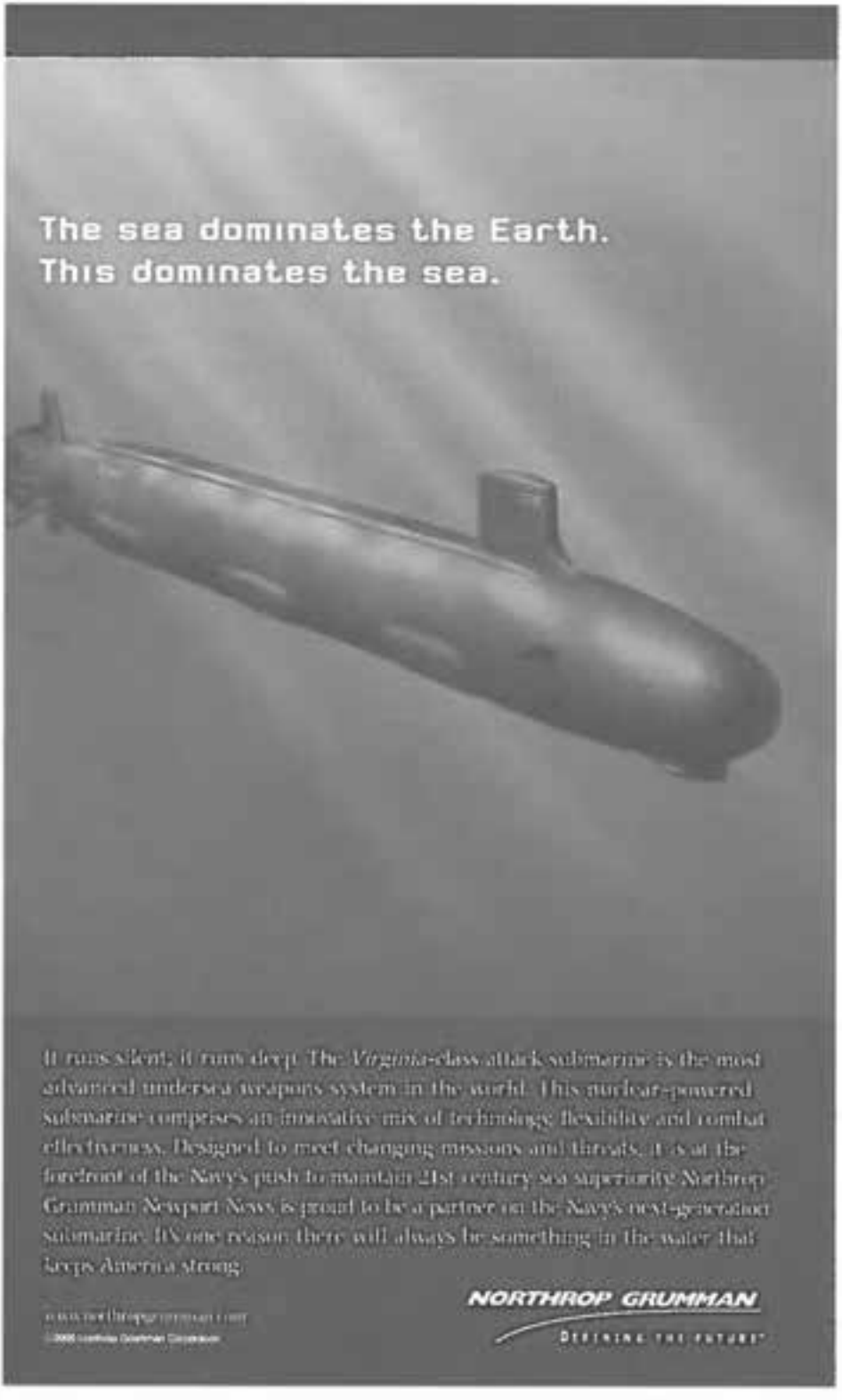
The fifth Annual Submarine History Seminar will be 11 April 2006 at the Navy Memorial. The topic is *"SP At 50!"* featuring a historical perspective of the Strategic Systems Project Office by some of the major participants. The Submarine Technology Symposium will be 16-18 May 2006 at The Johns Hopkins University Applied Physics Laboratory. The theme is *"Submarine Technology in an Era of Transition"*. Efforts to develop technologies that will support communications, Global War on Terror, Global Strategic Operations, and Anti-SSK Operations will be explored. There is an impressive slate of speakers for this classified program. Finally, the Annual Symposium will be held at the Hilton Alexandria at Mark Center on 7-8 June 2006. The program includes the Annual Awards Luncheon, Submarine Social and Distinguished Submariner Banquet. I encourage you to make every effort to attend these events.

The NSL is sponsoring an initiative with the Submarine Force Command Master Chief to recognize the newly selected Master Chief Petty Officers with a one year complimentary membership in the NSL. The NSL is actively supporting submarine reunions with announcements in the Review and a special section on our website. Membership materials are provided to recruit new members at these events. I ask for your support for growing the NSL membership. Mention the NSL to shipmates, friends and associates.

The Submarine Review provides a forum for discussing topics of interest to the Submarine Force. Jim Hay publishes a quality journal each quarter with timely and relevant articles about issues important to the Submarine Force. Seize the opportunity to express your views on subjects important to undersea warfare.

Jan joins me in wishing you a very Happy, Healthy, Prosperous, and Joyful New Year.

J. Guy Reynolds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FEATURES

"WILL CHINA RULE THE WAVES?" A PUBLIC LECTURE NEW YORK STATE MILITARY MUSEUM, SARATOGA SPRINGS, NY, 3 DECEMBER 2005

by Mr. Joe Buff

Mr. Buff is a novelist who has written several submarine-related books. He also has appeared frequently in these pages. He uses the novelist's craft to comment meaningfully on seemingly arcane subjects through broad observation and specific research. His first career was in financial management. His first article for THE SUBMARINE REVIEW used unclassified sources to create a technical, political-military view of submarine utility in the mid-21st century.

Ladies and gentlemen, thanks very much for coming. It's an honor for me to be here to talk with you about the important and serious problem of China that America now faces, whether many people realize it or not. Those of you who've heard me speak in the past, or have read much from my articles and op-ed essays over the years, know that I like to start by establishing a broad context, to then zero in more effectively on the main issue. I'll do that in today's discussion of the intentionally thought-provoking and forward-looking question, *"Will China Rule the Waves?"* I firmly believe that the only way to make permanently sure that the answer to that question is NO is for the U.S. Navy to attain, maintain, and retain decisive undersea warfare superiority against the increasingly muscular People's Liberation Army Navy (PLAN). The goal of this talk is to convey to you the reasoning behind why I make such a statement.

Overview of China — Some side issues that interconnect

There are a lot of things each of us knows about the People's Republic of China, at least at the level of unconnected dots or

unassembled pieces of a puzzle. To properly assess the level of danger that China can, in the future, present to burgeoning global freedom and America's way of life, it helps for clarity to put such factoids together in one place, gathered from wherever they sit in history books and daily newspapers.

China has an extremely bad human rights record, which isn't getting any better. Restiveness is violently repressed, often using lethal force. This has ominous implications. Beijing places a much higher premium on rigid centralized control than they do on the value of rank-and-file human lives among their own citizenry. We may, thus, reasonably conclude that in a military context, modern China would not be (and would not become) the least bit casualty-averse. That alone suggests a significant asymmetry between the U.S. and the PRC in any future saber-rattling or actual *hot* armed conflict.

The Chinese economy is powerful, and has been growing at a rate around 10% annually for a number of years. Some of this is the result of intentional manipulation of the yuan-versus-dollar exchange rate, to China's advantage and to America's harm—on many fronts of commercial competition, and in the vying for access to finite global energy reserves. After lots of summit meetings and diplomatic talks, Beijing remains essentially unyielding in this crucial arena of policy. I think it should be viewed as a form of economic warfare.

China's population is many times as big as America's; a recent census report by Beijing put that country's size at 1.2 billion. Americans will be familiar with China's attempt at population control via a rule of *one child per family*, with financial penalties for having more than one kid. What most Americans may not realize, and what Beijing will not admit, is that the family is by far the most important unit of loyalty in Chinese culture. Many families went ahead and had second and third children and simply never reported the births to local municipal authorities. One knowledgeable person stated, at a Naval War College seminar which I attended recently, that the total of these unregistered births is about 300,000,000 people, many of them now adults. The entire population of the United States of America is right around 300,000,000 people. I find that a frightening comparison. In reality, we're outnumbered five to one.

And the people of the People's Republic should not be underestimated. They're ambitious, driven, proud, and very patriotic. Remember, they're used to being oppressed by warlords and emperors for thousands of years; Mao's dictatorship and the varying forms of communism practiced by his successors are nothing new—and nothing unusual—to the residents of mainland China. The rural/urban social schism in China is also nothing new. I don't think such strife should be viewed as the seed of budding democracy in the PRC. If anything, it's just further testimony to demographic shifts inevitable as China undergoes its own peculiar, hugely sped-up version of an industrial revolution. What does deserve attention, and worry, is the emergence of China's superb university system. The number of world-class PhDs being graduated each year is truly amazing, especially in technical areas where America has been lagging. Take our annual new-PhD figures, add one or two zeros, and you get good data for China — another very disturbing comparison.

Lastly, before moving on to other topics, I'd like to debunk a myth that seems to have percolated through America since the conclusion of the Cold War. This myth (or wish) is that a large and growing middle class, and big international trade ties, prevent a country from starting an aggressive war. Counter-examples to this include Germany's precipitating two world wars in the 20th century, and even—granted, an extreme case—America's own bitterly fought War Between the States. My point here is not to open old wounds, but to caution that economic development in China, alone, cannot be counted upon as a factor discouraging Beijing from making aggressive war in the future.

China as potential military threat: Decoupled from BRAC debate

I mention the 2005 BRAC process because earlier this year some information outlets (Internet blogs, print media) presented what to me appeared to be a very flawed train of logic. It went like this: The Submarine Force doesn't want to close the New London Base. So, to preserve the base, they invent the need for a large number of SSNs in the future. To justify this large SSN fleet they create an emerging

enemy. For lack of anything better, that enemy is the *paper tiger* of China.

Obviously, there's something wrong with this picture. The BRAC Commission rendered its verdict on Groton back in mid-August. So that's been a moot point for months. Yet China is getting an increasing amount of concerned attention from the U.S. Navy—and not merely from the Submarine Force—under the leadership of the new CNO, Admiral Mullen. Headlines on China appear on the front pages of major newspapers on an almost daily basis, and those headlines are not reassuring.

We should remember that China gave the world Sun Tzu's classic "The Art of War" around 500 BC. That's millennia before von Clausewitz or A. T. Mahan or J. C. F. Fuller composed their own treatises on warfare. China practices what they preach, and they mean what they say. Are their central government's aspirations nowadays suddenly peace-loving? Listeners to this talk can judge for themselves, by examining a partial recent track record of China's cross-border acts of aggression:

1. Korea was the first big U.S.-China war. Our casualties were horrendous. Beijing formally warned the U.S. not to come near the Yalu River, because they saw such a move as threatening their security interests at the time concerning Taiwan. We ignored that warning, and our troops paid a heavy price.

2. China invaded and conquered Tibet in an act of blatant imperialism which to this day has gone mostly unpunished.

3. China invaded reunited, Communist Vietnam when Vietnamese actions concerning Cambodia and Laos threatened Chinese security interests in those areas. Vietnam, a seasoned warrior nation with lots of modern imported Russian and captured American equipment, repulsed China easily. This was a wake-up call to modernize their military that China took very seriously. They realized they couldn't fight a 1980ish enemy using their own 1950ish weapons, tactics, and command and control. They've been modernizing, both overtly and stealthily, for the past 25 years.

4. During the Cold War, relations between China and Russia varied. At times they fought bloody border skirmishes — China did not shy away from defending her territorial claims, even against that imposing opponent (and supposed ideological colleague), the USSR. For much of the Cold War, grand strategies revolved around which pairing would predominate in the ever-shifting triangle of China, the Soviet Union, and the United States. More recently, China and Russia have been best of pals. In 2005 they even held a major joint military exercise. Analysts in the West have described this war-game as in effect a giant arms trade show. Russia, already a substantial weapons exporter to China, got to display more of their latest hardware and electronic gadgetry in action.

5. High tensions prevail between China and Japan. This is partly because World War II-era hatreds linger and it's become more politically acceptable to express them aloud. But another reason is that China and Japan have overlapping economic and military areas of interest in the here and now. Indispensable sea lines of communications of the two countries intertwine. Recently a Chinese submarine was caught snooping where it shouldn't be in Japanese home waters, undoubtedly conducting espionage and measuring hydrography. That sub was driven off, but presumably others will be back.

6. China is not behaving the least bit conciliatory in the ongoing multi-way territorial dispute over the tiny Spratly Islands and their suspected giant petroleum reserves. In fact, units of the PLAN recently conducted naval maneuvers near the islands, a very provocative gesture given other stresses and strains in the region— including highly volatile deliberations over North Korea's status as a nuclear power.

7. In 2001, China forced down an American state-of-the-art EP-3 spy plane in what began as a mid-air collision in free international airspace, the fault lying with a Chinese fighter pilot who cut a game of *chicken* too close and paid with his life. But once the unarmed American plane made an emergency landing on Chinese turf, it was impounded, stripped of every item of possible military, intelligence,

or engineering value to Beijing, and the aircrew were held as virtual prisoners for days. Arguably, this belligerent conduct was a direct violation of international law on several counts.

8. In one non-classified Chinese military publication, which is viewed by Western analysts as reflecting central government thinking, a PLAN admiral wrote a piece which basically sent the unfriendly message: "U.S. carriers, keep out of Taiwan Strait or else." Beijing never disavowed this warlike message.

Perhaps most significant of all in trying to assess China's status as a potential aggressor in the future, we should all be aware that China's publicly declared intent is to have a world-class blue water Navy in the 2020s. China's fundamental military plans along that timeframe are summarized by what the Pentagon in 2005 labeled Beijing's 24-Character Strategy. (The Communist Chinese are great ones for sloganeering, and this strategy is expressed in the original PRC document using two dozen Chinese pictograms.) One of the key elements of the 24-Character Strategy is "Never claim leadership." To this I must say *Uh oh, watch out!* It reminds me too much of the old adage from politics and public relations, "Beware of unsolicited denials." I conjecture that China would not have as one pillar of her main long-term strategy the watchword to "never claim leadership" unless eventually claiming leadership was actually a primary goal.

Anyone who's gathered, analyzed, and used intelligence knows the crucial distinction between *intentions* and *capabilities*. Intentions mean what a country plans or wants to do. Capabilities mean the things which it has the wherewithal to do. Intentions and capabilities are distinct, they do not necessarily coincide, and in the real world they may even exist, within a nation, in a state of mutual contradiction or sheer impracticality. For instance, Imperial Japan had every intention to conquer and permanently control the Greater East Asia Co-Prosperity Sphere, but Tokyo ended up lacking the capability. Some analysts (but by no means all) argue that it's safer to determine and weigh a potential enemy's capabilities, since they tell you the worst that might happen, rather than try to divine that opponent's intentions, which are inherently intangible—and subject to your own misinterpretations as well as the other guy's disinformation campaigns.

Deciding what to think of China's 21st century destiny, and then choosing what if anything to do about it to protect American interests, come down to accurately understanding both Beijing's intentions *and* her capabilities. I'm already building a picture here of what I think of PRC intentions based on recent past and present behaviors. I'll come back to that, and to the question of capabilities, especially in her submarine *New Fleet*.

How China is & isn't like the old USSR as a threat to America

To further establish perspective, and dispel any false complacency, it seems useful at this point to compare and contrast the People's Republic of China of today, and the Soviet Union of yesteryear, as rivals to American superpower status. Just because we beat the one in the old Cold War does *not* mean that we will automatically beat the other in a new Cold War, or Hot War.

1. Things new PRC and old USSR have/had in common.

- Communist government, centralized control
- ICBMs with H-bombs capable of hitting entire U.S.
- Superb human intelligence (HumInt) operations within U.S.
- Superpower aspirations, non-theist societies
- Crucial nautical choke points likely centers of naval conflict
- Widening network of vassal/client states worldwide

2. Ways modern China differs from old Soviet Union

- Strong economy, not weak and imploding one
- Much larger population to ramp up toward robust armed forces
- Excellent year-round ice free harbors all along huge coastline
- Always had a quasi-capitalist under-culture
- China has carefully studied both USSR and U.S.

Some of these points bear elaboration. While Soviet-era *Godless Communism* was an oppressively atheist state, religion in the form of the Russian Orthodox Church played an important role in official society under the Czars. (Remember, Rasputin was a monk.) And since the fall of Communism, Russians from all walks of life have rediscovered great interest in their religious roots. China is very different. The predominant ethnic group is the Han culture, which mostly practices Confucianism—a philosophy, not a religion. Mainstream China is thus more non-theist than atheist. They never developed the concept of a God, a deity, or a Higher Power in the conventional Western sense. Why do I even mention this? Because I think that a truly non-theist society is more opaque to American understanding than we might realize. Differing conscious and unconscious personal attitudes toward basic issues such as:

- Where did the universe come from?
- What's the purpose and value of human existence?
- What ethical codes if any should people live by?
- What eternal consequences result from violating those codes?

will all drastically affect how a nation approaches matters of war and peace, of free speech versus blind obedience, and of altruism on the world stage versus cynical selfishness.

Another significant point, and one which doesn't give comfort to a dovish take on Chinese intentions, is that China has always had a quasi-capitalist element to its economy. The emergence of more active Big Capitalism in China should not be misread as a drift toward populist democracy. Rather, it's a sign of the central government correcting past mistakes and harnessing new tools to increase the country's overall strength. China has for millennia had local markets where common people met to buy and sell produce and cottage-industry goods. Even during Mao's vicious Cultural Revolution, young Red Guard thugs, after a *hard day at the office* beating up school teachers and doctors and lawyers, would stop at these markets on the way home — to purchase things at them, not disrupt them. Think about that for a minute.

When I say that China has carefully studied the U.S. and the USSR, in particular I mean that Chinese political leaders and military commanders have focused on the lessons of using or misusing naval power. In retrospect, it was the secret jousting between American and Russian submariners that played a major part in the U.S.'s Cold War victory, as did some celebrated (plus some presumably still classified) undersea espionage capers. The Kremlin's surface Navy, representing a massive investment in raw materials and manpower, never got to play a decisive role, and consequently in the end was something of a waste. One can even draw a parallel here to Hitler's Kriegsmarine, in which battleships and battle cruisers like BISMARCK, TIRPITZ, SCHARNHORST, and so on, had temporary nuisance value as a *fleet in being* until each of them in turn was sunk. Had all that steel and all those trained sailors been devoted instead to building and manning additional U-boats, the Battle of the Atlantic might have turned out very differently. And it's a point of history little known outside submariner circles that German U-boats actually sank more British merchant shipping tonnage in World War I than they did in World War II! Therefore, one may deduce from public statements and from general circumstance that Beijing and the PLAN understand full well that any foreseeable contest for supremacy at sea will depend in large part on submarine muscle. Submarines are 21st century capital ships; China's leadership grasps this as much as American submariners do. (Would that America's Congress so clearly comprehended the critical lessons here.) China also knows the vital importance of seizing and holding the initiative in cold (and hot) undersea warfare. Her rapid development of friendships with many countries that don't like America, when plotted on a map, reminds me eerily of the 19th century race among major European countries to acquire chains of coaling stations along every ocean's shores. For *coaling stations*, now read *naval bases*, and you'll get the idea. China's ambitions are definitely global, not regional.

Some further warnings from history

One of the hardest facts to challenge, or argue with, regarding world history is that sea power is a key to global hegemony. Nautical and mercantile potency very closely interrelate, as do naval vigor

and national security. Portugal, Spain, Holland, then France, each in their own day, thanks to their navies, were genuine superpowers. In some cases, their influence on the known world at the time is unexcelled even today. Yet each of them is now—limiting ourselves to the outdated context of *empire*—a minor shadow of their past. Napoleon's France, Hitler's Germany, and the Soviet Union each discovered the hard way that teeming, triumphant land armies alone are insufficient to retain control over even one continent. One can, alas, say the same thing about the UK: Britannia ruled the waves—note the past tense.

Though a definitive analysis of 500 years of European naval history would fill volumes, the causes of decline among these different former superpowers do show some common threads: complacency as to their vaunted place in the world, neglect of the need for ongoing vigorous sea power, and consequent under-funding of once mighty navies. The conclusion is that there's no reason, ipso facto, to just assume that American naval supremacy will simply go on forever unchecked. China's emergence as a rival must not be downplayed. In the perpetual game of hopscotch around the globe contesting *who's the boss?* in nautical terms, the mantle America currently holds might be dropped, or snatched from our hands.

As another (intentionally scary) cautionary tale about sea power, consider a simplified timeline of Japan:

1. 1854: Commodore Perry opens feudal Japan using gunboat diplomacy, delicately balancing "gunboat" and *diplomacy* parts.

2. 40 years later, Japan has a modern combat fleet via UK help.

3. 1905: Japan slaughters Russian fleet at Tsushima Strait.

4. 30 years later, Imperial Japan occupies Manchuria.

5. 1941: Tokyo's *Supercarrier* Navy creams Pearl Harbor.

Japan, thanks to some prodding from America (which proved in a big way the *law of unintended consequences*), went from being isolationist and almost pre-industrial to being one of the most

warlike imperialist powers on the planet. It took them quite a while to do this, but the pace of technical advancement and even the rhythm of daily life have accelerated notably since the end of World War II. The past few decades seem to have experienced a sort of modern-era time compression whose effects keep increasing almost exponentially. That being the case, I invite you to *do the math* for yourself on China. How much longer do they need to transform themselves from an isolationist, feudal society into a modern warlike imperial power, able to do other major powers grave harm? Hint: Their own government thinks the answer is twenty more years.

Is Taiwan a Red Herring?

Just as important as not missing a major threat that's right under your nose, busy hiding in plain sight, is to not become fixated on a threat that isn't there. So many commentators talk about the PRC's imminent danger to Taiwan that I've started to grow suspicious whether it's real. From the many years I spent in risk management, often dealing with investments for large financial institutions, I grew to be a contrarian—that is, someone who disagrees with the herd when they see the herd start to fall into group-think. I even wonder whether Beijing is not on purpose both overtly and covertly fueling American concern about Taiwan as a red herring, to distract us from something completely different. What that *something* might be, I'll discuss more below. Right now, let's take a cold-eyed look at the relationship between China and Taiwan today:

1. Taiwanese domestic politics have taken a very significant shift in recent years. Although their president favors declaring independence from China, Taiwan's Congress, controlled by different political parties, prefers improved ties with the mainland. The current Taiwan president is expected by many analysts to lose the next election. Meanwhile, Taiwanese businessmen and politicians visit China at Beijing's invitation, and a network of amiable personal relationships is budding.

2. China does not insist on taking over Taiwan politically. (They only threaten to invade Taiwan militarily if Taiwan ever declares itself fully independent.) Beijing much prefers the approach which they call *One country, two systems.* Taiwan would retain democratic autonomy in domestic affairs, but would renounce any claim to being a wholly separate sovereign nation. The controlling parties in Taiwan's Congress favor this *One country, two systems* approach.

3. Viewed rationally, it doesn't make much sense for China to invade Taiwan. Taiwan is an extremely valuable economic and infrastructure asset. Any invasion would reduce that asset to useless rubble. This would be completely counter to Beijing's own best interests. Much smarter, from their point of view, is to encourage driving a wedge between Taiwan and the U.S. This latter approach seems to be working nicely lately. Taiwan's Congress has repeatedly refused to approve increased military spending that the U.S. government wants to see in order for Taiwan to accept more responsibility for defending herself against China. Though hard-liners in America are quite displeased, it would seem that Taiwan doesn't feel she really needs so much defending. The premise that Taiwan is misusing America, forcing us to commit humongous resources to block a Chinese invasion across the Taiwan Strait on our own, I fear might derive in part from a lack of accurate perceptions on the part of some Beltway insiders, and in part from China's *red herring scheme.* (Now you see what I mean about being a contrarian.)

4. The *red herring scheme* I keep referring to is my conjecture that, as a what-if *worst case* scenario, China might have naval objectives more ambitious and advantageous than conquering Taiwan. Those objectives, I think, lie much farther out in blue water. If so, to realize her plans, China needs a good way to penetrate the nautical choke points in the chain of island countries that hem her in from the vast Pacific Ocean and Indian Ocean proper. These countries range from Japan to Taiwan to the Philippines to Malaysia and Indonesia. Thus, were Taiwan to become a true friend with Beijing, one major stronghold in this endless barrier-island string would, in effect, change hands. A gap in the network of choke points would suddenly open, a gap one thousand miles wide.

Imagine yourself an ambitious Chinese statesman, sitting in Beijing, looking at the same nautical charts that you and I can look at. Imagine yourself as rational yet ruthless—which would certainly be in character for this role-playing exercise. Then ask yourself, taking account of everything I said above: Would you invade Taiwan and invite open war with America on terms the American public by long custom is likely to support . . . or would you win over Taiwan by peaceful means and then take on the U.S. in a time and place of your own choosing, with the full element of surprise, and in a context where the U.S. electorate is likely to blanch at the very thought of armed intervention?

Announced PRC goal: Triple the U.S. submarine fleet in 20 years

If we look ahead to the 2020s, as we must, the U.S. Navy will then have about 60 SSNs, SSGNs, and SSBNs in commission, while China's *New Fleet* will have maybe 150 or 180. Those Chinese submarines will be a good mix of foreign-bought and home-grown diesel subs, nuclear-powered fast attacks, and *boomers*. This New Fleet is nothing to trifle with: The men will be well trained and the equipment will be good enough for China's purposes. (The two recent accidents aboard aging MING-class diesel boats can be dismissed as part of China's increasingly irrelevant *Old Fleet*.) China is already buying Improved KILOs from Russia, and some reports indicate the latest version is coming with air-independent propulsion. (Able to stay far below the surface for many days or weeks at a time, diesel/AIP subs represent a whole new spectrum of threat, and have been called by some *the poor man's nuclear submarine*.)

Right now alone, China has 18 submarines under construction, half of these in Russia and half at home. In contrast, the U.S. recently went through a *drought* in which not one new submarine was put into commission for six or seven years. At the moment, we're building VRGINIA-class SSNs at the paltry rate of one per year at least until 2012, and four OHIO-class SSBN-to-SSGN conversions are gradually being completed—and that's it.

China is arming her submarines with a variety of sophisticated weapons, including excellent sub-launched anti-ship cruise missiles, some of which are supersonic—and hence very difficult to defend against. These modern weapons also include the Russian Shkval supercavitating rocket-torpedo, capable of speeds of 200 or 300 knots underwater. American submariners say that they personally don't see these things as much of a threat, at least if they aren't tipped with an H-bomb warhead. But a Shkval moves so fast in a straight line that against a deep-draft surface target (think of an American aircraft carrier) it doesn't need homing sensors or even any warhead at all. The sheer kinetic energy of the rocket-torpedo platform is bound to smash through the hull below the waterline, so long as the Chinese sub gets reasonably close and has a half-way decent firing solution. Some hits from a salvo of Shkvals would put even a CVN-21 next-generation supercarrier out of action for the duration. If the Chinese sub is destroyed in return, Beijing achieved quite a bargain. If *twenty* Chinese subs are destroyed in return for each supercarrier mauled with heavy casualties, or each American SSN sunk, Beijing will still see themselves as having come out on top in the contest. And so will their submariners, even the ones who know they're about to get killed. In the First World War, 50% of German submariners were lost in action. Between the wars, this fact was generally known. Even so, in the Second World War, German sailors lined up in droves to volunteer for U-boat service. As the war progressed and their terrible 80% loss rate began to be impossible to hide from men on the waterfront, sailors never flinched from vying for a place in one of the U-boat crews. We can expect exactly this sort of courage and heroism from Chinese submariners.

Traditionalists view a navy that emphasizes submarines as inherently inferior/defensive, and one that emphasizes aircraft carriers as inherently superior/offensive. I'd argue that this distinction is becoming blurred to the point of maybe no longer applying. One reason is that ongoing advances in acoustic and non-acoustic submarine stealth, improved sensor and communications capabilities, increasing weapons payload capacity, and versatility of adjuvant vehicle mission profiles, render the latest SSNs and SSGNs more and more closely analogous to underwater CVNs. A balanced navy is always best, but *balanced* means different things to different

nations. National policy and strategic goals must enter the equation. It should be clear by now that China doesn't see a lot of things the same way that most Americans do— including the level of tolerance for heavy combat casualties. I'd furthermore argue that almost every major naval war in known history was in some important ways asymmetric. We can't measure China by our own standards, or we might make fatal, irreversible miscalculations.

Intelligence and counter-intelligence will also continue to play key roles as America's and China's navies change and grow. For instance, one embarrassment for the U.S. intelligence community was to completely miss a new PLAN diesel sub, the YUAN-class, until the first ship's existence was announced by Beijing. Some commentators disparage this vessel as *noisier than a steam locomotive*, but that misses some much bigger points. Western analysts were also surprised by how quickly the first new 094-class SSBN followed the introduction of the PLAN's 093-class SSN. Chinese designers want to learn everything they can, as fast as they can, and they're willing to take risks and buy or steal what they can't yet manage themselves. We have to assume, for instance, that all of the information the Walker spy ring sold to Moscow has been passed on to Beijing, for an appropriate fee, thus helping jump-start a new submarine arms race. What then will America do if China buys from Russia not just Improved KILOs with AIP, but also some of their superb AKULA-IIs (a very dangerous adversary for a LOS ANGELES-class boat), or even some of Moscow's next-generation SEVERODVINSK-class SSNs or BOREY-class SSBNs?

China has her own outstanding espionage apparatus at work within the U.S. The recently-arrested alleged Chi Mak spy-ring foursome is a case in point. Purported to have been in operation since 1990, it's been said that they sold China some of the most sensitive design secrets and acoustic profile data on the new VIRGINIA-class SSN, compromising that class's safety in any hostile waters. Other reports, possibly exaggerated, state that they or other Chinese spies also provided Beijing with full specifications of the Aegis integrated air-defense system, and China's first Aegis-clone cruiser was recently detected at sea. On another recent occasion, Chinese agents were interdicted at the last minute while attempting to buy special electronics that would have let Beijing

listen to the decoded downlinks from American spy satellites. This would have given China several invaluable prizes for free: unlimited access to a working constellation of the best spy satellites in existence, keen insights into what things the U.S. was most interested in spying on, and intelligence on how best to disguise their own secret activities from prying American eyes.

I put it to all of you in the audience today that these constant, widespread, relentless, shameless espionage efforts by the People's Republic yield further clues as to their ultimate naval intentions: Those intentions are neither benign nor purely defensive.

Red Herrings: Possible PLAN surprise sub surge strategies

China has (or will have) an edge in three important aspects of undersea warfare—a battle which we mustn't forget is fought from the surface and in the air and outer space as well as down in the water column. One aspect is her geographic situation. If a PLAN sub breaks through nearby anti-China choke points, that sub gains immediate access to the deep and vast waters of the Pacific Ocean, in which to exploit bad weather, protective acoustic propagation effects, and other local factors in order to disappear, lurk, and then attack. American subs based at Guam, Pearl Harbor, and the U.S. East and West Coasts, because of the tremendous distances involved, might lose the race to reach and block those choke points. The second aspect, by the 2020s, will be China's weight of sheer numbers of subs—which we can expect by 2025 to be accompanied by a gradual shift toward more leveling of the playing field as to quality of vessels and crews between the U.S. Navy and the PLAN. The third aspect of China's edge is that the PRC has no commitment (yet) to act as a worldwide policeman—or the opposite role more fitting to her, as a mob boss. Thus China can mass her forces to accomplish global policy via regional military actions or threats, whereas the U.S. Submarine Force is of necessity spread around the globe, and overstretched at that.

If China has three times as many subs as America, and our subs are divided between disparate theaters of conflict and counter-insurgency, China can achieve local undersea superiority in the Western Pacific, at least temporarily—and temporarily may be more

than enough to consolidate her objectives. A classic advantage of the aggressor is that they can choose the time and place of attack. China thus, through shrewd planning and skilled logistics coordination, could arrange in secret to surge all of her submarines at a time that a substantial portion of American subs are undergoing maintenance in dry dock, unable to even get underway for days or weeks—a delay that could act decisively in China's favor.

If we imagine close to 150 hostile submarines of many different classes all surging at once, even any friendly available diesel subs and ASW forces (Australia, Japan, etc.) would be unable to fill the gaps. Exploiting surprise, China could quickly achieve sea control (or at least sea denial) in major portions of the Western Pacific. Such a large number of submarines in motion at once would be impossible to keep from being noticed, of course, but that wouldn't be the point. Chinese submarines could follow individual courses that weave around and intersect with each other to play an effective shell game —it might be impossible for surprised U.S. and allied forces to keep track of which Chinese vessel was which, further disguising actual Chinese objectives for the surge. This would be a particular problem to the degree that some ASW detections rely on optical (LIDAR, LASH), MAD, or surface-wake anomaly signatures, which are less able to identify a target by name or even by class or type, compared to active and passive sonar. (Pre-positioned undersea listening grids might not be of much help against such an overwhelming wave of sortieing vessels.) Once out in the Pacific, the Chinese subs could by pre-arrangement rendezvous to form fifty or sixty mutually supporting or widely scattered three-ship wolf packs, each an expendable task group in an unflankable barrier or uncharted *smart minefield*, with orders to sink any American carrier or SSN that comes charging their way. (A campaign against U.S. merchant shipping would be bad enough in itself!)

What might the PRC's political policy and the PLAN's military objectives be in such a hypothetical surprise-surge scenario? Let's assume an *outside the box* worst case, where Taiwan is friendly or at least neutral to Beijing, and not Beijing's target. Well, the Pacific Ocean is peppered with small islands and atolls, all of great strategic value in any serious naval fracas. Many of these islands were once occupied by independent natives, then were taken over by various

colonial powers, and ownerships changed again as a result of World War I and World War II. Some of these islands and atolls now remain possessions of the United States. These include, for instance, Guam, Saipan, Wake Island, or Midway. Beijing could make the case that the U.S. is a hostile occupying power, and the job of the People's Liberation Army Navy is to liberate occupied peoples. Suppose the People's Republic were to exploit their temporary local dominance in sea power (and other military power) to invade and *liberate* these so-called oppressed masses and hold them under *protective custodianship*—permanently. This gambit fits perfectly with Beijing's espoused ideologies, and seems likely to receive huge popular support within China. Assume that China invaded in such a way as to minimize initial American casualties, and immediately released all POWs. Would the United States, faced with such a fait accompli, and faced also with the actual or prospective loss of several CVNs and SSNs (not to mention aircraft crews and Marines and various ground troops), really be willing to mobilize and replay World War Two-style island hopping? This would of course depend on many factors, including other military commitments from which the U.S. might not be able to quickly extricate herself, the attitude of the current White House administration at the time, the state of the American economy and national deficit, and the willingness of the American people to shed blood to take back abstract little dots on a map when we ourselves, arguably, years ago snatched those dots from Spain, or independent Hawaii, or whomever.

This is exactly what I mean by a potential PRC *red herring strategy*. Rather than a north-south arena of attempted dominance against the island nations off her shores, especially Taiwan, instead China and Taiwan implement the *one country, two systems* approach. Then China achieves an end-run past the other island nations in her way, accomplishes a bold west-east land grab in mid-Pacific, and dares an embarrassed U.S. to do something about it while PLA soldiers quickly dig in and install hefty anti-air defenses. Shouting matches at the UN Security Council, and fragmentary economic sanctions by third-party countries, would certainly not deter Beijing. The Red Herring Strategy reduces American stature and self-respect, perhaps forever, and leapfrogs China to the fore as a credible superpower.

This scenario, by the way, is designed to be controversial. Its purpose is to shake you up and get you to think.

There are some other points worth posing about Chinese submarine strategies and tactics:

1. While possible, it seems relatively unlikely that China would mimic the Soviet approach of establishing *bastions* of protected waters in which to keep her SSBNs safe from American interference while on strategic deterrent patrol. Russian and Chinese geography and hydrography are too different for this to work well. China's only potential bastion areas, the Yellow Sea in the north and the Gulf of Tonkin in the south, are rather shallow, and in both cases one entire shoreline consists of nations potentially very hostile to China: North and South Korea in the case of the Yellow Sea, and Vietnam in the case of the Gulf of Tonkin.

2. On the other hand, Chinese SSBNs need not be very well protected or even very stealthy in order to be effective playing pieces in a grand scheme to diminish American clout and spread our SSN fleet dangerously thin. I suspect that China knows from Soviet experience in the Cold War that it's unlikely a communist SSBN can for very long avoid getting an American (or Royal Navy?) SSN in trail in the boomer's baffles. The job of the SSN is to destroy the SSBN promptly under certain contingencies related to possible thermonuclear war. But if even really good Chinese SSBNs can't avoid being followed by Western SSNs (to the extent such SSNs are available), why not go for not-so-good Chinese SSBNs with not-so-good sub-launched ballistic missiles? In reality, even one Chinese H-bomb warhead hitting the continental U.S. interior with a circular error probably of a wildly inaccurate 1,000 miles presents an unacceptable threat. In this way China can dilute the effectiveness of our fast-attacks on deployment without even firing a shot, by using one crappy SSBN as strategic flypaper for a superb SSN.

3. In any major conflict with China, whether cold or hot or first one and then the other, SSBNs on both sides will take on much greater importance than was the case in the struggle between the Warsaw Pact and NATO. The reason, once again, has to do with geography.

One glance at a globe will reveal that the trajectories of any ICBMs launched from the heartlands of the U.S. and China at one another must pass over the heartland of the Russian Federation. Considering that in the late 1990s, a Russian early warning radar thought that a pre-announced Norwegian science sounding rocket aimed toward the North Pole was an inbound American ICBM warhead—and President Yeltsin went as far as opening the briefcase with the nuclear go-codes before the mix-up was resolved— it would seem to be the height of madness for the U.S. and China, in any limited or all-out nuclear exchange, to fight each other right over Russia's head. This would be an almost certain recipe for tragic misunderstandings, massive Russian retaliation against both other countries, and a true global thermonuclear holocaust. It makes much more sense for China and the U.S. to deploy SSBNs close to each other's shores, where the missile trajectories, should it ever come to that, would be unambiguous. Granted, this is a fine example of *thinking the unthinkable*, but as a professional risk analyst that's part of my job.

Conclusions: What should we do?

I believe that step one is to accept that a new cold war is already on with China. At least three strategies for dealing with this problem have been suggested:

1. "Hope and pray." I've tried to convey why I'm deeply convinced that China's ultimate intentions aren't benign. To hope and pray that her society and government will somehow turn peaceful and friendly simply won't cut it. Isolationism as an American strategy spells doom.

2. "Learn to speak Chinese." This alternative is unattractive. Surrender is not an option. Unilateral disarmament will only encourage Chinese aggression, a sure recipe for exactly the war America seeks to avoid.

3. "Wield steel fist in velvet glove." Henry Kissinger once said that diplomacy is ineffective unless backed by useable armed force. I believe this third strategy has important potential, and will even, as

more time goes by, prove to be essential both to preserving peace and—if necessary—prevailing in war.

My conclusions will look at how to implement the "steel fist in velvet glove" strategy:

1. Firstly, I think the U.S. needs to become much better at Chinese-style gamesmanship, deceit, and deception. In short, out-Sun-Tzu them!

2. We also need to learn (or relearn) truly world-class human intelligence and counter-intelligence tradecraft, and build a network of assets to counteract and counterbalance China's espionage against the U.S. We mustn't be shy on psychological operations either.

3. As Admiral Mullen and others have emphasized recently, the U.S. Navy needs to get better at antisubmarine warfare and also at counter-mine warfare. Important advances are being made on both fronts after years of semi-stagnation. The keys to success here remain the same as always: practice, practice, practice.

4. Unfortunately, with a few notable exceptions, in today's world the concept of *reliable allies* has become an oxymoron—a self-contradiction in terms. We must be mentally, physically, and fiscally prepared to go it alone in a major armed conflict. A robust carrier fleet remains essential, because experience has shown that we can't count on friendly bases, or even on overflight rights, among third parties close to a theater of battle. Yes, U.S. Air Force bombers deploying directly from American territory, and refueling repeatedly in flight, provide our country with planet-wide reach, but those USAF assets alone have finite munitions delivery rates. Shuttle bombing from carriers, well protected by ASW assets including SSNs, remains a necessary war-winning tool.

5. For reasons that by now should be obvious, it's vital to increase the VIRGINIA-class build rate to two per year as soon as possible.

6. To the extent that any further OHIO-class Trident subs are withdrawn from SSBN duty, those platforms must be converted as soon as possible to SSGNs, and not scrapped.

7. We must stay the course with the cost overruns and developmental delays of the Advanced SEAL Delivery System minisub. This transformational special ops transport vehicle is considered essential by Special Operations Command (SOCOM). Yes, the ASDS right now has problems. We need to fix them.

8. We need the largest possible SSN fleet over the next few decades to optimally conduct preventive or preemptive undersea indications and warnings missions, and intelligence, surveillance, and reconnaissance missions. The prolonged dwell time, stealth, and exploitation of electromagnetic surface-ducting effects make submarines indispensable platforms for all these taskings that are now a matter of national survival. We need to serve notice on China that we are watching them and are not pleased by what we see. Our submariners must continue to maintain the attitude of full-time warriors, as they did during the Cold War, and get in the adversary's face and stay there, *deployed and annoyed*.

9. The American public would benefit from some systematic, accurate education on National Defense and Deterrence 101. Outside the military community and its supporters-enthusiasts-hobbyists, it's sometimes shocking how unaware the average man or woman in the street really is about even the most basic aspects of military history, strategy, tactics, doctrine, and technology. The prevalence of this under-education is going to hurt us more and more in the years to come. How casualty-averse will our country be by 2020+?

In closing, I'd like to quote from Teddy Roosevelt, a genuine master of the purpose and uses of sea power. He once put it very bluntly, "Battleships are cheaper than battles." I also want to repeat a truism mentioned often by others, that nuclear submarines are capital ships of the 21st century. New capabilities are now emerging that were barely dreamt of when the Berlin Wall came down. To shortchange our Submarine Fleet's size going forward, to

underutilize its ever-increasing payload capacity, and to under-appreciate the hard work and sacrifices by every generation of our brave submariners, could mean that in the foreseeable future America will reap the whirlwind in a terrible conflict with China.

RECOMMENDED FURTHER READINGS:

Two good websites for technical specs on different submarine classes:

www.military.com

www.globalsecurity.org

Free on-line documents about China's military (as printable pdf files):

1. Annual Report to Congress: "The Military Power of the People's Republic of China 2005", Office of the Secretary of Defense, 19 July 2005

See www.comw.org/cmp/

2. "China's National Defense in 2004" whitepaper by the PRC government

See http://english1.people.com.cn/whitepaper/defense2004

3. "Effect of U.S.-China Trade on the Defense Industrial Base" testimony before the U.S.-China Commission by James A. Lewis, June 23, 2005

See www.csis.org

Today, in their own very quiet way, U.S. Navy submarines are involved in more critical covert operations than ever before. From the gathering and sharing of real-time intelligence with joint operations to the ability to serve as sea bases for ballistic missile defense and more, submarines' contribution to the big picture remains absolutely vital. For a detailed overview of how Electric Boat is quietly expanding the range of stealth, visit www.gdeb.com.

Nothing's as powerful as stealth. GENERAL DYNAMICS
Electric Boat

A BRIEF LESSON ON SUBMARINE DESIGN

by Mr. Mark Henry

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

It sometimes appears that *everyone* inside the Beltway is a submarine designer—*expert witnesses* testifying before Congress (and members of Congress too), senior DOD and Navy personnel, journalists and novelists, scientists and engineers working in submarine-related R&D, and others. They have, over the years, voiced their opinions (loudly or quietly) about what the *next* US Navy attack submarine ought to look like or the effects of introducing new hardware into an already existing submarine design. Unfortunately, with very few exceptions, these well-intentioned people do not understand the intricacies of submarine design and many of their conclusions regarding the ship design impacts of their ideas are erroneous.

In fact, there are very few people who do understand the intricacies of submarine design and those who understand them best are the naval architects who, at one time or another, have performed studies related to designing a new submarine and/or evaluating the total-ship impacts of major design changes to existing designs. In the United States, this group probably numbers fewer than three dozen people, more than half of whom are retired or working in other areas of ship design or in other fields. (Designers of *submersibles* are not included in this *count*.)

Examples of proposed submarine design changes include:

- Engineers, seeking R&D funds, propose new components for an existing submarine's engine room that are considerably lighter

than the existing components. The engineers, who *do* understand that to add "new weight" to a submarine requires taking some "old weight" out, state that this will permit carrying additional weapons without increasing the ship's size.

- A proposal is made to significantly reduce the crew of a new design submarine. With significantly less space required for its crew, the ship would be smaller and less expensive than an otherwise equivalent ship with a typical complement.

- Proposals are made to move weapons or propulsion machinery components outside of the pressure hull in a revised version of an existing submarine design. With less volume needed for these functions, the pressure hull and, perhaps, the total ship, can be made smaller.

- R&D personnel state that adding their new component to an existing submarine will greatly increase its effectiveness and, since the component *only* weighs X tons, it will have little effect on the ship.

Are the postulated ship design impacts of these proposals accurate? The answer is, *It depends!* Yes, it depends on the naval architectural attributes of the specific submarine design being addressed. What might be true for one submarine may not be true for another. To explain the naval architectural attributes that so greatly influence the impact of design changes, we'll start with a very short *course* on *early stage submarine design*.

Process for Performing Submarine Concept Studies

Early stage submarine design encompasses a broad range of design activities, from rough order of magnitude (ROM) studies, involving one or two people for up to a few weeks, to preliminary design, involving a large team of people for many months. This article focuses on design studies performed to an intermediate level of detail, commonly (and interchangeably) called *concept studies*, *concept designs*, and *feasibility studies*, hereinafter called concept studies.

The primary products of a submarine concept study are ship characteristics (displacement, length, draft, speed, etc.), arrangement drawings, and a weight report. They are performed to a level of detail enabling:

- definition of ship characteristics for use in operational effectiveness analyses
- calculation of weight groups for use in cost analyses
- accurate trade-off studies
- While sometimes useful, design studies performed to a lesser degree of detail (ROM studies) will not meet these requirements.

Beginning with a set of requirements developed by OPNAV [which come in the form of ship characteristics (such as depth, speed, and number of torpedoes) and specific payloads (weapon systems, sonars, etc.)], the conduct of a concept study entails four major steps: *arrangements*, *volumetrics*, *weights*, and *ship balance*.

Arrangements

Submarine arrangements is a graphical process (performed with paper and pencil or computer graphics) wherein the ship geometry is selected (hull diameter, pressure and outer hull configuration, major compartments, bow and stern shape, etc.) and the compartments are arranged to satisfy the design requirements in the minimum ship length. While submarine design is extensively computational, there is still a significant degree of *art* in arrangements.

The initial step for a new concept study is to select an appropriate overall ship geometry that will be driven by the ship design requirements, for example, reserve buoyancy (single or double hull), single or twin screw, number and types of weapon launchers (SSN vs. SSBN), etc. Unlike in surface ship design, submarine beam (hull diameter) is typically selected very early in the design process based on a number of factors with the minimum diameter of propulsion spaces (usually determined by the selected reactor in nuclear powered ships) and the number of platform decks in the operations compartment among the most important. With hull diameter selected, the arrangement process primarily involves establishing compartment lengths to accommodate the required systems. The

process yields a total minimum ship *stack-up length* satisfying various system-related geometrical constraints. The resulting arrangement drawing is extensively used in subsequent volume and weight calculations. Since the hull thickness and frame dimensions affect the arrangement of components, during this step the pressure hull is designed, using an appropriate hull material, to attain the required operating depth.

Volumetrics

In this step, surface and submerged displacement, and their centers of buoyancy, are calculated from the arrangement drawings. The everbuoyant volume of the submarine defines the *surface displacement*. Adding the net blowable main ballast to the surface displacement yields the *submerged displacement*.

The largest component of surface displacement is the pressure hull. Since it is typically defined by simple shapes, its volume and center of buoyancy are readily obtained. Hence, most of the effort required to calculate surface displacement involves those portions of the submarine external to the pressure hull: non-pressure hull structure, external components (air bottles, VLS tubes), recesses, and appendages (sail, control surfaces, propeller).

The KM (metacenter), used to determine surfaced stability, and the surface trim and navigational draft are also calculated using the results of the volumetric analysis.

Weights

In this most time-consuming aspect of the submarine concept study process, weights and their centers of gravity are estimated for approximately 160 weight groups to obtain the total A1 weight, similar to the lightship weight for surface ships. The weights and centers of various loads (diesel fuel, ammunition, provisions, etc.) are also calculated. Accuracy is essential to avoid potential large inaccuracies in ship size estimates and to enable valid tradeoff studies.

The primary sources of information for weight estimates are:

- historical data, found in weight reports for similar submarines,

which is appropriately modified to suit the requirements of the current design

- calculation of weight from the design, for example, pressure hull weight from hull scantlings

- direct input of weight data from cognizant system engineers, such as the weight of a diesel generator or combat system electronics component

Vertical and longitudinal centers of gravity are determined from the arrangement drawing.

The weight estimate includes sufficient margin to assure that the ship can accommodate weight increases occurring during design development and ship construction and to permit improvements to be incorporated into the ship during its service life without having to modify the ship's geometry.

Ship Balance

With displacement and weight determined, along with their respective longitudinal and vertical centers of buoyancy and gravity, the naval architect can *balance* the ship. This is also referred to as *finding the lead solution* because the computations determine the amount and proper location of lead ballast in the design. Since *balance* determines the submarine naval architectural attributes that so greatly influence the impacts of design changes, this step is more fully described. The process includes:

- Satisfying Archimedes' principle: Weight must equal displacement for neutral buoyancy.

If the displacement is greater than the weight, the ship is *volume limited* – the *arrangement* determines minimum ship size. Lead ballast is added to increase the total weight until it equals the displacement and there are no design iterations involving changes to the hull geometry. Volume limited ships have *excess margin*. Thus, there is essentially no space within the pressure hull to add new components but heavy items not requiring internal space might be

accommodated by removing margin lead. Spending large sums of money (on exotic light-weight materials, for example) to reduce weight has no benefit since saved weight will be replaced with lead ballast.

If the weight exceeds the displacement, the ship is *weight limited* and the displacement must be increased. This is usually accomplished by lengthening the pressure hull which adds both displacement and weight, but more of the former. With additional pressure hull volume, the main ballast tanks must also be increased in size to maintain the desired percentage of reserve buoyancy, further impacting weight and displacement. As a result, weights and volumes must be recalculated and the ship rebalanced. Weight limited ships have *excess volume* but this is usually spread around selected portions of the ship (perhaps providing improved access for maintenance) rather than concentrating it in empty compartments and, thus, providing a temptation to install even more equipment and worsening the weight limited situation. Weight savings are highly beneficial since they result in ship size reductions.

Achieving longitudinal balance: For the submerged ship, the longitudinal centers of buoyancy (LCB) and gravity (LCG) must be at the same longitudinal location for the ship to float at an even keel. [Envision a playground seesaw with children attempting to keep it level with their feet off the ground. The combined center of gravity of the seesaw and children (LCG) must be directly over the supporting fulcrum (LCB).]

Providing sufficient stability: The measures of surfaced and submerged stability, GM and BG, must meet minimum values to be certain that the submarine floats upright and has satisfactory submerged maneuvering characteristics.

The LCB and LCG are rarely aligned. To adjust the location of the overall LCG, *trim lead* is placed in either the bow or stern, but usually in the bow to compensate for very heavy propulsion and other components aft. If BG and/or GM do not meet stability requirements, the overall vertical center of gravity (VCG) is lowered by placing *stability lead* low in the ship. When trim or stability lead are added, weight increases with little or no change in displacement and the ship must be rebalanced. If the ship is weight limited, the pressure hull and main ballast tanks are lengthened to obtain more

buoyancy and the volumes and weights are recalculated. If the ship is volume limited, some of the excess margin is reallocated as trim or stability lead. (A volume limited ship could become weight limited if sufficient trim or stability lead are added.)

The process of adding ship length to obtain a match between weight and displacement (with the required GM, BG, and alignment of the LCB and LCG) requires recomputing displacements and weights (and their centers of gravity) for each iteration. The number of iterations required to attain sufficiently close agreement between weight and displacement seldom exceeds three or four.

Submarine concept studies, for which there is no previously existing baseline design (starting with a "blank piece of paper"), take approximately four to six man-months to complete and are typically accomplished by a team of two or three naval architects using a variety of computer-aided design tools and an extensive library of submarine design data. Roughly half of the total effort will be expended estimating the weights. Utilizing effective short-cut methods for recomputing volumes and weights, the final balancing process takes very little time.

So, to conclude this submarine design course, we see that submarine designs must be balanced and that they may be weight or volume limited and may have trim and/or stability lead. These are the naval architectural attributes that so greatly influence the impact of incorporating design changes.

Design Changes During Early Stage Design

During early stage design of a new submarine many *variant*, *trade-off*, or *impact* studies are typically conducted to answer a multitude of *What if?* questions; for example:

- What if the candidate design carried more (or less) weapons and/or weapon launchers?
- What if sonar system B was used instead of system A?
- What if a stronger hull material was used – how much deeper could the ship operate without changing ship size?

Each variant study defines the total ship effect or impact of a

specific design change – its effect on ship size and other characteristics.

Ultimately, all design changes entail material objects, having volume and weight, that are added to and/or removed from the baseline design, affecting total ship volume and weight, the function of various ship systems, operational characteristics, mission effectiveness, and life-cycle cost. By also determining the effects of the change on ship *performance* and *cost*, fully educated decisions can be made by higher authority as to whether or not to incorporate the specific design feature in the next baseline design iteration and, ultimately, in the final ship design.

Submarines in early stage design, existing only *on paper* (or computer files), can grow or shrink without impacting program plans or existing platforms and can be thought of as *rubber ships*. The baseline design (the one to be modified) meets all design criteria such as a certain percent margin or reserve buoyancy. When introducing changes (the variants), the design criteria are typically held constant, which may require increasing or decreasing the length of one or more of the pressure hull compartments and the main ballast tanks to balance the variant design.

In variant studies, the feature being varied must be fully identified in the baseline design; a variant study to determine the impact of changing feature X cannot be performed unless feature X can be separately identified (weight, space, services, etc.) in the baseline and the ship's naval architectural constraints must be known. Hence, new submarine designs, upon which a number of variant studies are intended to be conducted, must be performed to, at least, the previously discussed concept study level of detail. Quickly conducted ROM studies, including those using computer *synthesis models*, are rarely adequate for this purpose.

Design Changes After Early Stage Design

While there are instances of ships being lengthened during construction due to excessive weight growth or equipment substitutions, hull geometry changes are highly undesirable for ships in later stages of design (although still on paper!), under construction, or in service. To avoid geometry changes, the installation of new components may require shifting or removing existing components to make

space and/or removal of margin lead to compensate for increased weights.

A later, lengthened or otherwise modified *flight* of submarines may, for administrative purposes, be considered as members of the same *class* as the original versions. However, with new equipment installed and additional buoyancy, they may be operationally more capable and different in some of their naval architectural attributes too.

For ships in service, some initial design criteria may no longer be met. For example, incorporation of new components will consume future growth margin or reserve buoyancy may no longer be the *standard* percent because of changes to the main ballast tanks. Variant studies of this type usually determine whether it is practicably feasible to introduce the design change. More specifically, they answer the question, Can the design change be made without so adversely affecting the ship design that it has negative margin (the submarine is not neutrally buoyant), has insufficient reserve buoyancy, does not meet stability criteria, has insufficient electrical power or air conditioning, etc.?

Applying the Lesson

Let's return to the proposals listed early in this article and examine some of the naval architectural implications.

- Use lighter components in an engine room to permit *new weight* to be added (in the form of additional weapons) without changing ship size.

  This submarine's torpedo room is forward and has no room for additional weapons. Unless new weapon launchers and stowage structure are installed aft (not very likely), newly available weight in the stern would not help the weapon load situation. If the baseline ship had aft trim lead, the saved weight aft would have to be replaced to retain ship balance and, hence, saving weight with no other purpose in mind has no benefit. If the baseline ship had forward trim lead, the saved weight aft would permit reduction of the forward trim

lead and future growth margin would increase by the sum of the two savings.

- Significantly reduce the crew and reduce ship size by the amount of the reduced crew space required.

  Low density spaces (especially crew spaces) help *float* high density spaces (such as machinery and weapon spaces). If the ship is volume limited, the ship size can be reduced by, approximately, the crew space reduction. However, if the ship is weight limited, the resulting ship size reduction will be relatively small. (Such a change could cause a volume limited ship to become weight limited.)

- Move weapons or propulsion machinery outside of the pressure hull to reduce the size of the pressure hull in a revised version of an existing submarine design.

  External components have weight but relatively little buoyancy and, unless a large amount of internal weight can be saved, rather than become smaller, the pressure hull may have to become larger to float the external components and *new* associated non-pressure hull structure. (Typhoon and Oscar class submarines, the two largest submarine designs ever built, feature external weapons!)

The belief among some proponents that external weapons can be accommodated at less cost (in terms of ship size) than internal weapons may stem from their limited knowledge of the naval architectural details of adding twelve VLS tubes in later LOS ANGELES (SSN 688) Class ships *without increasing ship size*, a major selling point of the SSN 688 VLS program as it most likely would not have been approved otherwise. (While ship length and compartment dimensions did, in fact, not change, surface displacement actually *increased* and submerged displacement *decreased* by small amounts due to changes within the forward main ballast tanks.)

However, this *free* (in terms of ship size) capability enhancement came about as a result of very fortuitous circumstances. Early LOS

ANGELES Class ships had excess reserve buoyancy forward due to main ballast tanks design changes occurring during later stages of design. Further, these submarines carried considerable future growth margin, forward trim lead, and had single hull bow structure. If any one of these four naval architectural characteristics had been otherwise, installing VLS would have entailed lengthening the ship. Installation of VLS in the earlier STURGEON Class would have required either completely redesigning the front end of the ship (for external VLS) or adding a new pressure hull section aft of the operations compartment (internal VLS).

- Adding a new component, which *only* weighs X tons, will have little effect on the submarine design, certainly not requiring a modification to the hull geometry. (For simplicity, we'll assume that the component's volume is not an issue.)

- Looking at longitudinal balance, let's assume that the ship has forward trim lead.
  If the X-ton component is installed forward, remove X tons of forward trim lead; future growth lead is unaffected.
  If the X-ton component is installed amidships, remove X tons of future growth lead; trim lead is unaffected.
  If the X-ton component is installed aft, add X tons of forward trim lead, and remove 2X tons of future growth lead to satisfy Archimedes.
- Looking at transverse stability, let's assume that the baseline ship has stability lead.
  If the X-ton component is installed near the keel, remove X tons of stability lead; future growth lead is unaffected.
  If the X-ton component is installed near the hull axis, remove X tons of future growth lead; stability lead is unaffected.
  If the X-ton component is installed near the main deck, add X tons of stability lead and remove 2X tons of future growth lead.
  If the X-ton component is installed near top of the sail, add 2X tons of stability lead and remove 3X tons of future growth lead.

So, ignoring displacement effects, adding weight to a submarine (without also changing the hull) can impact future growth margin anywhere from no impact at all to as much as three times the added weight. This may be trivial for submarines with adequate future growth margin but for later ships of some classes, where multiple improvements have been incorporated, the future growth margin may be so low as to preclude adding any significant weight.

Conclusion

Hopefully, my readers now understand the naval architectural attributes upon which the ship impacts of design changes *depend* and, also, that these attributes can only be determined by performing the appropriate naval architectural analyses, including an evaluation of the ship's arrangement, volume, and weight, and balancing the design.

As has been explained, the ship impact of incorporating a change into one submarine design is not necessarily indicative of the impact of incorporating the same change into another design or even into the same ship but in a different manner. So, while I encourage innovative concepts, please be aware that the ship design impacts of those innovations are not likely to be plainly evident.

When a seemingly worthwhile submarine modification is identified, before spending large amounts of time and money on development, *do the naval architecture*—determine the total ship impact of the idea. It may be good, bad, or indifferent. However, even when the ship design results are unfavorable, a fuller understanding, by everyone involved, of the reasons why, may lead to a rethinking of the proposed modification that can turn it into a concept worth pursuing. NAVSEA and the submarine shipyards have the capabilities to do these studies—take advantage of them!

The United States is in danger of losing its capability to do the naval architectural analyses described above. Its most experienced submarine naval architects are aging and retiring (there is *one* experienced early stage submarine designer remaining in NAVSEA) and, with the lack of new early stage design studies, few are being trained to take their place. Submarine design skills are different from surface ship design skills—surface combatant designers cannot be expected to successfully design a submarine. Even if a new subma-

rine acquisition program is not in the Navy's near or mid-term plans, the continuing conduct of advanced submarine concept studies and technology assessment studies (to determine the total ship impact of installing the products of ongoing and planned R&D) would be sufficient to exercise and maintain submarine design skills and to train new submarine designers while providing valuable information in support of the overall submarine program.■

ETERNAL PATROL

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THE TRANSATLANTIC DIVIDE

by CAPT William L. Norris, USN(Ret)

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Much is made today of how America, the world's only remaining *superpower*, and its foreign and military policy are distressing transatlantic relations. Similarly, we hear that the European Union (EU) creation of a common European Security and Defense Policy (ESDP) will create a counterweight to US foreign policy. Then we hear that the French and Dutch voters' rejection of the EU Constitutional Treaty will stymie any effective EU actions for a decade. NATO is said to be no longer needed in a world in which Europe has no real threats. Although truth is often said to be stranger than fiction, where do the truths and fictions really lie? Where is there agreement and disagreement?

One could probably write a fairly large tome on this subject, but let us attempt to address this issue by selecting several specific subjects to discuss. These may not be either the best subjects for an example or the most contentious. But maybe they will start the dialogue. Let us discuss the following:

1. War on Terror
2. ESDP
3. EU Constitution
4. Nonproliferation and Weapons of Mass Destruction
5. Greater Middle East

The first thing with which Europeans and Americans disagree is that there is a *war* on terrorism. The Europeans would ask "How you can conduct a war on a thing?" At most, they would call it a

campaign. And Europeans do not sense they are at all at war as they have lived with national based terrorisms for years.

That could be changing. The Madrid bombings of last March and the London bombings of July this year are bringing a new awareness that international Jihadist terrorism can occur in EU countries. The fact that more people know London than Madrid places more emphasis on the deed. This apparently random terrorism is now viewed as a more real threat than Europeans wanted to admit. The events of 9/11 in the US had caused the EU to initiate some recommendations on changes to national laws that should be enacted in EU countries. However, most have been slow to take any action because they did not see the threat as either real or imminent. Europe (and the EU) is a land of law and personal freedoms. Just as with the Patriot Act, these laws (such as national ID cards) would impinge upon their freedoms. They have now seen two instances where countries with strong anti-terrorism laws in place have been able to fairly quickly run to ground the Jihadist terrorists from within their countries.

Europeans do see that the road ahead in this area has many twists, turns and bumps. The major industries of many European countries have been fueled by the immigration from all over the world to offset their own population stagnation or declines. They all now have indigenous population that are second and third generation nationals and citizens. The alienation or expulsion of this population in the name of internal security would be crippling to their economies. Any solution to curbing this *terrorism from within* must have an inclusive and uniting theme with these new citizens. And it must be a universal solution that does not end Jihadist terrorism at the expense of advancing some different ethnic or religious terrorism or curb the appeal of the *free and democratic* vision.

From the US perspective, the events of 9/11 permanently scarred the American psyche. The invulnerability of the homeland was forever shattered. The events of both Madrid and London were further reinforcement of how *easy* terrorism is and that those events could happen here. Yes, the Oklahoma City bombing could be viewed as terrorism, but most Americans tended to view it as the act of a very few *kooks* with no real associated cause. So Americans generally believed that 9/11 was different and seminal and demanded real action to reduce the threat.

Throughout the last half of the twentieth century, American leaders have tended to use the word *war* when they needed to mobilize the country's efforts. Besides the *Cold War*, we have seen *War on Poverty*, *War on Drugs*, and *War on Aids* as examples of this. To try and make the essentially overnight changes in a national approach to counterterrorism, a national mobilization in thought process was required. The changes needed in individual rights and civil liberties were much more acceptable in a national cause, especially when wars are not viewed as permanent and there could be some restoration when the need for mobilization of resources was over.

The US by its very aggressive use of force and other tools, has clearly placed itself at the top of the terrorists' target lists. As compared to the likes of Luxembourg or Estonia, the US should expect to eventually experience some terrorist action. Because the 9/11 event was so large to Americans, a basic US position is to try to do whatever is necessary to prevent anything similar. By such a definition, it is both a stretch goal that by its ambition begets strong action. While President Bush may have lost popularity because of the Iraq War, support of his counterterrorism policy remains strong and vibrant. We must be careful that we are not making our judgments based on what we see in the rear view mirror.

I believe that one should view ESDP as a natural outgrowth of the maturing of the EU. In the global world of today, foreign policy generally tends to be driven by economic (soft) power. Now the world is finding (and actually always knew) that not all problems can be solved with only *soft* power. From a start of six European countries forty years ago, the EU is now a community of twenty-five European countries and still growing. By many measures, the combined economic power of the EU is roughly the equivalent of the US. ESDP is a way of ensuring that its economic power cannot be held hostage through the lack of *hard* power and a policy for its use.

But the same rationale that brought this argument this far now begins to falter. Twenty-five sovereign powers have different national interests both inside and outside economic drivers. Twenty-five nations have leaders with different visions of both their countries place in the world and the EU's place in the world. Some of these nations have years of history and culture that define them.

Others of these EU nations are young in their present incarnation with developing economies and national interests, yet at the same time mired in an older ethnicity and culture. The EU is a union of nations divided by culture, history, religions and language.

For more than fifty years, the military power, or defense policies, of most of the twenty-five EU nations have been defined by the North Atlantic Treaty Organization (NATO). As NATO is evolving from a pure defense organization against a very specific threat in Europe to a collective security organization against an ill-defined or global threat, the EU is also seeking an identity. The static forces that characterized the old NATO and Warsaw Pact are the capabilities of today's European NATO forces. As each country has taken its peace dividend from the end of the Cold War, most countries are forced to offer the same static forces (in some cases these forces are even more static than before) to both NATO and the EU.

When two organizations are *competing* for the same forces and missions, the spawning of differences is inevitable. Some of these differences arise from the opinion and policies of the non-members of each group (France not a member of the NATO military structure, the US not an EU member, etc.). Others stem from the capabilities that are brought to the table, or maybe even absent from one group or the other. Still others are caused by disparities in the national interests that might merit their involvement in any forum. Some are driven by the name tags used to describe the missions (Peace-making, peace-keeping, etc.). In recent years, a few would even suggest that France and Germany have added to the differences by working to rid the continent of American influence. Both NATO and the EU are essentially consensus driven organizations which exacerbates any differences when action might be required.

In a *global world* there has to be place for both. Intervention somewhere in the world is a matter of when, not if. No nation can sustain the role of the world policeman. Neither can any nation sit on the side and claim that all the world's nations are good citizens who are always acting in the world's interests and will react to a *soft power* carrot. Nor can any but the most undeveloped nations contend that their national interests are not affected by a failed or failing state several continents away.

An ESDP is needed and is necessary. Yes, the economic,

legislative and judicial legs of the EU are healthy and sustainable without ESDP. But can the evolving NATO continue to be the continuing source of *hard* power that is necessary for the EU to continue to thrive and grow in a global economy? The US is often characterized as seeing every problem as a nail and only having a hammer to solve it. On the other hand the EU is seen as only having carrots and so every problem looks like a rabbit.

What if the US decides that it has neither a role nor a national interest in a world crisis, can the EU (or NATO for that fact) act without US logistic support? The answer for today for anything but the smallest event is no. A forcible insertion of peace-making forces would be extremely problematic for the EU. Therefore the laying out of a security policy and the commitments of the EU nations to support it is absolutely needed. An old American saying that *freedom is not free* also applies to EU economic power.

Along this line, a short discussion of the EU constitutional approval process is probably in order. The French and Dutch *No* votes this summer sent tremors through the EU. How could the voters reject so strongly the advice of their leaders? There are probably two underlying reasons. First, the growing general trend in democracies is to believe that major decisions should be made by the people at the polls. Ballots in the US are filled with *proposals* on laws or projects. Luckily, in most cases, these proposals only require an *interested* voter to read a short volume as opposed to the many tomes a French or Dutch voter would have had to read.

So the majority of voters then make their decision based on what they see and hear in the media or in what they talk about in the coffee house or over the backyard fence. A growing concern for Europeans is can the EU and their nations maintain the social services networks as the population ages. This type of decision making can quickly sink into such national and even regional emotional issues, the rumor *de jour* or even pure fiction for which no rebuttal is available. The voters really care more about what they believe the effect will be on their daily lives than the grand vision.

Second, there seems to be a growing trend of elitist government (and even corporate) leadership. To some degree this elitist trend seems to grow with longevity of the leader. The senior functionairies in the EU bureaucracy and EU governments are embroiled daily in

the issues addressed in the constitution and therefore clearly believe that they only put forth a visionary document that would resolve all issues. There seems to have been some belief that the voters would just rubber stamp the well wrapped package that their elite had provided them. Most of the countries that have ratified the treaty to date have done so in national legislatures where there may be more trust in the other elites and where discussions are more likely to be steered away from rumor and fiction, and even some cases, facts.

Thus when one submits something to the voters, the landscape must be prepared. There must be at least as much positive propaganda as negative. The rumors and fiction must be identified as such and countered. The loyal opposition attempts to embarrass those in power must be expected, and the radical fringe groups must be kept on the fringe. Those in power must remember that the voters' no votes may in fact be a vote against the government in protest over issues that are not even on the ballot, especially in a one issue ballot.

The rejection by the French and Dutch voters so closely followed by the wrangling of the national leaders at the EU summit may lead people to believe that the constitution is dead. It is not, as the *yes* vote by Luxembourg recently indicates. But a multitude of issues have been identified that must be worked and resolved. It should serve as a wake-up call to European leaders that their countrymen are disillusioned with the current path being traveled. This may result in a multi-year delay in getting an ESDP and on admitting further new members. A lesson learned is that the rules that will govern an institution after enlargement should probably be in place before the enlargement occurs.

Two related subjects that are often discussed in security and defense conferences are proliferation and weapons of mass destruction. With respect to Europeans, these discussions are normally fillers or sidebars. While speakers will openly brand the proliferation to and the possession of weapons of mass destruction by terrorists or rogue governments as the greatest threat to world peace, they do not seem to believe it to be a real threat. Therefore they are willing to let existing arms control conventions and UN sanctions attempt to control proliferation with the belief that if they fail, *soft* power, or in the worst case, the US *hard* power, will resolve, what they believe to be an unlikely scenario, favorably. There has always been a

struggle in and between governments on the *soft* power forms of non-proliferation and the *hard* power means of counter-proliferation.

There was also a belief that the Nuclear Non-Proliferation Treaty (NPT) would prevent any nuclear weapons proliferation concerns. Some people believe that the three new nuclear weapons nations since the NPT's inception (Israel, India and Pakistan) did so in violation of the NPT. They did not since they never signed the treaty. However, the main subjects of today's proliferation discussions, North Korea and Iran did sign the NPT and therefore are in violation of the NPT. Two other proliferators, Libya and South Africa, have now made national decisions to abandon their proliferation programs. Other nations probably investigated the development of a nuclear weapon in secret, but then decided that the cost/benefit equation at the time was wrong for them to continue.

That was then and this is now. Iran is now faced with a nuclear armed neighbor on its eastern border as well as the nagging Israeli one. There may be questions in the Iranian leaders as to the long term stability of the Pakistani government, or its entanglements with the *Great Satan*, the United States. What national pride is involved when Pakistan claims its technical superiority and claims an *Islamic* bomb? Iran is a self-anointed Islamic state and cannot believe itself a less capable nation than Pakistan, a more secular one. Maybe Iran is even looking to use its nuclear aspirations to define a new balance of power in the region. The isolationist and paranoid North Korean government may believe that possession of a nuclear weapon will ensure their sovereignty and well being when they are unable to provide for their peoples' common good. It may even be a bargaining chip to gain that capability.

The real dilemma today is getting world-wide consensus on how to deal with NPT violators, especially since the world has changed from the bi-polar (some would say multi-polar) state that existed when the NPT was originated. Are the guarantees of the NPT enough, in and of themselves, to assure the safety of smaller nations today who find themselves next to a new nuclear weapon state? The United States has provided extended deterrence treaty obligations to numerous nations. That commitment to extended deterrence may be a much more demanding and important one today than when it was given.

Since the first and only uses of nuclear weapons in war sixty years ago, nuclear weapons principal role has been deterrence. As more and more nations acquire nuclear weapons, we may be transitioning from deterrence on an international scale with well developed policies, protocols and command and control systems to an era in which nuclear weapons are weapons available to be used without the same level of deliberation and with unintended consequences to solve a nation's immediate tactical problems. We have greatly changed the entering arguments in the cost/benefit equations for new nuclear weapons states.

NATO has a nuclear policy that is underwritten by the United States, and to a lesser degree, the United Kingdom. In general, the association of nuclear weapons and NATO is treated as a sleeping dog that is let lie. The public demonstrations of the 1980s and 1990s are better left unprovoked and unrenewed. How long it can be kept out of the public eye is the real question. These non-strategic weapons were originally put in place as a deterrent to the onrush of the Soviet and Warsaw pact forces into Western Europe. President George H. W. Bush removed most of them in his Presidential Initiative in 1991. Today, NATO documents refer to these nuclear weapons as political weapons.

What they represent today is really a commitment of the United States to Europe. Our other military forces cannot totally leave Europe because those weapons represent assets which cannot be allowed to fall under any other nation's control. I believe that deep down Europe believes that even without a mission for those weapons, as long as they remain in Europe, the Europeans can rely on US participation in their defense needs. One might say that they are political weapons that keep the US bound to Europe.

There is some small chance that could change in the somewhat distant future as the limits of proliferating nations is reached. To me, the three nations that could change this future are Iran, Saudi Arabia and Turkey. The reason is that Iran becoming a nuclear state could cause both Turkey and Saudi Arabia to reexamine their cost/benefit calculations. First, Saudi Arabia as the keeper of two of the Islamic holy sites is already nervous about the rise of Islamic states and its affect on their kingdom. They certainly have the money for a nuclear weapons program. The Saudi kingdom's survival may come to

partially rest on not being blackmailed by an Islamist state with nuclear weapons, such as a nuclear armed Iran.

Turkey, as a secular nation, yearns for inclusion in the European Union. It also views itself as the leader of the moderate Arab nations. But Turkey's membership in the European Union is far from guaranteed, even if it fulfills its entire membership plan. There remain serious prejudices against Turkey as both an *Islamic* nation and an Asian nation that make its membership a problem with many Europeans. The words of a union of nations who share a common heritage and set of beliefs are a tough yardstick for Turkey. If Turkey were denied membership and the joining of a united Europe, it will view its NATO commitments and the need for its own nuclear deterrent differently.

Remember, Iran is on its eastern border. One must also wonder how Israel will react to having nuclear weapons states in several different axes.

The term *Greater Middle East* is being used much more frequently these days. There seems to be a somewhat naïve belief that by lumping all the nations from Algeria east to Iran, one solution can fit all. I believe that is a dream. The countries are too different and the existing major problems (e.g. Israel-Palestine and Iraq) must be solved before we can move very far forward. The Mahgreb (North Africa) is different from the Mashreq (eastern Mediterranean nations or the Levant to some) which is different from the Persian Gulf. Even within these three regions, the nations are hardly alike.

While peace and stability in these regions are vitally important to the European nations, as well as the United States and the global economy, a one size fits all approach will not work. A rational approach that solves each regional problem in the *Greater Middle East* must be developed and then we must build upon that for a longer term solution. Democracy, in and of itself, is definitely not a near or long term answer. What is *democracy*? Some Arabs will tell you that two-thirds of the Muslim world is democratic. Neither is the Islamist state a guaranteed solution. The focus needs to be on reform, job creation, women's rights, education, etc., this is what will secure the support of the people not empty slogans.

Europe looks to have a long term lack of manpower to keep its economies stoked with adequate internal labor. The *Greater Middle*

East appears to have a lack of industry and infrastructure to maintain stability after we leave an oil based energy system. The answer is also not just to move the people of the *Greater Middle East* to Europe. But a closer answer might be to move some of the jobs Europe can't fill with its shrinking manpower pool to the *Greater Middle East*. The new paradigm must be to create integration and growth. Europe well knows that there is no security for Europe in today's world without global security.■

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ARTICLES

THE PRIZ RESCUE

by CDR J. Powis RN
and CDR I. Riches, RN

CDR Powis is a submariner of many years standing and has commanded the Upholder Class SSK HMS UNSEEN, and the SSBNs HM Ships RESOLUTION and VICTORIOUS. He is now the RN staff officer for Submarine Escape and Rescue as well as the outgoing Chairman of NATO's Submarine Escape and Rescue Working Group (SMERWG).

CDR Riches is recently promoted and has served as the XO in SSKs and the SSBN HMS RESOLUTION, (a command qualified appointment in the Royal Navy). He is currently the head of the Submarine Escape & Rescue Project Team for the Royal Navy and led the team that conducted the rescue of AS 28.

The rescue of the Russian Priz-class submersible AS-28 by members of the Royal Navy's Submarine Rescue System (SRS) was a transformation into action of years of planning and practice assisted by an unprecedented international cooperative effort.

The Royal Navy's SRS is owned by the government but operated and maintained by the James Fisher Rumic Company at Renfrew in West Scotland. The system consists of the rescue submersible LR5, an A-frame launching system, generators and support services as well as a system for off-loading survivors at pressures of up to 5 atmospheres, all of which can be readily flown by cargo aircraft and operated from a ship of convenience. In support of the SRS is an underwater tracking outfit and the SCORPIO 45 Remotely Operated Vehicle (ROV).

Flying the SRS to a remote location and placing it aboard a ship of opportunity takes time and the survivors in a Disabled Submarine (DISSUB) will have limited resources of air, food, and water. To speed the rescue capability reaction, the Royal Navy's SRS plans to reduce the time spent in transit by simplifying the deployment process and actively keeping track of available shipping using a data

base fed from commercial sources. Also, an Intervention System has been devised based upon the SCORPIO ROV and capable of being flown to the DISSUB scene in a single C-130 Hercules cargo aircraft, although a faster aircraft is preferred.

The Intervention System is lightweight, self-contained and can be mounted on any vessel above a few hundred tons displacement with an area of open deck. It consists of the ROV, its handling system, and a standard 20-foot container configured as the control cab. This intervention equipment will arrive at the scene first to carry out surveys, debris clearance, and resupply of the DISSUB crew using watertight containers or *pods* that can be *posted* to the trapped crew via the escape hatches. With these pods the intervention system can maintain survivable conditions until the SRS arrives.

It was the intervention system that was deployed to the scene off Petropavlovsk in Kamchatka. The small PRIZ had no escape hatches; hence no pods or survival stores were transported in the single C 17 aircraft load.

SCORPIO 45

Dimensions	2.75 x 1.8 x 1.8m
Displacement	1400kg
Max Depth	900m
Max Speed	4kts
Max Payload	100kg
Tools	Cutter, Grasp, Radiological sensors

SCORPIO 45 is twenty years old and hence a rather dated ROV. It has been updated and carefully maintained and is more than sufficient for its purpose within the SRS. It can dive to depths that exceed the survivable limit of most submarines and can operate in reduced visibility, high currents, and rough surface weather. One of the main factors that contribute to the confidence in both the SRS and the Intervention system is the fact that through civilian operation the crews and maintainers have accumulated many years of experience in operating in a range of operating conditions.

The alarm was raised in Britain by a telephone call from the British Naval Attaché in Moscow. The call was received in the UK Submarine Operating Authority at Northwood (NW London) at 0630. It was fortunate that the naval attaché is a submarine engineer as his intimate knowledge of the rescue system, the technical language, and Royal Navy submarine rescue policy expedited the Royal Navy's response. And, his presence in Kamchatka as liaison and interpreter smoothed the way for the SRS deployment.

It was also fortunate that when the PRIZ alarm was sounded the SRS was being prepared for a rescue exercise in Norwegian waters. Much of the preparation for deployment was complete when the balloon went up. The Royal Air Force came up trumps by redirecting one of only four available C-17 transport aircraft and making it available for the long flight to Kamchatka. Without that aircraft a chartered commercial aircraft would have been required or a C-130 used, in either case a delay of several hours would have been incurred.

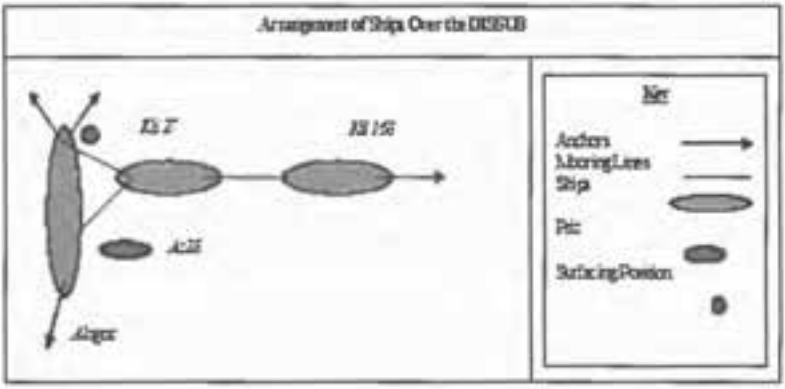
The Russians opened up access to a military airport some 40 km from the remote port of Petropavlovsk. However, upon arrival of the Intervention System it was found that, despite assurances otherwise, no cargo handling system was available that could lift the largest component of the system. Here lies an important lesson for all submarine rescue planning: airport and seaport combinations need to be inspected, as national policies concerning such matters are often different in crucial ways. In this case the Russians expected that we would have in-built systems for off loading as their aircraft do. Thus there was a delay in the offloading process until the U.S. Navy came to the rescue.

The U.S. Navy's reaction to the call for assistance was every bit

as determined as that of the Royal Navy. The American effort arrived with a huge amount of equipment loaded into four aircraft, which included two Super Scorpio ROVs, with a rather more sophisticated (and bulky) launch and recovery system than that used by the British system. Most importantly the USN planners had the foresight and space to bring cargo-handling equipment from one of their bases in Japan. All this equipment demanded a large team of personnel and the Americans also brought several hundred ration packs. Having arrived a few hours after the British team the Americans found that the British Intervention System was experiencing unloading difficulties and they provided the necessary machinery from that which they had brought to the party. Thus the British offload could be completed, the Russian convoy formed, and the transit to the port started. The Russians then turned their attention to unloading and preparing the U.S. Navy system. This spirit of international cooperation thus manifest was directly attributable to the numerous meetings and exercises in which the British, Americans, Russians, and others participate. Submarine rescue is a fairly arcane discipline with a small coterie of experts, hence the personalities are well known to one another. In this case the leader of the Royal Navy's SRS made the request for assistance in person to his friend running the U.S. Navy's effort, being in every sense colleagues rather than rivals. The rescue could then start with the U.S. Navy providing the backup system. In this event, this Anglo-American cooperation extended to the use of a U.S. Navy scuba diving team to assist in the deployment and rescue process as well as provision of a medical officer. Thus the team that conducted the rescue was a tri-national team. In addition, and perhaps more importantly, the exercises and conferences in which all had participated meant that there was a commonality of purpose, approach and method.

Upon its arrival at the military port of Petropavlovsk the Royal Navy intervention equipment was loaded onto the Sura-class buoy vessel Kil-27. The handling system was welded to the deck and 10 hours after arriving in the country the intervention system and its multinational team was underway for the DISSUB location.

Once at the location it was found that none of the Russian ships had dynamic positioning systems. Two rescue ships, the ALGAZ and Kil-168 (see diagram) had been moored, one ahead and one astern of



the DISSUB's position. The Kil-27 was moored between them and an attempt made to line up parallel to the DISSUB some 200 meters below. Such precise positioning is not required for ROV operations in the British SRS and the intervention of the British naval attaché was again central to the liaison process that married the British requirements to the Russian desire to do the best to assist the rescue effort. Enroute to the scene the British operators had briefed themselves on the likely situation awaiting them by watching Russian videos of the DISSUB made by a Russian Navy ROV. This Russian ROV had suffered several software problems and was unable to do more for the DISSUB. However, its contribution was of importance as the British team was well prepared for the DISSUB situation.

Once at the DISSUB scene, the British Scorpio conducted a brief survey to verify that there were only four strands of netting holding the AS-28 down as well as jamming the submersible's propeller and control surfaces. The Russian Navy had attempted to drag the AS-28 clear of the nets and other obstructions. In doing so they had inadvertently compounded the problems.

However, by the simple expedient of making the AS-28 slightly positively buoyant the British team found that they could reach three of the four strands with the cutting tool attached to the Scorpio. Cutting these strands of netting was fairly straightforward if rather protracted and the failure of one of the cutter guides delayed matters by requiring the recovery, repair and redeployment of the Scorpio. Once three of the strands were cut the final one was broken by the AS-28 achieving full buoyancy, which resulted in an uncontrolled

ascent to the surface. Fortunately in her rapid ascent, the AS-28 missed the three ships conducting the rescue. The entire crew of the AS-28 was extracted without further drama.

In addition to the efforts of British, Americans, and Russians, two other countries mobilised resources to assist: The Japanese and the Australians, both important players in the submarine rescue world, got equipment moving towards the DISSUB although the rescue was completed before they arrived. The Japanese effort comprised the submarine rescue ship CHIYODA with its DSRV rescue vehicle, the LST URAGA, and two minesweepers. The Japanese probably have the most sophisticated and capable submarine rescue system in existence and it is maintained at a high degree of readiness: The CHIYODA was underway within two hours of the alert. However, the limitations of tying such a system to a purpose-built ASR are well demonstrated by its inability to reach remote locations at a speed faster than that of the ship. CHIYODA's estimated time of arrival was late on 9th, some two days after the rescue was complete and 36 hours after the breathable air would have been exhausted in the AS-28.

Australia has a small rescue system known as REMORA. This system would neither have arrived in time nor have been able to assist in the existing circumstances. However, the commercial contacts of the Royal Australian Navy's submarine rescue organization identified a ship on contract to the Sakhalin Company subsidiary of Shell Oil working near the disaster scene, the SURVEYOR. The ship was not suitable as a rescue system mother-ship so did not appear in British or U.S. databases. Nevertheless, this ship would have been ideal for this rescue operation and she sailed, on the volition of the master. Two ROVs and an advanced diving system were embarked plus a powerful communications suite. By the time of the rescue she was some six hours from the scene and could have performed the task with little difficulty.

A key factor in the PRIZ rescue and in preparing for future submarine rescues is the International Submarine Escape and Rescue Liaison Office (ISMERLO), which was established in 2004 to assist the unification of worldwide technical and procedural standards in this area. ISMERLO has demonstrated the coordination of deployment efforts by providing a website chat page for communications

during a DISSUB alert. Experience to date in exercises and the fire at sea suffered by the Canadian submarine CHICOUTIMI in 2004 had proven the principal of the use of the website as a communications medium and the PRIZ rescue underlined its usefulness with over 1,500 hits from 19 countries. ISMERLO will also act as the international clearinghouse for lessons learned. Initial reviews of the PRIZ rescue have identified some key points:

- Logistics – Reliance upon diverse assets.
- Communications – Comms in remote parts of the world are difficult; the Iridium telephone system coped well with the crisis.
- Exchanges – Meetings, conferences, and exercises are vital to success; the membership in ISMERLO needs to be broadened to all submarine operating nations.
- Language – Language difficulties require positioning of liaison teams in the DISSUB area in advance of the SRS.
- Facilities – Expectations of facilities and capabilities at seaports and airports are often unrealistically high or tainted by the norm in one's own country.

The PRIZ rescue points the way to future efforts in this discipline and this level of international cooperation is set to become the norm. The future U.S. Navy's new SRDRS rescue system and the jointly owned British, Norwegian, and French NSRS system rely upon coordination with each other to guarantee the desired 98% availability. Further, similar requirements for aircraft and ships to conduct deployment dictate that coordination, probably by ISMERLO, will be essential. Acquisition of transportable systems by other submarine operators will exacerbate the need for central direction of effort. Forums for solving these problems are in place and the appropriate persons are attending them, thus the future looks safer and more open for submariners. This is perhaps the most significant legacy of the KURSK tragedy of August 2000.

A final factor in the PRIZ rescue was the fact that the Russian Navy has become very much more open in the arena of submarine

emergencies. The Russians are now full participants in the Submarine Escape and Rescue Working Group (SMERWG). This NATO group meets annually (in 2004 it met in St. Petersburg, Russia) and consists of several working panels covering the full range of submarine emergencies. In the last four years 37 of the 42 submarine operating nations have been represented at SMERWG and NATO submarine emergency exercises. Indeed, during submarine emergency exercise Sorbet Royal in 2005 the Russian participants acted as officer in tactical command for a serial with a Turkish submarine. The openness and willingness of the Russians to share the fruits of their efforts in this area is one of the truly important developments in this field in recent years. In this latest event, almost as soon as their inability to free the PRIZ became known the Russian Navy called for assistance via the ISMERLO website and more formal diplomatic means. That action saved the seven-man crew of the AS-28.■

REUNIONS

USS NATHANAEL GREEN SSBN 636 Apr 29-30, 2006
Cape Canaveral, FL
POC: Tom Carr reunion636@hotmail.com
Web Site:
http://www.angelfire.com/mo3/ozarkrunner/Upcoming_Events.html

USS CAIMAN SS-323 May 15-19, 2006
Flagstaff, AZ
Loc: Radisson Woodland Hotel, 1175 West Route 66, Flagstaff, AZ 86001
POC: Doug "Smitty" Smith, 360-377-4763 E-mail: dbfrider@comcast.net
Web Site: http://www.flamincaiman.org

USS SEA POACHER SS-406 May 18-21, 2006
Virginia Beach, VA
POC: Bill Brinkman, 512-255-0285
E-mail: seapoacher@austin.rr.com
Web Site: http://www.seapoacher.com

USS RATON SS/SSR/AGSS-270 Jul 12-15, 2006
Manitowoc, WI
POC: Bill Decker (540) 459-1928 E-mail: bdecker@shentel.net

USS BOSTON SSN-703/CA-69/CAG-1 Jul 13-16, 2006
Chicago-Oak Brook, IL
POC: Arthur L. Hebert, PO Box 816, Amherst, NH 03031-0816
Phone: 603-672-8772
Web Site: http://www.ussboston.org

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RABORN AND SMITH LED THE WAY AT STRATEGIC SYSTEMS PROGRAMS
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by David F. Winkler, Ph.D.

Dr. Winkler is a historian with the Naval Historical Foundation.

Berthed at San Jacinto State Historical Site east of Houston on the Gulf Coast, the battleship TEXAS (BB 35) floats as a testimony to a time when the big gun reigned as the ultimate of firepower in the Navy's arsenal. However, the ship's legacy extends beyond the three decades of service she gave to the nation spanning two World Wars. Indeed, two of the officers who led the Navy's effort to put strategic missile systems to sea cut their teeth on the vintage battlewagon.

Both William F. (Red) Raborn Jr. and Levering Smith served their initial seagoing tours as gunnery officers in TEXAS. Raborn graduated from the Naval Academy in 1928 and served in TEXAS until December 1932—just long enough to greet Smith, who reported aboard after graduating from Annapolis with the Class of 1932.

Following their tours in TEXAS, the two men's careers veered off in different directions, but were destined to be reunited a quarter century later.

After two follow-on tours in destroyers, Raborn underwent flight training and earned his wings on April 16, 1934. For the next seven years he made numerous flight log entries as he flew with fighter, scouting, and patrol squadrons and taught as an instructor pilot at Pensacola. Ironically, during World War II he would not use his flying skills in combat. For the first 15 months of the war he trained aircraft combat crews from all services in his billet as the Officer in Charge of Free Gunnery School, U.S. Naval Aviation Station Kaneohoe Bay, Hawaii. After a tour in Washington as the head of the Aviation Gunnery Training Division within the office of the Deputy Chief of Naval Operations for Air, Reborn finally reached the front lines as executive officer in HANCOCK (CV 19). As that carrier's second in command, he earned several decorations, including a Silver

Star for his leadership to contain damage from a bomb hit sustained during the Okinawa campaign.

In contrast to Reborn, Smith remained a blackshoe. After a tour as First Lieutenant in SHAW (DD 373), Smith attended Naval Postgraduate School, specializing in ordnance. After spending ten months with the Bureau of Ordnance just prior to the attack on Pearl Harbor, Smith went to sea and participated in eleven campaigns in the Pacific, serving on destroyers, cruisers, and carriers. Enemy action led to the loss of two of the ships he was serving on—HORNET (CV 8) and NORTHAMPTON (CA 26).

After the war, the two men continued to pursue their different career paths. Raborn had a series of afloat and ashore staff jobs before being assigned to the Bureau of Ordnance in July 1949. With the outbreak of the Korean War, he assumed command of the carrier BAIROKO (CVE 115) and conducted ASW operations in the Western Pacific into 1951. After this command tour, he attended the Naval War College. He then served as the Assistant Director of the Guided Missiles Division within the Office of the Chief of Naval Operations. His last afloat tour was as Commanding Officer of BENNINGTON (CV 20). During that tour his ship experienced a series of violent explosions while steaming south of Newport, Rhode Island on 26 May 1954. His efforts to limit the damage and evacuate casualties earned him additional recognition. Promoted to Rear Admiral, Raborn had a temporary staff job with the Atlantic Fleet before being assigned as the director of newly created Special Projects Office (SP)—which today is known as Strategic Systems Programs (SSP). Taking charge of the office on December 5, 1955, Raborn became responsible for giving his navy and nation a critical strategic capability during the early years of the Cold War.

While manned aircraft served as the primary delivery system for nuclear weapons during this era, both the Americans and Soviets had exploited technology from Germany's V-2 rocket program that had rained explosives down on London towards the end of World War II.

Three months prior to Raborn's arrival for duty in Washington, President Eisenhower approved a National Security Council recommendation to develop a 1,500-mile ballistic missile system, "with consideration for both land and sea-basing." A Joint Army-Navy Ballistic Missile Committee was formed on 8 November 1955 to

work jointly on the development of the JUPITER missile system. While the Army would focus on building the missile, the Navy would concentrate on developing the ship launching system. Secretary of the Navy Charles S. Thomas established SP on November 17, 1955 for this purpose.

Early on, it became obvious that the JUPITER missile, with its volatile liquid propellant, would be dangerous to place in a submarine. The question was whether solid propellant could power a submarine-launched missile. Levering Smith would provide the answer.

In September 1944, Smith began a three year tour as Head of Rocket Propellant, Pyrotechnic, and Chemical Warfare Division of the Bureau of Ordnance. He then reported to the Naval Ordnance Test Station, Inyokern, California, as Deputy Head of the Explosives Department. Smith's responsibilities at this facility—presently called China Lake—increased to include appointment as Head of the Rockets and Explosives Department and Associate Technical Director. In April 1954, after he was promoted to captain and designated as an engineering duty officer, Smith assumed command of the Navy Ordnance Missile Test Facility at White Sands, New Mexico. With his experience in rocketry, Smith was tapped to join the growing SP organization in Washington.

The reunion of the two former TEXAS shipmates would last for several years. Reporting aboard in April 1956, he initially served as the head of the propulsion branch. By this time the Navy had obtained Office of the Secretary of Defense support to pursue solid propellant development. During the month that Smith arrived, the Lockheed Aircraft Corporation was awarded a contract to determine the feasibility of placing missiles in submarines.

Led by Raborn, SP worked rapidly through the remainder of 1956 to design a solid propellant missile for submarine use. On November 9, Secretary Thomas proposed the POLARIS Program to Secretary of Defense Charles E. Wilson. A month later, Wilson authorized the Navy to pursue the POLARIS program and terminate its participation in JUPITER. Smith's responsibility increased to that of Associate Technical Director.

Able to act independently, Raborn and Smith accelerated the pace of the program. On February 8, 1957, Chief of Naval Operations

Admiral Arleigh Burke issued a requirement for the capability to launch a 1,500 nautical mile solid propellant ballistic missile from a submerged submarine by 1963. Following the launching of Sputnik by the Soviet Union, this deadline was advanced to December 1960. SP made this deadline. Concurrent advancements in solid propellant, warhead miniaturization, inertial guidance and ship navigation systems, hypersonic aerodynamics, and compressed air launcher design coincided to make this possible.

In January 1958, as numerous sub-contractors and government agencies worked on these critical components, construction began on GEORGE WASHINGTON (SSBN 598). Originally designed to be the fast attack submarine SCORPION, the hull was extended to allow the insertion of a 130-foot missile compartment.

On December 5, 1958, the Navy placed *Observation Island* (EAG 154) in commission as a test bed for the missile system and a training platform for the crew that would go to sea in GEORGE WASHINGTON. Meanwhile, test POLARIS launches from Cape Canaveral failed to yield success until the sixth try in late April 1959. Four months later, the *Observation Island* successfully launched a similar test missile.

The Navy commissioned USS GEORGE WASHINGTON (SSBN 598) at Groton, Connecticut on December 30, 1959. As America's first ballistic missile submarine proceeded with sea trials, inert missile launcher tests continued on the West Coast from a static underwater launcher located off San Clemente Island, California.

Just seven months after her commissioning, on July 20, 1960, GEORGE WASHINGTON successfully launched two POLARIS missiles from below the surface of the Atlantic Ocean off Cape Canaveral, Florida. Four months later, the submarine commenced her first operational patrol. Two months later, she would be relieved by USS PATRICK HENRY (SSBN 599).

However, the Raborn-Smith team did not have the opportunity to relax. Raborn would witness the commissioning of five additional SSBNs before he left SP in February 1962, promoted to Vice Admiral to serve as Deputy Chief of Naval Operations for Development. Smith, who had the unique distinction of being directly selected by President Kennedy for promotion to Rear Admiral continued on as the technical director under Rear Admiral Ignatius

J. "Pete" Galantin. He eventually succeeded Galantin on February 16, 1965, and would serve as director until November 14, 1977, when he was relieved by Rear Admiral Robert Wertheim.

Within seven years of the commissioning of GEORGE WASHINGTON, 41 POLARIS/POSEIDON fleet ballistic missile submarines, each carrying 16 missiles, would deploy to form an invulnerable leg in a triad that included land-based missiles and bombers that deterred Soviet attack and kept the peace during the Cold War—an outstanding accomplishment for those who served under the Raborn-Galantin-Smith watch. During Smith's long tenure, the name of the office changed from Special Projects to Strategic Systems Programs (SSP). Smith's legacy remains with us today—under his leadership SSP began the design work to eventually develop today's more capable TRIDENT submarine fleet.

As for Raborn, his service to the nation continued after he retired from the Navy with a 14 month tour as the Director of Central Intelligence starting in April 1965. He would then go on to do consulting work, as did Smith when he retired in 1977. Born in 1905, Raborn died in 1990 at age 84. Smith, who was born in 1909, died three years later at age 83.

The legacy of these two officers looms large in an organization that has recently passed its half century mark. A seminar that will highlight the history of the SP/SSP organization will be held at the U.S. Navy Memorial Heritage Center Theater on the evening of April 11, 2006. Presenters will include three of the successors of Raborn and Smith, retired Rear Admiral Robert Wertheim, and Vice Admiral Kenneth Malley, as well as the current director of SSP, Rear Admiral Charles B. Young. For information on attending this event visit the Naval Submarine League website at www.navalsubleague.com.

Sources: Facts/Chronology: Polaris-Poseidon-Trident Strategic Systems Programs, 2005; Peter Boyne, "In the Beginning... There was Special Projects!" *THE SUBMARINE REVIEW*, (April 2002), and the biography files of Raborn and Smith maintained in the Operational Archives of the Naval Historical Center. The author thanks retired Rear Admiral Jerry Holland, and Captain Peter Boyne for their assistance with this article.■

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LORAN
SHOWING THE WAY: LONG RANGE NAVIGATION (LAND, SEA, AIR)
PART I 1940-1942

by Mr. John Merrill

Mr. Merrill is a frequent contributor to THE SUBMARINE REVIEW and is a published author of several books on the history of undersea technology. He is a retired engineer with lengthy experience at the New London Lab of the Naval Undersea Warfare Center. He currently lives in Waterford, CT.

Loran, a World War II navigation system fulfilling wartime all weather needs with a near global coverage and importance to the war effort, was devised, tested, and broadly implemented within a period of less than four years. The destruction of Allied ships in the North Atlantic gave rise to the crash program to create the navigation system. It is still a system of importance in the new century.

This paper addresses the question, "Why and how did Loran happen?" To this end, background, events, and highlights are examined during the twenty-four months of research and development preceding the official transfer of the system to the Navy on January 1, 1943.

Loran was a concept and proposal in late 1940; the investigative system research was virtually completed by September 1941.[1] In 1942, the first Loran system operating at 1950 kHz was in use along the Northeast Atlantic Coast, providing long distance ship and aircraft navigation.

Extensive system implementation started in 1943. At the end of the war in 1945 at least 75,000 receivers and 100 transmitters were installed and 2,500,000 Loran charts distributed to all services. The charts from the Navy Hydrographic Office included fifty million square miles of the earth's surface.[2] About 70 stations had been installed, offering nighttime service over 30 percent of the surface of the earth, principally the most trafficked Atlantic waterways and

nearly the entire Pacific. Up to July 1945, $71,000,000 worth of Loran equipment was delivered to the services.[3]

After World War II

Loran was one of the three original projects[4] at the MIT Radiation Laboratory sponsored in 1940 by the National Defense Research Committee (NDRC). In the years following WWII, development continued under the aegis of the United States Coast Guard (USCG), to provide air, land and sea navigation for the military, for maritime interests and for the airline industry. The Korean, Vietnam, and Cold Wars again gave opportunity for Loran use in a variety of geographical areas. Technological advances involving satellites and missiles arose in the late 1950s, requiring navigational needs that were met with Loran C operating in the VLF spectrum (100kHZ). The Navstar/GPS system would later employ Loran's method of using time difference in the arrival of radio signals to calculate position.

Loran's Relevance in 2005

More than sixty years after Loran beginnings, the navigation system is still worldwide with additional potential value in the future to meet new needs. This is substantiated in an article appearing in the *European Journal of Navigation* in December 2003 asking "Is Loran-C the answer to GPS vulnerability?"

Loran's Capability to Mitigate the Impact of GPS Outage on GPS Position, Navigation, and Time Applications is the title of a December 2004 evaluation of eLoran (enhanced Loran) to address GPS backup. The article represents the findings of industrial and government organizations.

Concept

The Loran system allows a vessel or aircraft to determine its position in all weathers and at great distances from shore. A radio wave is sent from a master station and received by the ship or plane and slave stations. On receipt of the pulse, the slave sends out its pulse, which is also received by the vessel or plane. The ship or plane Loran receiver–indicator measures electronically the difference in time of arrival of the radio waves from a ground station. Using Loran charts for the area served by the ground stations, a line of position is

determined from the time difference. A second line of position is determined from another pair of stations. The intersection of the two lines provides a *fix*.[5]

Measuring the time of arrival of radio waves aboard a ship, aircraft, or fixed shore station immediately created an additional and diverse number of new challenges regarding how radio waves propagate over the various signal paths as well as a precise measurement of time. The signal propagation aspects were particularly demanding, as details relevant to the concept were not available. Further, system engineers were confronted with the design requirements for new receiving and transmitting equipment. Receivers suited for land, sea and air placed further demands. It should be noted that the ongoing war created severe time constraints on expediting the development and later implementation of the system on a nearly global basis.

Background

World War I was fought primarily with weapons and equipment available at its start. Within a year of the start of World War II, demands for new devices, weapons and systems presented broad challenges to the United States scientific and engineering community to meet the needs of England and France as well as the United States.

Response to the challenges, sometimes referred to as the physicists' and engineers' war, witnessed a continuing stream of new and frequently complex weapons and systems. It is important to point out that the theoretical information and the technologies available to work with were primitive compared to those at the end of the 20th Century. The technological advances made during the war years probed and pushed the boundaries of science and engineering forward.

The MIT Radiation Laboratory in Cambridge, Massachusetts, was the founding place of Loran. Overall in five years from 1940 to 1945, the broad accomplishments of the Radiation Laboratory, especially in radar (microwaves), have been said to be equal to twenty-five years of progress. Loran, a new and better aid to navigation, using 1950 kHz was unique at the successful Radiation Laboratory devoted primarily to radar.

Not unlike other scientific and engineering developments of the 20th Century, Loran evolved and attained global coverage by the effort and skills of many. Likewise, success of the MIT Radiation Laboratory rests on the talents at the Cambridge site, while industry's role is equally notable.

The story of Loran development and implementation quickly brings to mind Vannevar Bush, James B. Conant, Alfred Loomis, John Alvin Pierce, Richard Woodward, Admiral Julius A. Furer USN, Captain Lawrence M. Harding USCG, Melville Eastham, and others whose contributions to the new systems were substantial.

It should be stressed that beyond the laboratory and industrial production, thousands of civilian and military personnel (heavily USCG) made system implementation possible under the most arduous wartime conditions in impossible geographical locations topped by severe logistic demands. The classification of Loran as *Secret* was a further challenge to be met during the war years. After the war, the classification was removed.

The aforementioned scientists and engineers provide the milestones for the narrative. Considering the events surrounding Loran in the 21st Century loses the anxiety, urgency and importance of the moment in late 1940 when the roots of Loran were formed.

The Setting

On 15 June 1940, the time of the fall of France, President Franklin D. Roosevelt approved the establishment of the National Defense Research Committee (NDRC) under the leadership of Vannevar Bush. Earlier in May, Bush proposed to President Roosevelt the concept of NDRC to coordinate, supervise, and conduct scientific research for war purposes except for flight. The presidential letter appointed the twelve members of the Committee and selected Bush as chairman. The NDRC was established on 27 June 1940 under the National Defense Act of 1916.

Bush, dean of engineering at MIT from 1932-38 and in 1940 President of the Carnegie Institution of Washington, spearheaded all the significant World War II scientific efforts and accomplishments of the war years. His goal was scientific research towards the creation of new military tools and techniques. The NDRC worked in close liaison with the military but independent of its control.

Bush's World War I antisubmarine warfare research experiences in 1917-18 demonstrated to him the need for independence in pursuing scientific and engineering work with the military. This was not lost as he organized the national scientific and engineering resources in 1940 to meet the new German threat. Cooperation between military, scientific and industrial communities does not always prevail.[8]

Alfred L. Loomis

Attention to Alfred L. Loomis, mentioned above, is essential to the Loran narrative. Loomis has sometimes been referred to as the *last great amateur of science*. His scientific and engineering experience in the period up to World War II included much of the leading technology of the mid-20th Century. Precise time measurement, microwaves, cyclotron investigation and development, and medical advances were only a part of his experience. In addition, during the 1930s, his personal laboratory that he funded and staffed at Tuxedo Park near New York City included national and international visitors from across the science and engineering spectrum. Microwave studies, later critical to radar, comprised one aspect of the ongoing work at his laboratory.

Loomis was equally at home in the world of academic science at the University of California in Berkeley, California; at MIT at Cambridge, Massachusetts; and on the Washington scene. His achievements on Wall Street in the 1920s provided him with the means to pursue and independently support his scientific interests. In early June 1940, Bush appointed Loomis to be the head of the NDRC Microwave Committee. In the following months, Loomis had full involvement with the Tizard Mission.

The Tizard Mission

Henry Tizard, an English scientist and administrator started in January 1935 with a small committee to address using advances in science and technology to strengthen defense against hostile aircraft. The timely and quick response of his committee brought a December 1935 British government sanction to build the first five radar stations, initially known as Radio Detection Finding (RDF), to detect hostile

aircraft. By September 1939, all the radar stations were manned and ready for action.

It became abundantly clear to England, after ten months of war, a newly–surrendered France, and the successful U-boats, that the need for technical superiority plus productive power was essential. England turned toward the United States.

Churchill, becoming Prime Minister in May 1940, supported the concept of a technical exchange with the United States. Most of England's secret war-related technical developments were to be included in the exchange. In August 1940, with the support of Churchill and Roosevelt under Tizard's leadership, the mission (formally called The British Scientific and Engineering Mission to the United States) arrived in Washington to encourage cooperation and share technical knowledge. It was anticipated that even with United States neutrality its industry would develop and produce the British technical secrets.[8]

Detailed sharing of scientific and technical knowledge of wartime developments of weapons and equipments between the two countries had not occurred. The mission's success turned out to be a major event in part because the personnel in Tizard's British mission included a mixed team of scientists and serving officers from Army, Navy and Air Force with battle experience to interface with the United States armed services and others in Washington. The goal of the mission was to provide a basis to develop and build new weapon systems enhanced by the technical exchange. Previously, the neutrality of the United States was a factor that inhibited England's interest in a scientific exchange. British documentation on all the classified wartime developments included books, manuals, circuit diagrams, blueprints, films and notes. The 9.5 cm cavity resonant magnetron, developed early in 1940, provided a powerful source of microwaves and became the cornerstone of a number of United States- designed radars in the following five years. This mission and the technical information exchange in the late summer and early fall of 1940 provided the United States with what turned out to be a sixteen-month window of preparation before December 7, 1941.

At the time of the Tizard Mission visit to the United States, it was understood that aircraft bombing of fixed land targets and aircraft hunting enemy submarines needed precise information about their

own location. Britain's long range bombing in Europe was constrained because of lack of an aircraft navigation system with a reach into central Europe. It should be noted that in 1937, a British navigation line of sight system providing latitude and longitude was proposed. Location of a ship or aircraft was determined by the time difference of arrival of radio signals (20 to 85 MHz) received from two or more fixed transmitters. Development of the secret system called *Gee* (short for *Grid*) began in 1940.

Relevant to this, Tizard put forward his opinion that North America was the ideal place to work on the development of a long-range navigational system because of the on-going hostilities in Britain precluded testing. At that time, the desired system independent of weather conditions should have a range of 1000 miles or greater with an accuracy of the order of 5 miles.[9]

MIT Radiation Laboratory: A Sixteen-Month Head Start

The environment for the exchange was enhanced by the newly formed NDRC under Vannevar Bush with his knowledge and workings of the American scientific academic and industrial community. On October 16, 1940, shortly after the meetings with the Tizard Mission, the NDRC contracted with MIT* to be the site for the Radiation Laboratory (Rad Lab) to pursue radar in various forms and to implement the recently- developed British magnetron capable of creating powerful microwaves. The first Rad Lab staff meeting was held November 11, and the first assignment on that date was to design and improve night-fighter radar. [10] Officially, the Radiation Lab operated from October 1940 until December 31, 1945.

By March 1941 there were 90 scientists and engineers at work. Late in 1942, the Rad Lab budget reached more than one million dollars; the staff was close to two thousand and in 1945 near four thousand with one-quarter academics and about five hundred of them physicists.[11] R&D in Radar was the primary focus of the Rad Lab.

*Loomis, Bush, and other NDRC officials recognized that a civilian research laboratory had to be set up outside of military control, using NDRC funding, to ensure that cavity magnetron technology was developed and deployed as quickly as possible. With Bush and Loomis having strong ties to MIT, it was selected as the location for the new laboratory. The MIT radar research laboratory was originally named the "Microwave Laboratory," but soon became "Radiation Laboratory", or "Rad Lab."

All the work at the Rad Lab was at the secret level during the pre-war and war years. This requirement placed another level of difficulty on the efforts.

OCTOBER 1940 - JUNE 1942

Loran Begins

At its meeting on October 1, 1940, the Army Signal Corps Technical Committee established requirements for a "Precision Navigational Equipment for Guiding Airplanes."

In view of the above and the recent the consideration of Gee by members of the Tizard group, in October 1940 chairman Loomis of the Microwave Committee proposed a pulsed hyperbolic ultra high-radio frequency system (30-40 MHz) to meet the Signal Corps requirements. The eventual system at a much lower frequency provided an accuracy of one percent at range of one thousand miles. Research on the systems started immediately by members of the Microwave Committee. In addition to being a strong influence on the Loran group, Loomis provided his personal financing to the early project awaiting government support. In 1959, Loomis was awarded the patent for Loran Long Range Navigation System.

By early spring 1941, the task to investigate this approach was transferred to the MIT Radiation Laboratory with government support. As it was the third Laboratory assigned task, it was referred to as Project III. Initially, the research was identified as LRN for Long Range Navigation (and on occasion Loomis Radio Navigation). The full time navigation group evolved at the Radiation Laboratory under the direction of Melville Eastham, President of the General Radio Company, on leave from Harvard. The starting team of four or five grew to about 30 by 1943.[12]

Initial Loran Efforts

A committee that included members of large electronic companies and the Radiation Laboratory personnel met on December 20, 1940 [13] and arranged for the procurement, installation, and field-testing of one pair of transmitting stations and navigation equipment proposed by Loomis.[14] Ranges of 300 to 500 miles for high-flying aircraft were anticipated. At the time of this early procurement, the design and

planning included a system operating in the UHF spectrum at frequencies of the order of 30MHz.

First Procurement[15]

Company	Equipment
Bell Laboratories	2 crystal controlled timers
General Electric	1 1.5-megawatt transmitter
RCA	2 receiver-indicators
RCA	6 high frequency pulse triode transmitting tubes
Sperry	2 receiver-indicators (independent design)
Westinghouse	1 2.5 megawatt transmitter

Experimental Phase

Sites for the system's transmitter testing were made available March 24, 1941 when the Radiation Laboratory received permits from the Treasury Department to use two inactive USCG lifeboat stations. One lifeboat station was located at Montauk on Long Island, New York and the other at Fenwick Island, Delaware. These stations provided a 209-mile baseline and were within a reasonable distance of the Bell Telephone Laboratories, the project coordinator. By June 1942, both experimental transmitter sites were operating. These early negotiations eventually in 1942 brought the Coast Guard into the Loran development effort. The Coast Guard's Loran role became important, broad and intensive during the World War II years and beyond.

After system analysis, laboratory and fieldwork, interest in the UHF (30 MHz) part of the radio spectrum waned. One of the system goals was to have navigation coverage of the North Atlantic maritime routes. UHF signal propagation coverage was inadequate. By mid-spring 1941, frequencies of the order of 2000 KHz offered coverage advantages and other attributes.

John Alvin Pierce

Pierce,[16] at Harvard Cruft Laboratories from the early 1930's, was experienced in radio propagation, including ionosphere pulse sounding. This aspect of radio wave propagation was critical to the evolving navigation system. On July 1, 1941, at the time when testing of the first hyperbolic radio aid to navigation was about to begin, he took leave from Harvard and worked for nearly five years at the MIT Radiation Laboratory with the navigation system team. His broad and important participation in the Loran development included determining the range of pulsed radio waves when reflected off the lower or E-Layer of the Heaviside layer.[17]

While attending Radiation Laboratory navigation team meetings prior to leaving Harvard, Pierce designed and had constructed a pair of 5 kW 2000 kHz pulse transmitters. The lower frequency transmitters were installed for testing at the Delaware and Long Island former USCG stations.

Propagation tests were made between September 3 and 22, 1941. The main receiving station was set up in the Ann Arbor, Michigan home of a University of Michigan professor. Pierce installed receiving equipment in a station wagon and made signal measurements at Springfield, Missouri and Frankfort, Kentucky. The tests indicated the possibility of stable sky-wave transmission. A range of 1000 miles with the low power transmitters and the ground wave range proved greater than expected. As a result, the work at UHF was abandoned before the delivery of much of the equipment on order.[18]

Pierce emphasized in his report of the measurement trip the need for an improved method for reading time difference. During the next several months, efforts by the Radiation Laboratory navigation team developed a trace cathode ray tube indicator capable of a 1microsecond measurement and a multiple trace for pulse matching the signal from the master and slave stations. Direct synchronization at lower frequencies was also achieved.

A month after Pearl Harbor, Pierce made additional 2.8 MHz-8.5 MHz long-range signal measurements in Bermuda. Satisfactory ground waves from the 5 KW transmitters were measured at a range of about 720 miles. Importantly, these tests established the practicability of nighttime sky waves from the E layer of the ionosphere. After further enhancement to transmitter performance, 1950 KHz was

adopted as the frequency of interest.[19]

Admiral Julius A. Furer

At the outbreak of World War II, Admiral Furer became the Coordinator of the Research and Development and the senior member of the NDRC. He coordinated widespread research that sped development of modern weapons systems for the Navy. These services won Furer the Legion of Merit on 30 June 1945. Based on the results of the navigation system testing, Furer felt that a navigational aid might be developed.[20] His support, together with that of others, helped to bring about this practical long-range navigation system to aid in the war effort.

In late March 1942, signal test results at 2000 kHz showing significant ground wave coverage and improved cathode ray tube presentation of the signals led Melville Eastham to present the results of this ongoing laboratory and fieldwork to representatives of the Joint Chiefs of Staff. He also proposed a series of tests along the Atlantic seaboard to determine maximum range and the possible development of an aid to navigation.

The plan was to construct a chain of stations installed and operated by NDRC. with results to be submitted to those most interested. The Army showed little or no interest, and Admiral Furer suggested that the Radiation Laboratory carry out the plan and keep him apprised.[21] The test sites would be located along the United States and Canadian Atlantic coasts. In the middle of May 1942, Canada agreed to cooperate and with two sites in Nova Scotia complementing the two United States sites. This was a beginning.

Admiral Furer, observing the evolving long range navigation system, felt that Navy guidance and assistance should be available to the ongoing research at the Radiation Laboratory. Further, an emerging aid to navigation system in the future would come under the USCG. In keeping with this and mindful of the Coast Guard ongoing responsibility for United States Aids to Navigation, with support from Captain F. R. Furth of the office of VCNO, Captain Lawrence M. Harding USCG was assigned as Navy liaison officer in the development and implementation of the navigation system. He was assigned as naval representative for Loran to the Radiation

Laboratory and to undertake any necessary field activities.

Captain Harding, formerly of the U.S. Lighthouse Service, was deeply experienced in marine radio beacon technology. The future jurisdiction and administration of Loran by the USCG stemmed from this early and increasing wartime involvement with the evolving navigation system. Intensive and broad participation characterizes the role of the USCG through the WWII years and beyond. Because of Loran's utmost secrecy, Harding's orders to temporary duty at Cambridge, Massachusetts were unknown to his immediate supervisors. It is interesting that Harding became responsible for the system designation acronym *Loran* (Long Range Navigation).

System Test

With the 100 kW transmitters installed and tested in June 1942, it was important to determine as quickly as possible whether Loran had practical and immediate value to the war effort; Harding initiated a month long sea test on the Coast Guard weather ship USS MANASQUAN to determine the service range of the system. Observations and tests were also to be conducted on board a Navy blimp by Pierce. Military aircraft flights equipped with Loran to determine performance and range were scheduled.

Blimp K-2 Test

The first demonstration of the use of Loran was made using transmissions from the Fenwick, Delaware and the Montauk, New York experimental stations, Pierce made readings during the K-2 blimp test, on June 13, 1942. Pierce's measurements were made on an improved model of the laboratory receiver-indicator as the airship transited 250 miles between Lakehurst, New Jersey and Ocean City, Maryland and passed over lighthouses, bridges, and towers with accurate map locations. Loran charts were not available and readings were recorded as the various identifiable points were passed. Calculations the following week indicated errors of less than 20 yards, and the average of all errors was zero, to the nearest microsecond.[22]

With the airship ready to return from Maryland, Pierce decided to home along a line of position from a distance of 50 to 75 miles offshore. With the Loran receiver turned off for an hour and the airship somewhere over the Atlantic Ocean, the receiver was turned on and set for the known reading at Lakehurst. Adjustments were made to the flight course in accordance with the Loran readings to head for the hangar. Upon landing, the blimp headed for the exact *middle* of the hangar.

USS MANASQUAN Test

Likewise, the month-long sea test June 17 to July 17, 1942 aboard USS MANASQUAN confirmed estimated values for sky wave performance at night and determined the range of service as 1400 nautical miles at night 700 for ground waves in the daytime. It was observed that in inclement weather not suitable for celestial navigation, that Loran provided the capability to maintain a useful line of position from one pair of stations.

Airborne Tests

On July 4, 1942 a B-24 equipped with a Loran laboratory receiver indicator made a test flight from Boston to Cape Sable, Nova Scotia. System performance data was obtained with signals from the Fenwick, Delaware and Montauk, New York transmitters.

On November 1, 1942, a PBY flight to Bermuda demonstrated the use of Loran in obtaining fixes. The results from these tests provided a basis for system expansion and its recommendation to navigational agencies.[23]

Summary: Mid-1942

The complete receiver design was completed and an order for 250 Loran receivers for ships was place with the Fada Radio & Electric Company. Philco was the builder of Loran receivers for aircraft. Loran transmitters with 100 KW, operating at 1950 KHz, provided ground-wave range of about 600 to 700 nautical miles over sea water and sky-wave range out to 1300 to 1400 nautical miles by night. Position errors were estimated at about one percent of the distance from the Loran transmitting station.

System Expansion Begins

The above mentioned June and July systems tests, notably the blimp test, resulted in immediate high level interest in the navigation system. The Navy, Army, and NDRC took steps to apply the system to the war effort. The Navy requested NDRC to immediately procure equipment and install Loran stations in Newfoundland, Labrador, and Greenland. Receivers were to be acquired for key United States and Canadian vessels.[24]

Responsibility was given to the Army Signal Corps to procure airborne receivers for all services. Additional Northeastern Atlantic installations as well as the in the Aleutian region were planned. The Navy Bureau of Ships and the Coast Guard were assigned full responsibility covering all aspects of the system, including the training of operators and technicians for ground and shipboard equipment

Following arrangements with the Canadian government, a slave station constructed at Baccaro, Nova Scotia operated with the double-pulsed master at Montauk Point and at a different pulse rate with a second master station constructed at Deming, Nova Scotia. By October 1, 1942, the stations went into operation under the Royal Canadian Navy. These stations were the beginning of providing the Loran navigation system coverage across the Atlantic to the European Theater of war. Navigation assistance was essential for the wartime convoys. The two Canadian stations and Fenwick and Montauk provided operations 16 hours per day with the stations manned by US Coast Guard and Canadian Navy personnel standing watches supervised by NDRC engineers.[25]

On January 1, 1943, authority over Loran was transferred from the NDRC MIT Radiation Laboratory to the Navy. On the same day, the Coast Guard assumed operation of the Montauk and Fenwick stations. At the same time, the Navy Hydrographic Office assumed responsibility for the computation, drafting, reproduction, and distribution of the Loran charts and tables. Radiation Laboratory prepared the early charts. For the Radiation Laboratory Loran team and the US Coast Guard, the North Atlantic, Aleutian, and Pacific Loran chains were in the future.■

Endnotes

1. James Phinney Baxter 3rd, *Scientists Against Time*, MIT Press. Cambridge, MA, 1968, p. 151.
2. Henry E. Guerlac, *Radar in WW II*, American Institute of Physics, Tomash, New York, NY, 1987, p. 531.
3. Baxter, *op. cit.*, p. 142.
4. Robert Buderi, *The Invention that Changed the World*, Simon and Schuster, New York, NY, 1996, p. 252.
5. Malcolm F. Willoughby, *U.S. Coast Guard inWorld War II*, USNI, Annapolis, MD, 1987 p. 150.
6. Jennet Conant, *Tuxedo Park*, Simon & Schuster, New York, NY, 2002, p. 163-64.
7. C. P. Snow, Science and Government, Mentor Book, New York, NY, p. 37.
8. Buderi, *op. cit.*, p. 31.
9. Conant, *op. cit.*, p. 181, 198, 231.
10. Orrin E. Dunlap, *Jr. Radar*, Harper & Brothers, New York, NY, 1946, p. 132.
11. Daniel Kevles, *The Physicists*, Aldred A. Knopf, New York, NY, 1978, p. 107.
12. John A. Pierce, editor, *Loran: Volume 4 MIT Radiation Laboratory Series*, 1948, p. 21.
13 *ibid.*, p. 21
14. *The Coast Guard at War: IV Loran*, Volume 1, Section 1, Chapter 1, p. 5. http://www.uscg.mil/hq/g-cp/history/Loran_1.html
15 Pierce, *op. cit.*, p. 20.
16. John A. Pierce received 1990 IEEE Medal for Engineering Exellence "For the design, teaching, and advocacy of radio propagation, navigation and timing which led to Loran, Loran C, and Omega."
17. John A. Pierce, Memoris of John Alvin Pierce: Development of Loran, Navigation: *Journal of th Institute of Navigation*, Vol. 36, No. 1, Spring 1989, p. 4.
18. Guerlac, *op. cit.*, p. 526.
19. Guerlac, *op.. cit.*, p. 528.
20. Willoughby, *op. cit.*, p. 152.
21. The Coast Guard at War: IV Loran, Volume 1, Section 1, Chapter 1, p. 6. http//:www.uscg.mil/hq/g-cp/history/Loran_1.html
22. John A. Pierce, Memoris of John Alvin Pierce: Development of Loran, Navigation: *Journal of the Institute of Navigation*, Vol.. 36, No. 1, Spring 1989, p. 5.
23. John A. Pierce, editor, *Loran: Volume 4 MIT Radiation Laboratory Series*, 1948, p. 404.
24. Guerlac, *op. cit.*, p. 529.
25. Guerlac, *op. cit.*, p. 530.

EARLY DAYS OF SUBMARINE DEVELOPMENT SQUADRON 12

by CAPT Frank Andrews, USN(Ret)

CAPT Andrews was Commander Submarine Development Group TWO in the period 1962-1964.

May 1999 was the 50th anniversary of a hugely successful effort of the U.S., Post WWII, Submarine Force. It was born the *DevGroup* but changed its name to *DevRon* when it started to become famous. Hanging in there for 50 years, still going strong, and still contributing. These are reasons enough to look back, celebrate, and look forward.

Origins

In 1946, many—mostly aviators and black shoes—thought the Submarine Force no longer had a mission. After all, the Soviets were building submarines not surface ships, and everybody knew submarines could not sink other submarines. Indeed, the Battle of the Atlantic in which as many as 700 or so German U-Boats were sunk by US–Allied forces, was strictly an aviator and surface ship triumph. US submarine efforts in the Atlantic were near zip.

On the other hand, U.S. submarine action in the Pacific against the Japs was simply superb. Hard to argue with the destruction of more than two-thirds of all Japanese shipping by maybe 1% of US Naval forces. But sorry! In 1946, we will fight Russian subs on all oceans but with the techniques of the *Battle of the Atlantic* not the *Pacific*.

Thus there were two challenges for the sub tigers just back from a monumental naval victory in the Pacific. The first—and with only a hand full of stripes to fight back—was tough opposition from the Surface and Air Admirals in the US Navy. The other was from Mr. Joe Stalin, Soviet Admirals, and their run for world hegemony.

The first Commodore of the DEVRON was Captain Roy Benson later COMSUBPAC. I talked to him in 1982 to obtain his input for an article requested by Bill Ruhe, Editor of the Naval Submarine League 's magazine THE SUBMARINE REVIEW.

Admiral Benson told me that a most important group in early 1946 was the Submarine Conference in OPNAV. The Conference had, in fact, been established in 1926 to bring recommendations directly to the CNO. Discussions in 1946+ centered on new missions and new type submarines. Conference ideas lead to the conversion of Fleet Boats to Guppies, to an SS Oiler design, a Radar Picket, a Troop Carrier and SSKs. New Construction, too. The Tang class was pushed as was the small SSK-1 meant to be mass produced with the latest in sonar and fire control equipment. Nuclear Power and Hydrogen Peroxide Power were subjects of major interest. Also discussed and later tried out were the SST (target and training), the X-1 (midget harbor penetrator), ALBACORE (single screw, body of revolution), and the SSG (guided missile launcher).

Admiral Benson said "Gin Styer , the assistant to OP 03, presided over the Conferences. Vice Admiral Lockwood, ComSubPac for most of WWII attended. Other attendees included Rear Admiral Jimmy Fife, John Scott, Carl Hensel, Dave White, Joe Grenfell, Rear Admiral Swede Momsen Sr., and Dan Daspit". In those days Op 31 was the only submarine designated group in the Pentagon. Daspit would be a Captain USN as would the above named conferees except Styer, Lockwood , Fife and Momsen. The latter two in 1946 were making ready to leave for New London and Pearl respectively.

There might be 75 or more submariners attending the conference meeting each month with maybe 10 from OP31 and the rest from various non submarine jobs scattered through out the Pentagon or even coming in from the Fleet. OP 31 would usually have the lead in initiating the agreed upon action.

In a later Oral History for the Naval Institute, Benson talked more in detail about his own actions that led to a Fleet based Submarine Development Group. In 1947, RADM Fife left Washington to become COMSUBLANT. He took Benson with him to be the New Development Officer on his staff.

In 1948, Benson sold Fife on the idea of a special Development Group of four submarines to work with the Under Water Sound Lab (USL), Woods Hole Oceanographic Institute, and any other scientific crowd Benson could encourage to visit and help. His mission was to devise means for countering the Russian buildup in submarines. His method was to use the group as a sea going test bed with solid

technical support from the best brains in the Nation he could contact, especially USL right down the Thames River.

Fife bought in and sent Benson to OPNAV to sell the idea as a precursor of a formal letter to CNO recommending action. Over several days of visit, Benson found universal agreement amongst the submariners there, was told no letter is necessary and that the CNO would immediately sign out a directive creating a Group in New London and one in the Pacific. This must have been the origin of Project Kayo telling the Fleet to set up means to *solve the problem of using submarines to attack and destroy enemy submarines.*

Keep in mind the relative youthfulness of these Submariners leading the post WWII Sub Force in new directions. For example in 1946, Grenfell (class of '26) would be 20 years in the Navy; Daspit (class of '27) 19 years; and Benson (class of '29) 17 years. And these men were really the old timers in the Submarine Force at the time having been the war patrol skippers in the first years of WWII.

Backing them up, working somewhere behind the scenes, were in fact the real WWII tonnage skippers out of the Classes of '31 like C.C. Kirkpatrick, Ramage, and Barney Siglaff; or Pete Galantin '33 or Rueben Whittaker '34 or a large group of double or even triple Navy Cross people of the Class of '35.

Think of it. In 1944, the Class of '35 would have had nine years in the Navy as they came to command. Names in the Class of '35, like Cutter, Dornin, Maurer, Fluckey, and many more will always be part of Naval Submarine history. And this does not begin to mention others like Rindskoff, Dave Bell, Street and many other Navy Cross skippers in classes after '35.

Bottom line! This young and junior gang that sunk two thirds of all the Japanese shipping in the Pacific was not about to be told in 1946 by anybody, especially Air and Surface Admirals, that US submarines no longer had a mission.

USS K-1

In fall 1950, I received a set of orders as PCO of the new construction USS K-1. It was to be assigned to the DEVRON on commissioning and was to be my introduction to the unique culture of this organization.

K-1 is a story by itself but all part of Project Kayo and derived from the 1946+ meetings of the Submarine conference in OPNAV. In his Naval Institute Oral History, Benson gives RADM Momsen credit for being the lead conferee in pushing the K-1 design through OPNAV.

The Submarine conference was stimulated greatly by the German Type XXI submarine design. Thus followed the array sonar, the snorkel, and thoughts about mass construction, and a streamlined hull.

Commander Hank Arnold, a Submarine EDO and class of '37, was the Navy member of a U.S. team that went into Germany a few days before VE day. He told me that the group's purpose was to locate and document military R&D efforts of Nazi Germany. Details about the Type XXI were one of his group's discoveries as was the German study of heavy water. This Type XXI was motivated by Admiral Doenitz's discouragement in 1943 with the major losses of his Type VII and IX boats. In late 1943, a group of first class German ship and weapon designers were assembled for months in a secluded mountain area with funds and orders to do something. They did so and the Type XXI was the result. It became operational in 1944. It was semi mass-constructable, had a stream lined hull and super-structure, a super size battery and array sonar and a snorkel.

By war's end in 1945, 119 of these boats had been completed. None ever made an effective operational patrol because of difficulties with hydraulically operated equipment like periscopes and diving planes and the like. Designed speeds were 16 to 18 knots (hour rate). One of the Type XXIs was delivered to the U.S. for operational test. This information plus that from Arnold's group made a significant impact on the thinking of the Submarine Conference in OPNAV.

K-1 joined the DEVGROUP in 1951. The boat was meant to be mass constructable following the idea of the Type XXI. Hence the letter- number on the hull instead of the traditional fish name. It had a crew of about 40 , four tubes forward , three small diesel engines, a length of 196 feet, and maybe 8 knots max on the surface and submerged. The diesels were actually the type used as the auxiliary diesel on a Fleet Boat.

The main thing K-1 brought to the DEVGOUP mission was the first operational large passive array sonar—called the BQR4. It was

built by EDO Corporation and meant to be an improved mimic of the bow array found on the Type XXI sub. On its first real Fleet exercise off Bermuda, snorkeling HALFBEAK was picked up at 30 miles and tracked for 4 hours before simulated attack. And this at a time when operators knew nothing about Convergence Zone propagation. We did understand reducing self-noise, had a *rig for Ultra Quiet* bill and regularly practiced hovering. In Ultra quiet, every thing was turned off except the master gyro and a small lube oil pump used for lubricating the main motors. The boat was hot but very quiet. And we knew nothing about the CZ.

Lack of mobility eventually killed the K-1 class. On exercises in those days, all the Guppies or regular fleet boats would be along side by Friday at 2PM. K-1 would be in at 11AM on Saturday. Also the boat was in no way mass-constructable.

For myself and the rest of the wardroom, we received a great introduction to the culture of the DEVGROUP established by Roy Benson. That culture concentrated on an open door for all members of the scientific community and industry, a willingness to test out any new piece of equipment at sea and much time spent planning and executing full scale exercises. Close liaison was maintained with the British , who were keen on proper exercise data taking and analysis. And ADMINs were practically unheard of.

Later when I came back as Commodore, I was to learn more about the significant ASW sponsored research effort taking place in the Universities, in the Government Labs and in Industry. The Office of Naval research (ONR), a Committee on Undersea Warfare of the National Academy of Science (CUW) and BUSHIPS were major players in designing an all around navy to cope with the ever strengthening threat of the ever increasing numbers of Soviet submarines .

Some other details about K-1in 1951. The assumed target of the day was an eight knot snorkeling, cavitating transitor. Even so the fleet boats in the DEVGROUP with their JT sonar were detecting at maybe 9000 to 12000 yards. K-1's sonar was a broad band detector. Spectral analysis was later adapted from SOSUS work but used a paper plotter to show the line structure of a target. The Spectral Dynamics digital equipment did not come along until after1963. All elements in the BQR4 were analog. Classification was by *nature of*

sound. Sonar operators with good ears were valued people. We had one who was terrible ashore and we did hold up getting underway several times to manhandle him aboard . Wrong probably, but right for us.

Finally, we had access to all the *bearings only* fire control techniques. This included Lynch, Speiss, Cleerwater plots. And the Time-Bearing plot was a major tool. If the Bearing rate started to increase to like 5 to 8 degrees per minute, he was close so get ready!

On K-1, Joe Callahan'46 and Jimmy Carter '47 worked up the basis of the later-to-be-called Eklund Ranging Plot. We would head toward the target then across the line of sight to lead the target. Joe Callahan worked out the Math and Carter ultimately submitted the finished product as a *Qualification for Command Paper*. A few years later, Joe Eklund, as a Sub School Instructor, independently discovered and proved out the whole idea. I talked to Joe many years after. He had never seen the Carter paper. Joe deserves all the credit for the contribution since he did an excellent job of proving the method and training the whole Sub navy to use it. And Jimmy Carter made out OK.

I left K-1 in 1953 to go to command of HARDER, then to the David Taylor Model basin as Submarine Project officer. Here I met and became close friends with Marvin Lasky, a civilian scientist who was to be a major player in ONR's role in Propagation studies, in noise reduction studies and in the introduction of the towed array into the Fleet.

At my time at DTMB, noise reduction studies were just starting. Lasky's main project was looking at quieting possibilities that might derive from the single screw ALBACORE. Lasky and I made several sea trips with Jon Boyes who was then skipper of ALBACORE. It was Jon Boyes who convinced war time skippers like Slade Cutter that a single screw sub made sense for high speed submerged performance.

Two Years as Commodore (1962-1964)

This section is the one requested by Bruce Demars and Bill Browning. I was able to contact Jim Bellah, Art Gilmore, Cal Turk and Herb Crane for input. I would have liked to contact Sam Francis, Dan Bailey, Peter Hamilton-Jones RN and Art Jerbert also but time

ran out. Actually Jerbert retired from the Navy within two months or less after I arrived, but the TAG that was sold on my watch owes much to him and Robin King RN–both of whom worked for my predecessor , Jim Zurcher.

My list of major happenings with much help from those named above for both the historical compilation as well as the accomplishment at the time follows:

1. Creating a Tactical Analysis Group (TAG)

Exercise Analysis was being done in all earlier eras but the job was getting too much for hand techniques. Also Officers with Op Analysis training were becoming available. Charlie Woods, later Devgroup Commander, was in OPNAV at the time and with support from his boss, RADM Jack Maurer, got BUPERS to provide the billets.

In my time and before, much good exercise analysis took place and we did do barrier exercises to collect data for the various elements in the Weapon System Effectiveness (WSE) equation. However under Mike Moore, who relieved me , the Big Daddy series of exercise really took off. Sea data on Sub vs. Sub, collected rigorously and realistically, was to make a major impact on the McNamara people in Washington.

The first TAG leader was Big Don Whitmire, an all American football player before he came to the USNA. Hence the name *Big Daddy* exercises.

2. Measuring L-sub-S and calibrating the BQR2

Submarines were not collecting Sound Pressure Level (SPL) data in 1962. Considerable development had taken place at USL before this time, including the basics of calibrating the BQR2 sonar.

Commander Sam Francis, staff sonar officer on my tour, put together a manual for measuring Ls which was promulgated as the way for the operators to execute the action. I remember making a visit with Sam and Dennis Wilkinson, OP31, over to NISC to discuss the matter. At the time they had done very little thinking on the matter. The introduction of the methodology was a Sound Lab and DevGroup project. Art Gilmore was staff sonar expert and was

heavily involved in this and a multitude of other DevGroup sonar considerations.

3. Torpedoes

DevGroup produced the first firing doctrine for the Mk 37 torpedo. Firing scenarios were tested using the simulation programs available at Electric Boat. The WetHen Plotter was devised by the UK officers affiliated with DevGroup and further refined by the DevGroup (Cal Turk and Herb Crane). The device was manufactured and distributed to the Fleet by the Group.

DevGroup was also called upon to analyze under ice firings of the Mk 37 and some firings at Dabob Bay associated with sea surface capture of the fish.

4. Barrier Exercise data for OP 03 to sell the 637 class

Data collected over the past 6 years was put together as best we could given the different conditions existing when it was collected. It was mostly on SS vs.SS. But some was available from TULLIBEE and THRESHER OPS.

This started out as a matter of our local interest as simply a part of the DevGroup's mission. But then SubLant in Norfolk and OP31 in Washington started to take a serious interest. The fight for funding the SSN 637 class was underway. The data gathering continued and I was to make several presentations in OPNAV. The reports were well received because little analysed data on SOSUS, or VP aircraft or Surface Ship versus Submarine existed at the time. DevGroup and Squadron 10 then became involved in a major report described in the next item.

5. Preparation of a 637 Report to support selling the 637 Class

DevGroup and Squadron Ten were tasked to examine submarines against transitors, intruders and as trailers or surveillance OPS and as Carrier task force escorts. Squadron Ten covered Trailing and Escort OPS They had the experience—limited as it was—on the SKATE and SCORPION class under their command .

The report turned out to be a major effort coordinated by my class mate Norm Nash out of SubLant Norfolk. Many man hours

were spent on the lower base headquarters talking with Hank Hannsen from Squadron Ten and our own people. Bo Coppedge was the coordinator from OP31 and Dennis Wilkinson as OP31 was probably the 2 star leader in OPNAV to put it all together for the big pitch to whomever.

6. Sonar equation manual with data

In 1950 Captain Barney Siglaff put together a DevGroup briefing team to visit the entire Submarine Force and elsewhere in the Navy. His goal was to sell Sub vs. Sub. My classmate Charlie Bishop was Barney's Sonar officer and would attempt to teach the sonar equation to the attendees. It was a new concept. Many never did learn the meaning of its term and some would take a long time. The notion of decibel was particularly hard to grasp.

On my arrival in DevGroup, Art Gilmore taught me the Equation and how to use it to predict detection ranges if one had the right input numbers. And Sam Francis had the numbers. He put them in a loose leaf notebook called his "wizard book". He had obtained the data from the USNUSL people and the secret SAD (Sonar Acoustic Data) report by Urick and Pryce.

We all agreed it was high time to promulgate an operator's sonar manual for use in Range Prediction. Marvin Lasky of ONR sponsored a well known acoustician , Wysor Marsh at Raytheon, to work with Sam to write the Manual. It was first issued as DEVGROUP 1-62. It was simple to apply and best of all it had real data on the JT, BQR-2 and BQR-4. I think it might have been one of the forerunners of the outstanding submarine Naval Warfare Publication Series started later on by Bob Austin.

7. THRESHER Search

On 10AM, April 14,1963, a three officer meeting was taking place on the waterfront in SubRon Office spaces. Present were myself; Sneed Schmidt, ComSubRon2; and John Dacey, ComDesDevGroup from Newport RI. In came the duty officer to report—THRESHER was down and in trouble. It was off Portsmouth on its first sea trials after a nine-month post shakedown availability in the Naval Ship Yard there.

Red Ramage, DepComSublant, was sent immediately to the scene on a destroyer out of Newport. A flag officer on site was deemed most important. Within 24 hours I was sent out to relieve him. It looked liked a loss with all 129 people in 7500 feet of water. My job was to take over the search for the hull there 220 miles east of Cape Cod. A Board of Inquiry was soon formed in Portsmouth chaired by Vice Admiral Count Austin, former President of the Naval War College at Newport.

There were two summer search operations conducted with myself as Task Group commander. All the debris was finally located and photographed.

Art Gilmore was on the Staff of DevGroup and went with me the second summer to be Chief Staff Officer. Jim Bellah took over the DevGroup while I was away and most importantly look after all of the many concerns and problems of dependents.

Art Gilmore wrote these words for this paper. "This was an unfortunate but necessary phase of CSDG2's work. The fact that THRESHER was located at all using the crude equipment that was available in 1963 had important long term National Security implications. The 1963 effort to find THRESHER brought many concepts and ideas to the fore and provided the seed for future underwater search and recovery efforts. Some of these results are now appearing in books such as *Blind Man's Bluff*.

Catholic University (CUA) and its Graduate Acoustic Program (1964- 1981)

I retired from the Navy in 1964 and joined the Engineering Faculty at Catholic University as a Professor and Manager of the Acoustics Graduate Program. **Catholic University's (CUA)** program was largely education. It was initiated because our Physics department was getting out of the business of applied acoustics and more interested in fundamentals of nuclear physics

More important for this DEVGRU/RON history is the story of the post WWII transition of the efforts by WWII National Defense Research Committee (NDRC) and its Undersea Warfare Division into follow on organizations and efforts.

In 1962, as DEVGROUP Commander, I was unaware of this

history. After coming to CUA I found that all Government Labs (NEL, NUSC, NUC, NADC Johnsville) and University Labs (University of Washington, DRL Penn State, DRL Texas, Harvard, UCLA, MIT) and Oceanographic Institutes (Woods Hole, Scripps, University Of RI) had developed from roots in the WWII efforts of the National Defense Research Committee, Undersea Warfare Division.

A Committee on Undersea Warfare (CUW) of the National Academy of Science and the Office of Naval Research (ONR) were formed almost immediately after WWII's end to take over from NDRC.

Much of the success of the post WWII ASW effort of American Submarines is based on this significant focus by civilian scientists on the problem of sinking submarines. The DEVGRU/RON was both the recipient and contributor to those civilian organizations involved:

Recipient because of techniques furnished by the scientific community on noise quieting (sound mounts, acoustic filters, balancing techniques); signal processing for sonar (spectral analysis and multi beam digital steering); towed and hull array transducer design; acoustic torpedo design; hull and propeller design and quieting; propagation loss studies (bottom bounce, convergence zone, shallow water effects), digital fire control systems; contributor because of the real world experience and data the Group was able to give to the Scientific people.

The development of nuclear propulsion is a separate story from all this above as all nuclear trained officers appreciate. With the advent of nuclear power a new and major dimension was added to submarine mobility and independence of the ocean surface. Nuclear propulsion dramatically changed naval warfare as did sail then steam in yesteryear.

I also learned about the *Journal of Underwater Acoustics* (JUA). It is a major publication of classified papers by civilian groups. It is sponsored by ONR and has been in existence for as long as the DevGRU/RON. Craig Olsen, Skipper of HARDHEAD in the DEVGRU/RON 1963 is now the Editor of this publication.

In the JUA, one will find eight articles by Marvin Lasky covering the history of Undersea Acoustic developments from 1916 to about 1980. Any researcher on the subject of Submarine versus Submarine

Warfare would learn much from Lasky's reports. Lasky was given two civilian *Distinguished Scientist* awards for his work in ONR in bringing Towed Arrays into being.

Summary

In the beginning (1946 Post WWII) for the Submariners , the enemy was gradually identified—The Soviets because of their big Submarine Force build up and the rest of the Navy from the usual competition for defense dollars

Using the Submarine Conference in OPNAV, young vets of a huge WWII success in the Pacific campaign commenced moving with great energy and foresight taking full advantage of German innovations. Their goal—to make submarines useful to the mission of the U.S.Navy.

ONR and the CUW replaced NDRC after WWII. The two former groups provided the applied acoustic research necessary for solving the sub vs. sub problem.

Project Kayo was initiated to match at sea experience with Tactical Development.

Prototype and Brassboard model of equipment could be tested at sea.

DEVGROUP/RON became a center of Fleet tactical thinking for Submarines. As the first DevGroup leader , Roy Benson was a key contributor, but so were many other submariners.

The early DEVGRU/RON attitude of open shop and tell the truth based on sea trials was established by Captain Benson and has been maintained over the years.

K-1 was a good try. It introduced and quickly showed the effectivenes of the Hull mounted arrays for long range detection and aural classification. Its lack of mobility killed any follow up. It was not mass constructable.

DEVGRU/RON 1962—1964. Big items were: Creation of the TAG, Measuring SPL, Mk 37 Tactics, Barrier exercise data, SSN 637 study for OP31, Sonar equation manual, THRESHER search.

Fifty years of really significant progress by the Submarine Force's DEVGRU/RON came in many steps with each one building on the contribution of the segmented pasts.

Comment on a Future U.S. Submarine Force Contribution

I was privileged to be invited to a briefing by Jerry Ellis ComSubPac in November 1997 in Lockwood Hall. It was for the retired Submariners in the area. I was out in Pearl with my wife visiting our daughter who is married to a CEC officer.

RADM Ellis talked about the need to spread special equipment and assignments for mission development to individual boats and squadrons through out the Force. He had two reasons for this action. One was some uncertainty of the likely enemy targets and the other was funds.

Recently, I looked over a book by Pete Galantin, a very successful WWII sub skipper and former Four Star in charge of NAVMAT. The book's title was *Submarine Admiral*. It is his history of his time in the Navy.

It was interesting to see the similarity between the two views; one post Cold War and the other post WWII.

From RADM Ellis I heard diversity of equipment and missions such as mine field penetration, missile ops-coastal sub targets, escort of SAG and carriers, surveillance, deep submergence and open ocean attack.

From Adm Galantin I read that the Submarine Conference idea lead to the conversion of Fleet Boats to Guppies, to an SS Oiler design, a Radar Picket, a Troop Carrier and SSKs. New Construction, too. The TANG class was pushed as was the small SSK-1 meant to be mass produced with the latest in sonar and fire control equipment. Nuclear Power and Hydrogen Peroxide Power were subjects of major interest. Also discussed and later tried out were the SST (target and training), the X-1 (midget harbor penetrator), Albacore (single screw, body of revolution) , and the SSG (guided missile launcher)."

For the post WWII submariners, the SSK mission soon emerged as the primary one for attack boats. And the Polaris mission came forth too. But not in terms of cruise missiles.

I think the best future strategy is to hang in there and try lots of things. Eventually the primary direction will emerge.

There certainly is as much brain power and heart around today in the Sub Community as there was in 1946. I would expect the same future success as that produced in the past.■

TORPEDO TALES (PART I)
A FIRST PERSON ACCOUNT

by TMC(SS) Patrick Meagher USN(Ret)

TMC(SS) Patrick Meagher USN(Ret) qualified and served on USS CUSK SS-348, USS ANDREW JACKSON SSBN-619B, and USS BARBEL SS-580. He served on active duty with the Submarine Force from 1960 through 1977. He is a life member of USSVI, and an associate member of USSVWWII.

In early 1973, late January I think, we went out on Prospective Commanding Officers (PCO) ops for two weeks. We were scheduled to shoot about 30 torpedoes during that two week period. This was our first torpedo shoot since the previous summer as we had spent the previous six months deployed in WestPac, so we spent some time in the torpedo room checking everything and talking over how we were going to handle a daily shooting schedule that would run from sunrise to almost midnight.

The PCO class was planning to shoot MK 37 torpedoes after sunset. The MK 37's would have strobe lights for the torpedo retrievers to locate them. At that time I had a TM2 (SS), Henry Hernandez and four TM3s (SS), Scott Hayes, Walter (Ski) Sluzarski, Bob (Army) Armstrong, and George Cox for a torpedo gang, all with limited torpedo shooting experience. For that two week period I went off the watch bill so I could supervise torpedo preparation, loading, and firing. Everything went well for the two week torpedo shoot. We shot everything and the torpedo gang got a lot of experience. It was during this PCO op that we saw our first problem with the MK 45 Mod 2 torpedo that used the flex hose dispenser. I think we shot two and one *ate* the flex hose before it left the tube. The TM who had made up the flex hose told me that he had tucked the hose under the rubber retainer and there was nothing for the propellers to grab as the torpedo started-up before swimming out of the tube. I passed that on to the Gun Boss, LT. Bill Marks; *a MK 45 eating the flex hose is a big deal*! The warshot MK 45 torpedo had a nuclear warhead. It was wire guided, you could steer it to intercept the target submarine and

command detonate the nuclear warhead by backing down the *run to burst* command to the vicinity of the target submarine. The warhead was a W-34 also used in *Lulu*; the MK 101 air dropped depth charge[1]. The W-34 warhead had a yield of nine kilotons! If the MK 45 torpedo eats the flex hose before it leaves the tube you can't steer it to intercept the target submarine, the *run to burst* setting may be set to minimum safe range at the ordered running depth, and it is now running at reduced speed with broken propeller blades and counting off range from propeller shaft revolutions calculated at 40 knot running speed. I think you get the picture!

We continued to shoot torpedoes, at least 6 to 8 almost every week we were underway. We shot mostly MK 16 Mod 8's and MK 37 Mod 2's; the wire guided MK 37 that used the flex hose dispenser. There was no problem with the MK 37 using the flex hose dispenser because there was about 3 feet between the torpedo propellers and the face of the flex hose dispenser. Not so with the MK 45, there was only about eight to ten inches distance between the propellers and the face of the flex hose dispenser. We continued to shoot a few MK 45's with an occasional *flex hose eater*. The Gun Boss told me that the opinion of *higher-up's* was the torpedomen were not making up the flex hose correctly. I assured him we were. After this discussion I got together with the torpedo gang to figure out what we could do about the MK 45 flex hose problem. I told them I knew they were tucking the hose under the rubber retainer properly, however in the future I would personally verify the lay and tuck of the flex hose prior to closing the breech door on the tube. We kicked around some ideas about what was causing the problem.

Was the lay of the hose as it payed out of the dispenser, like at 12 o'clock, or 3 o'clock, that sort of thing, a problem? Was the *tuck* not tight enough?[2] Or could some of the MK 45's be taking more time than others to get out of the tube, or possibly the torpedo was moving rearward after the torpedo tube stop bolt rolled and the motor and propellers came up to speed to drive it out of the tube? I decided that we needed to get some stop watches and start timing a couple of events. Time between stop bolt rolling and seawater scoop on the battery dropping (you can hear the scoop drop) to when the propellers start turning, and then when it leaves the tube. I also decided to document the lay and tuck of the hose on the flex hose dispenser

using a Xerox copy from the torpedo Ordnance Publication illustrating make up of the flex hose to the torpedo payout tube. This data, tuck and lay of the flex hose and timing of firing events I passed to the Gun Boss to add to the torpedo firing reports.

We continued to shoot MK 45's on a regular basis and discovered with the next *flex hose eater* that it was a slow-starter. The stop watch timing told us the time between battery scoop dropping and the torpedo starting to move out of the tube was a couple of seconds longer than regular starters. With the *flex hose eaters* you usually had a lot of *junk* left in the torpedo tube you had to clear out. Pieces of propellers, chunks of flex hose, that kind of stuff. So we were looking at that to see if it would tell us anything.

Our next big torpedo shoot was two weeks of PCO ops in early summer. We had about 30 fish to load and shoot again. I think we had 4 or maybe 5 MK 45's to shoot during the two weeks. As it turned out one of them was a *flex hose eater*. By this time we had a pretty good data base and knew that it was slow-starters causing the problem. I didn't have to talk to the gun boss or skipper about the MK 45 problem because the data we were collecting did all the talking for us. We didn't hear any more about the torpedomen not making up the flex hose properly.

I assume the skipper and Gun Boss, using the data we had been collecting in the torpedo room, were able to convince Squadron and SubPac that a real *test* needed to be conducted to confirm our data. So after PCO ops we loaded six MK 45 exercise units and a tech rep from the torpedo station in Newport R I. came aboard with some special test gear. On Monday evening he hooked up a rod assembly that was attached to the MK 45 tail button and lead out through the guidance wire tube in the breech door. The purpose of the rod assembly was to determine if the torpedo was moving aft in the tube when it was released by the stop bolt. We flooded the tube, equalized with sea pressure, opened the outer door, and hand operated the stop bolt to the fire position. We got the diving officer to change the angle on the boat up and down by a degree or two. In the 15 minutes or so that we *played* with his *test gear* there was no movement of the torpedo. We closed the outer door, drained the tube and removed the rod assembly. The next morning the tech rep installed a modified flex hose dispenser cradle that had a linkage assembly on it that would

monitor torpedo movement rearward when the torpedo was actually fired. He made up the flex hose on that torpedo.

No movement rearward was noted when we fired the torpedo. We also had a fire control problem on the first two shots that created a lot of confusion. After launch the torpedo was observed to jump out of the water and shut down within 200 yards of the boat. Initially we thought it was an erratic torpedo. The same thing happened with the next torpedo we fired. The FT's solved the problem in about 15 minutes. It turned out the *run to enable* setting handle on the MK 15 Weapon Monitoring Panel (WMP) in the torpedo room was in the manual position and had overrode the setting from the MK 101 fire control system. As it turned out position of the setting handles on the WMP were not noted on the fire control checklist. The last five MK 45's were prepared by the TM's with the Tech Rep observing. We continued to record data as usual. It was either shot number five or six, I can't remember which, that was the slow starter and as expected ate the flex hose. The Tech Rep was convinced as we were that the flex hose problem was caused by the MK 45's with slow starting batteries. The extra couple of seconds in the torpedo tube until the torpedo started moving out of the tube was enough time for the propellers to wash some hose out of the dispenser to get entangled.

I was on BARBEL for about two more years. During that time we never heard a peep about the problem we had identified, No cautions, no warnings, nothing! You would think there would be some kind of all SubPac message alerting CO's to the problem with the MK 45 torpedo. Maybe there was, we sure didn't see it in the torpedo room. Knowing what was wrong with the MK 45 torpedo-flex hose dispenser combination certainly didn't leave us with good feelings about using the damn things in a real shooting war!

In 1976 I was on shore duty as a technical assistant in the tactical weapons shop of SubPac Staff. One afternoon LCDR "Tex" Hudiburgh, the tactical weapons officer, called me over to his cubical to show me the proposed fix for the MK 45 torpedo-flex hose problem. It had arrived by mail. It was a circular flat steel plate that was to be placed on top of the flex hose and under the rubber retainers of the dispenser. The hose was supposed to payout around the outside diameter of the plate and under the rubber retainers. Tex and I took a look at the plate and just shook our heads. There would

be no test of the flex hose dispenser fix in SubPac. As it turned out the MK 45 torpedo was withdrawn from service the following year. Let me tell you it was a happy day on the *waterfront* when the withdrawal message hit the boats!■

ENDNOTES:

1. Information on the W-34 nuclear warhead is available at www.johnstonsarchive.net/nuclear/wrjp159u.html

2. The process of making up the flex hose dispenser to the torpedo was as follows: With the dispenser sitting adjacent to the torpedo tube breech door pull off several feet of flex hose. Remove the plug holding the guidance wire in place and pull the slack out of the wire. Splice the dispenser wire to the torpedo wire. Place the flex hose connector over the torpedo payout tube and tighten the two sheer screws.

Install the flex hose dispenser cradle on the rear most torpedo tube roller. Install the flex hose dispenser (approximately 80 lbs.) on the cradle and tighten in place. (The next step is accomplished by feel using both hands around the outside of the dispenser which is now installed in the rear of the torpedo tube behind the torpedo.) Grasp the flex hose and feed all the slack back onto the dispenser face tucking it under the rubber retainer bands. Feed the guidance wire from the rear of the dispenser through the guidance wire tube on the torpedo tube breech door. Partially close the torpedo tube breech door. Plug the torpedo "A" cable into the breech door receptacle and lock it in the clamp assembly. Connect the plastic flex hose release tube from the dispenser flex hose release mechanism to the breech door connector. Close and lock the breech door and connect the guidance wire to the guidance wire connector.

ACKNOWLEDGEMENTS:

Much thanks to CAPT. William. L. Marks USN RET. and TMC(SS) George Cox USN RET. Both BARBEL shipmates reviewed my manuscript and provided additional important information and advice.

SEA MINES, THE SUBMARINE'S ADVERSARY AND WEAPON: 1775 TO 1918 PART II: 20TH CENTURY

by Mr. John Merrill

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Sea Mines, The Submarines's Adversary and Weapon: 1775 to 1918, Part I appeared in the January 2005 issue.

At the beginning of the new century, the relatively short Russo-Japanese War of 1904-05 brought naval encounters in the northern Pacific that proved costly in lives lost at sea and on land. Some of the losses were due to the defensive and offensive use of sea mines. It was a testing ground for sea mines against modern naval ships. Russian defensive mines prevented the Japanese from attacking Port Arthur, and the Japanese offensive use of mines impeded Russian ship movement to open seas.

Both sides as well as non-belligerents suffered severe losses from mines. In addition, there were self-losses by mining vessels. A further hazard from mines occurs when, due to storms or failure of mooring, the mines become adrift. Drifting mines as a danger continued throughout the century with hundreds of thousands planted in the various oceans.

This 19-month war focused attention to mines as an effective weapon, as can be seen by their broad use in successive wars at sea during the remainder of the 20th century. Previously, mines were placed in shallow water as an inshore weapon. In this war both sides used the mines in deep water. Russian mines were the cause of the largest number of Japanese ship losses.[22] The successful use of mines by the belligerents signaled mines had become an integral part of naval warfare.

Losses from Mines

Russian	Japanese
(Battleships)	(Battleships)
Petropavlosk sunk	*Hatuse* sunk
Pobieda, Sevastopol seriously damaged	*Yashima* sunk with crew
(Armored Cruiser)	*Ashi*, slightly injured
Bayan seriously damaged	(Coast Defense Ships)
(Cruiser)	*Hei Yen, Sau Yen* sunk
Boyarine sunk with crew	(Cruisers)
(Mine ship)	*Akashi* seriously injured
Yenissei sunk with crew (own mines)	*Myako, Takasago* sunk
(Gunboats)	(Gunboat)
Gremiatsky, Bobr, Otvagne sunk	*Kaimon* sunk
(Torpedo boat-destroyer)	(Torpedo boat-destroyers)
Vynoslow sunk	*Hayatori, Akatuki* sunk
	(Torpedo-boats)
	No. 8 and 48 sunk

The August 1905 peace negotiations held in Portsmouth, New Hampshire, and mediated by President Theodore Roosevelt resolved the conflict. There were additional impacts from the mines used during the war. Non-belligerent merchant ships were destroyed by mines adrift in the Yellow Sea because of poorly designed moorings or displacement by storms. It is interesting to note that no torpedo sinkings occurred during the war.

The Hague International Convention

With 44 nations participating, the Second Hague Peace Conference held from June until October of 1907 addressed the topic of sea mines. Increasing use of mines in wars from the middle of the 19th century and extensive use of mines during the Russo-Japanese War prompted the need for international regulation. Recognition of the efficacy and fear of sea mines is seen in Laws of War: Laying of Automatic Submarine Contact Mines (Hague VIII); October 18, 1907. Not all the participating nations had significant maritime interests. During the meetings, Great Britain was unsuccessful in convincing Germany and Russia to dispense with the use of mines altogether. This lack of agreement, especially between Great Britain and Germany, weakened the outcome of the Convention.

The Convention ended with thirteen agreed-upon provisions. Articles one and five were clear and unequivocal. Austria-Hungry, Japan and the United States ratified the convention unconditionally; France and Germany ratified it except Article 2; Great Britain ratified with a declaration; and Greece, Italy, Portugal, Russia, Spain and the South American Republics did not ratify it at all.[23]

> Article 1. It is forbidden-1 To lay unanchored automatic contact mines, except when they are to become harmless one hour at most after the person who laid them ceases to control them; 2 To lay anchored automatic contact mines which do not become harmless as soon as they have broken loose from their moorings; 3 To use torpedoes which do not become harmless when they have missed their mark.

> Article 2. Which forbids the laying of contact mines off the coast and the ports of the enemy, with the sole object of intercepting commercial shipping, is of limited value, for a belligerent has only to allege that mines were laid for a purpose other than merely intercepting commercial navigation.

> Article 5. At the close of the war, the contracting Powers undertake to do their utmost to remove the mines which they have laid, each Power removing its own mines.
>
> As regards anchored automatic contact mines laid by one of the belligerents off the coast of the other, their position must be notified to the other party by the Power which laid them, and each Power must proceed with the least possible delay to remove the mines in its own waters.

It is of interest that in 1907, the significance of sea mines on both navy and commercial navigation was fully sensed. The Articles relating to mines were scheduled to be effective in January of 1910. A second Convention addressing mines was scheduled for 1914, the year that World War I started, with mines becoming a significant weapon. Difficult to enforce, the mine-related Articles had little impact on the development of mines and mine warfare.[24]

After World War I, the drifting contact mine was banned, even if it was occasionally used during World War II. The drifting mines were much harder to remove after the war, and they caused about as much trouble to both sides.

The agreements agreed upon at The Hague were largely unenforceable. From a military standpoint they were impractical if mining was to offer any tactical or strategic advantage. This is borne out by the actions of the belligerents during World War I, when conditions prevented enforcement. The stipulations of the original 1907 Hague Convention were never updated or amended. They remain, for all practical purposes, the basic international agreement on mine warfare in force today.

In summary, "The Hague Convention denied any warship the right to sink an unescorted merchant ship without first sending over a boarding party to decide if its cargo was contraband."[25]

Pre-World War I

At this juncture, US Navy mine warfare capability as a significant weapon was limited both in producing mines as well as mine laying and sweeping mines. Great Britain was the resource for mine development. One of the reasons for the lack of acceptance of mines at this time and continuing into the 20th century came from an 18th century perception of mines. As mines came into use, mine warfare was persistently perceived as a weapon for second-rate nations. It was not considered in line with traditional naval ways of fighting. Over time, this caused a continuing cyclic approach to supporting mines. In wartime, strong interest in all aspects of mines prevailed. Between wars, research, and attention lagged.

As a result of the successful mining in the Russo-Japanese War and the world-wide attention to the 1907 mining discussions at The

Hague, the Navy requested Congress in 1907 for funds to convert certain cruisers of the Baltimore class (4500 tons, 20 knots) to mine depot ships. By June 1908, USS SAN FRANCISCO of this class was ordered refitted as a mine vessel and designated as a mine planter.

In 1909 with minimal ability to design and build mines, the U.S. Navy purchased the French-designed and -manufactured Sauter-Harle type designated as the US Naval Defense Mine Mark 2. This spherical mine with a contact inertia exploder and 175 pounds of guncotton came on the scene about 1909. Later in 1913, the French mine was used by the converted cruiser USS SAN FRANCISCO in mine laying and sweeping practice operations. Several years later USS BALTIMORE was modified and by 1915 conducted mining experiments in Chesapeake Bay and along the Atlantic coast. Later in 1918, USS BALTIMORE operated as a minelayer for four months in the 250-mile long North Sea barrage between Norway and Scotland.

Technical and chronological details of the evolution of the United States Navy sea mines starting with Mark 1 is found in Naval Weapons from 1883-to Present (1982) by Norman Friedman.

Other countries were following somewhat similar courses of action for mine warfare. France adapted cruisers of its *Du Chalya* class (4000 tons, 20 knots). For mine warfare, England modified the three cruisers *Iphigenia, Alatona*, and *Thetis* (3600 tons, 18 knots). Each cruiser was fitted for carrying 100 mines.[26] Attention to countermeasures were also addressed by Germany, Great Britain, Italy and Austria in the years leading up to the World War I.

Germany was in the forefront of preparing for mine warfare by specially designing, building, and launching the mine depot ship *Pelikan* (2360 tons, 15 knots) in 1890. Similar German ships, the *Nautilus* and the *Albatross*, were launched in 1906 and 1907 (1970 tons, 20 knots). In 1910, Russia initiated the development of a minelayer submarine called the KRAB, capable of carrying up to 60 mines, and commissioned in 1915. Performance of the mine-laying equipment did not meet expectations.

Germany's mine laying capability was such that two days after the start of the war, a minefield planted thirty miles off the English coast claimed a brand-new British cruiser. This and other success with mines and torpedoes is said to be attributable to the decade long

thorough development and testing by Germany prior to the start of the war.[27]

Mine developments prior to World War I in Europe included initial investigation of the magnetic influence mine. Counter-sweeping devices included mine wire cutters, snags, and explosive moorings.

At the beginning of the war, the U.S. Navy adopted a Vickers mine, the British Elia, licensed from Italy. The mine was equipped with a mechanically-triggered contact consisting of a 3 foot long protruding float and required the target ships to be within a few feet of the mine to be effective. Because of this contact mine's distance limitation and overall lack of reliability, England's immediate response was to bring 7,500 Russian mines left over from the Russo-Japanese War from the Pacific to the North Sea.

Later in a retrospective article, in June of 1934, the Naval Institute Proceedings commented about the capability of British mines in the early part of World War I. "These (mines) were so defective that German submarines, when pursued, would seek a British mine field and hide under for protection from attacking surface craft." Mine range and reliability, both elusive requirements, were pursued in the wars of the 20th century.

In September of 1916, an unexploded German E Hertz horn exploder contact mine was safely towed to shore and used for experiment and redesign. Consequently the redesigned British mine called the H2 became available in late 1917 in numbers that permitted offensive mining in enemy waters.[28, 29]

Subsequently, England used the first United States-designed mine, the Mark 5, a moored type with Hertz horns weighing a total of 1500 pounds with 500 pounds of TNT. Although the range for damaging enemy shipping was increased it was not an optimum distance. The Mark 5 was long lived and still in use in World War II.

Dardanelles and Gallipoli

A strip of water 38 -miles long by ¾ to 1-mile wide is the access to Constantinople and the Black Sea from the Aegean Sea. In 1909, British war planning included strategies for taking control of the Dardanelles and having access to the Turkish capitol and beyond.

In the latter part of 1914, German Army officers and men assisted

Turkey in fortifying the waterway with mines and howitzers and gun fortifications. It is of interest that the mines came from diverse sources. Russian mines found floating in the Bosporus were salvaged, refurbished and replanted. While French mines from Smyrna were also used. In addition, Bulgarian mines left over from the second Balkan War in 1913 were sown. With a total of about 300 mines, the defensive mine fields when completed along the Dardanelles included contact and shore detonated mines for miles across the waterway.

A British plan to take control of the waterway was put into operation in March 1915. It envisioned that a naval force would transit the Dardanelles. The intensive mining, combined with the shore batteries and mobile howitzers that could reach the minefields, brought the intrusion to a stalemate. British minesweeping was countered at night by the use of Turkish spotlights and enemy mine reseeding. An early Turkish mining of 20 mines sank the three British battleships OCEAN, BOUVET, and IRRESISTIBLE. In summary, the British battleships were kept at bay by mobile howitzers and the minefield batteries while the contact minefields blocked passage.[10] During the following ten months thousands of Allied troops tried unsuccessfully to advance using amphibious assaults along the Gallipoli peninsula with its awkward geography in a battle where relief, supplies or evacuation were impeded by the enemy mines and fortifications. With losses of more than 200,000 lives, British forces left in December. The total losses on both sides exceeded half a million. Integrated defensive mining was effective.

Germany's Mine Laying Submarines

During the War Germany constructed more than 350 submarines. The submarine minelayers are of interest. Naval Institute Proceedings November/December 1915 reported on German submarine mine layers with airtight chambers where mines, primarily contact type, are placed ready to be sown. A delayed rising mine was also used. The stowage chamber is flooded and the mines are released and sink. The 110-foot-long UC-5, an UC-1 type, was one of the 114 minelayers. In a 9-month period on 29 patrols, the UC-5 laid 200 mines and sunk 29 ships before it grounded and was scuttled. The UC-5's record was characteristic of the minelayers.

World War I German Mine Laying Submarines[31]

Type	Launch	Number	Mines	Crew
UC-1 Coastal Minelayer	1914-1916	15	12	14
UC-2	1915-1917	64	18	14
UC-3	1916-1918	16	14	32
UE-1 Ocean Mine Layer	1915-16	10	38	32
UE-2	1916-18	9	42	40

After the disaster at Gallipoli, Lord Herbert Kitchener, one of England's highly-ranked and important Army officers and a significant figure in the struggle on the Turkish peninsula, was dispatched in mid-1916 to go to Russia to encourage that country to persevere in its struggle with Germany. He was en route aboard the cruiser HMS HAMPSHIRE when the naval vessel struck a mine laid by a German submarine and sunk in ten minutes. Kitchener was drowned.

British Mine Laying Submarines

Between 1912-17, the Royal Navy constructed 58 E-class submarines capable of operating in blue water. Six were converted into mine layers. These submarines were responsible for sinking about 100 enemy ships off the German coast. Subsequently, they were used for mine laying in the English Channel.[32]

Responding to Mines

In late September 1914, weeks after the start of the War, England was taken aback by the loss of the three armored cruisers on the same day by a German submarine. This event and an increased sense of the danger from mines formalized England's War Orders on January 1, 1915 to take additional steps to be alerted to the presence of enemy submarines and mines. The orders provided prize money to trawlers and other vessels to report U-boat movements and participate in the capture or sinking of U-boats. Destruction of floating or moored enemy mines brought awards of £5 or £10. None of these measures

proved effective.[32] Early enemy success with mines and submarines was not anticipated. Preparedness for countermining was lacking and in the case of the enemy submarine, there was no antisubmarine device to detect its presence when submerged.

Later in the war, the United States like England would have mines planted by U-boats along some of its seaports to interdict commercial shipping. The ports required mine clearing. As the war began the United States minesweeping force consisted of only three converted fleet tugs and a few fishing trawlers.[34] Eventually, defense involved ten tugs on permanent minesweeping. Later the force was augmented by lighter mine sweeping equipment on destroyers and torpedo boats.

After United States entry into the war, a steel net was sunk across the Verrazano Narrows between Brooklyn and Staten Island to keep German submarines out of the inner harbor. German submarines planted mines around Sandy Hook, and 16 tugboats based at Staten Island were turned into minesweepers. "Working in pairs, they swept the ocean every day for 100 miles out from Sandy Hook, finding and exploding a large number of floating mines."[33]

Germany's early, continuing, and expanding submarine successes shifted Allied naval efforts to a stronger defensive role. These efforts bought about the development and implementation of simple hydrophones for submarine detection along with TNT depth charges, sea mines, and, later in the war, broad convoying of merchant ships. Each contributed to eventual victory.

Sea Mines and the North Sea Barrage

Plans for mining the North Sea from Norway to the Orkneys, off Scotland, to deter the U-boats en route to the Atlantic were under consideration as early as 1915. In 1913, a British war plan considered mining the Heligoland Bight off Germany's North Sea coast and the Strait of Dover with 50,000 mines. This was dropped because of cost. The extreme merchant shipping losses brought it to the fore again in 1917. The ship losses for April 1917 escalated to 900,000 tons.

This was a very critical time, as the German submarine war against unprotected merchant shipping was succeeding. Ventures against the U-boats irrespective of the approach always demanded inordinate support including manpower, equipment, and financing.

In the spring of 1917, two concepts, each a huge undertaking, were competing for immediate implementation and support. A consensus for greater support for merchant ship convoying to stem the U-boat was finally reached at this time. The barrage was also approved but with some restraint. Before long, the success of convoy enhancement became evident.

As planned the length of the barrage was 250 miles with a width of 15 to 20 miles. Initial estimate of the number of mines required as 120,000. This required number was substantially reduced with the development of the United States MK 6 (moored contact type mine), designed around a new galvanic firing device. Working at the Naval Torpedo Station in Newport, Rhode Island, Ralph C. Browne invented the mine's firing device.[36] The MK 6, in addition to Hertz horns, was equipped with two 70 foot vertical underwater antennas, one held above the mine by a float and the other the mooring cable below attached to the mine's anchor. Actual contact of the mine by the enemy vessel was not necessary. Contact by the U-boat with either of the mines vertical antennas produced galvanic action and initiated the explosion.

Enemy vessel contact with the Hertz horns provided an additional opportunity for an explosion.

The MK 6 vertical antennas above and below the mine substantially increased vertical and horizontal coverage and decreased the number of mines needed for a given area. Further, it did not require specialized minelayers and released mine layers for other assignments. The mine with 300 pounds of TNT was dropped from rails off the stern of surface vessel in water 30 to 3000 feet deep. Long-lived it was widely used from 1917 to about 1985. British mine planting began in March and that of the United States in June of 1918 and continued on until October as the war was moving to an armistice. Large mine laying ships could lay 5,000 mines in a four-hour operation.[37] Cruisers USS SAN FRANCISCO and USS BALTIMORE converted to mine laying were both assigned to the North Sea barrage and achieved laying thousands of mines in a few hours, Premature explosions of the MK 6 did not portend success. The United States contracted with automobile manufacturers to manufacture 6,000 mines a week. The United States produced, shipped and planted 56,611 mines and England planted 16,300. An estimate of the

cost of the barrage in 1918 dollars was $40 million.[38]

The barrage is deserving of historical attention both as an important high-seas mining operation and an incredible engineering and logistical challenge achieved in a short time. However, as commented in 1966 by Philip K. Lundeberg, "it proved less than an unqualified success." Mine laying operations started in June 1918 (six months prior to the end of the War). Lack of performance may be attributed to the haste of mine development and manufacture and the results of the barrage on a longer war are unknown.

Another and darker view of the barrage and the uncertainty of its effects was presented by "Submarine Mining, Orphan Child of the Service" Naval Institute Proceedings, 1934. In addition to pointing out the Navy's cyclic interest in sea mines, the article raised questions regarding the barrage's overall viability. As noted above, the barrage was only completed a few months before the end of the war and its long-term capability was not tested. From the article:

> "It is a fact that only 43 percent of the mines were on duty when, after the war, the mine sweepers cleared the fields and this was only a matter of months after they were laid, whereas they should have stood guard for several years...who classed the venture as "a bluff that worked"".

Magnetic Mines

By 1918, British researchers developed and implemented the magnetic influence mine. The mine, the concrete-cased M-sinkers resting on the bottom, detonated when they sensed a ship's magnetic signature. A bottom location provided the necessary constant magnetic reference to be able to detect the presence of the magnetic steel hull of a vessel or submarine. Features of the magnetic mines included no requirement for a mooring cable. Further magnetic mines resting on the bottom were difficult to sweep. Magnetic mines introduced late in World War I needed further development. During the inter-war years, enhancements made them a better weapon and both sides in World War II widely and effectively used them.

With the war ending in the first year of deployment, 1918, and the poor reliability of the newly developed magnetic mine, the overall

potential of the weapon was not fully understood or appreciated. In October of 1939 the First Sea Lord, Admiral Dudley Pound, wrote regarding the magnetic mine, "It is really the limit that after knowing about magnetic mines since the last war, no practical method of dealing with them had been evolved."[39] During World War II degaussing (demagnetizing) ships was developed to reduce ship's magnetic signature and sensitivity to magnetic mines. This countermeasure provided relief at a cost of time and money ($300 million).

The Royal Navy in April 1918, laid early M-sinkers off Zeebrugge, Belgium on the North Sea in conjunction with an attempted destruction of the U-boat pens. The mining at Zeebrugge also involved the British H2 mentioned above, an improved 1917 design based on an successful German contact mine configuration.[40] During 1918, 11 of the 31 U-boats lost by the Flanders flotillas were claimed by Channel minefields with a possible additional 11 losses from the same weapon.[41]

Use of magnetic mine is also cited in an article by Frank Reed Horton who wrote, "During the First World War, I served as an ensign in the United States Navy aboard a minesweeper in the North Sea. Our ship and its partner exploded more than 1,000 magnetic mines." Magnetic mines, in use late in World War I and requiring improvement, improved during the inter-war years and were widely and effectively used as an important weapon by both sides in World War II.[42]

Summary

At the time of the Armistice in November of 1918, the mine was a comparatively inexpensive weapon with a proven success in naval warfare. The mine was responsible for the highest attrition of warships, compared with that of all other surface weapons combined in that war. In World War I, more than 300,000 mines sank or damaged more than 950 Allied and Central Power, warships, merchantmen, and submarines.[43]

Allies lost 586 merchant ships and 87 warships not including 152 small patrol boats and minesweepers. The Central Powers' losses to mines included 129 warships, excluding an unknown number of merchant ships and submarines. Once again, the total ship damage in

WWI from mines was far greater than that by gunfire and torpedoes.[44]

The effectiveness of the submarine, the torpedo, and the mine almost from the first days of World War I was not anticipated. Countering each became an all-consuming task for both sides for the entire war. In the almost 90 years since the Armistice, means to counter the submarine and the two weapons continues to confound those involved.

A kind of consensus regarding the lack of preparation or anticipation of the submarine's *guerre de course,* the mine, and torpedo in some instances was based on the lack of fiscal resources in peacetime to meet the requirements of the military. In the case of Great Britain, attention to preparing for offensive high seas battleship or dreadnought encounter seems to have precluded adequate support for alternative weapons like the mine and torpedo. Throughout the war, the inexpensive mine inhibited battleship maneuvers or even putting to sea in some instances.[45]

Historical evidence shows that sea mines, depth charges and submarines at some point in their introduction received slow acceptance as they were perceived as being a weapon for nations with small or inferior navies. In the 19th century, acceptance of steam versus sail in the United States Navy was not unanimous.

During most of the first half of the 20th century, the concentration on capital-ship construction with the attendant cost and crew size was often steep competition for small ship needs and attention to new naval technologies. In retrospect, small-specialized ships for convoys, mining and countermining were frequently lacking. However, the role of mines in World War II, the Korean War, the Vietnam War, and the Iraq Wars have each brought careful attention to sea mines and their defensive and offensive roles as the weapons that wait.

Endnotes

22. www.exwar.org/htm/800htm.
23. Ferguson, *op. cit.*, p. 1703.
24. The Avalon Project, Source d. Shindler and J. Toman, *The Laws of Armed Conflict,* Martinus Nihjoff Publisher, 1988, p. 804-807.
25. Len Deighton, *Blood, Tears, and Folly: An Objective Look at World War II,* Harper Collins Publishers, 1993, p. 13.
26. Philip R. Alger USN, (translation from Le Yacht) The Employment of Submarine Mines in Future Wars, Naval Institute Proceedings, September 1908, Volume 34 No. 3, p. 1040.

27. Richard Alexander Hough, *The Great War at Sea*, Oxford University Press, NY, 1983 p. 48.
28. *Ibid.* p. 264.
29. Philip K. Lundeberg Undersea Warfare and Allied Strategy in World War I Part II: 1916-1918, Reprint from The Smithsonian Journal of History, Volume 1, No. 3, Autumn 1966, p. 67.
30. Hough, *op. cit.*, p. 155.
31. uboat.net
32. Www.exwar.org.
33. Willem Hackman, *Seek and Strike*, Her Majesty's Printing Office, London, 1984, p. 11, 12.
34. David A. Morris LCDR, U.S. Navy, The Mine Cycle: History, Indications, and Future,
http://www.globalsecurity.org/military/library/report/1997/Morris.html.
35. Http://www.geocities.com/fort_tilden/uboats.html.
36. Lundeberg, *op. cit.*, p. 64.
A.B. Feuer, *The U.S. Navy in WW I: Combat at Sea and in the Air*, Praeger, Westport, CT, 1999, p. 16.
37. Paul G. Halpern, a Naval History of World War I, Naval Institute Press, Annapolis, MD 1994, p. 439.
38. *Ibid.* p. 440.
39. Correlli Barnett, *Engage the Enemy more Closely: the Royal Navy in the Second World War*, Norton., New York, 1991, p. 91.
40. Lundeberg, *op. cit.*, p. 67.
41. Hough, *op. cit.*, p. 264.
42. Http://www.exwar.org/Htm/8000PopJ2.htm
43. Morris, *op. cit.*, p. 7.
44. Gregory K. Hartman, *Weapons that Wait: Mine Warfare in the U.S. Navy*, Anapolis, MD., Naval Institute Press, 1979, p. 15.
45. Hough, op. Cit., p. 59, 62.

SUBMARINE NEWS FROM AROUND THE WORLD

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From the October 2005 Issue

INDIA

Scorpene Deal Done

On 06 October 2005, Armaris and the Indian Government signed a construction contract for the procurement of six Scorpene class submarines. This follows an 08 September Indian Government announcement that the purchase had been formally approved. The transaction valued at US$1.8B involves the construction of six submarines at India's Mazagon Dock Ltd (MDL). The approval follows delays that began following the November 2002 announcement that the Scorpene design had been chosen.

Construction will probably begin on the first unit by mid-2006 with commissioning expected by 2010. Units two through six will probably begin at one-year intervals with the sixth unit of the batch being commissioned by 2015.

In a related story, on 07 October 2005, the Indian Ministry of Defense awarded Matra BAE Dynamics Alenia (MBDA) a contract (undetermined amount) for the submarine launched SM-39 Exocet anti-ship missile (ASM). The SM-39s are being procured for the six Scorpene class submarines.

Navy To Lease Two Russian Akula Class Submarines

In late October 2005, AMI received information that the Indian Navy would lease two Akula class submarines from Russia beginning in 2008. This information follows November 2004 reports that the sea service was on the brink of an agreement with Russia concerning the Akula II submarine RYS, which was started in 2003 for the Russian Navy but never completed.

Since the Indians would not receive the submarines until 2008, one of the units could in fact be the RYS and the second vessel could originate from Russian inventory. The Russian Navy, which rarely

goes to sea, will probably be willing to lease one of their own hulls to the Indian Navy since it will probably be better maintained by India rather than sitting pier side in Russia.

India has been in negotiations with Russia for nuclear-powered submarines since 2004 in an attempt to lease several vessels for training. India is attempting to maintain a professional group of nuclear trained personnel for the Advanced Technology Vessel (ATV) (Indian nuclear submarine), which is hoped to enter service sometime after 2011.

VENEZUELA

In The Market For Submarines

Press reporting in early October 2005 indicates that the Venezuelan Navy continues to explore its option for three new submarines. The latest naval plan (Naval Medium Term Plan of 2005) indicates that the sea service is in need of at least three submarines to replace the two Sabalo (Type 209) class, of which both units are undergoing a modernization effort in Porto Cabello.

The latest naval plan is very aggressive and outlines the acquisition of over 100 vessels including an aircraft carrier, submarines, corvettes, offshore patrol vessels (OPVs), landing craft, amphibious support ships, auxiliaries, patrol craft and naval aircraft. The corvette, OPV and naval aircraft requirements are expected to be met by a US$1.68B Venezuelan/Spanish Government deal in which the Venezuelan Navy/Coast Guard will receive four corvettes, four OPVs and 12 C-235 aircraft.

The aircraft carrier (completely unrealistic by AMI's assessment), submarines, auxiliaries and amphibious ships are in various stages of discussion. In regards to the submarine acquisition, it is known that the Venezuelan Navy is already considering the German Type 212/214 and the French/Spanish Scorpene. Reporting now indicates that the Russian Amur design is also on the table and is being seriously considered. AMI believes that the inclusion of a Russian-built submarine is probably for political purposes only. The Venezuelan Navy currently operates German built submarines and just completed a deal with Spain for the acquisition of surface vessels and aircraft. It seems that Venezuela would continue with the procurement of either German or Spanish-built submarines.

More than likely President Hugo Chavez, who is vehemently anti-US, is probably stoking the political flames by considering the procurement of weapons from Russia including submarines as well as amphibious and landing craft.

The current submarine acquisition plan calls for all three submarines to be in service by 2010. However, it will be difficult to meet this schedule considering the sea service has yet to make a decision on the design or how to finance the program. In addition, with the modernization and extended service life of the Sabalo class, the Navy will now have more time before it has to commit to a new construction submarine program indicating that the selection of design and construction contract could be several years down the road before any firm decisions are made. When a firm decision is finally made, it is unlikely that Amur will be chosen, rather a European solution.

FRANCE

Hike in 2006 Defense Budget, Naval Programs Funded

According to an announcement on 26 September 2005 from French Defense Minister Michele Alliot-Marie, the defense budget for 2006 will see an increase of 3.4% bringing it to €37.6B (US $45.2B) excluding pensions. This increase in the overall budget translates to a naval acquisition budget increase of €500M (US$601.4M) bringing it to US$4.8B for the year.

Increasing the Navy's portion of defense spending will enable the sea service to continue to fund all its major projects throughout the 2006 fiscal year. These projects include:

- PA2 aircraft carrier - €926M (US$1.1B)
- M51 sub-launched nuclear missile - €793M (US$954.4M)
- Rafael fighter aircraft - €752M (US$905.1M)
- Scalp naval cruise missile - €552M (US$664.3M)
- Le Triomphant class SSBN - €362M (US$435.7M)
- Syracuse III communications satellite - €245M (US$294.8M)
- ASMP/A guided missile - €218M (US$262.3M)
- **Barracuda class SSN - €188 M (US$226.2M)**

With the increase in the procurement budget for 2006, as well as a recent €127.5M (US$154.1M) contract with DCN Services Brest for through-life support services for Brest based warships, it appears

that the French Navy will see their fleet well supported and modernized in the coming years.

GERMANY

On 19 October 2005, the German Type 212 submarines U31 and U32 were commissioned into the German Navy.

From the November 2005 Issue

GERMANY

Naval Plans Moving Forward

As of late November 2005, it appears that Germany is still planning to move forward with its modernization effort in order to replace existing ships as well as support the nations shipbuilding industry. The following programs are currently planned to be funded or started beginning in 2006:

- A third Berlin class Combat Group Support Ship (EGV) to supplement the two already in commission.
- Two additional Type 212A submarines to supplement the four units that are already in commission or under construction.
- Four Type 125 class Stabilization Vessels.
- The initial units of up to 30 NH-90 ASW and SAR helicopters designated for the German Navy.

Programs that may begin in the near term (2006 through 2008) are a result of several courses of action since 2002 including steps to realign the armed forces into a smaller force while at the same time trying to maintain core competencies within the defense industry, specifically the naval shipbuilding industry. Major cutbacks announced since 2002 include reduction of the K-130 corvette program from fifteen to five units, the Type 125 stabilization vessel from eight units to four, the Type 212A submarine program from eight to six units and the cancellation of the Amphibious Transport Ship (LPD - EtrUS) program.

At the same time, the Minister of Defense took some positive steps and modified several procurement programs in order to shore up domestic orders for the German shipbuilding industry. These changes include:

- Move two additional units of the Type 212A submarines (units five and six) to the left to immediately follow the first four units in 2006 (could be delayed) with the two Israeli Dolphin class being constructed first.

The fifth and sixth units of the Type 212A could also begin construction by late 2006 or early 2007 in order to keep a steady work flow at HDW, which will commission the fourth Type 212A in late 2006. It must be noted that the 22 November decision by outgoing Chancellor Gerhard Schroeder to sell two additional Dolphin class submarines to Israel could affect this program. Germany is expected to contribute US$452.1M to the program from an undetermined Ministry (could be Ministry of Defense), which may or may not effect the funding for the Type 212A. Additionally, if the Israeli Dolphins begin construction by 2006, this could delay the start of the German Type 212As by several years.

SINGAPORE

Swedish Submarine Procurement Now Firm

On 06 November 2005, the Singapore Ministry of Defense (MINDEF) officially accepted the offer to procure two Vastergotland (A17) class submarines from Sweden for US$128.3M. This follows September 2005 press reporting that indicated the Republic of Singapore Navy (RSN) made the decision to procure Sweden's final two Vastergotland (A17) class submarines. Commissioned in the late 1980s, the last two units of the class (Vastergotland and Heisingland) will be decommissioned by 2006 in order to meet the reduced Submarine Force level prescribed in Sweden's Defense Resolution of 2004.

The transfer agreement between the Singapore MINDEF and Kockums of Sweden calls for the transfer of both units by 2010 with Kockums conducting a modernization package prior to transfer. The package will include modernization and conversion for tropical waters, a logistics package and training for the crews; very similar to the transfer package for the four units of the Sjoormen class that were transferred to Singapore from 1997 through 2001.

The RSN plans on replacing two of the Sjoormens (Challenger class - first commissioned in 1969) with two Vastergotlands (com-

missioned in 1987-88) in order to maintain a four-submarine fleet.

The procurement also deepens Singapore's ties with Sweden and improves the chances for a viable Viking project in the future.

ISRAEL

Submarine Procurement Approved By Germany

In late November 2005, press reporting indicated that Germany had agreed to sell two additional Dolphin class (Type 800) submarines to Israel. The €1.17B(US1.37B) deal was approved by outgoing Chancellor Gerhard Schroeder, who departed office on 22 November 2005. At least one third of the total price (US$452.1M) will be paid for by the German Government.

The agreement was formalized on 28 November 2005. A construction contract will probably be in place by early 2006 with construction beginning at ThyssenKrupp Marine's HDW Shipyard in Kiel by the close of 2006.

Reports also indicate that the two submarines will be powered by a Siemens/HDW PEM AIP fuel cell/battery propulsion plant but will retain a conventional diesel-electric propulsion system to charge batteries that can support high-speed operations, while the added AIP capability can recharge the batteries and support extended low-speed operations. The first three Dolphins purchased by Israel were powered by an all diesel-electric propulsion system.

With construction beginning by the close of 2006, both units will probably be delivered and commissioned into the Israeli Navy by 2012.

SOUTH AFRICA

On 03 November 2005, the first South African Navy Type 209, S101, was commissioned in Germany. S101 is scheduled to arrive in South Africa in late March 2006, following training in the Baltic Sea. Two additional units of the class are under construction at HDW in Germany.■

DISCUSSION

COMMENTARY ON "NAVAL ARCHITECTURAL ASPECTS OF AMERICAN NUCLEAR SUBMARINES' DESIGN"

by Mr. Mark Henry

Mr. Henry is a League member and is Treasurer of the Capitol Chapter. He is a naval architect and retired from the Naval Sea Systems Command in 1999 after 35 years of working in early stage submarine design and submarine-related R&D management. His last position was as Head of Submarine Preliminary Design and as Principal Naval Architect for the VIRGINIA Class.

Dr. George Sviatov's interesting and stimulating article in the July 2005 issue of THE SUBMARINE REVIEW touched on a number of topics worthy of a reply.

Chief Designers

Dr. Sviatov seems to believe that the US Navy keeps the names of the *Chief Designers* of its submarines secret. Well, George, it's not that the names are secret; it's just that we don't know who the Chief Designers are either. The way the US Navy *does* submarine design there really isn't anyone who can be given that title. For example, let's look at who was involved in the VIRGINIA Class design.

The Centurion Study Group was established in 1990 to develop notional characteristics for a new attack submarine to possibly replace the SEAWOLF class. In early 1991, NAVSEA began low-key concept design efforts to determine what sort of submarine (large or small, how capable, and at what approximate cost) would result from these characteristics. The initial *design team* included a Ship Design Manager plus the Branch Head and several naval architects from the Submarine Preliminary Design Branch.

Some time later, after considerable dialog between OPNAV and NAVSEA, many dozens of New Attack Submarine (NSSN) concept design studies had been completed by NAVSEA's Submarine

Preliminary Design Branch and similar design groups at the two submarine shipyards, Electric Boat Division (EB) and Newport News Shipbuilding Company (NNS). Eventually, the New Attack Submarine Program Office was established under a Program Manager. Among many others on his staff, a Technical Director oversaw the ship and ship system design and NSSN-related R&D and a Ship Design Manager oversaw ship-related design efforts. Another Design Manager directed the design of the combat system while the design of the propulsion plant was directed by NAVSEA 08, with most of the related propulsion plant design work performed by EB.

The Submarine Preliminary Design Branch moved into NSSN Program Office spaces to directly support the NSSN program and the Branch Head was given the additional title of Principal Naval Architect. Further NSSN concept design studies were conducted by NAVSEA and the two shipyards until, in 1994, the basic design of the ship was well established. With *early-stage* design completed, the Submarine Preliminary Design Branch returned to its own offices where it both supported the NSSN Program and began looking to the future. Further VIRGINIA Class design, through detailed ship design, was performed by EB and, currently, VIRGINIA class submarines are being built by EB and NNS in a teaming arrangement utilizing very large integrated modules.

So, George, who was the Chief Designer? Not the Principal Naval Architect. While he was *chief* of the naval architectural efforts during the early-stage design period, he had limited influence on ship operational requirements and the design of the many systems that made up the submarine. It wasn't the Ship Design Manager, Technical Director, or Program Manager either. While each, in turn, was *chief* of a broader span of activities, each was further removed from *design* and none had very much direct influence on the selection of operational characteristics. If this doesn't make identifying a specific *individual* Chief Designer difficult, note that some of these managerial positions were held by more than one individual during the time period described.

The situation for SEAWOLF was somewhat similar to that described for VIRGINIA. In this case, however, there was less shipyard involvement in concept development but considerable involvement by both shipyards in the preliminary design and contract

design phases. Detailed ship design was performed by Newport News Shipbuilding utilizing a propulsion plant design developed by Electric Boat under the direction of NAVSEA 08. While the submarines were built by Electric Boat, the renamed Northrop Grumman Newport News (NGNN) remains the lead design yard for the SEAWOLF Class.

"Prototype" for the VIRGINIA Class

Dr. Sviatov wrote, "the Navy decided to take as a prototype not the SEAWOLF but the Improved LOS ANGELES class SSN . . . ." With respect to torpedo tube and vertical missile launcher architecture and number of weapons, it certainly is true that VIRGINIA is similar to *later* LOS ANGELES Class submarines. However, the VIRGINIA design started with the proverbial "clean sheet of paper." In fact, there were *many* clean sheets of paper involved since, during the early-stage design phase, more than one hundred attack submarine concepts (baseline designs and multiple variants thereon) were designed and evaluated. Besides many based on a new propulsion plant (with the S9G nuclear reactor), concepts based on the existing LOS ANGELES, SEAWOLF, and OHIO propulsion plants were also designed and evaluated. And, to be sure that *nothing* was missed, a number of AIP and diesel-powered concepts were also designed and evaluated. Because of the types of questions that were being received from the senior leadership, it was deemed necessary to develop all of these concepts and to conduct cost and operational effectiveness analyses (COEA) for each of them.

So, while VIRGINIA and later LOS ANGELES Class submarines do have a similar weapon and launcher arrangement, this configuration was not an *input* to the NSSN design and many of the details are different. In fact, the earliest NSSN concepts, smaller and less effective than VIRGINIA, did not have this architecture.

Improved SEAWOLF concept

Dr. Sviatov's proposed Improved SEAWOLF variant with 28 VLS tubes and 42 additional internal weapon stowage positions would certainly be a very potent attack submarine. However, his statement that one Improved SEAWOLF equals three VIRGINIAs is *only* true from the point of view of *firepower* and not for other

performance attributes.

The proposed modification (an additional 375 tons of displacement) needed to increase SEAWOLF's weapon capacity to a total of 120 is Dr. Sviatov's rough estimate based on his considerable experience in submarine design; no design work or calculations were performed. Based on my own experience, such an increase in firepower would entail adding, *at least*, twice the proposed displacement increase. Nevertheless, I understand Dr. Sviatov's position to be that his Improved SEAWOLF would be highly desirable even if the necessary displacement increase was substantially more than his estimate. Of course, the *actual* ship size increase can only be determined by *doing* the *naval architecture*, i.e., developing a ship *arrangement* and then performing the *volumetric*, *weight*, and *ship balance* calculations. (See "A Brief Lesson on Submarine Design" elsewhere in this issue of The Submarine Review.

Dr. Sviatov recommends that his Improved SSN21 concept be *considered* for the US Navy's submarine of the future and, in fact, this *probably will happen*! As in the past, studies for a future attack submarine for the US Navy are highly likely to include a wide variety of submarine concepts, including some based on SEAWOLF. Whether the future SSN resembles SEAWOLF (in any form) is less easy to predict. At this time, I would predict not, but the answer depends on a future world situation that my crystal ball cannot discern—and that is exactly why highly-capable, multi-mission attack submarines are the platforms of choice.

Measures of quality

In his discussion of alternative submarine designs, Dr. Sviatov utilizes *tons of ship displacement per carried weapon* as a measure of design quality. While this may be a reasonable measure for ships that are otherwise equivalent in their multitude of characteristics, it is not appropriate for grading very different designs. The objective is to provide the Fleet with an adequate number of effective yet affordable submarines, not to send the greatest number of weapons to sea. It should be noted that some current, very important submarine missions do not require *any* firepower.

A submarine of VIRGINIA's size could be designed to carry

many more weapons than VIRGINIA can currently accommodate and it would have a more favorable tons of ship displacement per carried weapon ratio. However, to put more weapons *in*, something has to come *out* and the resultant loss of other capabilities (e.g., speed, stealth, combat systems) would lead to a very undesirable platform. Alternatively, through the development of advanced technologies, the size of various ship systems might be reduced thus providing more space for other functions (such as more weapons) in a given sized ship or, perhaps, reducing ship size. A proper balance of capabilities and cost is the goal to be achieved.

Bigger is better?

This has probably been argued since the first naval vessels were conceived – probably including biremes versus triremes. Absolutely speaking, it can certainly be said that "bigger is *more*" and, also, that "bigness" sometimes has its own detriments. Generally speaking, bigger *is* better when it comes to the *performance* of multi-mission attack submarines. Of course, when cost is entered into the equation, "better" takes on a whole new meaning where bigger and better may be unaffordable.

In conclusion, I thank Dr. Sviatov for his recent (and past) articles on submarine design. I hope that he will continue his writing.■

A FURTHER COMMENT ON COLD WAR SUBMARINES

by Norman Polmar and Kenneth J. Moore

Mr. Friedman's commentary, using such provocative terms as *iron grip*, reveals a failure to understand the context of Cold War Submarines. Indeed, at times it is difficult to understand if he takes issue with the authors' views or with the authors' reporting of Soviet views.

His comments can best be addressed on the basis of four points:
1. Admiral Rickover: His influence on submarine design, especially after loss of THRESHER (SSN 593) in 1963 was not subtle. We suggest a reading of Rickover's public and uncensored testimony before key congressional committees; interviews with members of the U.S. submarine community who worked with (and against) him; and discussions with his supervisors—Secretaries of the Navy, Chiefs of Naval Operations, Commanders of the Bureau of Ships and Naval Sea Systems Commands, to understand his influence on submarine design. We did so in researching this book.

The conclusion, which has been stated in several articles by submarine designers in the Naval Institute Proceedings, is that our discussion of Rickover's role in U.S. submarine design is *right on.*

Yes, Rickover *lost* several battles; at times he was convinced by logic to change his views, as in the issue of single-versus-twin screw issue for SSNs. But he won the vast majority of his battles, and his victories did have benefits, among them the unmatched safety record of the U.S. Navy's nuclear propulsion program.

2. Soviet design competition. The competition among the Soviet submarine design bureaus was (and is) relentless. Mr. Friedman is incorrect when he makes simplistic *assignments* of submarine types to the bureaus, such as SSBN and SSK submarines to Rubin. With a more careful reading of the book, he would have learned that the Rubin design bureau was not relegated only to SSBNs and SSKs, but the bureau also designed the attack submarine KOMSOMOLETS (Project 685) and several SSGNs, among them the Oscar (Project 949). He would have learned that Malachite, beyond designing the later attack submarines, also produced SSBN and SSGN designs

(Projects 639, 679, 687, among others). Mr. Friedman would find it very instructive in this regard to visit the design model archives of the submarine bureaus in St. Petersburg and Nizhny Novgorod.

Many of the *other* types of submarines designed and proposed by the Rubin, Malachite, and Lazurit bureaus are discussed and illustrated in Cold War Submarines. There certainly was and still is design competition among the remaining bureaus.

3. Soviet torpedoes. With respect to torpedoes, Mr. Friedman is critical of the Soviet practices, and not of our book. He admonishes the USSR for having developed and employed so many types of torpedoes while the U.S. Navy has successively concentrated on the Mk 37 and then the Mk 48 (with serial improvements). He would do well to look into the problems with those torpedoes; for example, there were difficulties in firing a two-torpedo *salvo* with the Mk 48, and that torpedo's performance was faulty under ice. There were many other problems that cannot be discussed in this forum.

During the long career of the Mk 48 there have been several efforts to develop *other* torpedoes, especially an anti-surface ship weapon and the current *half-length* Mk 48 as U.S. naval leaders realized the value of multiple weapons. The Soviet torpedo inventory—coupled with a greater number of launch tubes than found in U.S. submarines—gave them flexibility and redundancy, which, in their view, were valuable attributes. Also, Soviet forces were trained and armed for nuclear war at sea--something abhorred by the U.S. Navy. Accordingly, nuclear torpedoes, including the remarkable, 200-knot VA-111 Shkval, added to the number of types and capabilities of torpedoes carried in Soviet submarines.

At one point the U.S. Navy must have felt the same way, deploying SSNs with combinations of Mk 48s, Mk 45 ASTOR torpedoes, Harpoon missiles, SUBROCs, anti-ship and land-attack versions of the Tomahawk, and even mines, thus creating the same loadout problems that Mr. Friedman dislikes.

Finally, Mr. Friedman's attempt to relate the number of torpedo types to the loss of the KURSK is beyond any logic. Submarines of most nations have had major torpedo problems. After circular-running torpedoes sank two U.S. submarines in World War II should the U.S. Navy have immediately discarded the Mk 14 torpedo?

4. Sources. Mr. Friedman criticizes Cold War Submarines for not using the large number of Russian magazine articles on submarine programs that have been published during the past decade. A careful reading of our book's 48 pages of notes and bibliography will identify many of those books and articles.

But many of the articles that Mr. Friedman praises appear to have the same sources, and even the same *errors*--some officially sanctioned. Rather, our primary sources were the Soviet submarine designers and scientists, whom we interviewed at considerable length, and their principal assistants. The men and women whom we interviewed—many never before having had discussions with Americans—were able to cite (and in some cases provide copies of) their personal papers and official reports to help our research, making Cold War Submarines a unique treatment of U.S. and Soviet submarine design and construction.

Beyond the design bureaus, we also held discussions with officials at several related research institutes and at a major shipyard.

Rather than Mr. Friedman's convoluted views on Cold War Submarines, we prefer the following appraisal by Vice Admiral George Sterner, a submariner and former Commander, Naval Sea Systems Command, who concluded his review in the Naval Institute Proceedings with:

> Cold War Submarines has a special appeal to those dedicated operators who manned the submarines in the Cold War. The evolution of Soviet submarine tactics and the political context that motivated their leadership are fascinating. The evolution of the Soviet submarine documented in the authors' easy style with pictures and detailed elevation views of each submarine design will interest professionals and novices alike. Most fascinating, however, are the accounts of the people who actually led the race for undersea supremacy.■

LETTERS

TRANSIT AGILITY - 1900 STYLE

Commander Wainwright's letter dated January 8, 1901 to the Chief of the Bureau of Navigation which appeared in the April 2005 issue of the Submarine Review provides a glimpse of early submarine operations. Please note that when this letter was written our Submarine Force was about three months old and consisted of one submarine–USS HOLLAND.

The first three paragraphs of Commander Wainwright's letter shed light on USS HOLLAND's role as a school boat. Paragraph 4 refers to an operation with quite a different purpose.

During the year 1900 HOLLAND VI came to Washington from New York, demonstrated operational capability, and was acquired by Congress for a reluctant Navy. In its enthusiasm Congress ordered a second HOLLAND VI, then six more submarines of an improved design. Meanwhile HOLLAND VI manned by its new Navy crew participated in a fleet exercise off Newport, Rhode Island gaining much attention from the national press for sidling up to an anchored battleship at night, announcing its presence, and constructively sinking the battleship. Some Congressmen, a few far-sighted naval officers and stockholders in the HOLLAND Torpedo Boat co. were delighted. A number of senior naval officers were less pleased by the exploits of the little submarine. They had struggled over many years to modernize our obsolescent Navy by replacing wooden sailing ships left over from the Civil War with sleek steel steam-powered cruisers and patrol vessels. Money for new construction ships was hard to come by, and they resented its diversion to submarines, which were considered little more than toys. Further, they correctly noted that the submarine boat always was towed during transits between ports, raising doubts about HOLLAND's self-sufficiency.

So it was not a surprise to Lt. Caldwell to receive orders to take USS HOLLAND to the Norfolk Navy Yard and return under its own power. USS STANDISH was assigned as escort for the trip.

Lt. Caldwells' comments on the voyage appear in two letters he wrote to his mother–one before the trip and one after. In a letter dated 29 December, 1900 he wrote: "There is a rumor about that we are to be ordered to make a trip to Norfolk and return to satisfy the authorities as to our ability to run long distances. I should like the trip very much if the weather is not too cold."

While at the Norfolk Navy Yard he wrote a letter home dated 20 January, 1901 in which he said:

"My trip down here was a decidedly hard one for me but was to my mind a success, which made up for my hardship. We left Annapolis at one o'clock in the afternoon, and ran all that night, so that I got no sleep for thirty-six hours, and was wet through most of that time. The following night we anchored, and arrived here on Thursday. Fortunately I suffered no ill effects from my repeated drenching with spray, although it was very cold. Going back I expect to take it more easily. We have been waiting here all this time to get into the drydock, which we did on Friday. I expect to get out of dock tomorrow and away to Annapolis on that or the following day."

What else can you find in Captain Styer's files?

Cheers,

H.H. Caldwell
Box 283
Sagamore, MA 02561

BOOK REVIEWS

SOME RECENT SUBMARINE BOOKS

by Captain James C. Hay, USN(Ret)

Several books have been published in the past year, and one will be published shortly, which will be of interest to League members. They range in history from the American Revolution through the 20th century, including World War II and its aftermath, to present day Chicago-yes Chicago.

Starting with the Revolution, Scholastic, Inc., of New York will publish in March of 2006 a small book entitled Bushnell's Submarine: The Best Kept Secret of the American Revolution, by Arthur S. Lefkowitz. It is aimed at the 9 to 12 year old age group and looks to be a useful way to introduce kids and grandkids to the beginnings of the wonderful world of submarining. The advance sheet provided by the publisher describes the book and its author in a concise three paragraphs:

> "This is the thrilling, and largely unknown, story of the invention of the world's first submarine and how it was used in the Continental Army's desperate attempt to hold onto New York City in 1776. Yankee tinkerer David Bushnell, the nearly forgotten genius, christened his invention "The Turtle," and in the Turtle's first, and only, military exploit, it bravely attempted to sink the flagship of the British fleet in the middle of New York Harbor.
>
> Making liberal use of journals, diaries, maps and eyewitness accounts, one of American history's most exciting events comes alive in great historical detail. We see how the innovation of this one individual, along with the encouragement of such luminaries as Thomas Jefferson, George Washington, and Benjamin Franklin, epitomized the ingenuity and potential of the new nation.
>
> Arthur Lefkowitz is an independent researcher and the author of George Washington's Indispensable Men and The Long Retreat, which was just named the best book about the

American Revolution in 2003 by the American Revolution Round Table."

On a more familiar plane, but in keeping with the Connecticut roots of the modern Submarine Force, Dave Bishop has put together an enjoyable pictorial history of the SubBase on the Thames, appropriately entitled Naval Submarine Base New London. Published in 2005 by Arcadia of Charleston, Chicago, Portsmouth and San Francisco as part of their Images of America series, Dave's book (ISBN 0-7385-3808-6) covers the history of the Base from its beginnings just after the Civil War up to the present day. Having had some personal experience with SubBase, NLON during which I had the opportunity to learn a little about the history in order to think creatively about its future, I can attest that Dave Bishop has done an outstanding job of illustrated biography of a difficult subject.

Over the past year we witnessed, in the BRAC process, several opinions put forth about the utility of the Base and its current value as "a center of submarine excellence". The current state of facilities did not just happen; they evolved and will continue to evolve to best fit the needs of the evolving and improving Submarine Force. Dave has produced for publication far more photographic evidence of that evolution than I saw during any of my seven tours there (four submarines, two schools and command of the Base). I can attest to the value of this book and heartily recommend it to all with an interest in the past, and future, of the U.S. Submarine Force.

A personal memoir by an officer with long sea experience, including war patrols, can be counted upon to provide lots of sea stories, plenty of lessons learned and many familiar names as young officers but who were much older and more senior when I knew them. Captain Herb Mandell has given us a full, at times poignant, picture of his naval life at sea and ashore from the Naval Academy in the thirties to his retirement in the early sixties. His book Submarine Captain and Command at Sea, published by Collage Books of Naples, Florida in September of 2005 is a warm, very personal history of the mid-twentieth century as seen by an officer who was in the middle of it all.

Captain Larry Wigley is a retired submarine skipper who has given us a novel in the could-it-happen-here genre. His novel Mission

Complete has been published by Publish America. The book is fiction but is too close to possible for us to pass on commenting. Larry has provided us with the following precis:

> The world's most sophisticated nuclear attack submarine, USS JACKFISH (SSN 945), returned to its homeport, Groton, Connecticut, ten days before Christmas.
>
> On the evening of twenty December, Commander Bruce Stewart, the commanding office of JACKFISH, meets in a highly classified conference with high military and civilian persons. At the meeting, it was revealed that an ultimatum was delivered to the President of the United States from a Soviet/Cuban terrorist group demanding a ransom of billions of dollars and the disarmament of the United States strategic nuclear weapons arsenal.
>
> The ultimatum would be met or the terrorist would launch nuclear cruise missiles from the US nuclear attack submarine TIGERFISH at exactly midnight Christmas Eve and annihilate the cities of Norfolk, Virginia, Washington, DC, New York, and Groton, Connecticut.
>
> TIGERFISH had been pirated while at anchor off Piraeus, Greece, the victim of an expertly developed and exceptionally well-executed plan by the integrated Soviet/Cuban team. The submarine was still operated by its American crew in bondage, confined in movement by leg and arm shackles with severe brutality and torture under the guns of the terrorist guards.
>
> The options available to the President of the Unite States is to conduct a nuclear preemptive first strike, to honor the ultimatum, or to dispatch Commander Stewart and JACKFISH to seek out and sink TIGERFISH.
>
> The President gambles at his best option-Stewart and the JACKFISH.
>
> Heavy seas and reduced visibility during the outbound leg of the voyage from Groton, Connecticut, coupled with the death of a ship's diver while unfouling lobster pot locator lines from the propeller shaft and an almost mission abort fire in the ship, reduce significantly the already limited time available to meet the deadline for completing the mission.

The President had directed no one else in JACKFISH be provided any details of the mission. The executive officer's friction and resentment toward the captain for not being provided the details of the mission increase as the JACKFISH gets closer to the mission area and the torpedo shooting point was approached.

Weapons are launched under potentially complex conditions between the captain and the executive officer.

The loud explosion and breaking up noises heard by the JACKFISH sonar operators in the direction of TIGERFISH signify MISSION COMPLETE."

The Chicago part of this recent book summary has to do with the exhibit of the World War II U-Boat, U 505, which was captured at sea and is now at the Museum of Science and Industry in Chicago.

On 4 June 1944 the German submarine U-505 became the first man-of-war since the War of 1812 to be captured by the U.S. Navy in battle on the high seas. Attacked by the American hunter-killer force Task Group 22.3 off the coast of West Africa, the U-boat was forced to the surface after a fierce bombardment. Abandoned by the crew while partially afloat, she was boarded by American sailors and secretly towed to Bermuda. Renamed USS NEMO, the submarine made a war bond subscription tour of Atlantic and Gulf of Mexico ports before docking at Portsmouth, New Hampshire, to await scrapping in accordance with an Allied agreement regarding postwar retention of operational enemy U-boats. These events are vividly described in the pages of this book along with the story of how the U-505 became a major attraction at the world-renowned Museum of Science and Industry in Chicago.

Author Jim Wise, a retired Navy Captain with several books to his credit, tells how Admiral Dan Gallery, the commander of Task Group 22.3, saved the boat and became a major force in convincing the Navy Department not to scuttle the submarine but to transfer the U-505's ownership to the science museum, where she would be put on display to commemorate the thousands of Americans who had been lost

at sea during World War II. Wise chronicles the boat's arduous journey down the St. Lawrence River and across four of the five Great Lakes to the shores of Lake Michigan for restoration. He then offers a memorable description of the staggering engineering feat that moved the sub overland to an outdoor exhibit area at the museum, where she was opened to the public in 1954. In 1989 the U-505 was designated a National Historic Landmark.

By the turn of the 21st century, museum executives had determined that nearly fifty years of exposure to the elements and more than 24 million visitors had taken their toll. They raised millions of dollars to restore the U boat and to build a temperature-controlled site four stories below ground. In addition to the fully restored German submarine, the exhibit area of "The New U-505 Experience" also includes artifacts and interactive stations to give visitors a taste of what it was like for the crewmen in battle. This book showcases some two hundred photographs, including some of the submarine's new homes while under construction.■

NAVAL SUBMARINE LEAGUE HONOR ROLL

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