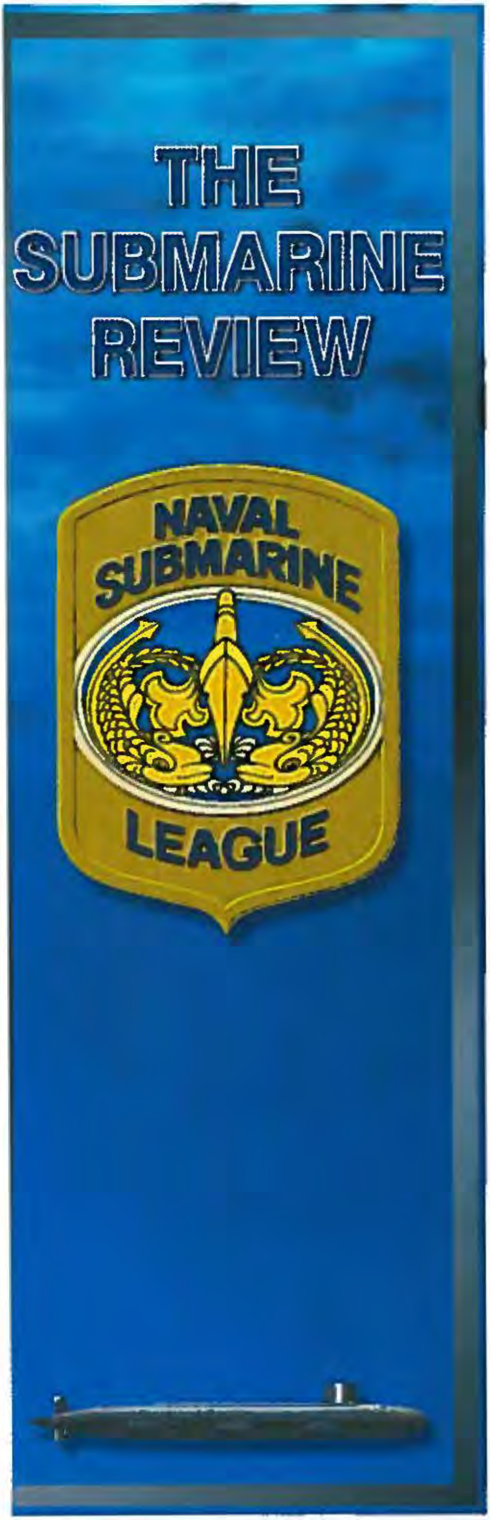

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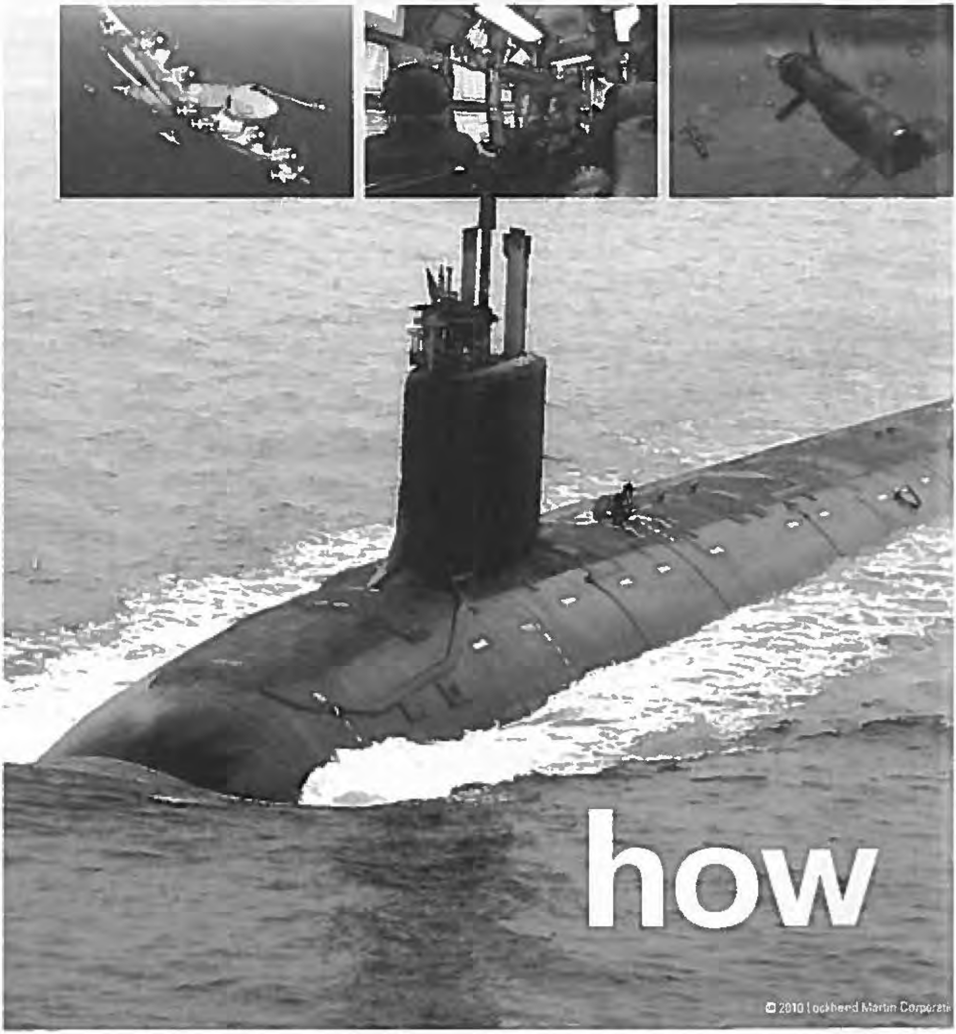
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EDITOR'S COMMENTS

The three FEATURES of this issue are varied as to source and subject, and all three are important to all members of the submarine community, and for a variety of reasons. All include words of wisdom from acute, highly placed observers looking at the world of US submarines from three different aspects.

The Eulogies to VADM J. Guy Reynolds focus on one man's life in submarines from both a personal and a professional view. As we have all long understood, the *lessons to be learned* from J.Guy's words and actions, of course, are many and varied, and as always in sea stories the real benefit to each person listening to, or reading of, those stories comes from their own distillation of the actual words for the real meaning. Here is a case where ADM DeMars uses that familiar form to describe and eulogize a friend and colleague—but there is a lot of meaning there for all in the submarine world—particularly the youngsters in this business. Dave Smith of Raytheon and Jim Quick, Guy's son, followed the same sort of memorialisation concerning J.Guy's relations with industry and in his family life. We shall all miss J. Guy Reynolds.

The second FEATURE is the address which Mr. Ron O'Rourke delivered at the Annual Submarine Technology Symposium in May. Mr. O'Rourke has long been valued by the submarine community for his cogent observations of issues effecting submarines. His vantage point for observation is in the Halls of Congress where his understanding of the processes involved in the vital business of funding naval matters is most valuable to those of us who may have somewhat more narrow views of those vital interests. This year's address, as in the past, is most interesting and raises points of real concern.

The third of our FEATURES is Admiral Kirk Donald's speech at the Commissioning of USS NEW MEXICO (SSN 779). ADM Donald centered his remarks on the concept of *Stewardship* and what it means to the design, construction and operation of a ship as complex, and as important, as NEW MEXICO. The use of that concept seems so appropriate that it is a wonder that it has not been used in such a broad context more frequently.

We are indebted to ADM Donald for his insight as to what it is we do; as we are also indebted to ADM DeMars for his manner of pointing up the same goals.■

Jim Hay
Editor

THE SUBMARINE REVIEW

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

Articles for this publication will be accepted on any subject closely related to submarine matters. Their length should be a maximum of about 2500 words. The League prepares **REVIEW** copy for publication using Word. If possible to do so, accompanying a submission with a CD is of significant assistance in that process. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the **REVIEW**.

A stipend of up to $200.00 will be paid for each major article published. **Articles accepted for publication in the REVIEW become the property of the Naval Submarine League**. The views expressed by the authors are their own and are not to be construed to be those of the Naval Submarine League.

Comments on articles and brief discussion items are welcomed to make **THE SUBMARINE REVIEW** a dynamic reflection of the League's interest in submarines.

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

FROM THE CHAIRMAN

After a valiant struggle against lung cancer, the League lost its distinguished President of nine years, VADM J. Guy Reynolds. I'd like to especially thank those individuals and corporations who have contributed to endow a Dolphin Scholarship in J. Guy and Jan Reynolds' name in perpetuity. If you have not participated, please visit the NSL Website (www.navalsubleague.com) for a donation form.

I am also pleased to report that Commander Submarine Force has approved a new Fleet award, the VADM J. Guy Reynolds Award for Excellence in Submarine Acquisition. The first award will be presented at the League's next major event, the Annual Symposium, which will be held October 20-21, 2010 at the Hilton McLean in Tysons Corner, Virginia.

The Naval Submarine League started the fiscal year on a sound financial and program foundation. The generous contributions of corporate benefactors and individuals resulted in a modest surplus that will help restore the corpus and support the educational grant programs.

The 9th Annual History Seminar, *Ocean Surveillance During The Cold War*, was held jointly by the NSL and the Naval Historical Foundation on 15 April at the Navy Memorial. The Seminar addressed the contributions of undersea systems to the overall success of the Cold War ASW mission. Supported by Seminar Chairman RADM Jerry Holland and Moderator CAPT William Manthorpe, RADM Tom Brooks, RADM Eric McVadon, and CAPT Jim Donovan discussed the contributions of the intelligence, maritime patrol air and ocean surveillance systems respectively. Each provided a unique historical perspective on the exploitation of information collected from many sources to form a fusion network that allowed ASW forces to actively prosecute contacts of interest. These seminars have been well-received and provide an opportunity to present first person reports on Cold War operations.

The 2010 Submarine Technology Symposium (STS), *Increasing the Submarine's Value in Theater Operations and Irregular Warfare,* co-sponsored by the NSL and Johns Hopkins Applied Physics Laboratory, was a resounding success. VADM George Emery, the Chairman of the STS, did a superb job of organizing the 11-13 May classified forum at JHU-APL. The revised format of this year's STS, that featured an active duty submariner reporting on an operational need at the start of each technical session, was well-received. The attendees were challenged by ADM Greenert, ADM Donald, VADM Donnelly, and RADM McAneny to aggressively develop solutions for identified needs and to improve submarine capabilities in support of existing and new requirements. Ronald O'Rourke presented his challenges to the shipbuilding program and proposed several alternatives for consideration by the Navy to achieve proposed program objectives. His remarks are in this issue of the *Review*.

The Annual Symposium Submarine Force Cocktail Party will be held on Wednesday evening, 20 October. Please look for your registration package in early September. It will include registration information, a draft agenda, and a ballot for the election of NSL Board of Directors' members.

The corporate sponsorship program for our major events has allowed the League to maintain the costs of these symposia. I ask that when you see a Corporate Benefactor at a League event, please join me in thanking them for their support. The 72 current benefactors are listed in the back of this issue.

The League continues to address issues of importance to the Submarine Force. Your support in establishing the build rate for VIRGINIA Class submarines at two submarines each year was recognized in this year's budget. This year the replacement of the OHIO Class Submarine Program is identified in the Five Year Defense Plan. I encourage you to continue your strong support for the preeminent leg of our Nation's strategic deterrent.

I also ask you to encourage friends and colleagues to join the League. Please refer them to the webpage and click on "Join NSL." I also ask for your literary contributions to *The Submarine Review*. CAPT Jim Hay, USN (Ret), Editor of the *Review*, welcomes your input to maintain its quality and currency. This journal goes to all submarines, members of Congress, and industry leaders. Your experiences are valued and needed to keep the *Review* relevant in these changing times.

Please join Sheila and me as we continue to pray for the safety of our forces and particularly submariners deployed around the world. I am honored to represent you as Chairman of the Naval Submarine League. Enjoy your summer.■

Richard W. Mies
Chairman

IMPORTANT NOTICE

The Naval Submarine League will be shifting to the email domain "navalsubleague.com" over the next three months.
This change will be announced by an NSL UPDATE.
The new NSL address will be subleague@navalsubleague.com


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U.S. Navy photo by Paul Farley

FEATURES

IN REMEMBRANCE OF VADM J. GUY REYNOLDS, USN (RET) 10 DECEMBER 1937 – 29 MARCH 2010

The life of VADM J. Guy Reynolds was celebrated at a Memorial Service on 7 April with remarks from several speakers.

Admiral Bruce DeMars, Past Chairman of the Naval Submarine League, spoke extemporaneously. He said he wanted to celebrate a life well lived. He described Guy as a most unique person suitable for the Reader's Digest feature *The Most Memorable Person I Know*. He characterized Guy as a towering intellect hidden behind a gruff exterior which he effectively used to disarm people. He had massive integrity—always strived to do the right thing. He had tremendous judgment; which he displayed in marrying Jan.

Admiral DeMars took this opportunity to recognize the wonderful family that surrounded Guy in his finals weeks. Their actions were admirable. He mentioned that Guy was a survivor. He was nearly lost overboard from the sail of the submarine he commanded when he went up to fix something he thought was too dangerous for his crew. He survived that. He survived a collision with a Soviet submarine. As Senior Member of the Nuclear Propulsion Examining Board he presided over the first and only failure of a nuclear powered surface ship in overseas waters. He had many conversations with CINCLANTFLT, the CNO and Admiral Rickover but he survived.

Admiral DeMars noted how he had rescued the heavy weight torpedo program and then was pressed into action to resuscitate the SUBACS program. We were trying to invent something for which we didn't have the time, money or brains. SUBACS A was to go to a 688 class submarine for which there was not another combat system available. If this was not fixed we would have a large, fast vessel with no offensive capability—the first Littoral Combat Ship! Guy immediately changed the name to BSY 1/2 which took care of about one third of the congressional staffers. We then worked together to restructure the program, beat up on the contractor, pleaded with congress not to take away any money and used skimmed money from other submarine programs. Nearing the end we were still $60M short. It was Guy's idea to go see Mel Paisley, the ASN (RDA). We met with him and the Comptroller of the Navy, a two star. Paisley asked all the right questions—had we skimmed our own programs, had we beat up on the contractor, and had we made peace with Congress. Following our appropriate answers he directed the Comptroller to skim $60M from the aviation and surface programs and put it into the BSY 1/2 program. It was one of the high points of Guy's career.

Admiral DeMars described how he and Guy would, during the warm months, stop off on Friday on the way home at Marco's on Washington Street in Old Town Alexandria. They would sit outside in their whites and each have a martini before proceeding home. They discussed the preceding week and what was upcoming the next week. Admiral DeMars concluded by saying that all his memories of Guy are good, he misses him and will never forget him.

Daniel L. Smith, a Raytheon Company vice president and president of Raytheon's Integrated Defense Systems (IDS) business, spoke as the representative of the industry side of Guy's legacy.

"Jan, Jim, Cathy, Peter and Reynolds family … thank you for allowing me the honor of paying tribute to Guy.

All of us here today salute the dignity and life of Guy; as well as the patience, courage and loyalty of Jan. It used to be said that behind every great man was a great woman … in Reynolds World, Guy would lovingly admit Jan was never behind … quite the opposite … she was in front towing Guy to do his right and best work. She was the CEO; he only the President. As evidence, I offer that many of us waited every year impatiently at the Christmas holidays for the Annual Report!

Guy often said to us "everybody is a hero in the "O" club; especially after the 4th drink". While he was known to imbibe a bit, Guy was not this style of hero ... what he did mattered; almost always in multiple ways.

From Chicago to eternity, Guy lived his life to fight "the Tyranny of the Program Record". He used this mantra to describe any situation which he found to damage the status or reputation of his Country, his Navy, his Submarine Force or his family and friends. He was relentless in his passionate belief that seapower was the key to American superiority and that American superiority meant global security. With true guile, he further philosophically engineered that submarines were the true enabler to seapower (he once commented to me that greater than Zumwalt stealth was achieved by NAUTILUS (50 years or so earlier), as the boat had zero radar cross section at depth), and of course that nuclear power was the best and righteous power source for a U.S. platform this significant. All of this was *status quo* for Guy ... the endearing part of him was his artistry in weaving his stories to make his philosophy real and logical using three circles and a few bullet points.

Maybe the most famous of the Guy *Ven diagrams* was when he became the true father of Submarine Open Architecture in the mid 1990's when he drew one big circle (network), two smaller but large circles (cc and sonar) in what became known as the *Mickey Mouse* chart. With this simple diagram he engineered the conversion from expensive stove piped proprietary electronics to affordable capability for the Submarine Force. I believe he also adopted, and began to groom, a young Rick Breckenridge during those intense days.

While most here, and those wishing they were here tonight, no doubt have personal life stories of Guy, I firmly believe that his greatest accomplishments are yet to be realized. The legacy of Guy that is implanted deep within many of his family, shipmates, friends and associates stretching around the globe (Australia tie story) is simply a legacy of excellence. Excellence as defined by four simple principles offered by Mr. Kip Tindell, Chairman and CEO of the Container Store. Mr. Tindell said "Excellence can be achieved if we: 1) care more than others think is wise, 2) risk more than others think is safe, 3) dream more than others think is practical, and 4) expect more than others think is possible". These were without question the attributes of the Guy Reynolds we loved and salute.

Guy and Jan are integral members of the Smith family. They have helped us build our life, retire from the Navy, marry a son and a daughter, say good-bye to parents, become grandparents, live with cats and now start over with a dog. Over the last months, Guy provided us subject matter expertise as we searched for our first family boat. It is not by luck that we now own a 23.5 foot Grady White Gulfstream, fully inspected and accepted by Guy. The name of our boat, named in his honor, with Jan's blessing, is *Forever On Patrol*. She will perform her duty on waters of New Hampshire's Lake Winnipesaukee where evil diesel submarines will never go.

Guy always told retiring Flag Officers to "know who you want to work with, all else is negotiable". We will always be honored he chose to work with us. He also often remarked "good ideas come after the first martini, and that would be a Tanqueray– Up – Ice Cold – with no Vermouth". Tonight if he could, he would say to us "old truths never die, they are just re-learned ... so keep learning".

In closing, remember Guy's rules of Washington ... "You Never Win, You Never Lose" ... you just keep fighting till the final bell and pray you made a positive difference. Have no doubt Guy ... YOU DID ... Fair Winds and Following Seas 'til we meet again!"

VADM Reynolds' funeral service was at the United States Naval Academy Chapel with his burial with full military honors in the Naval Academy cemetery on 8 April 2010. His son, Jim Quick, delivered the eulogy that is printed here.

What a journey, what a battle, what a victory in life! Thank you for coming to celebrate the life of J. Guy. Guy led life to the fullest, which is honored by the wonderful turn out from all of his friends and relatives gathered here today.

On January first, doctors at Bethesda gave Guy 4 to 6 days to live. Based on Guy's incredible will, stubbornness and intent on not letting anything defeat him; Guy gave his family and friends 3 months of incredibly rewarding time to spend with him.

Guy has had a tremendous influence on his family, his friends and our nation. Here are just a few ways to describe his legacy.

Submariner- The Caring Bridge messages we have received from Guy's fellow submariners, especially from his command on the PINTADO are amazing. Guy loved hearing your messages and thank you to everyone who took the time to send them. It was a hi-lite of the day when we would read your messages to Guy. I'm still not sure about all the leg wrestling stories, but I will leave that to the participants. I'm also not sure how about many other subs that ran into soviet subs, but that may be classified information.

A Patriot – Guy's contribution to our nation is extensive. From naval, especially submarine duty, service in Vietnam and service with the defense intelligence agency, Guy certainly wanted to be on the front lines. There were many stories that he told that began with "Don't tell your mother that I did this"

A Troublemaker - I'm not going to talk a lot about this particular character trait in this setting but many of you have heard the stories. Don't cross J. Guy.

A Father & Grandfather – Guy always treated Cathy, Pete and Susan, me and Lynne and his grandchildren Lauren, Nick, Andrew and Vicky with wonderful love, generosity and respect. It was great fun this past summer to listen to him lecture Lauren, his first grandchild in college about setting and achieving goals in life. There was a lot of eye rolling around the dinner table that night.

A Partier – Guy was a work hard and then have fun type of person. He always found time to enjoy friends and family. Based on the entries on his website he has had many fun times, but I will mostly cherish sitting on the front porch in Montross, shucking oysters, drinking beer, talking about life, business, our wives and an occasional cigar when brother Pete is with us.

A Brother – Guy had tremendous love and respect for his sister Ann and brothers Bob and Jack. We spent many evenings sitting with Guy over the past few months listening to stories about growing up in Illinois.

A Gardener/Oyster Grower – Guy loved his garden and his oysters. Years ago I did not quite understand it. You can buy all this stuff at the grocery store. After some reflection it was obvious that Guy got a lot of relaxation, enjoyment and satisfaction from his garden and oysters. These activities actually mirror his success in life. He used energy, creativity and thoughtfulness and got great satisfaction from his success. Sometimes he was too successful. He would go out to the garden and bring a bucket of beautiful tomatoes or some other creation and proudly present them to Mom. She would look at him with a loving smile and say those are beautiful, but we already have 100 of them. Typical of an overachiever. Every season he had new ideas for his oyster containers, what vegetables to plant, or improvements to the garden irrigation system. Some worked and some didn't, we laughed about the ones that didn't and enjoyed the ones that did.

One of the many memories about Guy battling cancer was a day in January when Pete and I were sitting with him at Bethesda. He started a conversation about buying a John Deer tractor. Then he wanted Pete and me to figure out how to attach his oxygen tank to the tractor so he could go and work in his garden. Pete and I smiled and said there could be some complications with that idea. That did not faze Guy. His next suggestion was that once we set up the oxygen on the tractor the next goal was oxygen on his jet ski.

A Superstar - Shortly after Guy came home from Bethesda a fellow Admiral came to visit. I will never forget his comment when he left. He said Guy was the **Superstar of his generation in the Navy**. This was emphasized by the wonderful tributes given to Guy by Admiral Bruce DeMars, Admiral Kirk Donald, Mr. Dan Smith, and especially Brother Pete.

A Friend – Our family has been blessed with the help of many wonderful friends. We greatly appreciate all of your love and support. Guy received a tremendous amount of comfort from Father Mandato's visits and blessings. Thank you Father. Could you bless my wife a few more times? We had fun talking about how to best administer the Lourdes holy water that Father Mandato left with us...a simple cross on the forehead, just a sip from the bottle or the sip mixed with gin. Kevin and Becky Brenton have given us so much support with regular visits, and help with getting Guy outside with his wheel chair and oxygen during his last few weeks. After Guy spent 20+ days at Bethesda receiving the best medical care in the world, he came home to having Mom, Cathy, Pete and I doing our best to keep him comfortable, keep his oxygen flowing and administering medication. Guy's brother Bob and sister Ann arrived shortly after and while the work was hard, we had many rewarding and enjoyable moments spending time with Guy. Jane and Roger Sexauer were regular visitors and Jane's tremendous support, advice and humor will live in our hearts forever. Guy always looked forward to visits from Admiral Bruce Demars. Admiral Demars stood as Mom and Guy's best man when they renewed their vows after Guy came home from the hospital. Our family will never be able to thank Rick Breckinridge enough for his contribution to taking care of Guy. From picking up Pete during a blizzard, to coordinating Guy and Mom's renewal of marriage vows, to creating the Caring Bridge site, plus many other vital roles, Rick has provided a tremendous amount of support. Guy's friends from the submarine league have been a great help and thank you again to everyone who has helped make Guy's final days as comfortable as possible.

A Husband - Guy's enthusiasm, intelligence, drive and work ethic led him to a very successful career serving our country as well as in the business field. But I know with Guy looking down at us today he would want to say that his most important success was the love and life he gave to Mom. Although he was occasionally in the dog house, it has always been clear that he was totally devoted to giving Mom the best life he could and he certainly achieved that goal. When he was in his bed fighting cancer he would say "I'm glad everyone is here to take care of Jan". He looked forward to their dates each night so he could spend time with Mom and also negotiate for a little extra gin or wine. I have to report that he was usually successfully in those negotiations.

Guy would not want this service to be anything but a celebration of life. Although he has left us way too soon, I believe his message would be to live life to your fullest, work hard to achieve your goals and enjoy your family and friends.

We will all have ways to remember Guy. Living in Portsmouth, NH I will think of Guy whenever I cross the bridge to Kittery and see the subs at the Shipyard. I will think of him when I see the ocean, open an oyster, open a cold beer, see a vegetable garden and most importantly visits with Mom.

Thank you for being with us today.■

LUNCHEON ADDRESS AT NAVY SUBMARINE LEAGUE-JHU/APL SUBMARINE TECHNOLOGY SYMPOSIUM

by Mr. Ronald O'Rourke May 12, 2010

Editor's Note: Mr. O'Rourke is the very respected observer of Naval Affairs for the Congressional Research Service. He has graciously consented to address The Submarine Technology Symposium for a number of years. His views have consistently been very valuable to the submarine community.

Thank you for the introduction. It's great to be back here, and I very much appreciate the opportunity to speak to you today. I remain impressed by the submarine community's continued willingness to listen to challenging points of view. Organizations that do so, I think, are better off in the long run.

As always, I should state at the outset that these views are my own and do not necessarily reflect those of my employer.

Changes in the Arctic

In addition to the kinds of issues I usually speak about at this symposium, I was asked this year to make a few comments about the changing situation in the Arctic, because CRS recently came out with a report on the topic that I coordinated. So let me start with that.

The diminishment of Arctic sea ice is prompting increased human activities in the Arctic, and raising a lot of questions about the region's future. There's interest on the Hill about this, and the new CRS report is intended to respond to that interest by providing an introductory overview of some Arctic-related issues, including the issue of potential implications for U.S. military forces.

For this symposium, one of the things that's notable in the public discussion of the potential implications for U.S. military forces is how little mention there is of submarines. The discussion focuses mainly on how the diminishment of Arctic sea ice is opening up potential new operating areas for Navy and Coast Guard surface ships, and how the two services are exploring what changing conditions in the Arctic might mean for future surface ship and aircraft operations in the region.

The relative lack of mention of submarines is quite a change from the Cold War, when submarines were a big part of the discussion about U.S. military forces in the Arctic. Whether this change should be a concern for the submarine community, and if so, what the submarine community might do to raise its profile in that discussion, is something that submarine supporters might want to examine.

The Navy at the moment isn't racing ahead with major new investments to support increased surface ship and aircraft operations in the Arctic. But it's studying what changing conditions in the Arctic might mean for future required capabilities, and those studies could eventually lead to some investments. The submarine community may want to ensure that its views are heard in that process, particularly in terms of how submarines might contribute to Arctic domain awareness and Arctic environmental observation and forecasting, which are gap items called out in the QDR.

Converting more Ohio-class boats into SSGNs

I was also asked to comment on the possibility of converting more of the Ohio-class boats into SSGNs. The final report on the 2010 Nuclear Posture Review suggests that the 13th and 14th Ohio-class SSBNs might be released from SSBN duty following the completion of the mid-life refueling overhauls on the first 12 Ohio-class SSBNs. If this were to happen, it would create a clear opportunity for converting the 13th and 14th Ohio-class SSBNs into two additional SSGNs, which would help mitigate the projected attack submarine shortfall. This in my view is a significant potential opportunity for the attack boat community to watch for.

Modernizing existing attack submarines

I want to switch very briefly to the topic of the modernization of in-service attack submarines, and specifically the ARCI program. I recently received an update briefing that reminded me just how much this program is improving the capabilities of the existing attack boat fleet. Indeed, given the improvements in mission capabilities that are realized through this program, it's not too much of an exaggeration to say that, in some ways at least, the impact of this program is almost equivalent to adding boats to the fleet. Among the many efforts underway in DOD to improve the capabilities of existing platforms, I would be surprised if this one did not rank among the most dramatic. It's therefore surprising to me that the ARCI program doesn't get more attention. As an example of an open architecture approach that is achieving substantial gains in capability within limited resources, I find it curious that this program isn't highlighted more often.

Attack submarine procurement in 30-year shipbuilding plan

Let me turn now to the new 30-year shipbuilding plan that was submitted in February along with the budget request. In terms of submarines, a lot of the discussion about the new 30-year plan has focused on the Ohio replacement boats, which I'll get to in a moment. There's also been discussion of how the shipbuilding plan maintains the two-per-year rate for the Virginia class through the end of the FYDP. Less attention, by contrast, has been paid to what happened to the attack submarine line in the years after the FYDP.

What happened is this: Compared to the previous 30-year plan, the new 30-year plan contains 9 fewer attack boats–a total of 44 vs. 53 in the previous plan. That's a reduction of about 17%, or about one out of every 6 boats that were there previously. This reduction converts the projected attack submarine shortfall from the bathtub shape that we've been familiar with into one that's more open-ended in the sense that it doesn't get back up to 48 boats by the end of the 30-year period. That's a significant change—and one that has not, in my view, received as much attention as it might warrant. It's also significant for the submarine community—for reasons I'll get into later—that this new 30-year plan shows a significant shortfall in the cruiser-destroyer force that was not in the previous plan.

Ohio replacement program – SSBN(X)

Let me turn now to the main event for my address today, which is the Ohio replacement program. Not long after starting my work at CRS in 1984, there was an article on the Seawolf program in the defense trade press that quoted someone as saying, "If you want to gather a crowd in Washington, just say you're designing a submarine."[1] It's a quote, I think, that has withstood the test of time, because the crowd has now gathered for the Ohio replacement program.

Various observers are concerned about the potential cost of this program and the impact it may have on the amount of funding available for other shipbuilding programs. Indeed, for many observers, this is probably the leading issue regarding the program.

The Navy's report on the 30-year shipbuilding plan acknowledges the issue, and shows reductions in other shipbuilding programs in the years when the Ohio replacement boats are being procured.

Potential impact on other shipbuilding

Even so, there are reasons to think that the program's impact on other shipbuilding programs could be even greater than what is shown in the 30-year plan.

One of these reasons concerns the unit procurement cost of the boats, which the Navy estimates preliminarily at $6 billion to $7 billion. My CBO counterpart, Eric Labs, is currently completing CBO's independent estimate of the cost of the 30-year shipbuilding plan, and as a part of that, CBO is developing its own estimate of the unit procurement cost of the Ohio replacement boats. Given past differences between CBO and the Navy on such matters, I don't think anyone should be surprised if CBO's estimate is higher than the Navy's.

A second reason for concern relates to the profile in the 30-year plan for the level of shipbuilding funding. The profile shows the shipbuilding budget increasing by about $2 billion per year in constant dollars in the middle years of the plan—the years during which the Ohio replacement boats are to be procured. Putting that $2-billion-per-year hump in the profile permitted the Navy to avoid showing even deeper reductions for other types of ships in the years when the Ohio replacement boats are procured.

There's little in the 30-year plan, however, to explain how the Navy will be able to increase the shipbuilding budget by $2 billion per year during those years. Indeed, DOD and Navy leaders are now warning others to expect no substantial real increases in the shipbuilding budget in coming years. So right now, that extra $2 billion a year looks like magic money.

And a third reason concerns the change in the country's finances looking forward that has occurred as a result of the late-'08 financial crisis and subsequent events. I think you have all seen by now the size of the budget deficits that are now projected for the next several years, and the associated projected increase in the debt-to-GDP ratio. CBO is projecting that the debt as a percent of GDP, which is currently about 63%, will grow to 87% in 2019, when the first Ohio replacement boat is to be procured, and reach 90% the following year.

Although we've all seen these projections in recent months, I'm not sure the system has fully internalized what they could mean for the defense establishment. Preventing this projected increase in debt as a percent of GDP could force a major rethinking of what we can afford to do as a nation, including in defense. It could lead to a significant real decline in the defense top line, and within that, the Navy top line and the size of the shipbuilding budget.

11 at-risk Virginias

When I look at these three factors, my first conclusion is that it appears unlikely that the Navy would be able to procure two attack boats in the same year that it procures an Ohio replacement boat, even if a part of the cost of that Ohio replacement boat is deferred to the following year, as appears to be the assumption in the 30-year plan. Since the Ohio replacement boat will cost more than twice what a Virginia-class boat costs, getting two Virginias while also paying for something approaching one-half the cost of an Ohio replacement boat is like procuring three Virginias, and few people would argue that a shipbuilding budget about the same size as today's in real terms, or smaller, would support that without causing unacceptable reductions in other shipbuilding programs. Since there are two years in the 30-year plan that show two Virginias in the same year as an Ohio replacement boat, one might conclude that the second Virginia in each of those two years is not likely to happen.

By the same token, it might also be difficult for the Navy to procure even one Virginia in the same year that it procures an Ohio replacement boat, if the Ohio replacement boat needs to be fully funded in the year it is procured. There are as many as nine years in the 30-year plan that might fit that description. That's another nine Virginias that might not happen.

So the total number of Virginias that are at some risk of not happening is about 11, or about one quarter of the total number of attack boats in the plan. If those 11 boats fall out of the plan, the attack boat force might decline to 34 by the final years of the 30-year plan. And even if a way is found to put about half of those 11 boats back into the plan, the attack boat force would still number 40 or fewer in the latter years of the plan.

At this point, submarine advocates could ask: Why should the Virginia class be the program that absorbs the cost impact of the Ohio replacement program? Why not some other shipbuilding program? It's a fair question.

Cruisers and destroyers

This is where my earlier comment about cruisers and destroyers comes in. There are two categories of relatively expensive ships that the Navy tends to procure each year, year in and year out. One of them is attack submarines, and the other is cruisers and destroyers. Other types of ships are procured in some years but not others, or, in the case of the LCS, are less expensive. So if you want to pay for as many as 11 Virginias, it's hard to do that without reducing funding for cruisers and destroyers.

Arguing in favor of a reduction in the cruiser-destroyer line would not be such an easy thing, for two reasons. First, the cruiser-destroyer community has taken a lot of cost out of its plan by canceling the CG(X) cruiser in favor of the Flight III DDG-51. The Flight III DDG-51 might not be the ship the surface community would prefer if it had its druthers. It won't have the capabilities of a CG(X), but it's a lot less expensive, and the surface Navy has decided that it'll be enough to get the mission done.

Second, even after taking a lot of cost out of the cruiser-destroyer line by canceling the CG(X), the 30-year plan still doesn't include nearly enough destroyers to maintain the cruiser-destroyer force at the required level of 88 ships. The force is projected to decline well below that number in the final years of the plan.

In short, in terms of both cancelling the CG(X) and facing a force-level projection that drops well below required levels, supporters of cruisers and destroyers will be able to argue that the surface community has already given at the altar, and should be spared further reductions.

Their argument could be reinforced by supporters of the shipyards that build surface ships of all kinds, who could argue that while submarine production can be sustained by one Ohio replacement boat per year, reducing funding for surface ships so as to permit procurement of Virginia-class and Ohio replacement boats at the same time could force one or more of the surface yards to drop below minimum sustainable levels of work.

I don't want to rule out the possibility that reductions in a combination of surface ship programs might free up enough funding to procure some of those 11 at-risk Virginias. That's why I spoke a minute ago about the possibility of recovering maybe half of those 11 boats. But this scenario might represent a best case view.

Options for addressing the situation

So, if this is the situation we're looking at, what are some options for addressing it? I want to spend a few minutes going through some.

One of them would be to open a debate about the value of naval forces relative to other military forces in defending the nation's interests in the years ahead, so as to support an eventual shift in DOD budget shares to the Navy.

This option faces headwinds. Current operations in Iraq and Afghanistan, for one thing, tend to focus attention on the value and needs of the ground forces, and not the Navy. In addition, making a case for a larger Navy share of the DOD top line might require more explicit public discussion of China's military modernization effort, which is something the executive branch doesn't seem too interested in. And the federal budget situation I mentioned earlier might lead to a reduction in DOD top line, which could offset some or all of the effect of gaining a larger share of that top line.

Another option that has been mentioned in hearings this year would be to fund the Ohio replacement boats outside the shipbuilding budget—for example, in a newly created strategic forces investment account. There's some precedent for such an arrangement in the National Sealift Defense Fund, where DOD sealift ships and Navy auxiliaries are now funded, and in the way in which most BMD acquisition programs are funded through the Defense-Wide R&D account rather than service R&D and procurement of accounts. Skeptics, however, might argue that this option might not result in additional funding for the procurement attack submarines or other kinds of Navy ships, because the funding for the Ohio replacement boats might simply be moved out of the shipbuilding account along with the boats themselves.

Two more options would be to transfer the detailed design costs of the Ohio replacement program, and the nuclear fuel core costs of the boats, from the shipbuilding account to other Navy accounts, so as to reduce the procurement cost of the Ohio replacement boats, and particularly that of the lead boat, as they appear in the shipbuilding budget. Doing this, however, would reduce the procurement cost of the follow-on boats by only a few percentage points, and would put added pressure on the receiving budget accounts.

An additional option that I have outlined in my CRS report on the program would be to spread out the funding profile for the Ohio replacement program by starting procurement two years earlier than currently planned, and ending it two years later than currently planned. The boats funded ahead of the current schedule would still be executed as if they were funded on the current schedule, and executing the final boats in the program a year or two later than currently planned might depend on the Navy being able to extend the service lives of the final Ohio class boats by one or two years. This option would not reduce the total procurement cost of the Ohio replacement program, and might even increase it somewhat by reducing the rate of learning in the program. But it could permit a greater use of incremental funding in the program, which could reduce the program's impact on other Navy shipbuilding programs in certain years.

Reducing procurement cost of Ohio replacement boats

Three more options would aim at reducing the procurement cost of the Ohio replacement boats themselves.

One of them would be to avoid cost-increasing features in the boat's design that are not necessary to meet the boats' threshold operational requirements. I'm not sure how many opportunities there might be in the boat's design for doing this, but the submarine community will likely be pressured to show that all such opportunities are being pursued. This option could preclude using the Ohio replacement program as an engine for developing technologies that might benefit downstream submarine designs.

A second option for reducing the procurement cost of the Ohio replacement boats would be to increase the program's R&D funding, in order to mature any technologies whose development is not currently in the program's funding plan, but which if matured and incorporated into the boat's design, could reduce its procurement cost. This option would increase the program's near-term cost and technical risk in return for the promise of a downstream benefit in reducing recurring production cost. Again, I'm not sure how many opportunities there might be in this regard.

A smaller boat with a smaller missile

And a third option for reducing the boat's procurement cost that has been mentioned in hearings this year would be to design the boat around a missile that is substantially smaller than the D-5. Such a boat could be a variant of the Virginia class design, or an entirely new design. The smaller missile could be a C-4-sized missile, or a missile of a different size that is nevertheless substantially smaller than a D-5. I want to spend a few moments focusing on this option.

In connection with this option, the Navy has stated that no C-4 missiles are available for refurbishment because only a limited number of C-4 rocket motors remain. The Navy also states that C-4 missile hardware, including equipment sections, nozzles, and avionics, has been destroyed or disposed of.[2] The Navy's D-5 life extension program, however, involves the procurement of D-5 missile motors, as well as other critical components, and also includes the redesign of the guidance system and missile electronics, which must be replaced to support the extended service life.[3] Given the kind of work entailed in the D-5 life extension program, the Navy may need to provide some more details on how many C-4 missiles remain in existence, and what the feasibility and cost would be to make C-4s ready for use on a Ohio replacement boat.

Regarding the idea of producing new C-4s, and updating their guidance systems to make them more accurate, I imagine that most or all of the C-4 production tooling has been disposed of. But that doesn't mean it couldn't be reestablished. Even with the cost of reestablishing the production tooling and updating the guidance system, the total cost of a smaller boat with new-production C-4s might be less than that of a larger boat armed with life-extended D-5s. The Navy may need to provide more details on the costs associated with producing new C-4s with updated guidance systems.

The Navy has stated that it studied various Virginia-based design options, and concluded that a Virginia-based design would have technical and operational shortcomings and risks.[4] It's not surprising that a Virginia-based design would have shortcomings, but the Navy may need to provide some additional information on what these shortcomings are, and why they would be showstoppers in terms of performing the mission. And while a Virginia-based design might pose risks, the Navy's anticipated new design would pose some risks as well. The Navy may need to clarify exactly what Virginia-based options it has studied—including whether any of these options were designed around a C-4-sized missile—and what the technical and operational shortcomings and risks of these designs were.

A new-design boat designed around a smaller missile might lack some of the technical and operational shortcomings and risks of a Virginia-based design. It's not clear whether the Navy has studied a new-design boat designed around a smaller missile. I imagine the Navy has not studied this option in detail, since the program's baseline intention was to design a submarine capable of launching the D-5. If so, it might clarify matters for the Navy to examine and report on what this option might look like.

Costs and capabilities

Given the costs to acquire a smaller missile, and particularly to develop one, I don't know for certain whether the combined cost of a smaller boat and a smaller missile would be less than the combined cost of a larger boat armed with life-extended D-5s. But the Navy doesn't know that for certain either, in part because the Navy has not estimated the cost of developing a smaller missile.[5] The Navy should know what these comparative costs are, and be ready to show them to others.

If it happens to turn out that the combined cost of a smaller boat and a smaller missile is less than that of a larger boat with life-extended D-5s, then the follow-on task would be to examine the differences in capabilities between the two options, particularly those stemming from the reduced range/payload of the smaller missile. A boat with a smaller missile would likely have substantially less nuclear deterrent capability. The question would then become one of examining requirements for the nuclear deterrence mission in coming years, which might or might not be the same as what they have been in past years, and determining whether a boat with a smaller missile could meet those requirements. The impact on the UK successor SSBN program would also need to be examined.

For the submarine community, it might seem late in the game for others to be raising the question of a smaller boat with a smaller missile, because a lot of work has already occurred on the program, particularly in the form of the Analysis of Alternatives (AOA) for the program. But these other observers haven't yet seen the AOA.

In addition, the Ohio replacement program has its roots in developments that occurred prior to the financial crisis of late-'08. In light of the change in the nation's finances that has occurred since that time, and the potential impact of the Ohio replacement program on programs for building other ships, including attack submarines, it might not be unreasonable to examine whether the founding precepts of the Ohio replacement program remain valid. This is part of what I meant when I said earlier that I'm not sure the system has fully internalized what the changed financial projections could mean for the defense establishment.

I'm not arguing for or against any particular design option for the Ohio replacement boats. What I'm instead suggesting is that it might be helpful if the program were to proceed on the basis of a full understanding by all stakeholders, both inside the Navy and elsewhere, of the relative costs, capabilities, and risks of all plausible options for this program, particularly in light of the budget circumstances that have developed over the last year and a half.

Other options

If, in the end, an Ohio replacement boat armed with life-extended D-5s is the best solution, then there are some remaining options that might be examined for addressing the scenario of an attack submarine force that could be reduced to 40 or fewer boats.

One of these would be homeporting more attack boats in forward locations like Guam or Hawaii. Another would be dual-crewing of attack boats. And a third would be service life extensions for the 23 Improved 688s. And here, I'm talking not about an extension of a few months to two years, as was discussed by the Navy a few years ago as a means of mitigating what was then the bathtub-shaped attack boat shortfall. I'm talking instead of service life extensions on the order of 10 years or more, which would require refueling the boats.

I understand that it's not clear whether such a thing would even be feasible, due in part to the question of whether the pressure hull could last that long. And even if it were feasible, it would likely be expensive in terms of the cost for each year of additional service life gained. But if things like additional forward homeporting and dual crewing are not enough to make do with an attack boat force of 40 or fewer boats, it would be prudent to explore this option, so that the submarine community can be certain about its feasibility and costs, and be prepared to show this to others.

And if it turns out that the option is just not feasible, and that forward homeporting and dual crewing are not enough to make do with an attack boat force of 40 or fewer boats, then I'll give you one more option that might go down a little easier, since it relates to another part of the Navy, and that would be to significantly extend the service lives of surface ships, particularly the 22 Aegis cruisers and the 28 Flight I and II DDG-51s. The 30-year shipbuilding plan calls for operating these ships to age 35. The idea here would be to extend their lives to something like 45 years, so as to defer the need for procuring their replacements until after the Ohio replacement boats are funded. That might make it easier to put more of those 11 at-risk Virginias back into the budget, and bring the attack boat force closer to 48 boats.

Extending the service lives of these cruisers and destroyers to something like 45 years would have a substantial cost, and it would pose some technical challenges. But it would not present some of the feasibility issues associated with extending the Improved 688s beyond 40 years. So a final option that submarine supporters might consider would be to begin thinking of the Aegis cruisers and the Flight I and II DDG-51s as their new best friends. This would entail encouraging the Navy to begin planning for the Service Life Extension Program (SLEP) of these ships, and for treating these ships well in terms of maintenance funding between now and the time that they would undergo their SLEP overhauls.

Conclusion

As you can see, I'm trying to think through the various aspects of the situation I have outlined today concerning the impact of the Ohio replacement program on other shipbuilding programs, and particularly the Virginia-class program. I think we all need to do this, and that, in light of the shift in the nation's finances that has developed over the last year and a half, this effort should include the examination of options that previously were not considered necessary to examine. Hoping for the best is not a plan, and the risks of doing only that might now be particularly great, given the new budget situation. I hope that, in these remarks, I have given you a few ideas to pursue, as we try to work our way through this.■

Thank you.

ENDNOTES

1. Charles Doe, "Navy Seeking Submarine for 21st Century," *Navy Times*, April 28, 1984: 30.

2. Source: Navy information paper dated March 24, 2010, on SSBNs and SLBMs, responding to questions posed by CRS and CBO.

3. Source: Navy FY2011 justification book for WPN account, PDF page 17 of 196.

4 Source: Navy information paper dated March 24, 2010, on SSBNs and SLBMs, responding to questions posed by CRS and CBO.

5. Source: Navy information paper dated March 24, 2010, on SSBNs and SLBMs, responding to questions posed by CRS and CBO.

NEW MEXICO COMMISSIONING
Admiral Kirkland H. Donald, U.S. Navy
Director, Naval Reactors
27 March 2010

Thank you Ms. Stiller for your kind introduction. Congressmen Scott, Heinrich, and Nye, Secretary Rumsfeld, Admirals Greenert, Harvey and Giambastiani, fellow flag officers, and honored guests: Welcome, and thank you for your participation in today's ceremony.

Mr. Casey, Mr. Mulherin, NEW MEXICO Commissioning Committee, the Electric Boat-Northrop Grumman Newport News Shipbuilding team, officers and crew of NEW MEXICO, congratulations on the superb effort that has brought us to this day in the life of this ship, the State of New Mexico, and our Nation—a day USS NEW MEXICO starts living her motto—*defendemos nuestra tierra*—we defend our land.

And finally, to our ship's sponsor, Mrs. Cindy Giambastiani, today is the day you bring your ship to life. Your involvement and support of this crew has set the tone of what we all know will be a beautiful relationship that will carry this crew throughout the life of this ship.

Today is a celebration of a collective effort that started many years ago and involved many hands. As I thought about the countless individuals that have contributed to the Virginia class and this ship the word stewardship came to mind. Stewardship - more than an easy, clean definition; it is a concept—an ethos—a way of behaving. It is caring for something as defined by ownership, without actually owning the asset. Much like "class" stewardship is tough to completely capture in words but is readily identified by its presence or absence.

It is about *moving the ball forward* to the best of your ability when it is your turn to take the handoff knowing others will enjoy the benefit of your labor. It is deeply intertwined into the most basic aspects of public service, leadership, and serving something greater than one's self—and it is in a very tangible sense the reason we gather today.

Starting in the early 90's—before many of NEW MEXICO's crew were out of diapers—the funding support and design work to build a new class of submarine began. The civilian and uniformed leadership—some of whom are with us today—did the hard work, aligned decision-makers, gathered public support, defined the requirements based on anticipated threats and missions, and controlled the costs.

In short they were stewards—stewards of our Nation's security and its treasure. People that understood and believed the words of President Kennedy, "Control of the seas means security. Control of the seas means peace." Over nearly two decades—from the start of the Virginia class work until today—the people in the leadership roles have changed but the personal involvement and support for this ship—for the good of the Nation—have remained, and remain so today.

The stewardship of the design engineers, construction planners, and skilled technicians followed suit by leveraging efficiencies and lessons learned from over 100 years of submarine construction in order to reach an optimal mix of mission capability and cost reduction.

These great Americans cared about getting all the complex systems, and all the components unique to submarine operations in the most hostile environments—down to the finest detail—exactly right to support shipbuilders and Sailors with whom they would never work or know personally.

The stewardship of Electric Boat-Northrop Grumman Newport News Shipbuilding team: in a unique, collaborative effort this alliance has created the worldwide standard for building ships through their Virginia class construction work. Their combined capability is unmatched in efficiency, quality and cost. Even with an enviable record of performance on the first five submarines of this class—the team that built NEW MEXICO set a new schedule benchmark of just 70 months to delivery. This achievement did not come easy.

There were bumps in the road but at the end-of-the-day, this mission-ready ship was delivered in shorter time than any other ship of the class thus far—and a year faster than the last Virginia class built in Newport News (NORTH CAROLINA 70 vs. 82 months).

Aside from the significance of this accomplishment from an engineering and cost saving perspective, it means another much needed asset will be delivered to the Fleet sooner than expected to meet the vitally important needs of our Combatant Commanders for these submarines—needs that play a critical role in our current conflicts and deter potential adversaries (or near peer competitors). I challenge this remarkable shipbuilding team to continue their good stewardship of the public dollar and trust by showing that lessons earned in this project reap benefits as lessons learned on other projects.

To every member of the NEW MEXICO shipbuilding team—thank you. Thank you for your expertise, your attention to detail, and your very real contribution to our national defense in building a magnificent submarine that you won't personally deploy on, for Sailors most of whom you will never meet: Stewardship.

To the officers and crew of NEW MEXICO, you are off to a great start. Successful crew formation, new construction period, training ramp up and sea trials are accomplishments for which you should be proud. More than meeting these milestones you have also established a record of excellence in the short life of this ship: First Virginia class submarine to earn their tactical weapons certification prior to the post-shakedown availability, first boat built here in Newport News to earn their fully electronic navigation certification prior to sea trials, and already the recipient of the Squadron 8 Engineering Red "E" for damage control and engineering excellence.

As I previously stated, part of stewardship is *carrying the ball forward* to the best of your ability when your time comes. The funny thing about life is that you don't always have a say when it will be your turn to carry the ball. LT Wielkoszewskiknows all about that. Due to an unexpected personnel transfer, he became the Weapons Officer of NEW MEXICO while on his first sea tour. He and his department worked with the shipbuilders to make the combat systems training capability available as soon as possible in the construction process allowing for the opportunity to earn their tactical weapons certification early. As a result, NEW MEXICO is closer to being ready for the frontline of our national defense. Each member of the crew must do their part on a daily basis and prepare themselves should opportunities of greater responsibility arise. I remind you of Aristotle's words, "Excellence is an art won by training and habituation. We are what we repeatedly do. Excellence, then, is not an act but a habit."

So while you have started a record of success—your hard work has just begun. You are still in the formative years of the culture of this ship. Many Sailors that will report long from now will be affected by the standards you espouse now. You will have a meaningful legacy—both in the camaraderie and spirit of the crew, and material condition and longevity of NEW MEXICO. She is built to last over three decades - but will only achieve those years of service through your committed stewardship.

Finally, I want thank Cindy Giambastiani for her dedicated service to the Submarine Force over many years and specifically for her care and compassion for this ship and her crew. Cindy, you are a shining example of selfless service through your work in the community and for our Sailors. NEW MEXICO could not be in better hands with you as her sponsor. Since the christening you have contributed to the personality of this ship and we all look forward to you *bringing her to life* in a few minutes.

As you can see, the list of contributors to this day are many and the significance and function of each individual is varied but the spirit of stewardship rings true. Each of you that remain associated with the Submarine Force are called to continue to act in the best interest of the ship, the shipyard, the Navy, the American citizens, and Nation; not for the benefit of self, but for country.

I thank you again for joining me for this momentous occasion. I look forward to the continued success of USS NEW MEXICO and her crew. Thank you.■


"AHEAD 100 KNOTS."

<u>*ARTICLES*</u>

A SUMMARY OF HISTORY OF SUBMARINE RADIO COMMUNICATION PART ONE

by Edward Monroe-Jones, LCDR., USNR (Ret), Ph.D.
CAPT Robert Baker, USN (Ret)

Dr. Monroe-Jones is an Industrial Psychologist consulting in Organizational Development and Labor Relations. He is also the Director of the Submarine Research Center in Bangor, Washington. He Qualified in Submarines twice: as an enlisted man on STERLET and as an Officer on SIRAGO. He is a frequent contributor to <u>THE SUBMARINE REVIEW</u>.

Captain Baker served as a Radioman in four submarines making RMC(SS) in THEODORE ROOSEVELT before being commissioned as an LDO. He continued in submarine communications billets along with a seven year tour at the White House. As a Captain he commanded NAVCOMSTA Puget Sound and NAVCAMSEASTPAC. He retired after forty years service.

After Tesla and Marconi demonstrated to the world the strange, new phenomenon of wireless communication, the United States Navy recognized the potential of instantaneous communication by and to ships at sea. Until the turn of the twentieth century, ship communication was principally by semaphore flags. Such communication was restricted to line of sight. The potential of radio brought the prospect of maritime safety in navigation and collision avoidance as well as tactical coordination.

Civilian engineers and business entrepreneurs began designing and building radio equipment. Civilian hardware development outpaced the Navy's ability to visualize what an integrated radio communication system might entail. Formal training of personnel was a few years in the future when the Navy began to learn by experience. Shipboard personnel often constructed radio equipment using civilian manufactured parts. As a result, some ships had reasonable success with radio communication while others were left at the gate.

Transmitting equipment used spark generators and frequencies were crystal controlled. Nothing was known of interference so *atmospherics* from sun spot aberrations, ignition noise, frequency drift and a host of other problems caused radio communication to be less than reliable. Operators couldn't understand why at some times of the day their signals could be heard hundreds of miles away and at other times only for short distances. Adding to these vagaries were receiver difficulties in fine-tuning frequencies and the variance in transmitting equipment. Most of the Navy's transmitters and receivers were made by civilian companies such as Slaby-Arco, Shoemaker, De Forest and Fessenden. They ranged in transmitting power from one kilowatt to 3.5 kilowatts and each ship had its own preference of equipment.[1]

Shore installations were built to provide aids to navigation. During 1904 the transmitting stations at Cape Cod, Massachusetts and Norfolk, Virginia began transmitting time signals for use in navigation. The following year, new stations at Portsmouth, New Hampshire, Key West, Florida and Mare Island, California added the service to a dedicated frequency.[2] Meanwhile, the federal government saw the need to exercise some control over the rapidly expanding competition for frequency use. President Theodore Roosevelt established the Interdepartmental Wireless Telegraph Board within the Navy Department. It promulgated Instructions for the Transmission of Messages by Wireless Telegraphy, U.S. Navy. As the potential of radio became evident, the Navy tried to structure a communication system that would be of benefit to all mariners. It began a service of broadcasting Notices to Mariners that were produced by the U.S. Hydrographic Office.[3]

The Navy found itself as the sole provider of prompt communication during the April, 1906 San Francisco earthquake. The earthquake and subsequent fires destroyed telegraph offices in the city. USS CHICAGO docked at the Ferry Building at the foot of Market Street and transmitted messages to the Mare Island Navy shore facility which then relayed information across the nation via telegraph lines. USS CHICAGO and its radiomen became instant heroes and the Navy's commitment to better radio communication was enhanced.[4]

In the meantime, submarine development was also progressing. The Lake Company in Quincy, Massachusetts and the Electric Boat Company in Groton, Connecticut were designing and building more dependable submarines. By 1910 several submarines had been equipped with transmitters and receivers. There was no dedicated space for such equipment and installation was at the expense of what little habitability was available.

Weather and sea water incursions affected submarine radio equipment. Moisture coupled with heat caused shorts, warped condenser plates and blown-out transformers. Prolonged use of transmitters caused heat which ruptured power supplies.[5] Antenna installation proved to be a difficult problem. The need for a lengthy end-fed antenna raised as far off the deck as possible meant installing collapsible masts at both ends of the submarine. To transmit and receive, meant breaking rig for dive and sending men out onto the narrow deck to raise the antenna masts. Friedman described a submarine's antenna as follows, "The USS OCTOPUS was tested with a primitive radio antenna, although it was not permanently installed. Consisting of 30 foot masts and 50 feet of wire, the antenna could be used when the submarine ran surfaced or awash. Its range was about 40 nm."[6]

From today's perspective it is a wonder that radio equipment in 1911 worked as well as it did. The primitive nature of submarines worked against the effectiveness of the equally primitive radio equipment. In a 1911 exercise of the fleet, submarines were assigned the mission of attacking several battleships. Only three of seven boats managed to make an attack; the remainder having never received the initial radio message to engage. It was clear to the Navy that submarines were of only marginal value to the fleet and that radio communication was antithetical to their design.[7]

In other respects the Navy was moving with faltering steps to organize radio communication. In 1908 the Secretary of the Navy established separate components of Navy Radio—the Shore Establishment and the Fleet. Shore communication was essentially in the hands of Naval District commanding officers. At sea, circuit discipline was controlled by individual ship captains who had varying degrees of trust in radio as a reliable communication system. Perceptions of flag rank officers were skeptical and naive. One ship captain assigned Ensign Harold Dodd to the wireless room because he knew how to play the piano and could tune the instrument. The captain assumed that this talent qualified the ensign to take responsibility for the ship's radio equipment.[8]

Figure 1. The E-2 in New York Harbor, 1912, showing the boat's collapsible masts and paired antenna. The masts were folded and secured to the deck on rig for dive. From Submarine Research Center collection.

Figure 2. The S-22 in Long Island Sound circa 1922 showing its retractable antenna mast and paired antenna fore and aft. From Submarine Research Center collection.

Training of fleet personnel was absent in the early days of Navy radio communication. Signalmen were self trained in the art of Morse Code taken from radio. While the Bureau of Navigation was nominally in charge of such training, it failed to recognize the need. Despite this, fleet exercises in 1906 often used radio communication as the primary tool for maintaining a ship's station in formation and for coordination of movements.[9] By the beginning of the First World War, the Navy had established its first radioman's school, although at the time the personnel were called Wireless Telegraphy Electricians. The Navy's first manual for the Wireless Telegraphy Electrician rate started with the basics, "Sparks accompanied by a sharp crackling sound are produced between highly electrified bodies when brought very near each other. After the spark has passed, the bodies are found to be discharged."[10] Chapter II of the 1915 Manual for Wireless Telegraphy was titled, "Production, Radiation and Detection of Ether Waves."[11] In more modern phraseology the title meant, "Transmission and Receipt of RF." Wireless telegraphers received training in electronic theory. For example, the basic equation, Inductance equals Current divided by Resistance is discussed in detail as it relates to Capacity in AC circuits. The trainees were expected to understand electronic relationships which mathematically involved square root and complicated algebraic expressions.[12]

As America watched the battles in Europe during the First World War, its industry began to accelerate. Radio equipment saw many innovations as the Navy continued to improve its communication procedures. In 1915 the first three-element tube was developed. Its oscillating properties made use of heterodyne reception feasible with resulting improved continuous wave reception. At the same time the Poulson arc transmitter also produced sharper continuous wave transmission. These accomplishments made possible longer distance communication with lower output power. The Alexanderson alternator made low-frequency transmission successful. By 1916 the alternating current tube transmitter had largely replaced the spark gap with electronic oscillators. Dials were fixed to the shafts of the tuning condensers making it possible to calibrate each receiver so that the operator could tell where to align it for specific frequencies.[13]

Just as important to improved equipment was the advance of submarine antennas. The typical First World War American submarine still had forward and after collapsible masts that required rigging while the submarine remained on the surface. Permanent jumping wires stretched from the periscope shear to the bow and stern. A horizontal, center-fed antenna ran from the mid-point of the forward jumping wire to the mid-point of the after jumping wire. Some versions included preventers to keep the long jumping wires from whipping in the wind. Insulators were spaced at the ends of the jumping wires.[14] While electronic schematic diagrams of Telefunken, Fessenden and Marconi spark transmitters were included in the 1915 operator training manual, instructors were supplementing the curriculum with instruction on modern tube-producing CW signals.[15]

The 1915 Wireless Manual was updated during the war with instruction on radio operator procedures including symbols that remained in the Navy's CW communication lexicon as long as Morse Code was used.[16] These Morse Code procedural abbreviations evolved into shortened standardized prosigns which were combinations of two letters sent together with no space separating the letters. They included AR to mean, *end of message*; DE to mean, *from*; AS to mean *wait*; BT to mean, *break*; SK to mean, *end of transmission* and a host of others. Most were derived from frequent usage and were the product of operators' attempts at brevity. Also, in early use was a system of Q Codes which used normal spacing. These were intended to quickly convey operator to operator set-up information and radio processing, but were never used within the text of a message. Examples included QSL to mean, *I acknowledge receipt*; QRX to mean, *wait*; QRV to mean, *ready to copy*; QRL to mean, *this frequency in use* and QSU to mean, *please call me when I have finished*. The Q Codes were quickly adopted by the Navy and were included in the formal training curriculum.[17]

Also included in formal training was circuit discipline. Robison's Manual for Wireless Telegraphy, which continued to be the primary instruction resource during the First World War, described several basic principles, including, "When a ship is within ten miles of another which is receiving faint signals, the first ship should not attempt to send until the receiving ship has finished, unless she sends on a widely different wave length and even then she should not use more than one kilowatt. Ships in the same vicinity (within 20 miles) should not use more than one ampere in the aerial when communicating."[18]

By 1916 the Navy's shore stations were operating with regularity, but the only one able to consistently transmit in distances exceeding 1000 miles was the one at Arlington, Virginia. Congress allocated funds for the building of six additional shore transmitting stations, but it was several years before they were operational.[19]

When America entered the war, Congress immediately passed several bills allocating funds for the construction of military equipment. Included were significant numbers of ships and within that allocation, was a significant number of submarines. Although the Armistice of 1918 came before most of the allocated submarines could be built, the Navy retained the authority and submarine development/construction during the succeeding decade proceeded at a steady pace. Running parallel to submarine development were advances in radio communication.

During the early 1920s the Naval Radio Research Laboratory continued its interest in the basics of radio waves. It obtained information about the origin of static caused by the earth's magnetic field while the Navy Radio Test Shop concentrated on radio equipment research and manufacture.[20] Specialized research was also being conducted in the Navy Yards. The Boston Yard worked on keys, condensers and antenna design, the Brooklyn Yard on frequency changers, the Washington DC Yard on receivers, amplifiers and transformers and the Mare Island Yard on quenched gaps and motor-generators.[21]

Figure 3. Interior of Fourth Naval District Radio Center in 1925. Permission of Naval Historical Foundation.

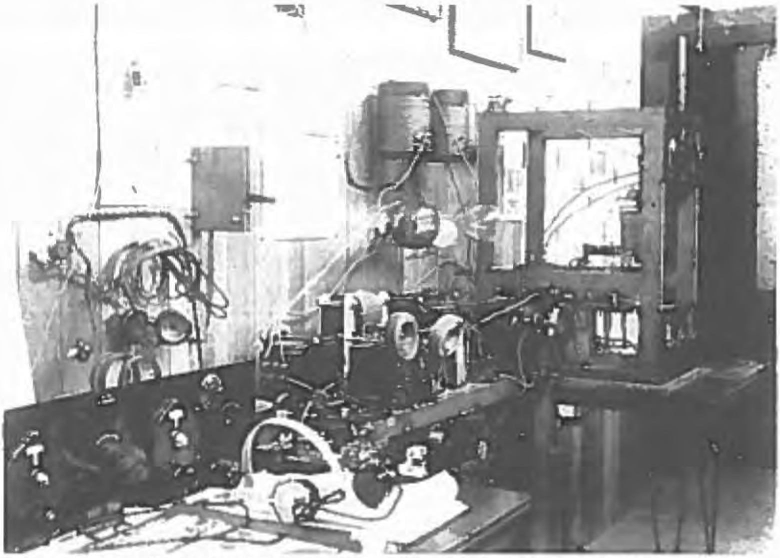

Figure 4. A radio test stand in the Navy Radio Test Shop in 1923. From Submarine Research collection.

At the same time, transmitter and receiver improvements continued at a steady pace. The model TL transmitter, designed and built by Navy engineers was ready for production in 1923 and was tested on USS WYOMING. It produced six kilowatts using a spark transmitter. While the TL was being developed, the smaller 100 watt Model TM, alternating current transmitter was designed for submarines. The TM was modified and became the TW which was matched with RE, RF and RG receivers, all of which operated on the four meter band.[22]

In 1926 the Navy began producing transmitting equipment which used oscillating vacuum tubes. The improved but bulky transmitting equipment, models TB, TF and TG were placed on surface ships while the smaller and less powerful TE (replacing the TM) was assigned to some submarines. Although not completely satisfactory, they were an improvement over the small spark sets previously installed in submarines. The Model TF, similar to the Model TE, but not configured for fitting into submarines, was installed in submarine tenders. Those submarines not equipped with the Model TE transmitter were given the older Model TM which, although still using a spark gap, was an improvement over the older 500 watt transmitters.[23]

The mid 1920s saw the Navy's interest grow in frequency selectivity. Its intent was to transmit and receive multiple signals simultaneously at one location. During this same period, the Navy, together with various commercial radio manufacturers, investigated the possibility of receiving radio signals through sea water. The radio station at Nauen, Germany, transmitting on a frequency of 24 kilocycles, was received by a submerged submarine off New London, Connecticut, some 3,234 miles distant. This submarine was fitted with two multiloops located at right angles to each other with the loops 14 feet below the surface. It was also discovered that, with the submarine at periscope depth, any high-powered station transmitting on a very low frequency could be received at distances up to 3,000 miles. Continued experiments proved that single turn loops were as efficient as multi-turn ones and that, at a particular frequency and specific depth of receiving antenna, the effective range of signal was directly proportional to the power delivered to the transmitter antenna. Based upon this information, the Model RA receiving equipment was designed for submarine installation. It utilized Navy components and a specially designed loop tuning system, and covered the frequency range of 16-1200 kilocycles.[24]

In 1924 the first high frequency receiver was installed in ships in the fleet. Because of the *skip* phenomenon, high-frequency radio could not be used in the same manner as the lower frequencies; however, the signal to noise ratio with lower power outputs was so favorable that the Navy continued to pursue its interest in high frequency transmission. The Navy issued a frequency plan that included signals up to the 18,000 kilocycle band. By the end of the 1920s the fleet had far better equipment and such higher frequencies were routinely being used. The use of higher frequencies was coupled with an improving knowledge of antenna inductance. Battleships with tall cage masts provided the best platforms for antennas while submarines with no appreciable rise above the deck other than periscope shears had to improvise.[25]

While during the 1920s, submarine transmitter and receiver development saw the replacement of the spark gap by the vacuum tube, antenna problems were difficult to overcome due to the nature of submarine construction.

In 1922 the O-10 had a fore and aft running antenna supported at its centerline by the bridge. Its function was to act as a loop antenna. It also carried an additional higher antenna supported at its center by a telescoping mast just aft of the bridge.[26] Also during the 1920s the V, R and S Class submarines housed husky, retractable radio masts that were designed to raise their paired antenna as far above the deck as possible. These telescoping masts exceeded the height of the raised periscopes by 10 feet or more.[27]

As radio reception improved during the latter 1920s, modifications were made to the S Class boats to include a permanent loop antenna that ran aft from the bridge to a dedicated stanchion at the boat's stern. This antenna improved the boats' ability to copy CW while running at periscope depth.[28]

The stock market crash and resulting economic depression adversely affected commercial and Navy radio development. Some few improvements were made in radio equipment by service personnel, but these were limited in nature. A singular accomplishment was the tactical radio transceiver which used a frequency of about 60 megacycles.[29] As the nation began to recover from the economic morass, the Navy turned its attention once again to building better transmitters for submarines. TAR-2 and XF-1 high-frequency transmitters were installed in the new fleet type submarines. Also included in the modern submarine inventory were the TAQ and TAQ-1 low-frequency transmitters. Aligned to these transmitters were RO-RP low, medium and high frequency receivers which were also installed in the larger, fleet type submarines.[30]

The Bureau of Engineering wrestled with the problem of space allocations in submarines. It was clear that radio equipment had to be located close to antenna trunks that penetrated the pressure hull. This meant that submarines had to place radio equipment as near to the periscope shears as possible. Inevitably, the space allocated was immediately aft of the periscope wells and this placement meant sacrificing space from the control room.

The 2000-3000 kilocycle band was found to be superior for tactical uses. This allowed the lower-powered submarine transmitters to better utilize their limited antennas. During the late 1920s the Bureau of Engineering recommended that submarines test high frequencies and if found to be successful it would assign them specific operating frequencies for intrafleet communications.[31]

Friedman described the Bureau's work, "The new strategic scouts needed long-range radios. WWI boats had flat-top antennas supported by pairs of collapsible masts, which took time to erect or take down. BuEng substituted pairs of cables extending from bow and stern to a T-topped mast telescoping from the periscope shears, forming fore and aft loops. A boat could transmit at periscope depth by using a short antenna fixed to a periscope. In February 1930, an S-boat used the new antennas and the associated new radio to contact a station 7,900 nm away. The submarine could make contact at 2,000 nm by using three feet of vertical antenna pushed up through the surface. Low frequency signals (less than 100 kiloHertz) could be received at depths up to 64 feet."[32] In the fall of 1935, the cumbersome loop antennas were replaced by wing antennas that strung from the bridge fairwater down the port and starboard sides of the boat to deck stanchions at the bow and stern.

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THE CONVOY SOLUTION—IGNORED UNTIL ALMOST TOO LATE

by CAPT John F. O'Connell, USN (Ret)

Captain O'Connell is a retired submarine officer. He is currently at work on a history of submarines and has offered several fruits of his research for articles in THE SUBMARINE REVIEW.

Early during World War I, the submarine began to emerge as a formidable weapon system. During 1914 submarines sank a number of capital ships. The war began August 1914. On September 14, 1914, the U-21 torpedoed and sank HMS PATHFINDER, a light cruiser operating in the Firth of Forth near Edinburgh, Scotland. PATHFINDER's forward magazine exploded and she went up in a fiery blast, along with over 250 crewmen.

About a week later U-9, a paraffin-electric boat, an earlier model of U-boat equipped with very smoky kerosene engines, was on patrol in the North Sea near the neutral Dutch coast. The weather was stormy and she had been driven south by heavy seas. On 22 September she came across three armored enemy cruisers, HMS ABOUKIR, HMS CRESSY and HMS HOGUE. The heavy weather had forced their destroyer escorts back into port. U-9 had two torpedo tubes forward and two aft plus two reload torpedoes.

The armored cruisers had no sensors capable of detecting a submarine except for their lookouts. Commencing an approach at periscope depth U-9 torpedoed ABOUKIR first, and then went below periscope depth to reload. ABOUKIR's commanding officer thought his ship had struck a mine and requested assistance from her sister ships. They moved in to rescue survivors. When U-9 returned to periscope depth she found HMS CRESSY and HOGUE and their boats engaged in rescue operations, and ABOUKIR sinking. U-9 put two bow torpedoes into HMS HOGUE and ten minutes later she was gone also. U-9 finished off the trio of armored cruisers by hitting HMS CRESSY with her last two torpedoes, after missing with one torpedo. There were almost 1400 casualties, and the Royal Navy thought that an entire German U-boat flotilla had been involved. Naval warfare would never be the same again.

During 1914 the Allies lost only thirteen ships totaling 64, 163 displacement tons. In addition to the ships already mentioned, they included HMS HERMES, HMS HAWKE, and HM SUBMARINE E-3. French battleship JEAN BART was also torpedoed and badly damaged.

The British Expeditionary Force (BEF), consisting of a number of Royal Army infantry divisions were all safely transported to French ports without any losses to U-boats. There were two reasons: the German Army had not seen fit to inform the German Navy of its war plans for a fast sweep through Belgium into France to take Paris and repeat its 1870 triumph so no naval plans were made to interfere with BEF movement; and the BEF troop convoys were heavily escorted by destroyers.

Convoy of valuable ships was an old technique dating back at least to the Napoleonic Wars of the early 1800s. Large groups of valuable merchant ships gathered at a convenient port, and waited for a suitable number of escorts. When ready the convoy sailed for its destination, with frigate escorts harrying the plodding merchant sailing ships back into formation when they straggled. If an enemy sail was sighted a frigate or two would give chase while the convoy proceeded on its way. A fast sailing privateer vessel like a Baltimore clipper might be able to cut out a prize or two but the bulk of the convoy would reach its destination. The same plan applied to steam ships although they were less affected by winds. Sail-powered frigates gave way to steam-powered destroyers, but the theory was the same.

The Royal Navy instituted a distant blockade of all ship traffic to and from German ports upon the outbreak of war. Before long the effects of the blockade were felt. German government authorities looked for an answer. Their hopes for a short war, based upon taking Paris quickly, had vanished. The German High Seas Fleet and the British Grand Fleet were not an even match, with the Grand Fleet's capital ships outnumbering their German opponents, so there was no hope of breaking the blockade. In late 1914 German naval authorities suggested that an unrestricted U-boat campaign against merchant trade around the British Isles would be a counter to the British naval blockade. German U-boats had demonstrated their ability to operate all the way around the British Isles. Ship sinking's mounted rapidly. However neutral nations began to complain about the U-boat tactics when they sank ships without warning. During 1915 and 1916 the rules governing U-boat operations varied as neutral nations' protests waxed and waned. In May 1915 a U-boat sank Royal Mail Steamer Lusitania off Southeastern Ireland with a large loss of civilian life, including over 135 American citizens. During 1915 the number of ships sunk or captured by U-boats increased to 660 ships, with a tonnage of 1,302,822 gross register tons. The U-boat campaign continued on into 1916. During 1916 the total of ships sunk reached 1390 for a gross register tonnage of 2,239.162 tons. All of these ships were individual sailers. Convoy was used by the Royal Navy but it was reserved for troop transports and for the essential bulk coal trade from England to France. None of the convoyed ships were sunk.

During 1915 and 1916 there was a classic example of the value of convoy in protecting ships. It took place in the Baltic Sea. This time British submarines were the raiders and ships carrying iron ore from northern Sweden to Germany were the targets. British submarines were sent into the Baltic Sea at the request of the Russian government to assist in defending Russian Army flanks against German naval forces in the area of present day Lithuania. The Royal Navy also had its eye on the Swedish iron ore trade. When the opportunity presented itself in late 1915, RN submarines shut down the unescorted Swedish iron ore trade, sinking or capturing a number of ships. Then ice shut down operations for the winter. In spring 1916 when operations were again possible RN submarines found that a very different set of circumstances had developed. The German Navy had instituted strict convoy procedures for Swedish or other ships carrying vital iron ore. A total of 70 torpedo boats and armed trawlers were available as escorts. In addition each convoy had an escort ship armed with 4-inch guns. The Swedish iron ore trade proceeded without a hitch or any losses. The lesson to be learned was a variation on the old saying about the fox and the hen house, "Some day's chickens, some day's feathers". The chickens were unprotected iron ore ships, easy targets. The feathers resulted when convoy was in place.

In late 1916 it became apparent to all the leading German hierarchy, including the Kaiser, that there was no hope of winning the land war on the Western Front. Mass attacks were stalemated by the ever-present machine gun. Tremendous artillery barrages in advance of an attack tore up the ground making it difficult to advance. Meanwhile the German Home Front was suffering dreadfully from the economic effects of the British blockade. However the off again—on again U-boat campaign had shown that even in its restricted form, it could sink a huge amount of Allied and neutral shipping. If a totally unrestricted U-boat campaign was instituted, the prediction was that so much shipping would be sunk that Great Britain would be forced to the negotiating table by late 1917. With Great Britain out of the war, Germany could then deal with France. However, such a campaign would inevitably draw the United States into the war on the Allied side. Never mind, the U-boat campaign advocates noted the current size of the U.S. Army - ranking after little Portugal, and predicted that it would take two full years for the United States to draft, organize and train a large army, and get it across the Atlantic Ocean and into combat. It would be too late.

The die was cast and in late January 1917 an unrestricted submarine campaign was announced to commence on February 1, 1917. No ship near the British Isles would be safe from attack. Ship losses quickly mounted. In February 520,412 tons were sunk; in March 564,497 tons; and in April 860,334 tons went down or were captured. By the end of April there was only six weeks wheat supply remaining in the United Kingdom. It appeared that the U-boat campaign was well on its way to achieving success. Back on 3 February the United States had ended diplomatic relations with Germany in protest against the unrestricted submarine campaign. On 17 April 1917, after substantial debate the Congress declared war on Germany.

RADM William Sims, USN, President of the Naval War College, was dispatched to England in early April in response to a request by the U.S. Ambassador in London for a high ranking naval officer to deal with the Admiralty in what looked more and more like U.S. participation in the Great War. Sims arrived on 9 April and proceeded to London where he met with Admiral Sir John Jellicoe, RN, First Sea Lord. Jellicoe and Sims had met years before on the China Station. After initial reluctance Jellicoe finally revealed the true state of affairs—Great Britain was close to being forced to the negotiating table with Germany. Her food supplies were running out. Sims was appalled and shocked. British censorship had kept the facts from the British public and the world. When RADM Sims asked Lord Jellicoe about a possible solution to the U-boat campaign; Jellicoe told him that the Admiralty had no solution.

Actually the solution was convoy, and it was already at hand. It had worked to safely move the BEF to France at the start of the war, and to move troops around within the British Empire since then. It worked to safely convey vital coal from the British Isles to French ports to fuel French industry. It had also worked for the German side in the Baltic Sea to allow the shipment of iron ore from Sweden to Germany. By gathering a number of ships into a protected convoy, the submarine was frustrated. It could no longer overtake and capture or sink a single unescorted ship. It had to face destroyer or trawler escorts, armed and ready to fight. It might get in a single submerged attack on a convoy but its pickings would be very slim indeed. The bulk of the convoyed ships would escape to make port and deliver their vital cargoes.

The reluctance of the Admiralty to adopt convoy on a wide scale is very difficult to understand today. Apparently its reluctance stemmed from two sources. The first was faulty operations analysis that assumed that a convoy would be much more easily sighted by a lurking submarine than a single unescorted cargo ship. Another faulty ops analysis assumption was that gathering multiple ships into convoy made for more targets and a greater kill opportunity for a submarine. This overlooked the fact that once a submarine attack was made, escorts could hold the submarine down while the convoy got clear. The other factor was the assumption by Merchant Marine and Royal Navy officers that merchant captains would be incapable of following zigzag steering and other convoy procedures adequately.

As 1917 continued shipping losses went up and up. However, in May 1917 several test convoys sailed from Gibraltar to the United Kingdom and from Norfolk, Virginia to Great Britain. All the convoyed ships reached port safely. In August 1917 the Admiralty officially adopted convoy as a standard procedure. By December 1917 shipping losses fell to only 399,000 tons. Most of these losses were to independently sailing ships. Prior to October 1917 some 1500 ships sailed in about 100 convoys. Their loss rate was only one out of 150 ships in convoy (6/10th of 1%). Independently sailing ships had a loss rate of 10%, a clear indication of the value of convoy to protect ships from the U-boat threat.

As 1918 began it was clear that the unrestricted U-boat campaign had failed to bring Great Britain to the negotiating table. However the end of the war was not yet in sight. Russia was about to drop out and dissolve itself into a bloody civil war, freeing German troops on the Eastern Front to move west to augment those already facing French, Belgian, British and American troops in the front lines. A major German ground offensive from March until June 1918 used up all German reserves, and left the German army unable to take further offensive action. Increasing numbers of American troops joined the Allies monthly. Finally on 11 November 1918 an Armistice was placed into effect ending the fighting.

It had been a close run race and convoy had saved the day.■

DOWNED BY A DUD

by CDR John Alden, USN (Ret)

Editor's Note: Commander Alden is a retired submarine officer with WWII war patrol experience. He has done extensive work on the details of the U.S. Submarines on attacks on Japanese shipping and is responsible for clearing up many differences in the various post-war measurements of success and failure.

The unhappy story of defective torpedoes which afflicted our submarines during World War II has been recounted in practically every history or memoir of that great conflict, along with the story of how submariners overcame the defects one by one and ultimately succeeded in throttling Japan's maritime lifelines. What is not well known is that even dud torpedoes managed to send a few enemy ships to the bottom. While these results were insignificant in contributing to the overall destruction, they provide an unusual sidelight of the submarine war. The cases that follow were extracted from the historical record and are offered for their witness that unexpected success can be found no matter how uneven the odds.

TRITON versus #5 SHINYO MARU

17 February 1942. USS TRITON (SS 201) under the command of Lt. Cdr. Willis A. *Pilly* Lent was on her second patrol at 32-12N 127-42E in the East China Sea when the officer on watch at the periscope sighted a steamer heading toward Japan. Lent immediately came to the normal approach course, made ready torpedo tubes #1 and #2 forward, and gave the order to fire at 1431 (time zone not given), only to see both fish miss astern. Quickly reversing course, four minutes later he fired two more from stern tubes #9 and #10 at a track angle of about 140 degrees. This time he got one hit under the after well deck of the target, which he described as a conventional single-stack cargo carrier of about

5,000 tons with two stick masts, a straight bow and counter stern, apparently a coal burner. The ship stopped, but after about two minutes started ahead again. When last observed, it appeared to have settled considerably by the stern but was steering on a northerly course.

About four hours later another ship was encountered. Although it was too dark to see details, the ship appeared to be a single-stack cargo type of between 5,000 and 7,000 tons, painted dark gray, with the appearance of a naval auxiliary. Lent let fly forward tubes #3 and #4 and again saw one hit under the after well deck. The target stopped and settled aft, then there were two strong explosions, upon which Lent took his boat deep in case there was an escort present. In his patrol report be claimed—and was credited with—damaging the first and sinking the second of these ships at 6,000 tons each.

Now switch to the Japanese side. The #5 SHINYO MARU, a former cargo ship serving as a converted gunboat, was patrolling southwest of Goto Island on 16 February when at about 1800 (Tokyo time) it was struck by a dud torpedo which pierced and flooded the engine room. The ship stopped, powerless, and drifted. Early on the 17th a submarine approached the helpless ship. To fend it off the Japanese captain dropped depth charges, whereupon the flooding slowly increased until the hapless gunboat finally went down on 18 February at 32-14N 127-14E with the loss of 15 crewmen.

Readers will probably be quick to point out discrepancies and conflicts between the U.S. and Japanese accounts. Unfortunately, things don't look the same from above and below the surface, so it is seldom that reports of such actions will agree in all particulars, but in this case the differences are greater than usual. Early patrol reports such as Lent's were written before a standard format was prescribed by higher authorities and were often sketchy and missing important information. Lent was overcautious and went deep without confirming the result of his attack, and offered no real evidence of having damaged either target. Neither he nor any higher authority seemed to consider the possibility that the two attacks were on the same ship, even though the descriptions were so closely alike. There are also internal contradictions between different sections of the patrol report. A few months later submarine skippers would swear that their torpedoes were misfiring, but Lent didn't claim that his hits were duds. It is known that TRITON carried Mk 14-1 torpedoes, but even this key piece of information was omitted from many patrol reports written in the early months of the war.

Japanese sources also often disagree about details of engagements, to the point that it is sometimes impossible to match their accounts to any reported submarine attacks. In this case the reports agree in the most important particulars, and there was no other submarine in the area.

PERMIT versus HOKUTO MARU

4 March 1943. The venerable USS PERMIT (SS 178) under Cdr. Wreford G. *Moon* Chapple was on its seventh patrol (Chapple's fifth in that boat) in Empire waters at 39-30N 142-08E and running submerged when a convoy was sighted at 0637K time (one hour behind Tokyo time). There appeared to be five ships in box formation escorted by a small inter-island freighter armed with guns fore and aft and depth charge racks at the stern. At 0729 Chapple fired Mk 14-1A torpedoes from tubes #3 and #4 at the leading ship in the inboard column and heard a *magnetic* explosion. Two minutes later he fired tube #2 at the original target and tubes #5 and #6 at the lead ship in the outboard column. These torpedoes all missed. The escort promptly came after the sub and dropped 15 depth charges as Chapple evaded. He claimed that the first ship, a 5,600 ton freighter, was either sunk or damaged but was not credited with either result. In his patrol report Chapple wrote: "Hit was magnetic which indicates that torpedo had not reached its set depth." He was obviously referring to the secret Mark VI exploder. He had set his torpedoes to run at 12 feet, but apparently believed that they had passed well under the target and been triggered by the magnetic influence of the ship's hull.

According to the Japanese, convoy 2303B consisting of the HOKUTO MARU, BANSEI MARU, KOTAI MARU, SUMIDA MARU, and TAISEI MARU, and escorted by the converted gunboat #2 HIYOSHI MARU, had left MURORAN on 3 March for Shimizu. The HOKUTO MARU, a commercial cargo ship of 2,262 gross registered tons, was loaded with 2,080 tons of coal. At about 0630 on 4 March its lookouts spotted the tracks of three torpedoes, one of which, a dud, hit the ship in the forward end of #1 hold. Sighting a periscope 250 meters off the port bow, the Japanese captain attempted to ram the sub but aborted the effort to avoid striking the SUMIDA MARU and returned to his assigned place in the convoy. After another ten minutes the crew realized that the ship was taking on a great deal of water, so the captain turned to head for the coast while efforts were made to reduce the flow. However, the ship continued to go down by the bow and at 0643 the engine stopped. The crew was transferred to the *#2 HIYOSHI MARU* as their former ship slowly sank until at 0712 its stern rose vertically and the HOKUTO MARU went to the bottom.

Chapple never received official credit for this ship. The Joint Army-Navy Assessment Committee (JANAC) concluded that the HOKUTO MARU had probably been sunk by a mine at 42-00N 141-00E. The basis for this decision is no doubt buried somewhere in the archives. If any readers are veterans of PERMIT's eighth patrol, here's some long-delayed recognition of their unacknowledged success.

SCAMP versus SEINAN MARU

The new USS SCAMP (SS 277) under Commander Walter G. Ebert was on its first patrol east of Honshu at 1725K in the afternoon of 20 March 1943 when it encountered a small convoy at position 41-06N 141-26E, starting what Ebert whimsically named the "Battle of Monomi Saki." Ebert maneuvered to fire three stern tubes at what he took to be a 2,600 ton cargo ship resembling SEIKYO MARU. The first torpedo prematured after 15 seconds, but Ebert saw a splash at the target's waterline at the time the others should have hit. No one in the conning tower heard an explosion, but men in the after torpedo room reported two hits and some in the engine room heard three. Ebert then started an approach on the second ship of the convoy, which he identified as the loaded freighter TATUMA MARU. At that point the sonar operator reported high-speed screws, which proved to belong to a single-stack destroyer "crossing astern with a bone in his teeth, no doubt after us. Range close." Ebert fired three bow torpedoes at the warship, but they missed. SCAMP was then subjected to a drubbing from 17 depth charges before escaping. Based on the evidence noted above, Ebert claimed three hits resulting in damage to the first target. He also complained that many other torpedo failures, including four additional prematures, were experienced during the patrol. (Presumably they were all Mk 14s; the records are not specific but Ebert mentioned trying to recalibrate the magnetic exploders.) On his return to port he was credited with a disappointing three ships damaged.

The Japanese records are rather terse and do not identify the convoy, noting only that the small commercial freighter SEINAN MARU of 1,338 tons was hit under the forward mast at about 1630 by a dud torpedo and had to be run aground at 41-06N 141-27E because of flooding. It was still there, presumably under salvage, until on 11 June 1943 it was hit by two more torpedoes and so heavily damaged that the wreck was abandoned. JANAC credits the SEINAN MARU as probably sunk by USS RUNNER (SS 275) at 41-00N 141-30E. That boat was on its third patrol under the command of Lieutenant Commander John H. Bourland. After leaving Midway on 28 May for the so-called polar circuit it was never heard from again; JANAC's assessment was probably based on the knowledge that no other sub was in the area. (RUNNER may have been lost in a newly-laid minefield along the route to its assigned area.) In any case, SCAMP seems to deserve at least half credit for destroying the SEINAN MARU.

HALIBUT versus SHOGEN MARU

On 6 September 1943, USS HALIBUT (SS 232), newly under Lieutenant Commander Ignatius J. *Pete* Galantin, was on its 6th patrol off the south coast of Hokkaido when a target was sighted through the periscope: a 6,000 ton freighter similar to the ITALY MARU, heavily loaded and with a deck cargo. There were no escorts in sight, and at 0552K Galantin fired bow tubes #5 and 6 at a range of 3,300 yards on a 115 degree starboard track with a depth setting of 10 feet. Two minutes later he noted a very small splash of water under the target's stack, and the sonar operator reported two weak explosions. These were not heard through the hull, and the freighter appeared to swing toward the submarine. At 0601 Galantin fired his last two bow torpedoes (all were Mk 14-3As set for contact rather than magnetic detonation), saw the ship turn away, and was sure no hits had been made.

Then, after another seven minutes, the skipper was surprised to see that the target was slowing down and settling by the stern; his first torpedoes must have been effective. At about 0640 sound reported breaking-up noises, and when the periscope was raised "it was all over. The only thing in sight was the bottom of his keel and it soon disappeared." Two boats full of survivors were left at the scene. This is apparently the only occasion where a ship hit by duds was actually seen to go down. Galantin and his boat properly received credit for its sinking.

In his analysis of the attack Galantin noted that the very small splash observed and the low intensity of the explosions indicated that the torpedoes had run deeper than set. These symptoms would suggest that the exploder had been triggered magnetically, even though it had been set otherwise.

The Japanese account is very sketchy, merely reporting that the SHOGEN MARU, a commercial cargo ship of 3,362 tons, was torpedoed and sunk about 0500 at HALIBUT's position. No crewmen were killed by the attack.

An interesting sequel occurred at 2125K that day when Galantin fired four stern torpedoes at what he thought was a destroyer, at an ideal range of 2,000 yards and a 95 degree starboard track. Again he was disappointed that no explosion resulted, although men below reported hearing a dull thud. Sonar then detected a whistling sound like a circling torpedo, so Galantin immediately went deep and six minutes later heard two end-of-run explosions. What actually happened was that two dud torpedoes had hit the heavy cruiser NACHI, causing slight damage. Intelligence later learned that the cruiser reached port with one of HALIBUT's fish embedded in its side. Galantin fired 23 torpedoes during the patrol and claimed only four hits, three of which were clearly duds. Many of the 19 misses were undoubtedly also attributable to faulty torpedoes or exploders.

HARDER versus KOYO MARU

The redoubtable Lieutenant Commander Samuel D. *Sam* Dealey, commanding USS HARDER (SS 257) on its second patrol, was patrolling along the 50-fathom curve off the coast of Honshu on the night of 9 September 1943. Not having obtained a navigational fix in 24 hours, he was somewhat unsure of his position - about 35-30N 140-40E - when the SJ radar picked up a contact hugging the coast. Dealey eased his way inshore where the depth was 23 fathoms and waited on the surface until the target came into sight. At 0438K with the range down to 1,700 yards he fired bow tubes #1, 2, and 3 at a 4,000 ton cargo ship. The torpedoes (Mk 14-3As with Mk 6-1A exploders set for contact) left a phosphorescent track, the target zigged, and the *fish* apparently missed ahead. The freighter then sent a blinker message to an escort and radioed a warning on the 450-kilocycle channel. With the escort dead ahead, Dealey cleared the bridge and passed 1,200 yards abeam the warship with "one thumb on the diving alarm," making 20 knots. The escort never saw the sub as Dealey cleared the area and headed back to deep water.

According to the Japanese records, the 3,021 ton commercial cargo ship KOYO MARU left Yokohama on 8 September bound for Hakodate, together with the KOAN MARU and the escorting minesweeper *W 3*. She was loaded with 300 tons of flour, 150 tons of steel products, and 850 tons of general cargo. At about 0340 the next morning, in the Katsuura Sea, she was hit in a coal bunker by a dud torpedo. The leak caused the boiler to flood, and the crew abandoned ship, transferring to the other two vessels which continued to watch the slowly sinking maru. At 1500 the old destroyer SAWAKAZE arrived and took the cripple in tow, but it soon nosed down and after another hour went down at 35-23N 140-38E.

Dealey was not credited with this sinking during the war, and a Japanese escort caught up with him on the HARDER's sixth patrol. However, the postwar JANAC assessment concluded that the KOYO MARU (which it rated at 3,010 tons) was probably sunk by HARDER.

SEAHORSE versus DAISHU MARU

Lieutenant Commander Slade Cutter, commanding USS SEAHORSE (SS 304) on its second patrol, spotted the smoke of a convoy in the Korea Strait west of Kyushu at 0117H on 22 November 1943 and immediately headed toward it. After about an hour he could see that it consisted of three small cargo vessels heading eastward at five and a half knots and escorted by two destroyers. Diving to periscope depth, he selected as his target a ship resembling the 3,817 ton AKITA MARU and at 0245 fired four Mk 14-3A torpedoes from the bow tubes, with Mk 6-1 exploders set for contact firing. After hearing two correctly-timed explosions, he found the target obscured by heavy smoke, and sonar reported that its screws had stopped and crackling sounds could be heard. With a destroyer coming in fast, Cutter pulled the plug and went deep. During the next hour or so the escort dropped 13 ineffective depth charges as SEAHORSE slipped away and was ultimately credited with downing a 3,800 ton cargo ship.

Japanese records identify the victim as the DAISHU MARU (or TAISHU MARU in some sources) a commercial freighter of 3,323 tons. At about 0812 Tokyo time it was hit on the starboard side of the engine room by a dud torpedo. Flooding ensued through the hole and the ship sank at 1233, with the loss of three of the crew.

Some Conclusions

There are many instances of other ships that were damaged by duds, and possibly others that were sunk; the records are often too sketchy to be sure. The cases described above, all involving various models of the Mk 14 torpedo and its infamous Mk 6 exploder, are illustrative of the three major defects later identified and corrected: torpedoes running deeper than set, an unreliable magnetic exploder, and a firing pin that could jam and fail to make contact with the detonator.

Both Chapple and Galantin thought that their torpedoes might have run deeper than the depth set. This problem was exposed by tests run by Admiral Lockwood in Australia during June and July 1942. After some initial reluctance, BuOrd corrected the problem by relocating the pressure-sensing mechanism and providing a kit for modifying torpedoes already in the field. The change was indicated by suffixing the letter A to the Mk 14 model numbers, so it had already been accomplished in both cases. (The Mk 14-3 differed from the 14-1 mainly in having a heavier warhead and several internal parts made of stronger steel.) Nor does depth control appear to have been a problem in TRITON's case, since the torpedoes clearly hit the sides of the victim. However, the skippers in all six instances described here successively lowered their depth settings from 12 feet in the first two cases and 10 feet in the next three to 8 feet in Cutter's attack.

In TRITON, PERMIT, and SCAMP cases the magnetic feature was apparently armed, but the Japanese reports clearly show that the torpedoes hit the ships' sides, in which case neither the magnetic nor the contact detonator operated correctly. On the other hand, the fact that one of the SCAMP's torpedoes prematured would indicate an over-sensitive magnetic exploder.

Two significant policy changes were made before the next three attacks occurred, reflecting growing official concern about submarine torpedo performance. In April 1943 submarine commanders were ordered to use a prescribed standard format for reporting attacks, including listing the model and serial number of each torpedo and exploder fired. Then on 24 June 1943 Admiral Nimitz instructed the boats in his Pacific command to deactivate the magnetic feature of the Mk 6 exploder. Thus HALIBUT, HARDER, and SEAHORSE torpedoes were all set for contact detonation but failed to explode. A possible cause was that they had hit the target too squarely; their track angles ranged from 115 to about 138 degrees. In the earlier PERMIT and SCAMP attacks the track angles were almost 90 degrees, while the TRITON's was 140 degrees. Apparently the firing pin could jam over a wider range of angles than a near-90 degree hit.

Oddly, a fourth and potentially lethal defect does not appear to have received the attention focused on the other three: circular running torpedoes. These caused the known loss of two submarines, TULLIBEE (SS 284) and TANG (SS 306) and 157 of their crews. Unfortunately, confirmation of these tragedies was not received until the 10 survivors were recovered from Japanese prison camps. Reports from other boats that managed to dodge their own erratic torpedoes caused most skippers to became particularly sensitive to any visual or sonar indication of a circular run and make haste to escape by speeding up and turning away or going deep. Nevertheless, submariners will always wonder whether other missing boats may have fallen victim to this most insidious torpedo defect.■

UNSINKABILITY OF AMERICAN AND RUSSIAN NUCLEAR SUBMARINES

by Dr. George Sviatov
Captain 1 Rank (Ret. Russian Navy)

Dr. Sviatov is a frequent contributor to THE SUBMARINE REVIEW and has been a knowledgeable observer of submarine characteristics across the world.

After the deaths of American nuclear submarines THRESHER and SCORPION and Russian nuclear subs KOMSOMOLETS and KURSK there had been a lot of publications about these tragedies and their details. But unfortunately there were almost no naval architectural analyses of these catastrophes.

It is understandable that the American and Russian naval architects in their design bureaus are not interested in publicly discussing such a delicate subject. But this problem is so crucially important that it deserves an independent and not a biased analysis.

It should be mentioned that the American and Russian naval architects who design surface ships are much more certain relating to their vessels. The notion in principle is very simple. A major surface warship, let us say, from a destroyer class and bigger, must preserve her buoyancy and stability with flooding of any two compartments.

As to combat submarines' designers, the situation is different.

During the many years of development of submarines in various countries there had been developed certain criteria of that class of combat ships damage control or unsinkability.

On the diesel-electric submarines of the USA, which were built before and during World War II, the surface unsinkability had been provided. A submarine had to remain on the surface with flooding of any one compartment and two adjacent ballast tanks.

Surface unsinkability of these submarines was provided by a certain level reserve of buoyancy and by dividing the pressure hulls on several compartments. On the American Fleet Type World War II submarines the pressure hull was divided by significant strength transfers bulkheads on 8 compartments and reserve buoyancy was sufficient—some 30%.

On these submarines was provided also some degree of the so-called underwater unsinkability, in other words, the ability of a submarine to sail underwater with one flooded compartment. The main means to prevent the flooding of the whole pressure hull were the sufficiently strong transfer bulkheads. These bulkheads on the Fleet Type submarines were designed in such a way to prevent the flooding of the adjacent compartments in a case of one compartment flooding on the working (close to maximum) diving depth, which was not so great—some 300 feet.

Russian naval architects now, like American naval architects in World War II, provide surface unsinkability of a nuclear submarine with any one flooded compartment and two adjacent ballast tanks with reserve of buoyancy some 30%.

American naval architects, wishing to provide the highest possible speed on a relatively low maximum power of the first generation of serial production nuclear submarines (Skipjack class' standard nuclear power plant of some 15000 hp in comparison with 35000 hp on the first generation Project 627 Russian nuclear sub November class), decided to reduce on their serial nuclear submarines the reserve of buoyancy from 30 to 15 percent.

But they did it not without a hesitation, which appeared in the unique American nuclear two reactors and two turbine compartments nuclear (initially radar picket and later attack) submarine TRITON with 11 compartments and 35% reserve of buoyancy. On that unique sub the surface and also some underwater unsinkability with any one flooded compartment had been provided.

And not only TRITON had the usual previous conventional submarines reserve of buoyancy. The British post World War II diesel-electric submarines of Porpoise type, French subs of Narval class and American submarines of Tang and Barbell classes were designed with reserves of buoyancy 25-35%. And the Russian nuclear submarines of all classes had and have their reserve of buoyancy not less than 30%.

For a comparison of these two different approaches in designing of American nuclear submarines it is reasonable to compare longitudinal cuts of the US nuclear submarines.

They were built some quarter of a century ago, but the naval architectural principles of SSN THRESHER are almost the same for all the most modern nuclear attack (and in principle also for ballistic missile nuclear submarines) of the United States.

The pressure hull of THRESHER SSN is divided by relatively strong transfer bulkheads on 5 compartments with one reactor and one turbine compartment and the reserve of her buoyancy is some 15%. With flooding of one of these power plant compartments the submarine is losing her ability to sail and use hydrodynamic forces for compensating of her negative buoyancy, but will preserve her surface unsinkability.

But with flooding of anyone of three other compartments THRESHER SSN would be able to provide her surface unsinkability and some degree of underwater unsinkability.

The pressure hull of TRITON SSN was divided by sufficiently strong transfer bulkheads on 11 compartments with two reactor and two turbine compartments and the reserve of her buoyancy is some 35%. With flooding of any one compartment, except of reactor or turbine, the sub will preserve 100% of her horse power and will be able to use all of her power for compensating a negative buoyancy, and even with flooding of one reactor and one turbine compartment simultaneously she will preserve 50% of her power for such a compensation.

But now the most interesting problem is in comparison of the two newest nuclear attack submarines: the US serial construction nuclear attack submarine of Virginia class and the Russian mass production nuclear attack submarine of Acula class.

They represent the most contemporary and advanced items in the development of nuclear attack submarines in these countries.

They have such tactical-technological characteristics:

	VIRGINIA	ACULA
Surface displacement, t	6080	7500
Submerged displacement	7835	10000
Reserve of buoyancy, %	15	30
Length, beam, draft, feet	377x34x30	371x43x33
Number of compartments	3	6
Number of torpedo tubes	4	8
Number of missile launchers	12	0
Number of torpedoes and missiles	38	40
Power of nuclear plant, hp	25000	45000
Underwater speed, knots	30	35
Diving depth, m	500	600
Number of compartments	3	6
Number of reactors	1	2
Number of turbines	1	2
Surface unsinkability with one flooded compartment	not provided	provided
Underwater unsinkability with one flooded compartment	not provided	provided
Complement	134	73

The really one significant difference between the American and Russian subs is their reserve of buoyancy (15% and 30%).

American naval architects consider that 15% reserve of buoyancy is sufficient from the point of view of the same degree of a sub's surface and underwater unsinkability with one flooded compartment, probably considering that in such circumstances the only one way of escaping sinking is surfacing of the submarine. Russian naval architects are more conservative and the reserve of buoyancy of their submarines is not lower than 30%.

The crucial question is: how much speed increase is reached by American naval architects by reducing the buoyancy reserve of their nuclear submarines from 30 to 15%?

The answer is: very little, not more than a couple of knots. And this gain could be compensated by easily increasing the power plant horse power not more than 10%.

So, by my opinion the game here does not cost the value of the candles.

But what can be done for increasing the unsinkability of existing force of the US nuclear submarines?

There, by my opinion, exists only one way: to provide more strength (let us say to 5 atmospheres) to the submarines' decks, making them watertight and consider the submarine's unsinkability in this more narrow sense.

As to the Russian naval architects-submariners, they preserved the classical 30% buoyancy reserve for the contemporary nuclear attack and ballistic missiles submarines and providing by such a way a little more degree of surface and underwater unsinkability of their nuclear subs.

By my opinion the Russian approach is more correct and the United States Navy must consider a Russian way as an option in the development of the future American subs and not ignore its own positive experience of World War II submarines and SSN TRITON or at least to increase in reasonable degree the watertightness of the decks of their future nuclear submarines.

It should be mentioned that my idea about watertightness of the American nuclear submarines is an assumption. I do not know if it exists in reality on the US subs or not, but I know that it was not implemented on the Soviet nuclear submarines. But I never read or heard about a possibility to use that idea for increasing survivability of submarines. If it is my invention, I would be very glad to present it for American and Russian nuclear submariners.

The problem of nuclear submarines' underwater unsinkability with one flooded compartment is extremely important, especially for nuclear submarines of the United States. But, being a Russian by birth, education and professional formation, I am also recommending its implementation for nuclear submarines of Russia and other civilized countries.

Presenting my personal point of view that Russian naval architects-submariners are more conservative and cautious and not welcoming the idea of reduction in half the reserve of buoyancy and number of compartments on their nuclear submarines, I like to present the point of view on this subject of former Assistant

Secretary of the Navy for Research, Engineering and Systems Melvin R. Paisley:

> "The Soviet submarine technology advantages for quieting, strengthened double hulls, higher speed, higher reserve buoyancy, and deeper operations are advances which by and large were not stolen or brought from the United States. Some technologies are Soviet design decisions which are different from our decisions. Other technologies are the result of using by them advances of high strength hull materials. The Soviets are ahead of us in these technologies" (Testimony before the Committee on Appropriation, House of Representatives, 2 April, 1985).

In conclusion I would like to say, that what had been done, cannot be undone. But first, for the future United States nuclear attack and ballistic missiles submarines might be reasonable to think about increasing on them the reserve of buoyancy from 15% to 30% and second, about increasing the number of their compartments from 3 to, let us say, 5 or at least to increase the strength of their decks, probably, by two times.

And another important consideration.

The Russian KURSK nuclear sub had perished from blasts of torpedoes in their first compartment because their control rooms had been in the second compartment. So, by my point of view, the control room on a safe nuclear submarine must be at least the third compartment, what is absolutely impossible for the contemporary US nuclear submarines which have only three major compartments.

But the Russian naval architects are not significantly better in aspects of submarines unsinkability because of having six compartments on the Acula class nuclear attack submarines' they put the subs' control rooms in the second compartment as it was made on the perished KURSK sub.

In other words they did not take into account the lessons of the tragic destinies of the Russian attack nuclear submarine KURSK.■

CLOSE-ABOARD RANGING WITH THE PERISCOPE

by LCDR Jon Walsh, USN

LCDR Walsh served aboard USS NEWPORT NEWS (SSN 750) and USS MAINE (SSBN 741)(Blue) before becoming an Engineering Duty Officer. He is now the Submarine Auxiliaries Inspector for INSURV.

It is morning watch during the last inbound transit of the deployment. Last night the boat encountered the remnants of a late-season hurricane, and the watch team stayed below decks during the night. The rain continued at dawn, but the seas have since calmed, and it is time to shift the watch to the bridge. The relieving OOD and lookout open the hatch, and Control buzzes with activity as the off-going watch standers energetically assist with the bridge rig. As the messenger is transferring his lanyard from the cockpit to the flying bridge, the ship takes a roll, and he slips off the wet, rounded edge of the sail. Fortunately, the lookout spots him as he glances off the hull and splashes into the wake.

"Man overboard, port side!"

The OOD keys the 7MC and orders, "Left full rudder! All stop! Man overboard, port side."

The control room shifts efficiently to the casualty situation. The quartermaster keys the GPS for man overboard, then shifts his plot to 200 yards per inch and marks the bug. Meanwhile, the FTOW generates his own stationary contact in fire control. These three technologies are meant to help locate the man, but all three are wrong from the outset. The ship was going 14 knots at first, and has already traveled over 100 yards since the messenger fell. The situation is changing too rapidly. The lookout keeps his eyes on his shipmate as long as he can, but loses him in the choppy seas. He searches in vain with his binoculars. The Contact Coordinator spots the sailor next. He already has his microphone in hand, and keys it without taking his eye off his shipmate. "Bridge, Coordinator, man bears 148, range 230 yards."

The quartermaster marks his plot immediately; the initial mark was way off. The FTOW adjusts his contact, too. The Contact Coordinator loses sight of the man in the heaving seas, but regains visual contact with cueing from the quartermaster's updated plot.

"Bridge, Coordinator, man bears 135, range 260 yards."

The lookout can't yet see the messenger among the waves, but the OOD knows where to steer.

"Bridge, Coordinator, man bears 095, range 120 yards."

As the Captain arrives on the bridge, the OOD is already driving the ship for a textbook recovery. When the diver goes topside, his man is bobbing amidships just yards away. The messenger has bruises and a mild concussion, but he'll be fine.

How did the Contact Coordinator judge the distance so precisely? He used a simple variation of the periscope ranging method taught in Submarine School.

To find the range to a visual contact, submariners use the venerable masthead height equation shown in Figure 1, a diagram from the now-declassified Submarine Torpedo Fire Control Manual published in 1950.

Editor's Note: In review it was noted that this method was previously described in a 4 December 2002 memorandum prepared for COMSUBDEVRON TWELVE.

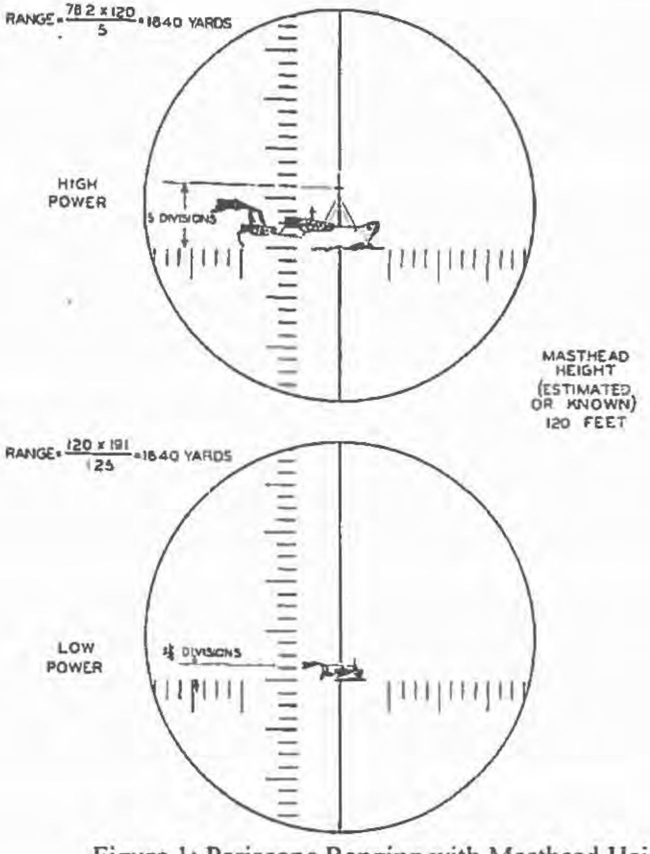

Figure 1: Periscope Ranging with Masthead Height

The formula works through trigonometry. The masthead height (MHH) represents the short side of a triangle, and the number of periscope divisions corresponds to the subtended angle Θ. We modify the conversion factors slightly for quick, easy use during periscope observations (*mental gym*):

In low power: Range(yds) ≈ 20 * MHH(ft) / # of divisions
In high power: Range(yds) ≈ 80 * MHH(ft) / # of divisions

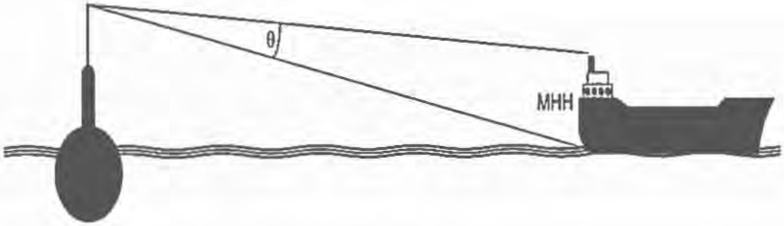

Figure 2: Masthead Height

Provided we know the masthead height with some precision, this method is accurate enough for contact coordination and for computing a torpedo firing solution.

On the other hand, the formula is highly inaccurate for a small contact with uncertain masthead height:

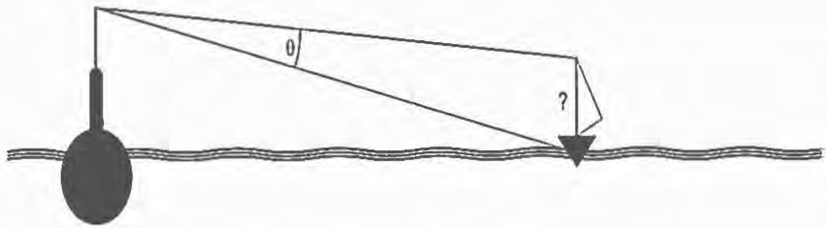

Figure 3: Uncertain Masthead Height

The equation fails completely for a *contact* with no masthead height at all (e.g. a man overboard, a lobster pot, or a northern right whale):

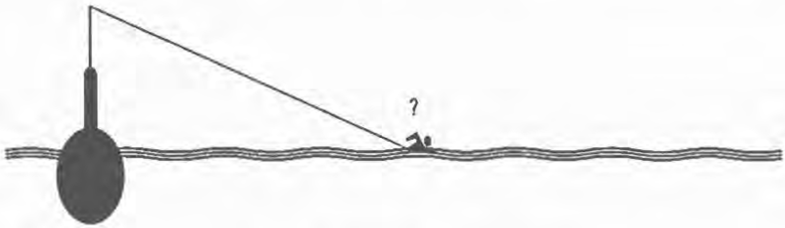

Figure 4: No Masthead Height

This article shows how to obtain a timely, accurate periscope range to such contacts. The method, called *Height-of-Eye Ranging*, works very well when certain assumptions are met.

Assumption 1: Own ship's height of eye is known.

For a submarine operating on the surface, the height of eye (HOE) is simply the height of the periscope optics above the keel (a known, fixed value) minus the keel depth (a measurable, fixed value when operating on the surface).

Assumption 2: The horizon is visible and steady.

The horizon makes an excellent reference, as long as fog, land, or rain doesn't interfere with the line of sight.

Assumption 3: The world is flat.

We'll get back to this one.

Height-of-Eye Ranging works by the postulate of alternate interior angles.

Consider a man floating in the ocean near a surfaced submarine. We'll call him Oscar.

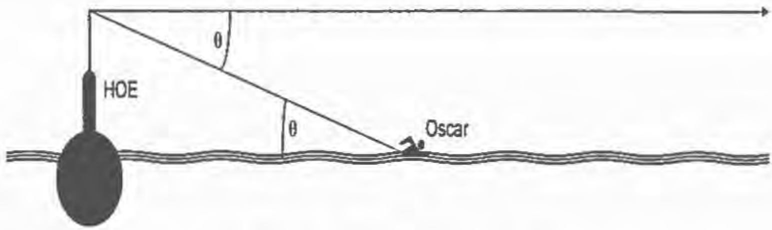

Figure 5: The World Is Flat

From Oscar's point of view, the subtended angle Θ from the submarine's waterline up to the periscope optics is a function of his range to the submarine and the periscope height of eye. From the scope operator's perspective, the angle subtended from the horizontal plane down to Oscar's position is the <u>same</u> angle Θ. Thus HOE could substitute for MHH in the masthead height equation to find the range to Oscar—if only Assumption 3 were true. The horizon would be infinitely far away and lie in the horizontal plane, and we could calculate the range to Oscar out as far as we could see him.

However, the world is not flat, so Assumption 3 must be revised.

Assumption 3A: The world is *nearly* flat.

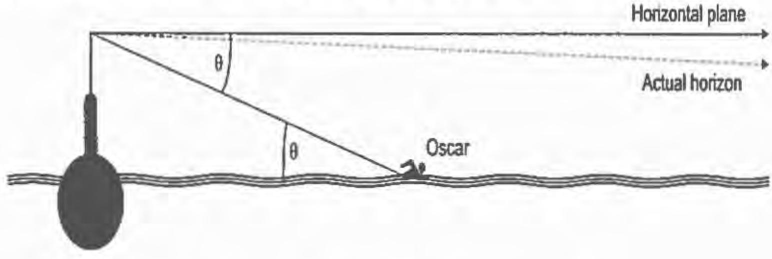

Figure 6: The World Is Nearly Flat

The actual horizon is ~1/9 of a degree below the horizontal plane as seen from the periscope. For such a small angle, a linear approximation is valid over some range, then falls apart as Earth's curvature comes into play. If Oscar is close aboard, Earth's curvature has little effect.

To use the Height-of-Eye Ranging method, first find the height of eye of your periscope during surfaced operations. Then multiply the HOE by ~17.75 to find the HOE Constant in yards. The following table gives representative values.

Periscope type	**HOE (ft)**	**HOE Constant (yds)**
688, #1 scope	40	710
688, #2 scope	36	640
774	38.3	680
SSBN / SSGN	48.5	860

The formula for Height-of-Eye Ranging is:

In low power, range(yds) = HOE Constant / # of divisions below horizon

In high power, range(yds) = 4 * HOE Constant / # of divisions below horizon

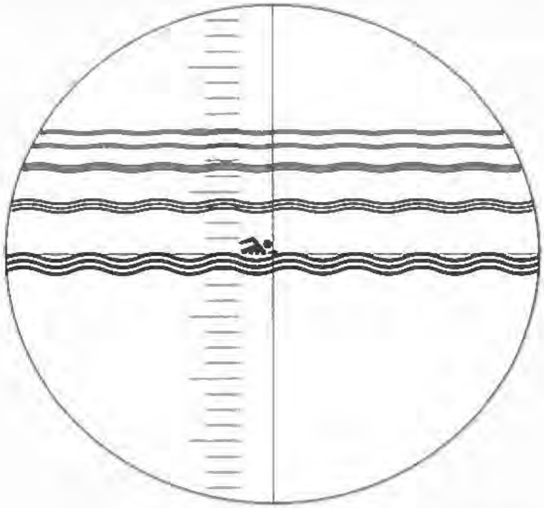

Figure 7: Divisions Below the Horizon

In this example figure, USS NEWPORT NEWS (SSN 750) is conducting a man overboard drill during TRE workups. Oscar is visible through #2 periscope in low power. He appears 8 divisions below the horizon. His range is therefore 640 / 8 = 80 yards.

Height-of-Eye Ranging is accurate within 10 yards for objects inside a 600-yard radius from the periscope. The accuracy degrades to about 8% at 1000 yards, and rapidly falls apart beyond that. The technique easily accommodates close-aboard range tripwires for the 500-yard Naval Vessel Protection Zone and Right Whale Protective Measures. Simply plug in the tripwire range and reverse the calculation to determine the corresponding number of divisions below the horizon.

To train your periscope operators with Height-of-Eye Ranging, start by finding the distance from the periscope to the waterline of own ship's rudder. (The actual value can be found in the SSM or ship's drawings.) Then practice finding the range to offshore buoys and small craft held on radar during a surface transit. A conversion table of divisions and ranges posted on each scope can be helpful.■

SUBMARINE NEWS FROM AROUND THE WORLD

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From the March 2010 Issue

SWEDEN - Contract in Place for Next Generation Submarine

On 26 February 2010, the Swedish Defence Materiel Administration (FMV) signed a contract with Kockums AB (part of ThyssenKrupp Marine Systems) concerning the overall design phase for the next generation submarine (A 26) for the Royal Swedish Navy (RSN). This follows information reported in AMI's January 2010 Hot News that the Swedish government was in negotiations with Kockums concerning the design contract.

These actions confirm Sweden intends to stay in the submarine business, which has been in question for the better part of a decade. A new class of at least four submarines will in fact replace the remaining GOTLAND (A19) and SODERMANLAND (A17) classes that were commissioned in the late 1980s through the mid-1990s. Although the program has been delayed by several years, AMI believes that a construction contract could be in place as early as 2013 in order to have the first unit in service by 2018 to replace the SODERMANLAND. The submarines will be built at Kockum's Malmo Shipyard.

The new submarines are being designed for littoral operations but will also possess ocean-going capabilities and will have the Kockums Stirling Air Independent Propulsion (AIP) system for increased on station time. As noted in AMI's January Hot News, this program could also be linked to Norway's Future Submarine program, if the Royal Norwegian navy (RNoN) decides to replace the six units of its Ula class. Norway began conceptual studies for a replacement of the Ulas under the Ny Ubat Project 6346 program. However, a final decision on whether to stay in the submarine business has yet to be made. If Norway decides to continue operating submarines, it would be very expensive to go it alone and could benefit by joining with Sweden similar to the

Viking Program of the 1990s prior to cancellation. Norway has no submarine building capability and it would be economically beneficial to join a program in progress in order to reduce overall costs.

UNITED KINGDOM - Go Ahead for 5th and 6th Astute Submarines

In late March 2010, AMI received information that the UK Government had signed a contract with BAE Systems Submarine Solutions concerning units 5 and 6 of the Astute class submarine program. The contract covers the full funding of unit 5 and the initial funding for long lead items for unit 6. These two units, that will more than likely be followed by a seventh unit in 2011; will allow for the continuance of the class and the eventual transition (following unit 7) to the Future Nuclear-Powered Ballistic Missile Submarine (SSBN) program that will begin around 2017.

The commitment to units 5 and 6 and a 2011 commitment to unit 7 ensures a consistent workload for the UK's submarine building industry and maintains the skilled workforce that is vital for the Future SSBN program.

Currently, the first unit of the class, HMS ASTUTE, is conducting sea trials, unit two (HMS AMBUSH) is under construction and will be launched in late 2010 and unit three and four (HMS ARTFUL and HMS AUDACIOUS) are in advanced stages of construction.

VARIOUS DID YOU KNOW?

PORTUGAL: On 23 February 2010, the Portuguese Navy's last Daphne class submarine, NRP BARRACUDA (S 164), was decommissioned.

From the April 2010 Issue

Pakistan

Submarine Design Still Undecided

In early April 2010, the Pakistani Navy (PN) Media Affairs Director (Captain Mobin Ashraf Bajwa) confirmed that a final decision on the design for up to five new submarines to be procured by Pakistan has not yet been made. Earlier reporting in November 2008 indicated the PN was close to completing a deal with ThyssenKrupp Marine Systems (TKMS) to acquire Type 214 Air Independent Propulsion (AIP) submarine to meet the Navy's requirement. The contract with TKMS was expected to be for three submarines and options for two additional units with all the vessels being built at Pakistan's Karachi Shipbuilding & Engineering Works (KSEW). The first three units were estimated to cost around US$1B, which also included technology transfer agreements. The Type 214 design was apparently recommended by the PN (as they believed it was technologically superior) to the Pakistani Government, however, contract negotiations were never completed.

Earlier reports also indicated the German solution bested the offer by DCNS of France, which included the new Marlin design (AIP Scorpene). DCNS previously provided three Agosta 90B class submarines, technology transfer agreements, logistics support, and upgrades to KSEW for submarine construction and appeared to be in the strongest position to win the next PN submarine program prior to the November 2008 reporting on TKMS's inside track for the deal.

With the latest announcement by PN Media Affairs, Pakistan's sea service is still considering both offers as they work toward the most favorable deal with Pakistan. It appears that the PN is attempting to leverage its existing relationship with China for new naval ships by announcing that it was also considering the Chinese Type 041A Yuan class design for the submarine requirement. AMI believes that the PN is using the Chinese submarine option as a negotiating tactic to wrest the best deal from either DCNS or TKMS. The PN likely knows that both European designs offer better performance compared to the Yuan, although the Chinese solution will undoubtedly be considerably less expensive. Another issue that will affect the submarine design decision is the logistics and operational integration challenges of incorporating new designs into Pakistan's existing force of French-supplied Agostas (buying German would also be an integration issue, though not as much as China...on the other hand, the PN successfully integrated the China sourced Sword class frigates...so maybe the Pakistani's do not see integration of the Yuan as such a major problem).

Even though the submarine competition remains alive and well, the timeline is not open ended. The PN will need to move forward as soon as possible since it will only have two active submarines given the need to keep one unit of the three Khalid class in overhaul/upkeep at any given time. A decision on the final design can be made at any time with the only question being who will make the best and final offer. AMI believes that this decision can be made by the end of the year.

ISRAEL - Dolphin Submarine Program Growing

In mid-April 2010, AMI received information that the Israeli Government was continuing to negotiate with the German Government and ThyssenKrupp Marine Systems (TKMS) for additional Dolphin II submarines. This information supports and updates earlier reporting received in September 2009 and January 2010 that indicated that the Israelis were in negotiations with ThyssenKrupp for two MEKO class corvettes and a sixth Dolphin Submarine.

HDW built and delivered three Dolphin class submarines for Israel between 1994 and 2002. Under the original program, Israel planned to acquire two additional units (Dolphin II with AIP) that began construction in 2008 and were scheduled to be delivered in 2012.

Information received in April indicates that the Israeli Navy has increased its total submarine requirement to nine units and may already be negotiating four additional units. Now the program appears to envision hulls 6/7/8 and 9 in addition to the 4th and 5th that were included in the original program.

As with the first three units negotiated in 1992 and two units negotiated in 2005, Israel will push for deep discounts from TKMS. As a reference point, the Israelis paid an estimated US$459M (per unit) for units four and five although the actual cost of the Dolphin II is around US$700M. Germany paid the initial US$452.1M of the US$1.37B deal.

INTERNATIONAL - Trends in the Global Submarine Market

Key Points

- AMI forecasts that the global new construction submarine market will be worth approximately 194B in 2009 USD over the next 20 years. This represents almost 28% of the value of all worldwide new construction naval spending projected for 2010-2030.
- While submarines make up more than a quarter of the global naval market by value, the number of new submarine hulls built, and total spending on new build submarines, are both expected to decline compared to earlier 2008-2028 forecasts.
- Future submarine market spending is concentrated in the US and the Asia-Pacific region, and to a lesser extent Russia. By contrast, future sub construction spending by NATO countries has dropped by 27% compared to the 2008 20 year forecast.
- Submarine spending in the Mid-East/North Africa and Latin American markets is expected to remain steady, with gradual improvements to existing forces rather than any dramatic increase in numbers of types of submarines added to regional navies.

State of the Current Market

The current worldwide submarine inventory includes 277 diesel-electric boats operated by more than 39 nations. An additional 152 nuclear-powered boats are also in service with China, France, Russia, the United Kingdom and the United States.

Asia-Pacific Region

The Asia-Pacific Region has now passed NATO as the world's second largest submarine market, with 104 new submarine hulls expected to join navies in the region over the next 20 years. In contrast, the forecast for NATO spending on new submarines over the same period has dropped to US$43B, with 58 new hulls expected to be delivered to NATO navies through 2030.

Middle East North Africa

Elsewhere, demand for new submarines is expected to remain steady in Middle East and North Africa (MENA) and Latin American markets over the next 20 years. The majority of the units to be procured in these markets will replace older boats in service that are approaching or already beyond their effective service lives. The exception to this pattern is Iran, where Navy submarine procurements include locally designed and built Qaeem class small conventional submarines as well as the even smaller Ghadir class mini-sub.

Submarine Exports

Of the over 39 nations that operate diesel-electric submarines, only about one-third have the capability to design and build their own vessels. Other countries continue to require foreign assistance for vessel construction or resort to purchasing used submarines on the international market. The major export submarine suppliers include Russia, France and Germany, while South Korea is making a concerted effort to move from indigenous construction for its own navy to exporting submarines to foreign customers.

By far the most widely exported submarine design is the Russian Kilo class, with sales of over 40 hulls to ten nations. Reasons for this success include the Kilo's relatively low cost (estimated at between US$100-300M per hull) compared to German and French alternatives. Russia's willingness to sell submarines to a wider variety of customers, and favorable financing to support struggling Russian shipyards have also contributed to Russian submarine export success.

TAIWAN

Future Submarine (Kwang Hua 8): For the past decade, the ROCN has continued to look for a supplier to satisfy its requirement for diesel-electric submarines. In April 2001, US President George W. Bush made the public announcement that the US would sell up to eight submarines to Taiwan. Due to its excessive price; in mid-2007, the Legislative Yuan and US Government agreed to split the submarine program into two parts Phase 1 for concept definition and design and Phase 2 for actual construction. US$375M was authorized to begin Phase 1 in late 2007, however, the US has not responded to Taiwan's Letter of Request (LoR) to officially begin the program.

VIETNAM: On 10 March 2010, Russia's Admiralty Shipyard announced that the first of six Kilo 636 class submarines for the Vietnam People's Navy (VPN) will begin construction in the Autumn of 2010.

From the May 2010 Issue

United Kingdom - New Government Coalition Supports Future Nuclear Deterrence

In late May 2010, AMI received information that the United Kingdom was likely to continue with its nuclear deterrence modernization effort following the 06 May elections in which a new coalition government was formed. It appears that the coalition government led by Conservative Mr. David Cameron (Prime Minister) and Liberal Democrat Mr. Nick Clegg (Deputy Prime Minister) and the general alliance of both parties formed a majority coalition in Parliament favoring the continuance of a nuclear deterrence with a Future Nuclear-Powered Ballistic Missile (SSBN) force.

Assuming that the UK will move forward with the SSBN option, the initial maingate approval is expected by the end of 2010. Design work on the Future SSBN began in April 2007 when the Ministry of Defense (MoD) and industry formed the Future Submarine (FSM) Project Team and consists of the MoD, BAE Systems, Babcock Marine and Rolls Royce. The team is tasked to deliver the first SSBN to the Royal Navy (RN) by 2024 at a cost of no more than US$15.9B-US$20.2B for three or four units. The delivery date of 2024 assumes that only three submarines will be built in the new class essentially allowing the HMS VANGUARD to retire in 2022 without replacement. If four units are built, all units of the Vanguard class will be replaced on a one-for-one basis essentially maintaining the UK's CASD at current levels.

GREECE - Frigates and Submarine Pushed Past 2010

With Debt problems taking the forefront of the news coming out of Greece and leading the discussion all over the European Union (EU), rumors abound over the proposed budget cuts that are being considered by the Greek Government and , in particular, the Ministry of Defense (MoD).

In late April 2010, AMI received information that the Greek MoD was considering making cuts to the defense budget that could amount to as much as 25 percent. With the continuing rivalry between Greece and Turkey, there are concerns that deep cuts in the defense budget will affect the balance of power between the two nations.

With this said, statements by Greek sources in mid-May indicate that deals are continuing to be worked between the governments of Germany, France and Greece with regards to defense procurements, more specifically the FREMM frigates and Type 214 submarines. Information received seems to indicate that there may be a little tit-for-tat occurring with regards to the procurement of German submarines and French Frigates, helicopters and fighter aircraft; in other words possible paybacks for the austerity package.

The basic fact is that the domestic submarine and frigate programs will provide jobs in Greece, although it is unknown where the actual funding for the programs will come from. It is possible that these programs will indeed move forward, providing job stimulus, the question now becomes when.

ISRAEL - Update on Dolphins

In early May 2010, AMI received additional information concerning the Israeli procurement of Dolphin II class submarines and MEKO A-100 corvettes from Germany. This information updates AMI's April 2010 Hot News Article (Dolphin Submarine Program Growing http://www.amiinter.com/wnpr/hotnewsarch/april10.html) that indicated Israel was negotiating for additional Dolphin II class submarines and two MEKO corvettes.

AMI's source indicates that the German Government will pay up to 50% of the costs for the six Dolphin II submarine. Although three additional units (7-9) are still being considered, no decision has been made on how much (if any) payment sharing/financing plan would be offered, although AMI believes it is very probable as ThyssenKrupp Marine Systems (TKMS) needs new orders at its Howaldtswerft Deutsche Werft AG (HDW) yard in order to maintain workforce stability.

As mentioned in April's Hot News, it appears that Germany and Israel have both realized that it was an opportune time for both countries to increase cooperation on naval equipment. Israel needs to meet its expanding naval requirements at a time of high budgetary pressures and TKMS and the overall German shipbuilding industry was in need of some type of stimulus measure to keep two of its major naval construction yards fully employed.

VIETNAM - Building its Three Dimensional Fleet

In late April 2010, the Vietnam Ministry of Defense (MoD) finalized a purchase agreement with Viking Air (Victoria, British Columbia) of Canada for six DHC-6 Twin Otter Series 400 aircraft.

The acquisition of the aircraft completes the sea services' desire for a three dimensional naval service consisting of air, surface and subsurface units. In December 2009, press reporting indicated that Vietnam had agreed to a US$1.8B contract with Russia to procure six Kilo (Project 636) class submarines. On 10 March 2010, Russia's Admiralty Shipyard announced that the first of six Kilo class submarines for the VPN would begin construction in the autumn of 2010.

UNITED KINDGOM - New Defense and Security Review by the End of 2010

On 12 May 2010, the United Kingdom's (UK) new Defense Minister (Secretary of State for Defense) Dr. Liam Fox announced that a new Strategic Defense and Security would begin immediately and be completed by the end of 2010. The new Defense

Minister was appointed following general elections in the UK on 06 May in which a new coalition government was formed with Conservative Mr. David Cameron becoming Prime Minister and Liberal Democrat Mr. Nick Clegg becoming Deputy Prime Minister and a general alliance of both parties forming a majority coalition in Parliament.

Dr. Fox stated that the new review would ensure Britain's defense would be based on a clear definition of the country's strategic interests, an assessment of its NTO role and other partnerships, threats faced, military capabilities needed to protect the nation's interests and the programs needed to deliver those capabilities. The Defense Minister also stated that with resources being tight, organizations, structures and policies would be scrutinized as well.

The one general consensus among both the Conservative and liberal parties was for the UK to renew its submarine based strategic nuclear deterrence, in other words replace the Vanguard class nuclear-powered ballistic missile submarine (SSBN). The exact form (hulls, new missiles, number of both, etc.) may be affected by the new defense assessment as well as the severely restricted budget environment.

INTERNATIONAL - World Missile Developments

In an ongoing effort to update AMI International's World Missile Systems Online, the following information is provided regarding world missile developments that occurred during May 2010.

RUSIA: In a 10 May 2010 statement from Russian Chief Navy Commander Vladimir Vysotskii, it was announced that the Russian navy would be taking over control of the production of the problem-plagued Bulava submarine launched ballistic missile (SLBM).

Due to many production problems that have been blamed for causing over 50% of test flights to fail, the Navy sees that it has to take control of every stage of production, right down to *screws and bolts* in order to maintain the quality required to assure successful launches.

It is anticipated that with the Navy now in control of all aspects of the missile's development and construction, further tests will be much more successful than before. Eventually the Bulava will be loaded into the Borey class SSBNs, but until then, tests will continue from the Dmitry Donskoy, a Typhoon class SSBN that has been outfitted as the test platform for the Bulava.

The first Borey class was commissioned in 2009 and is scheduled to enter full service with the Russian navy in 2011; however the delay in the Bulava missile could push the date to the right. All, seven units of the Borey class are scheduled to be built through 2020, all will be equipped with the Bulava SLBM, making the success of the program even more vital.

VARIOUS DID YOU KNOW?

Brazil: On 27 May 2010, the first Scorpene class submarine for the Brazilian Navy (BN) began construction at DCNS in France.■

DISCUSSION

RE: REFLECTIONS ON THE COLD WAR AT SEA, PART 1

by Mr. Norman Polmar

Norman Polmar is the Co-Author of Cold War Submarines: The Design and Construction of U.S. and Soviet Submarines (2004).

Editor's Note: The article in question appeared in January 2010 issue of THE SUBMARINE REVIEW.

Admiral Jerry Holland's enthusiasm for nuclear-propelled submarines, which I share, is well known. But his arguments for them could have more impact if he could bring more factual to his writings. Some of the more apparent errors and arguable statements in his recent "Reflections on the Cold War at Sea" are:

p. 93 "The P3 [sic] a much more capable aircraft began to replace the P2 in the deployed sites in 1958." The P-3 Orion became operational in August 1962.

p. 94 "After 1969 all Soviet new construction was devoted to submarine and anti-submarine programs." This was certainly not correct: The large aircraft carriers of the TBILISI/ADMIRAL KUZENTSOV class and the nuclear-propelled carriers of the UL'YANOVSK class were begun after 1969; these were the largest ships to be built in the Soviet Union and were certainly not ASW ships. Similarly the SLAVA-class cruisers, SOVREMENNYY-class destroyers, and several other warship classes begun after 1969 were neither submarines nor ASW ships.

p. 94 "Where the Kresta I has bristled with surface-to-surface missiles, the smaller Kresta II...." The Kresta II was slightly larger that her predecessor--7,700 tons with an overall length of 520 feet compared to the Kresta I's 7,500 tons and 510 feet.

p. 94 "In 1970 and 1975 the Soviets ran major military exercises that included maritime scenarios. The last and largest in 1975, OKEAN II, included deployments of some 200 ships and submarines." Okean 1970 consisted of more than 200 ships and submarines, while Okean 1975 (the correct designation) had about 120 ships and submarines, according to U.S. and Soviet publications.

p. 94 "Thereafter [after 1975], out of area deployments declined markedly so that the presence of Soviet surface warships other than submarines [sic] was a relatively rare incident." Soviet out-of-area ship days actually increased in the 1980s, and beginning in the late 1970s, the regular cruiser and destroyer deployments were joined by the four KIEV-class aircraft carriers, at the time the largest warships constructed in the Soviet Union. Thus Soviet deployments continued in numbers with a significant increase in surface warship capabilities.

p. 95 "From 1954 through 1958 the Chief of Naval Operations Arleigh Burke...." Admiral Burke became the CNO in August 1955.

p. 96 "but soon [Soviet SSBNs] ... so resembled the American George Washington Class SSBN that some accused the Soviets of *scaling up* the Revell plastic models of the American ships." This is "urban myth"--the Revell GEORGE WASHINGTON (SSBN 598) kit, issued in 1959, showed a submarine with only eight missile tubes; by the time the corrected model was sold in 1961 the Project 667/Yankee design had been completed. But the U.S. and Soviet submarines differ considerably: the Yankee SSBN has twin reactors, twin screws, and a very different internal arrangement (such as the 16 missile tubes being placed in two compartments); the Yankee had a greater diving depth and, significantly, could launch missiles at a faster rate, from a greater depth, at higher speeds than could Polaris SSBNs.

p. 97 "Eventually the Soviets replaced all their Yankees with Deltas." This is a strange statement; it is similar to saying that the U.S. Navy replaced all of its Polaris-Poseidon submarines with Trident submarines. Such replacements are a natural progression, but when the Cold War ended in 1991 the Soviet Navy still had about 15 Yankee SSBNs as well as the more than 40 Delta SSBNs in their inventory of more than 70 ballistic missile submarines.

p. 99 "Hence the suspicion that [spy ship] PUEBLO's seizure was instigated by the Soviets in order to get their hands on a coding machine." Available Soviet and U.S. documents reveal that the Soviets were greatly surprised by the North Korean seizure of the PUEBLO. Indeed, the Soviets would not want to provide a precedent or rationale for U.S. interference with their large fleet of intelligence collection ships (AGIs in NATO parlance).

p. 101 "At the end of the Cold War, there seemed to be no question about whether the correlation of forces at sea favored the United States or the Soviets." On the basis of lengthy discussions with Soviet naval officers and senior submarine designers both here in the United States and in Russia (seven visits to Russia from 1991 to 1998), I can reliably state that Admiral Holland's view of the correlation of forces was not shared by the majority of his Soviet contemporaries.

One hopes that part 2 of his article will be more factual and hence credible.■

RE: REFLECTIONS ON THE COLD WAR AT SEA, PART I

Admiral Jerry Holland Replies
to Mr. Norman Polmar's comments:

When one publishes more than occasionally one learns to eat crow from time to time. On the other hand, writers generally are pleased when someone demonstrates that their material has been read by mentioning his ideas or exposition. If the reader is someone with expertise in the field and makes the effort to rebut or question the original author's work, even more satisfaction arises. In such instances the operative adage is, "Better to be insulted than ignored."

In some of the instances that Mr. Polmar has pointed out, I plead guilty to an over reliance on secondary sources and personal memory. The essay was meant to be *A Look Around* aimed at fellow submariners, not a *Target Bearing* dissertation on the intricacies of the Cold War. Nevertheless, I acknowledge errors Mr. Polmar has enumerated—either as substantive or exposition—and apologize to readers of the Review for their commission.

Specifics:

My P3 date was a program point—probably the milestone permitting limited production.

I would acknowledge that my generalization on the shift from anti-carrier to ASW in Soviet new construction may have been over-stated. However the CIA analysis indicates that Kruschev hated the Navy's plans for big surface ships and that Gorshkov used ASW and anti-carrier as the argument for continued shipbuilding. Classification of *Kievs* as ASW Cruisers followed. The air wing of those ships consisted primarily of helicopters, the exact missions of which were never very clear but seemed to relate to ASW. My observations led me to believe SOVREMENNYS were ASW ships though certainly were armed for surface warfare. The large carriers Mr. Polmar describes were proposed in 1975 but not laid down until 1988, finally approved in the chaos of the Soviet fall. They were never finished and so I conveniently ignored them. The three SLAVA's that Mr. Polmar described as hedges against the failure of KIEV were Fleet Flagships that I never had the opportunity to see.

Regarding the size of the Krestas. My use of the adjective *smaller* is indeed in error by 535 tons. However, the operative observation is that the shift from the four Kresta I's to the ten Kresta II's was a shift from anti-carrier to anti-submarine warfare.

I assume both OKEAN designations are correct. I used the ONI designations of the time and I believe Mr. Polmar is using the Soviet nomenclature. The size of each exercise varies between various sources. I accept Mr. Polmar's version but the end result seems to me to be the same whatever the sizes.

I remembered Admiral Burke speaking at my graduation from the Naval Academy in June 1955 and I thought he was then the CNO. His actions in sequestering major funds for Polaris date from 1956. I should have been more careful with the dates and more specific with the actions. I apologize for this error.

Mr. Polmar's comments on my discussions of Soviet SSBNs are expositional rather than substantial.

That there was a suggestion by knowledgeable people that the PUEBLO seizure was instigated by the Soviets is a fact. That such an idea may have grown out of conjecture rather than knowledge I do not know. NSA's encoding section would have some self-interest in such a theory. However building a crypto-machine from scratch to use the key lists from Walker-Whitworth would have been a formidable but probably not an impossible task. I have no doubt that finding a reference to such in Soviet archives, even for so skilled a researcher as Norman Polmar, would be very difficult. If my Soviet contemporaries did not see the correlation of forces favoring the United States they were indeed even blinder to the obvious than we had been previously. The statements of a senior Russian Admiral to Admiral Trost on his visits, the posters Admiral Bacon purchased in Russia showing the American submarine as the menace, are evidence that the bastion plans came into being in response to the Soviet judgment that the correlation of forces did not favor them at sea.■

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THE BATTLE OF THE ATLANTIC 1939-1945

COMMENTS ON THE "BATTLE FOR THE ATLANTIC" BY VICE ADMIRAL JAMES SAGERHOLM

by Mr. Daniel A. Curran

Dan Curran was a former submarine officer who served several tours in SSBNs. Following his return to civilian live he stayed in touch with the submarine world. He was a frequent contributor to THE SUBMARINE REVIEW, a special friend and a fine shipmate. He recently passed away and it is with all respect that we publish here his final contribution. At the end of his article is a partial listing of his various naval related articles and reviews. We shall miss him.

Vice Admiral Sagerholm recently authored a comprehensive overview of the Battle of the Atlantic, the longest campaign of World War II. He included the reasons for the German failure at the end. His review won a well deserved first literary prize in 2009's SUBMARINE REVIEW. The comments presented here are no way a critique of Admiral Sagerholm's three part overview but are intended to provide some amplification of the Allied effort in the battle of the Atlantic. As we shall see, elements of the German defeat had a profound effect on the American submarine campaign against the Empire of Japan.

Part One described the evolution of the German Submarine Force from World War One to the period preceding the Second World War. The early U-boats had nearly crippled the Allied effort. Admiral Karl Doenitz, a World War One German submarine commander, now head of the U-boat command, was determined to avoid the mistakes of the earlier World War. The United States Navy was equally determined to learn as much as possible about the German effort before it entered the war. It was incumbent on the U.S. Navy to have a qualified person on the scene in London.

Charles Lockwood became Chief of Staff to Commander Submarine Force, U.S. Fleet in 1939. From that important job, Lockwood was sent to London, in February 1941, as naval attaché and observer for submarines. Lockwood left that assignment after the United States entered World War Two. He also left with the firm knowledge that the German wolf pack tactic had two weak points. First, *unbreakable codes* were breakable. Second, central control of wolf pack communications was subject to direction finding and triangulation. He also recognized that there was an unknown flaw in both the design and the operation of the German magnetic torpedo detonators (the British had similar problems). Lastly, he learned that the German acoustic torpedoes could be defeated by the Royal Navy's towed FOXER acoustic countermeasure system.

Lockwood carried all of this knowledge, first to his Australian assignment and then to Pearl Harbor after the 1943 death of, Rear Admiral Robert English, then COMSUBPAC. English and several of his staff died in a West Coast plane crash. Ralph Christie was brought in from the East Coast to relieve Lockwood in Australia.

Lockwood immediately faced three submarine torpedo problems. The depth control and the contact pin problems were eventually solved. Lockwood's knowledge of both the German and the British magnetic detonator problems prompted Lockwood to recommend to Nimitz that the magnetic detonators on the American torpedoes be disconnected. Meanwhile, Ralph Christie, in Brisbane, Australia, had supervised the magnetic detonator tests in Newport. He ordered his captains to keep the detonators connected (later rescinded by Kincaid). Harry Hull (Navy Cross, ex-THRESHER) served under Christie in Australia and was later Lockwood's torpedo and gunnery officer. Hull told me that Lockwood was right.

As a side note, when Admiral Christie passed away in 1987, Guy Reynolds, President of the Submarine League, then SUBPAC, presided over Christie's memorial service.

When Harry Hull reported to COMSUBPAC in 1944, he brought the MK 27 acoustic torpedo out with him. He told

Lockwood that the torpedoes were for defensive purposes. Lockwood, with the understanding that the acoustic torpedoes could be defeated with countermeasures, told Hull to have his subs use them offensively. Fred Milford reported in a SUBMARINE REVIEW article several years ago, that 24 Japanese ships were sunk using the MK 27. Commander John Alden, in letters to me and THE SUBMARINE REVIEW, stated that the MK 27 numbers could not be substantiated by the Japanese war records but several small craft were sunk by the torpedo. Regardless, the episode showed Lockwood's aggressiveness and understanding of the limitations of his weapons.

Charles "Swede" Momsen, of submarine rescue fame, had directed the rescue of the crew of SQUALUS in 1939. He commanded one of Lockwood's squadrons. Momsen urged Lockwood to try wolf pack tactics. Lockwood directed Momsen to lead a wolf pack consisting of CERO, SHAD, and GRAYBACK in the East China Sea. Momsen rode CERO. Lockwood recommended Momsen for the Navy Cross. Momsen also received the Legion of Merit for commanding the first American wolf pack in enemy waters. When Momsen returned, he wanted to command a wolf pack controlled from Hawaii, Lockwood said no, relying on the lessons he had learned in London. The Navy developed its own wolf pack tactics which were used successfully to the end of the war.

From the beginning of the war, the Japanese naval code had been broken and Lockwood worried that our naval codes might be decoded by the Japanese. Nimitz and Lockwood also remained very wary of revealing to the Japanese that their code had been broken. Several opportunities to direct our submarines to major targets were skipped to avoid giving the Japanese any clue as to the status of their code. This was another lesson from Lockwood's London tour. See W. J. Holmes' book, Double Edged Secrets, (Naval Institute Press) for more on this subject.

As a side note, while researching the Lockwood article, I reached out to as many participants at Pearl Harbor as possible. One officer on Lockwood's staff was Walter Welham, then a junior medical officer. Captain Welham is the father of my classmate and fellow submariner Walt Welham, both good guys. Captain Welham steered me to Holmes for additional information on Lockwood's staff.

Admiral Sagerholm mentions in Part Two that the British had invented radar and the Americans had succeeded in perfecting the radar. There is a little more to that story and the story has an unusual ending. The British developed the first successful working model of radar. The heart of a radar set is a magnetron that generates the radar signal's frequency. A magnetron needed to be precisely machined. The Allied manufacturing companies of that day could manufacture ten to twenty magnetrons a month when the need was ten to twenty thousand a month. The British asked for American help and specifically asked for Bell Labs and Western Electric assistance. President Roosevelt's science board reached out to other companies as well. Percy Spencer, American engineer and inventor, was the chief engineer at Raytheon. With a flash of genius, Spencer figured out that the magnetron could be built from laminated parts and soldered together. Raytheon was able to increase production to 2,600 magnetrons per day! Spencer was awarded the Distinguished Public Service Award by the U.S. Navy.

In 1945, Spencer supposedly had a chocolate bar melt in his pocket while working in the radar lab. The official story of Raytheon, The Creative Ordeal, only talks about Spencer experimenting with pop corn and other food in the radar lab. With another flash of genius, he had the lab people construct a box with a magnetron. The microwave oven, as we know it, grew out of this activity. Spencer received the original patent for the microwave oven. Raytheon bought Amana Company to build and market the ovens with easily constructed inexpensive magnetrons. An urgent request from the British military led to an inexpensive appliance located in every modern kitchen in the world. It should be noted that Percy Spencer never finished grammar school and learned about electronics in the U. S. Navy during his enlistment in World War One.

In Part III, Admiral Sagerholm mentions the period from January 1942 to the summer of 1942 when the German submarines roamed freely from Boston to Florida. United States had no war-footing activity along the East Coast including no blackouts, no convoys along the coast, and no naval forces. Admiral King ordered all his conventional fleet units north to Halifax to support the North Atlantic convoy operations. The German submarines deployed to the East Coast to exploit the American lack of action. The Germans named their operation *Drum Beat* and the German submariners called it their *Happy Time* as they freely sunk shipping up and down the coast. Millions of gallons of crude oil washed up on the East Coast beaches (no trace remains due to evaporation and microbe action). The British grew quite concerned and complained to General George C. Marshall to intercede with President Roosevelt which he did. However, Roosevelt had already taken action.

The President served as assistant secretary of the Navy during World War One. A shipbuilding program of wooden subchasers was started in 1917 under Roosevelt's auspices. Before the next war, and in anticipation, Roosevelt, as President, ordered a new subchaser program to be started in 1937.

Churchill wrote in his book The Second World War, Volume Four, the Hinge of Fate:

> *"For six or seven months, the U-Boats ravaged American waters almost uncontrolled, and in fact almost brought us to the disaster of an indefinite prolongation of the war."*

The President wrote to Winston Churchill in March of 1942: (quoted from Churchill's The Second World War, Volume Four)

> *"My Navy has been definitely slack in preparing for this submarine war off our coast. As I need not tell you, most naval officers have declined in the past to think in terms of any vessel of less than two thousand tons. You learned this lesson two years ago. We still have to learn it. By May 1, I expect to get a pretty good coastal patrol working from Newfoundland to Florida and through the West Indies. I have begged, borrowed, and stolen every vessel of any description over 80 feet long..."*

The WWI small wooden ships had a length-over-all of 110 feet with a full load displacement of 85 tons. The WWII subchaser length was 110 feet 10 inches and displaced 148 tons. The WWII shops had a designed speed of 21 knots and a crew of three officers and 25 enlisted. Depth charges, K-guns, and 30 caliber guns comprised the small ship's armament. The ships were built in forty-eight small wooden boat building yards along the East Coast, West Coast, Mid-West, Gulf Coast, and Halifax in the Maritime Provinces. The subchasers were soon patrolling the American coastal waters assisted by the Army Air Force, Coast Guard, and Navy coastal units.

LCDR Reinhard Hardegen advised the other U-Boat captains after Hardegen's second *Drum Beat* patrol:

> *"The small subchasers are dangerous because of their silhouettes which don't often show up on the periscope. On the surface they can be detected by their wake but not their shadow. If they would ever learn to patrol at slow speed, they would be fatal."* Hardegen's advice is quoted from Michael Gannon's book Operation Drum Beat (*Harper and Row*).

By mid-summer of 1942, the increasing number of subchasers, a focused naval strategy (blackouts and coastal convoys) and allied technology forced the Germans back to the mid-Atlantic and their ultimate destruction.

As Admiral Sagerholm pointed out in the final part of his article, the Germans failed to exploit their technologies in time to win the Atlantic battle. The corollary is, of course, that the Americans and their allies rapidly developed their technologies to ultimately destroy the German submarine threat. The only suggestions I can make to Admiral Sagerholm's overview is in the bibliography. I would substitute the 1959 Dönitz book with the 1990 edition that includes the German historian Jurgen

Rohwer's Introduction and Afterword (Naval Institute Press). I would also add Michael Gannon's Operation Drum Beat to get a view from both the German and the American sides during the *Happy Time*.

The last comment concerns Admiral Sagerholm, himself. James Sagerholm left an indelible mark in my memory that has lasted for over forty-six years. Basic Officers Submarine School Class 125 consisted mainly of year group 1962 Academy, NROTC, and OCS officers. The class also contained several more senior officers including the Submarine League Executive Director, then Lieutenant Mickey Garverick. James Sagerholm, then a Lieutenant Commander, was the senior officer in the class. On November 22, 1963, Commander Sagerholm entered each Sub School classroom to announce that President Kennedy has been shot and seriously wounded during a visit to Dallas, Texas. Of course, the classes were dismissed and we returned to our living quarters to learn that the President had died from his injuries. We could do nothing but ponder the fate of our country and grieve for the President and his family.

Mr. Curran's works include, among others:

Book Reviews

1991: Memoirs Ten Years and Twenty Days by Karl Dönitz, the 1990 edition, with an Introduction and Afterword by the German historian Jurgen Rohwer. Rohwer revealed to Doenitz, in 1979, that the British had broken the German naval code and had used HF/DF to locate the wolf packs. This was contrary to Dönitz's belief that the 9 CM radar was the chief reason for the accuracy of attacks on the wolf pack submarines.

1992: Operation Drumbeat by Michael Gannon. Gannon explores, in detail from both the German and U.S. sides, the German submarine actively, along the United States East Coast, during the first six months after Pearl Harbor. The German submariners called this the *Happy Times* with no blackouts and no U.S. Navy threat.

2000: The Terrible Hours: The Man Behind The Greatest Submarine Rescue by Peter Maass. The story is centered around Charles "Swede" Momsen and his involvement with the submarine rescue activities and his later duty under Lockwood in the Pacific theater including the first wolf pack operation.

Articles
1998: "Remembering VADM Charles A. Lockwood". The article details Lockwood's activities as the Commander of Submarine Forces, Pacific including the torpedo problems, OPERATION BARNEY, the foray into the Sea of Japan near the end of the war, and his knowledge gained as naval attaché in Britain before the United States entered World War Two. Admiral Harry Hull assisted me with the article among other Lockwood staff and submarine skippers.

1995: Mr. Curran also published a six part monograph, "The Subchasers of Manchester-By-The-Sea" in his hometown newspaper, the Manchester Cricket. The story centers on Yankee craftsmen at the local boat yard who built eight wooden subchasers during World War Two. The Naval Institute book Subchaser by Edward D. Stafford is the story of one of the Manchester, Massachusetts subchasers.

ETERNAL PATROL

CAPT Edward L. Armstrong, USN (Ret)
Mr. Daniel A. Curran
VADM Charles H. Griffiths, Sr., USN (Ret)
CAPT Evans P. K. King, USN (Ret)
CDR Lawrence B. "Larry" Moore, USN (Ret)
COMO Attilio D. Ranieri, Italian Navy (Ret)
VADM J. Guy Reynolds, USN (Ret)

MEETING THE U-BOAT THREAT VIS-À-VIS THE CONVERGENCE OF TECHNOLOGY

by Mr. Don Messner

Ed. Note: Mr. Messner qualified in DIODON (SS-349) and served from 1954-1957. He subsequently spent 30 years as a microwave engineer in the defense industry with companies such as Litton Industries and Boeing Aircraft.

May 1943, often referred to as Black May, is recognized by most historians as the turning point in the Battle of the Atlantic. In fact, author Michael Gannon has written a book entitled *Black May* in which he documents events of that month and clearly shows the role of the U-boat changing from being that of the *hunter* to being that of the *hunted*. Records indicate 41 U-boats were lost in May. That's over twice the previous monthly high of 18. Additionally, 37 more U-boats were damaged and had to return to base. Losses for the month exceeded the German shipyards build rate and continued to do so. Clearly, the tide had turned and the U-boat no longer ruled supreme. Why? The answer to this simple question is complex. One has to look at a multitude of items as no single event, thing or happening can be cited as being responsible for the dramatic turn of events.

To begin, the organizational commands were changing and maturing. The Tenth Fleet was officially created in May 1943 by CNO Admiral Ernest J. King—their mission—Anti Submarine Warfare or simply ASW. The Antisubmarine Warfare Operational Research Group (ASWORG) had been established to enlist top civilians and scientists to do a *think tank* analysis of ASW techniques employing theory of probability, past data, strategic and tactical procedures. Also the Bay of Biscay offensive action plan, code named Operation Derange, was underway.

New ASW platforms were rapidly being deployed in the fleet. Among them were task groups with escort carriers (CVEs) and their air squadrons in concert with, new to the fleet, destroyer escorts (DEs). Their mission - protect the convoys and keep the U-boats at bay, i.e., sink 'em. Also modified B-24 Liberators (VLRs) for extra range to further close the *Atlantic Air Gap* were becoming available.

New weaponry and operational techniques were introduced. Among them were the hedgehog forward launched *hand grenade*, straddle bombing of surfaced U-boats, deeper settings for depth charges (ash cans), and acoustic torpedoes that chase *sound*.

Acquisition systems continued to be introduced and improved. Centimetric radar was made possible by the invention of the resonant cavity magnetron. The Leigh Light and its 400 kilowatt light source took darkness out of the equation. High Frequency Direction Finding (HF/DF commonly called Huff Duff) continued to be a gift for the convoys as the U-boat Wolfpacks, under micro management of Admiral Dönitz and Rear Admiral Godt, continued to ignore radio silence and expose their locations.

Sonar, Asdic as the British called it, was standard equipment on most convoy duty ships by this time, and Ultra top secret message intercepts, of which there were hundreds, routinely took 2 days to decrypt but still kept convoys informed as to the whereabouts of the enemy wolfpacks. Both, long established anti U-boat stalwarts, they continued to play an integral role in the demise of the U-boat.

As Samuel Eliot Morison, author of the 15 volume edition entitled *History of United States Naval Operations in World War* II summarizes the situation in Volume X, *The Atlantic Battle Won*, "Dönitz, as a naval commander, had been overpowered by his enemies' anti submarine forces, overwhelmed by their superior seamanship and tactics, *out-improved* by their new devices."

It can safely be stated that all of the above were not autonomous unto themselves. They each contributed to the mission of "protect the convoy—sink the U-boats" in their own special way, but when used in conjunction with other advanced systems, they were far more powerful. The synergy of the complementary systems made the combination significantly greater than the sum of the parts.

A prime example of synergy is that of the new escort carrier (CVE) task groups formed within the newly created Tenth Fleet which had autonomous control over all ASW missions. For the first time a centralized command with the authority to set priorities and staff the missions with equipment and personnel appropriately. The convoy protection afforded by the CVE task groups with their squadrons of F4F Wildcat fighters and TBF/TBM Avenger torpedo bombers, operating with a squadron of destroyer escorts (DEs), a new class of ship specifically designed for this mission, armed with forward launching hedgehogs was formidable. The ASW missions of task groups formed around CVEs BOGUE, CARD, CORE, CROATAN, BLOCK ISLAND and SANTEE speak for themselves in naval history.

A second example, which this paper will explore in detail in keeping with the theme of the title, is the combination of 10 centimeter radar, the Leigh light, straddle bombing and the B-24 Liberator VLR aircraft. A look at each individually and then in combination follows.

Microwave Radar / Centimetric Radar / 10 Centimeter Radar:

The acronym Radar is derived from its definition, Radio Detection and Ranging. The term *Microwave Radar* simply identifies the approximate frequency range at which the radar is operating, and *Centimetric Radar* was a term coined by the British in WWII to differentiate a new short wavelength, top secret radar from those available earlier in the war. But before discussing the merits of this new short wavelength radar and its effect on hunting U-boats, a brief tutorial on some technical terms will be helpful.

Wavelength and Frequency

Wavelength and frequency of a radar signal are not mutually exclusive. In fact, they are directly related, albeit in an inverse manner. Simply stated, as one gets larger the other gets smaller and vice versa. The mathematical relationship is shown by the following:

$\lambda = v / f$ where λ = wavelength of radar signal (meters)
v = velocity of light (or the radar signal) in free space (300×10^6 meters / second)
f = frequency of radar signal (Hertz)

and an abbreviated conversion table shows:

Frequency (MHz)	Wavelength (centimeters)
100	300
300	100
3000	10
10,000	3

The operating frequency, and thus the wavelength of the signal, is an important design consideration of any radar system. Low frequency radar signals with longer wavelengths tend to bend with the curvature of the earth thus providing an over the horizon capability. Higher frequency radar signals with shorter wavelengths give better resolution, e.g., fire control radar, but are more line of sight transmissions and are lost in the ionosphere more quickly, i.e., shorter range.

For the purpose of this paper, low frequency radars are in the frequency range between 100 and 1000 MHz (300 cm to 30 cm). Within this range, a curious transition of how the physical characteristics of component electronic parts is realized occurs. Whereas below approximately 100 MHz standard resistors, capacitors and inductors, or *lumped* components including vacuum tubes can be used. (Note: it wasn't until the early 1960s that transistors started to replace the vacuum tube.) Above 1000 MHz these components are physically realized in a *distributed* form due to the effect of component stray capacitances and inductances, and wavelength now becomes a major design consideration. Between 100 and 1000 MHz is the transition zone and presents the circuit designer with a significant technical challenge. This is mentioned lest the reader feel that extending the design of a radar to higher frequencies was a straight forward process. It wasn't.

Remembering that frequency and wavelength are inversely proportional, the microwave engineer uses this to advantage for certain system components, the antenna being the most obvious. Antenna design for transmitter antennae has always been wavelength related, e.g., quarter wave, half wave, etc. It is quite critical and requires tuning to match the transmitters output to the antenna. Receiver antennae are more forgiving but follow the same general rules.

The first radars were in the VHF range (30 MHz to 300 MHz) and their antennae were huge because the wavelengths were between 10 meters at 30 MHz and 1 meter at 300 MHz - not convenient for aircraft mounted radar. Centimetric radars are much higher in frequency, in the 3000 to 10000 MHz range and their corresponding wavelengths are 10 cm and 3 cm respectively. One can readily see that airborne centimetric radars take advantage of the shorter wavelengths for smaller, easier to mount antennae.

Pulse Width

Pulse width (PW) is the duration, measured in time, of a single pulse emitted from a radar. This is where the transmitted power is *packed*, and until the invention of the cavity magnetron, radars were restricted to frequencies below 300 MHz as electron tubes couldn't handle the necessary power to achieve an effective radar range at higher frequencies.

Short pulses provide better resolution as long pulses tend to *smear* the target. However infinitely short pulses can't store the peak transmitted power so a compromise must be made. Pulse widths in the order of 1 or 2 μsec (microseconds) are common. A time domain analysis of the pulse would show a signal within the pulse resonating at the transmitted frequency.

Pulse Repetition Frequency

Pulse repetition frequency (PRF) is the number of pulses transmitted per second. A low PRF is necessary for long range radars, i.e., adequate time must be allowed for the pulse to travel to the target and return before another pulse is transmitted. High PRFs are for short range radars such as fire control radars.

PRFs of 500 are common for normal search radars.

Range

Theoretical maximum range as determined by the PRF is only a number and seldom a design criteria. The actual or maximum *working* range or *useful* range is determined by the radar's power output, its frequency or wavelength, the curvature of the earth, the height of the transmitter's antenna, the size and altitude of the target and lastly atmospheric conditions which in themselves are not always predictable, e.g., solar activity, atmospheric attenuation and rain squalls.

Peak Power & Average Power

As previously mentioned, transmitted power is the power *packed* into the transmitted pulse which has a finite width, e.g. 1 or 2 μseconds. Peak power is simply the power generated and transmitted during the time of the pulse. Average power is the peak power multiplied by the ratio of pulse *on* time to pulse *off* time. For example, if the radar has a PW of 1 microsecond and a PRF of 500, the *on* time is 1 micro second and the *off* time is the time between pulses as determined by the PRF. In this case the off time is 2 milliseconds, i.e., every 2 milliseconds a pulse is transmitted which equates to 500 pulses per second, the PRF. In this example the ratio is 1/2000. This figure, at best, is a figure of merit number as it is driven by other specifications.

Prior to the invention of the cavity magnetron, peak powers in the kilowatt range necessary for radar could only be generated at frequencies below 300MHz (100 centimeters) due to the limitations of the electron tubes available. In essence, the cavity magnetron replaced the high power vacuum tubes and allowed kilowatts of power to be generated in a pulse at centimeter wavelengths, a quantum leap in technology, allowing for centimetric radars.

British Airborne Radars:

Radar technology was co-invented in 1934-35 by British and American engineers. Robert Watson Watt, often called the *father* of radar, was British and was attached to the National Physical Laboratory in Berkshire, and three American engineers, Leo Young, known personally by the author, Robert Morris Page and Albert Taylor who were attached to the Naval Research Laboratory at Anacostia, Washington D.C. are generally given this credit. But for the purpose of this mission, i.e., meeting the U-boat threat, the British contribution is more significant as will be shown.

The first British airborne radar was flown on 17 August 1937 in an Avro Anson aircraft. It generated 100 Watts of power at a wavelength of 1.25 meters (240 MHz) and, although crude, it demonstrated in sea trials with the aircraft carrier HMS Courageous and battleship HMS Rodney it was capable of tracking targets in adverse weather conditions. Crude is synonymous with prototype or breadboard—sometimes called a laboratory curiosity. But in this text, crude is an adequate description of the most challenging part of the radar, the antenna system.

ASV Mk I

For the next 3 years, improvements were made, and by the end of 1940 it was nomenclatured as the ASV (Air to Surface Vessel) Mark I radar and installed on a couple dozen Hudson light bombers and a like number of Sunderland amphibious patrol bombers. Although not designed specifically to hunt submarines, early tests showed a submarine could be picked up at 3 to 6 miles depending on the altitude of the aircraft, e.g., 1000 to 6000 feet. Further modifications, including a new antenna array, improved the range to 10 to 15 miles.

ASV Mk II

The second generation airborne radar, designated ASV Mk II, was a re-engineered Mk I designed for mass production. It was first flown in August 1940, but not until March 1941 was it flown for ASW missions as Bomber Command had higher priority. It operated on 1.7 meters (176 MHz), had a peak output power of 7.5 KW with a 2.5 microsecond PW and a PRF of 400. It had an effective U-boat detection range of up to 36 miles, but could pick up bigger targets at twice the distance. Two versions of the Mark II were manufactured, a forward looking and a side looking version, the difference being the antenna system. The side looking version proved best for anti-submarine warfare, and several thousand of these were manufactured and installed on various Coastal Command aircraft including Wellingtons, Sunderlands, Hudsons, Whitleys, Catalinas and, the real work horse, B-24 Liberators.

By mid 1941, the ASV Mk II was accounting for a marked increase in attacks on surfaced U-boats. The typical approach would be a radar run to within a mile or two and then visual for the bombing run (straddle bombing was soon found to be very effective). This proved quite effective for the daylight hours, but night runs were a problem because radar *clutter*, or sea return as it is often called, made the target obscure at ranges under a mile. The cause of *clutter* is seldom discussed, but it is a natural phenomenon in any radar. It occurs during the PW transmit time when the receiver theoretically is desensitized or blanked. Because the desensitization or blanking process is not perfect, some of the transmitted pulse leaks into the receiver causing the perceived clutter on the screen. On a PPI (Planned Position Indicator) scope, it looks like one huge, solid contact 360 degrees in azimuth stretching out for a mile or more. Something other than electronics would have to be found to solve this problem, and solve it they did. The installation of the Leigh Light, a topic to be covered in a following section, would overcome the problem by June 1942.

ASV Mk III

The next generation airborne radar was nomenclatured as the ASV Mk III. It was made possible by a quantum leap in technology. Some WWII historians rate this as the most significant technological advance during all of WWII just short of the development of the atomic bomb, and this leap was made possible by the invention of the resonant cavity magnetron by two British physicists from the University of Birmingham, John Randall and Henry Boot. This invention allowed the technologists to move the radar transmit frequency from the 200 MHZ range (wavelength in meters) to the 3000 MHZ range (wavelength in centimeters). Thus the coined word centimetric radar—S band as it was known in the U.S. Other benefits of the resonant cavity magnetron were, unlike the klystron, its ability to produce high power in a fairly narrow beam width which in itself reduced the close in clutter on a PPI display and increased the useful minimum or close in range. Also, a major advantage for the airborne version of centimetric radar was the relatively small size of the parabolic antenna in comparison with the 1.5 meter radar's clumsy antenna. This made for a comparative easy installation on the aircraft.

The first naval radar employing the use of the cavity magnetron valve, as the British called it, was the shipboard Type 271 radar. The 271 operated at 9.7 cm (3100 MHz), had a peak power of 70KW, a 1.5 μsec PW, and a PRF of 500. This equated to a range of 25 Km at sea level but in reality for acquisition and tracking of U-boats it was in the 3 to 5 Km range. It worked outstandingly well in the fog and at night—a real plus for the ASW team. By May of 1942, the Type 271 was on over 200 Royal Navy ships of all kinds. A further plus for the Allies ASW teams was that the German radar warning receivers (RWR) were blind to centimetric radar until November 1943 when the 3rd generation RWR, Naxos, was configured on the U-boats.

However, it wasn't until February 1943 that centimetric radar was adapted for ASW airborne use. The main reason for this delay wasn't so much technological problems, but more one of priority. RAF Coastal Command, responsible for ASW, took second priority to RAF Bomber Command who lobbied intensively for the resources to manufacture the 10 centimeter H2S (sometimes written as the chemical symbol for Hydrogen Sulfide, H_2S) terrain mapping radar. Bomber Command received the top resources mainly because the H2S was close to production and 24 bombers, Halifaxes and Stirlings, were outfitted with the H2S by the end of 1942.

The new airborne centimetric radar was nomenclatured as the ASV Mk III and had the following characteristics: wavelength / frequency, 10 cm / 3000 MHz; peak power, 50 KW; PW, 1 μsecond; PRF, 750; effective maximum range, 160 Km depending on altitude; and effective range for U-boat detection, 10 to 16 Km. It was configured on reconnaissance bombers such as Wellingtons, Catalinas, Halifaxes, Sunderlands and B-24 Liberators.

German Radar Warning Receivers:

To fully understand the impact radar had on the demise of the U-boat, one must be aware of the electronic counter measures the U-boat fleet had at its disposal. In today's parlance, they would be ECM/ESM systems. From late 1942 through the end of the war, the U-boats had some form of passive radio/radar detector on board. Three generations are discussed below, the stories of which are equally as fascinating as that of centimetric radar.

1st generation radar warning set - Metox

The need for some type of radar warning system was established as early as February 1942 by U-331's commander while operating in the Mediterranean. U-boat loses to aircraft were escalating and the German's rightly suspected that radar equipped aircraft were the cause. Not only were the British using radar, but the Leigh Light was deployed on a squadron of Wellingtons in April 1942 to aid night, radar-guided attacks.

In August 1942, U-boats U-69, U-107 & U-214 were outfitted with a prototype radar warning system which, when a signal was intercepted within its frequency range, sounded an audible tone, the louder the tone, the closer the contact. Except for the performance of a clumsy, make-shift antenna, satisfactory results were reported. Dönitz then ordered all U-boats to be outfitted with this 1st generation radar warning system, FuMB-1 (Funk Mess - Beobachtung—gerät which translates as a passive radio/radar detector system). This was essentially accomplished by year's end.

The receiver, the Metox R-600, was designed and produced by a French firm of the same name. It was gratuitously offered to Admiral Dönitz by the French Admiral Darlan and was used to receive signals in the 1.25 to 2.5 meter band (120 - 240 MHz). The design was made possible by *back engineering* a captured ASV Mark II radar set which was recovered from a downed aircraft in Tunisia. It was capable of detecting many of the Allied radars which operated in the 1.4 to 1.5 meter band (200 - 215 MHz) as well the British airborne ASV Mark II air to surface radar operating at 176 MHZ and the British ship borne type 286 radar operating at 214 MHz. It had an effective range between 10 and 50 Km depending on the altitude of the radar, e.g., surface ship or aircraft.

The *clumsy* antenna for the Metox system was dubbed Biscay Cross (Biskayakreuz), named as such as the system was used primarily when the U-boat was traversing the Bay of Biscay en route or returning from patrol (see more about the Bay of Biscay in the following section titled Leigh Light). The antenna was not a factory design but rather a *jury rigged* fleet design. It was rushed into service as an intermediate fix until a more permanent design and installation could be installed by the shipyards. This reflected the urgent need as too many U-boats were being caught on the surface without warning while crossing the bay.

(*Note: There is some confusion about the Biscay Cross. Some credible authors identify it as the U-boat's 1st generation radar warning receiver in its own right. This is in error as it is simply the antenna which is cabled to the Metox receiver to complete the system.*)

The Biscay Cross antenna consisted of two pieces of lumber shaped like a cross to support the antenna wires. The transmission line came up through the open conning tower hatch which didn't please anyone. It literally had to be brought topside in a disassembled state, assembled and then rotated by hand. In the event of a crash dive it was quickly disassembled and tossed down the hatch. Because of the time required to disassemble it, and the cable running through the open hatch, many U-boat commanders disassembled it shortly after Metox gave the first alarm of a contact as more often than not, the contact was an aircraft and the commander didn't want to jeopardize his boat for the sake of a cable preventing the upper hatch from closing.

Padfield in his book *Dönitz, the Last Führer* relates a story about a captured English pilot who told his interrogators that the RAF hardly ever used their radar in ASW work since Metox radiated spurious signals which could be detected up to 90 miles, and they simply homed in on the *beacon*. The German's realized the story could be a deliberate deception, but they couldn't risk the chance it was true, and in August 1943 Dönitz ordered the use of Metox discontinued, one year after its introduction. Further, this reason seemed to be a logical explanation for many of the uncanny mysteries such as missed convoys and the escalating rate of losing U-boats since February 1943. In reality this was true, but the ruse was used to hide the fact that the Allies were using centimetric radar (10 cm band) which Metox could not detect.

In any event, it wasn't long before U-boat commanders suspected that the Allies had radar outside the Metox frequency range. They were experiencing far too many surprises by Allied aircraft. This was confirmed when on 2 February 1943 an RAF Stirling bomber was shot down near Rotterdam. It was equipped with the 9.7 cm radar which German technicians reconstructed and discovered the *magnetron valve* which made centimetric radar possible.

Centimetric radar along with the Metox radiation problem and the Biscay Cross antenna deficiencies led to the 2nd generation radar warning system.

2nd generation radar warning set - Wantz (Wanze) or Hagenuk

Officially nomenclatured as FuMB-9, the 2nd generation radar warning receiver used on U-boats overcame two of the three short comings of Metox, self radiation and the *clumsy* antenna.

Reception of centimetric radar would not be addressed until the 3rd generation.

The Wantz system, introduced around August 1943 at the same time Metox was discontinued, was designed to receive signals in the 1.2 to 1.8 meter band (166 to 250 MHZ). Although a more narrow band than Metox, it still could intercept the Allied radars which operated in the 1.4 to 1.5 band and the British airborne ASV Mark II radar. The design of a system to capture centimetric radar, which was being widely used, was still in the R&D stage. Logically it can be assumed that Wantz was only intended to be a stop gap measure until a design capable of receiving centimetric signals would be available.

Developed by Hagenuk, a German electronics company, Wantz did solve the antenna problem, and it improved, but didn't eliminate, the self radiation phenomenon. The antenna called Runddipol was a round dipole type permanently mounted to the superstructure with cable assemblies running through the pressure hull so it didn't have to be disassembled prior to diving. A drawback to dipole antennas is their directivity which translates as their inability to accurately report bearing information unless rotated. The round dipole is a crude antenna array used to circumvent this problem. Very little in the literature discusses the effectiveness of this antenna as it wasn't in use for more than a few months.

The second problem, that of self radiation, technically is in theory easy to solve but not completely eliminate. It is reasonable to assume that Metox was a regenerative receiver. This is based on how quickly the unit was produced and *sent to the fleet* and some of its performance characteristics, namely poor sensitivity which translates as short range—less than ten miles or about line of sight. The regenerative receiver is a simple design, more complex than the simple crystal set, but offering some selectivity (tuning range) and amplification using a minimum of parts. Hence, it could be built and tested rapidly. The down side, although not considered serious at first, was that its internal heterodyne oscillator signal radiated in the reverse direction through the antenna. The simple receiver of this type provides almost no *reverse attenuation* of this signal thereby becoming a small transmitter in its own right.

The Wantz most probably was a superheterodyne receiver for two reasons—it took longer to design and put into production as it is more complex, and its self radiation was significantly less than its predecessor. The superheterodyne receiver accomplishes the reduced self radiation by adding a *tuned RF (radio frequency) front end* section to the receiver. This front end, or first stage of the receiver, consists typically of an RF amplifier stage and a tuned circuit. The combination allows reception of the desired signals, with some amplification (gain), and provides greater than 20 dB reverse attenuation to the internal local oscillator signal - the culprit signal. In other words, in comparison, the superheterodyne's radiated signal is minus 20 dB or 1/100 that of the Metox signal—a real significant improvement.

Because of the RF gain, Wantz had greater sensitivity than Metox which resulted in greater range – approx 50 – 100 Km all else being equal. However, Wantz was still ineffective as a warning receiver for 10 cm (centimetric) radar which the British were using, and after too many Wantz configured U-boats were caught on the surface by Allied aircraft, its use was discontinued in November 1943 in favor of the next generation radar warning receiver.

3rd generation radar warning set - Naxos

There were attempts to improve Wantz, namely Wantz G2 and Borkum, but neither of these sets were capable of receiving 10 centimeter (cm) radar and their *active duty* time was just a stop gap measure. The true 3rd generation radar warning receiver had to be capable of intercepting 10 cm radar.

As previously mentioned, an RAF bomber, a Stirling—four engine heavy bomber, was outfitted with a 9.7 cm radar, the British airborne H2S. It was sent on a covert mission over occupied Rotterdam on 2 February 1943 to determine whether the radar could clearly differentiate the city from the surrounding landscape. As fate would have it, the Stirling was shot down by the Germans and was not damaged sufficiently to effectively destroy the radar. The salvaged equipment was recognized as nonstandard equipment by the Germans and was dubbed the Rotterdam Gerät (apparatus). It was sent to the laboratory for evaluation where, through reconstruction, the Germans discovered it was a cavity magnetron radar and thus confirmed suspicions that the British had a radar outside the frequency limits of their current radar warning system, i.e., Metox.

As a result of this discovery, AEG Telefunken was tasked with the challenge to design a receiver capable of intercepting 10 cm signals. This was no simple task as vacuum tubes of the time couldn't amplify 3000 MHz signals, and a method of heterodyning the incoming signal to a lower frequency where amplification could be achieved had to be used. Telefunken's solution was to use a germanium point contact diode in the front end of the receiver to perform this heterodyning function. Design wise, at the time, it was probably the only viable solution, but every design solution has its compromises, and this one had two serious drawbacks. A germanium point contact diode is very fragile and strong signals will *blow* the diode much like a fuse—thus rendering the equipment useless. Also, without any pre-amplification, the ambient noise threshold of the diode is high resulting in poor sensitivity, i.e., detection range. The system also had growing pains with its new antennae much like the Metox system. Be that as it may, the resultant was a system capable of detecting 8 to 12 cm (2500 - 3750 MHz) signals with a detection range of 5 – 8 kilometers and was nomenclatured as FuMB-7, Naxos.

In spite of the importance of developing a 10 cm radar warning system for the U-boats, first priority for the Naxos system was the Luftwaffe (I guess General Göring hollered louder than Admiral Dönitz, as it was no secret the two didn't see eye to eye). The Luftwaffe started flight tests with Naxos in September 1943 with the U-boat following the cancellation of Wantz later that year. In early 1944, Naxos was being installed on U-boats and the German Admiralty must have thought that all was well. The irony here is that as soon as the Germans could intercept 10 cm radar, the Allies deployed 3 cm (10,000 MHz) radar and held the advantage through the end of the war in 1945.

(Note: US submarines had the SV radar which was a 10 cm radar followed by the SS/ST radar which was a 3 cm radar.)

Leigh Light:

The Leigh Light was a British invention installed on Wellington bombers outfitted for ASW night missions during the Battle of the Atlantic in WWII. It was created out of necessity to improve the ratio of kills to sightings of U-boats during these night missions. It solved the close in radar interference problem of surface clutter allowing the pilot to switch from a radar guided approach to a visual approach for the final run.

It was well known that the U-boat Command established five submarine bases on French soil shortly after the fall of Paris and France in June 1940. These bases, located at Lorient, Saint Nazaire, Bordeaux, Brest and La Rochelle/La Pallice, were all on the Bay of Biscay which substantially forms the western most coast of France with direct access to the Atlantic. From these bases, the U-boats had to traverse the bay both departing for and returning from patrol, a distance of between 100 to 400 miles depending on the base. It provided a much shorter run to the patrol area compared to leaving Kiel and exiting into the North Atlantic via the North Sea—thus maximizing time on station. Four of the bases were operational by the end of 1941 with the last, Bordeaux, following a year later.

This, then, was a natural place for Allied planes to stalk the enemy, and so they did. However, shortly after the stalking began, Dönitz ordered the U-boats to cross the bay at night on the surface and submerge during daylight hours seeking the protection of darkness from the predators. This scheme worked for awhile, but soon Allied planes were equipped with radar and they began to harass the U-boats with various degrees of success. Radar worked well in the daylight because the final run was visual and the pilot could time his drop accordingly. But it worked only to a degree at night as the contact was lost in the radar's clutter during the close-in final approach. Unfortunately, all radars experience this *clutter inconvenience* in some form as previously discussed under ASV Mk II airborne radars.

Various schemes of *lighting up* the air were tried. First it was flares, but flares only illuminated an area in close proximity to the aircraft. Multiple flares were tried in a succession of drops until the U-boat was sighted, and then a fly around was executed for the line-up and bomb run. Often by this time the U-boat had submerged and the bomb run was ineffective. Time delayed flares were tried. These flares were fired from a buoy previously released from an aircraft which by now had circled around and was lining up for the kill. Again the U-boat often had sufficient time to *pull the plug* and avoid danger. A better solution was still needed.

Enter Squadron Commander Humphrey De Verde Leigh, a WWI RAF pilot. Aware of the problem, he designed and built the prototype model of what was to become the Leigh Light. It was a huge 24 inch (610 centimeter) diameter carbon-arc spot light which was rigged to fit in the under belly of a Vickers Wellington medium range bomber. Its lumination was rated at 22 million candela (see note below), powered by rechargeable batteries and controlled from the front turret of the aircraft. It was rotatable in azimuth and elevation meaning the aircraft didn't have to bore sight on the target - a real advantage. Another advantage was that it didn't exhibit back glare or *dazzle* to the benefit of the air crew.

In April 1942, RAF Squadron 172 flying Wellington VIIIs was outfitted with the Leigh Light. They became operational, literally, on 4 June 1942 when a target, the Italian submarine *Luigi Torelli*, was detected as it was crossing the Bay of Biscay having sailed from La Pallice out-bound on patrol. The Leigh Light was switched on and the Wellington dropped two braces of bombs seriously damaging the sub but not sinking it. The Leigh Light had operated as advertised and now the die had been cast.

The following month on 5 July, U-502 was to become the first confirmed kill of a U-boat using the Leigh Light in the Bay of Biscay. From then on the German's referred to the Leigh Light as *das verdammte Licht*.

Leigh Lights were not successfully fitted to the Halifax heavy bomber due to mechanical interference of the bomb bay doors and were not considered for the Sunderland amphibious patrol bomber.

However, they were successfully fitted under the wing of the Consolidated B-24 Liberator long range bombers as well as Wellingtons and Catalinas. They were in service to the end of the war.

(Note: 22 million candela is the most agreed upon published number. Other ratings are 80 million candlepower and 50 million candles. A candela is a standard unit for measuring light adopted in 1948. It equates to approximately 18.4 milliwatts per steradian, a spherical measurement which baffles most of us (It is analogous to antenna theory which most engineers don't understand either). My best translation, and I am an electrical engineer, is that it is $(22 \times 10^6) \times (18.4 \times 10^{-3})$ Watts or approximately 400KW radiating from a point inside a sphere equally in all directions. Now put a reflector behind it to focus it and radiate in one direction and the result is one hell of a blinding, bright light.)

Straddle Bombing:

Straddle bombing of U-boats was reported as early as 27 August 1941 when an RAF Hudson, while on routine patrol about 80 miles south of Iceland, sighted a U-boat surfacing about 1200 yards distant. It immediately dropped to an altitude of 100 feet, commenced an attack and released 4 – 250 pound depth charges set at 50 feet. The *stick* of four straddled the submarine while in the act of diving, and the resultant explosions caused sufficient damage to its water tight integrity forcing it to surface. Shortly the crew waved a white flag and the Hudson called for naval surface patrol craft support. When support arrived, the sea state was such that a boarding party could not be launched until the following afternoon. At such time U-570 was boarded and towed into port. Score: RAF 1 – U-boat 0.

By Black May, straddle bombing had become the preferred technique for attacking surfaced U-boats. A preferred scenario after sighting the U-boat would be for the pilot to line up with the U-boat's track, either up or down, drop to an altitude of about 50 feet off the deck and engage the intervalometer, an electromechanical device that enabled a stick of depth charges (or bombs) to be dropped at specified intervals or spacings — typically 40 to 60 feet. The depth charges were mounted, port and starboard, under the wings of the aircraft with their fuses set to ignite at a shallow depth of about 25 feet. The intervalometer was activated at the optimum release point, the intention being at least one depth-charge fell near enough to cause catastrophic damage. Terence Bulloch, the most decorated pilot in Coastal Command, preferred to line up at an angle 20° off of track, but depending on circumstances, attacks have been reported from all angles of the compass.

A text book example of a well laid pattern of 250 pound depth charges or bombs would consist of a brace dropped on each of the port and starboard sides set to explode at 25 feet. The explosions would crush the outer tanks of the submarine destroying the saddle tanks or literally blow the U-boat out of the water causing the keel to fracture. Both scenarios rendered the submarine incapable of diving making it an easy prey for a follow-up attack. Often the damage was serious enough that a second attack was not necessary as the initial damage caused the sub to surrender on the surface or seek the depths of Davy Jones' Locker — forever.

<u>B-24 VLR Liberator</u>:

How apt the B-24 was given the name Liberator. Most of the first production run of B-24s went to Britain's RAF (ca 1941) who nomenclatured it as the Liberator. The name stuck and was *adopted* by subsequent users including the US Army Air Corp, RCAF (Canadian), RAAF (Australian) and the US Navy which officially called it a PB4Y-1 instead of a B-24 as the Navy had their own nomenclature system and weren't about to adopt the Army's.

And liberate it did. It was the venerable workhorse of WWII in all theaters. Its primary design mission may have been that of a 4 engine multipurpose heavy bomber, but as a *multipurpose* aircraft, it was assigned a plethora of missions including maritime patrol, anti-submarine patrol, reconnaissance, tanker, cargo hauler, and personnel transport.

The beginnings of the B-24 date back to 1938 when Consolidated Aircraft was requested by the US Army Air Corp to produce B-17s under license to Boeing Aircraft. This was part of a government program to expand American industrial capacity for production of critical items as the hand writing was on the wall with regard to war in Europe and war in the Pacific. Of interest to submariners, a similar program was established between Manitowoc Shipbuilding Company and Electric Boat whereby Manitowoc would, under license to EB, use EB's design for the modern Gato class fleet boat and provide submarines to the US Navy. (*Note: Under 2 contracts, Manitowoc delivered 28 of the finest Gato and, later, Balao class boats to the USN in an extremely successful program.*) However, unlike Manitowoc, Consolidated decided not to build B-17s under license but instead to submit a more modern design of its own. The Army Air Corp then asked Consolidated to submit a design study for an aircraft with greater range, higher speed and greater ceiling than the B-17. Thus, the beginning of the B-24.

The contract for a prototype was awarded in March 1939 and the aircraft was delivered before the end of the year. Flight tests were successful and 7 more development aircraft flew in 1940. Consolidated then began ramping up for production with orders from Army Air Corp (36), RAF (164) and France (120). Most of the early deliveries, including the 120 for France, who by this time had capitulated to the Germans, went to the RAF who immediately assigned a portion of them to Coastal Command for use on anti-submarine patrols in the Battle of the Atlantic — a fortuitous move. Bomber Command and BOAC, a passenger/transport company, received the balance.

An early variant of the B-24, known as the VLR or Very Long Range Liberator, became available early in March 1941. Much of its thick armor plating and some heavy turrets were removed to reduce weight and allow for extra fuel tanks thereby extending its range. This was a costly mistake for those used for bombing runs over Germany but a great benefit for Coastal

Command's use as reconnaissance aircraft.

The British nomenclatured them as Liberators GR-Is. A later version, Liberator IIs, available late in 1941, introduced self sealing fuel tanks and powered gun turrets.

Prior to mid 1941, air cover for convoys in the mid Atlantic was very limited, but by July of that year, the air cover improved as VLR Liberators were assigned in to Coastal Command's Squadron 120 based in Iceland for use on ASW patrols. Prior to this time, air coverage by land based aircraft varied from 400 to 700 miles vectoring east of Newfoundland, south of Iceland and west of Ireland - distances were a function of assigned aircraft and time on station. This left a 300 to 400 mile gap in the mid-Atlantic outside the range of land based aircraft where U-boats could and did roam at will. This gap became known as the *Atlantic Air Gap* or simply the *Gap*. The VLR Liberators mission was to close this gap.

For over a year, the VLR Liberators of Squadron 120 did a yeoman's job protecting convoys transiting the gap as they were the only aircraft with the range to close the gap. The major problem was there were too few of them. It wasn't until the Atlantic Conference held in Washington DC in March 1943 relief was provided by supplying the RCAF with additional VLR Liberators—a direct result of the number one priority of the conference being the defeat of the U-boat. By May, Black May as stated previously, these Liberators were on assignment and the gap was essentially closed. Shortly thereafter Dönitz withdrew *his* U-boats from the mid Atlantic and sent them to greener pastures in the Indian Ocean and South Atlantic. Dönitz' strategy of just sinking enemy ships, regardless of the type, still was foremost in his mind.

Epilogue:

Black May indeed was the beginning of the end of the U-boat's reign in the Battle of the Atlantic and elsewhere. The VLR B-24 had succeeded in closing the *Atlantic Air Gap*. Outfitted with 10 centimeter radar, the Leigh Light and employing the straddle bombing technique, as discussed above, it became a most formidable ASW weapon system. Another equally formidable weapon system was the escort carrier (CVE) task groups armed with their air wings and the new Mark XXIV acoustic airborne homing torpedo. Additionally the task groups squadron of destroyer escorts (DE), armed with hedge hogs proven to be 50% more efficient than standard depth charges, became the nemesis of the U-boat. Advances in sonar, sonobuoy and MAD gear technology along with maturation of the Huff Duff triangulation system also came to fruition in May 1943. Factor in the success of breaking the Enigma code (Ultra) and using the information discreetly only added fuel to the fire to make life untenable for the U-boat.

The loss rate of U-boats throughout the rest of the war averaged over 20 per month. In 1943 the losses were 238 U-boats, and in 1944 the number was 245 lost boats followed by 160 additional in 1945. The best documented numbers available show that 1160 U-boats were built and delivered. Of these 796 were sunk between 1939 and 1945. Additionally 203 were scuttled at wars end and 161 surrendered.

Grand Admiral Dönitz knew that he was sending *his* submarine crews on suicide missions where maybe, at best, 20% would return. This must have pained "Onkel Karl", as Dönitz was affectionately called, to no end, but Germany had made a conscious decision to keep the U-boats at sea thereby tying down Allied resources such as the task groups and VLR squadrons lest they be used elsewhere.

Finally, not enough can be said about "that mysterious group of civilian scientists and university professors" called ASWORG. Founded in the spring of 1942, it was an Operations Research group chartered to do *think tank* analyses of ASW situations and submit recommendations on how to be more efficient and productive. Also, they recommended new/improved weapon systems, and the university laboratories helped develop them. Among the most famous was the Radiation Laboratories (Rad Lab) out of Massachusetts Institute of Technology where they *perfected* radar.

When Germany realized they needed a scientific organization such as ASWORG, it was two years later, and to their dismay, they realized most of their scientists and engineers were Jewish and had been interned in concentration camps—Hitler had shot himself in the foot again, but that is another equally fascinating story.

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Editor's Note: An additional excellent resource for the Battle of the Atlantic is SLIDE RULES AND SUBMARINES; American Scientists and Sub Surface Warfare in World War II, by Montgomery Meigs, 1990. National Defense University Press.

AN ASW HISTORY OF THE U-BOAT WAR

by LT Sam Mason, USN

LT. Mason is currently serving at the Naval Postgraduate School.

Executive Summary

There were many factors that contributed to Allied victory during World War II in the Battle of the Atlantic. However, paramount among these were Germany's failure to innovate and adapt to changing circumstances, the successful knitting together of Allied anti-submarine warfare commands, the development of sound ASW and convoy doctrine, the development and growth of American industrial potential, and the changing role of cutting edge technology on the battle field. While each of these factors certainly played a part in the ultimate Allied victory, it is the sum total of these parts that truly made a difference and paved the way to resolution of this conflict in history.

In true Mahanian fashion, the Battle of the Atlantic was Germany's attempt to cut the sea lines of communication between Britain and her allies—most specifically the United States, and thus strangle their primary protagonist within the European theatre. The fact that this did not occur can be traced back to several strategic, operational and organizational factors whose combined influence enabled those pages of history to be written as they were.

The Allies won the Battle of the Atlantic because they 1) capitalized on Germany's failure to innovate and adapt to changing circumstances, 2) recognized the strategic value of organizing and "intertwining" the various intelligence communities with those facets of high command charged with the direction of shipping and ASW in the Atlantic, 3) understood the importance of exploiting the vast industrial capacity of America, 4) valued the imperative necessity for both inter-agency and intranational cooperation in applying sound ASW and convoy doctrine, and finally, 5) recognized the operational level influence of innovative ASW tactics and the role of advanced technology.

Pride of an Empire

"Impossible to see, the future is…"

~Yoda

In the early months of 1942, the German U-boat command embarked upon an unprecedented massacre of military and merchant vessel traffic that stretched from as far North as Newfoundland and as far South as the Trinidad Islands. Eagerly enforcing Grand Admiral Karl Dönitz's ideal of *guerre de course*, U-boat commanders succeeded in sinking an average of 650,000 tons of war material per month. (Cohen and Gooch, p. 59) This unprecedented assault on the life-blood of the Allied war machine foreshadowed grim prospects of a positive outcome to the war for the Allies.

When considering the central objectives of undersea warfare, it is important to note that, at least in the early part of the war, Dönitz superbly exploited the strategic and tactical value of undersea concealment. This fact was clearly illustrated on October 14th, 1939, when German U-boat commander Gunter

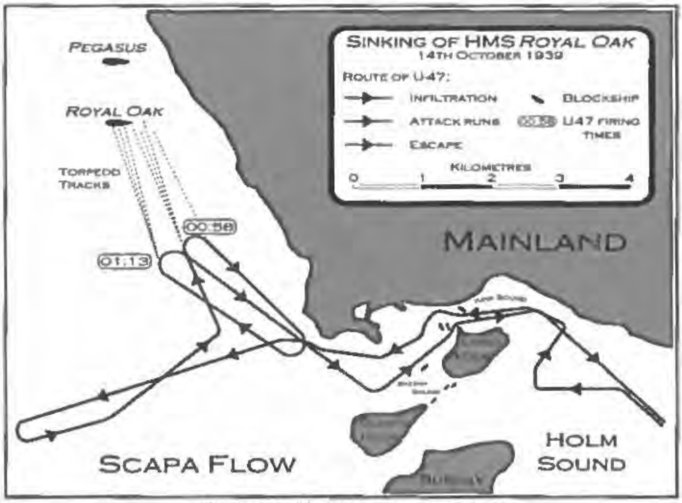

Figure 1. U-47 in Scappa Flow

Prien successfully infiltrated the British fleet anchorage at Scapa Flow. Aided by the complete absence of any form of ASW response, Prien's torpedo attacks quite efficiently sank the British Fleet's flagship, *Royal Oak* at her moorings. In the confusion that followed, U-47 made good her escape where upon their return to Germany, Oberleutenant Prien was promptly hailed a hero at having penetrated the previously impregnable British Naval stronghold. (McKee, p. various)

Another key to Germany's initial maritime success had to do with an enormous error on the part of Allied commanders, who failed to match the correct organizational structure to the problem of ASW and convoy transport. (Cohen and Gooch, p. 79) It is ironic that at the time, the Royal Navy's Operational Intelligence Centre's ability to collect intelligence via various sources, and then organize and collate that data efficiently was supremely successful. However, Allied forces continued to sustain losses because this vital information was not being disseminated to waiting unit commanders quickly enough.

Yet, these major advantages that German Naval commanders enjoyed were quickly squandered when they failed to realize that their initial successes were based on circumstances that could change, thereby necessitating organizational and doctrinal adaptability and flexibility in order to successfully mitigate these newfound risks. However, unmindful of this error, previously sound undersea warfare doctrine grew lax and outdated, and with the advent of Allied convoy shipping techniques and a significant increase in available British and Allied anti-submarine patrol aircraft, Germany's undersea Navy became largely ineffective. Ultimately, under pressure from the Führer, Germany's Navy became more surface-centric, and by late 1943, Admiral Dönitz's wolf-packs were operating increasingly as solo combatants and in oceans of necessarily low strategic value.

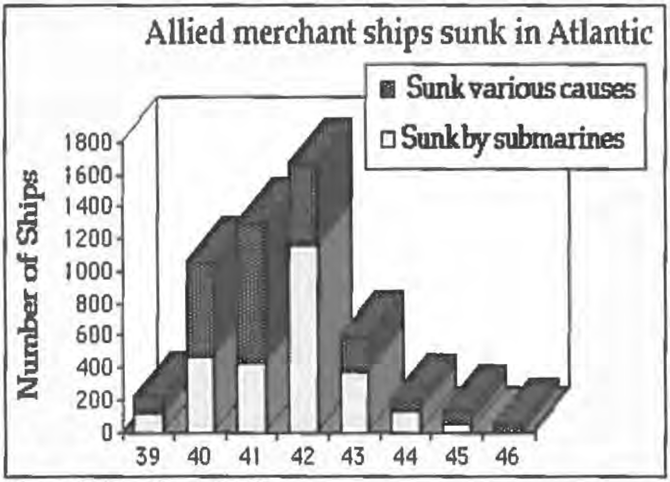

Figure 2. Merchant ship losses

Intelligent intelligence
"Viva La Revolution"
~Che Guevara

The next reason that the Allies ultimately won the Battle of the Atlantic was because they recognized the strategic value of organizing and "intertwining" the various intelligence communities with those facets of high command charged with the direction of shipping and ASW in the Atlantic. This impressive revolution in military affairs began to bear fruit in the spring of 1943, when Allied losses due to U-boat attacks had declined considerably (See Figure 2). Paired with the influx of new shipping assets such as the Liberty and Victory class ships, merchant shipping gains exceeded 1.2 million tons. What is more, the predator had now become the prey, where Allied "hunter-killer" groups accounted for 16 U-boats sunk in the summer months of that same year. (Baer, p. 204)

This impressive turn-about was a direct result of the Royal Navy's Operational Intelligence Centre, whose ability to collect intelligence via various sources, organize and collate the data efficiently and then disseminate that vital information to waiting unit commanders was so successful that by the end of the war, they had received permission to communicate not only "hard" intelligence, but also well educated guesses made by talented analysts on the movements of German U-boats. (Cohen and Gooch, p. 76) This revolutionized the Allies' capacity to safely conduct convoy traffic across the Atlantic Ocean by routing them away from waiting wolf-packs, as well as direct scarce surface and air assets to both escort those convoys potentially in danger, as well as destroy tracked U-boats. Hence, the German submarine threat was overcome, not as much by killing the predator (though that did occur and in increasing numbers in late 1943), but rather by making the "prey" less vulnerable. (Baer, p. 199)

While the achievements of the Royal Navy's OIC, and subsequently later in the war, the US's TENTH FLEET were indeed impressive, what made this organizational factor remarkable was the astonishingly efficient command and control (C2) structure that encouraged this free exchange of information. It has already been mentioned that OIC had a direct line to the Allied unit commanders, but in addition to this closely knit link, one must note as well that OIC communicated directly with the RAF and the Royal Navy, making swift use of all of the intelligence at their disposal to improve and standardize existing ASW doctrine. Their range of influence expanded further when the US established their own organizational analog to Britain's in the form of the TENTH FLEET, under ADM King. Ironically this command did not own any ships per se, but did put into practice the hard lessons learned by the Brits. (Baer, p. 203) Indeed, under British guidance allied ASW operational strategy slowly but surely evolved from a prewar ambivalence to reactionary defensive tactics, and ultimately to offensive ASW operations bound under centralized control. (Manke, p. 2)

Interestingly enough, this organizational concept had not yet been fully developed at the beginning of the war and the Allies were losing tremendous amounts of war material as a result. Germany had, at the time, a secure means of communicating with all of her submarines and when taking into account the limited number of vessels ADM Dönitz had at his disposal, Germany's *guerre de course* was tremendously effective. However, this advantage was gradually eroded due to Dönitz's proclivity towards centralized control (resulting in excessive radio transmissions) and his somewhat paranoid grip on an under-manned and overworked staff. While Allied forces were expanding their intelligence and control operations, Dönitz was slowly weeding out the "leaks" from his command.

Fueling the War Machine

"An army moves on its stomach..."

~Napoleon

This next point that was instrumental in the Allied victory in the Battle of the Atlantic is rooted in the grand strategic development and leveraging of America's vast industrial potential. President Roosevelt, having seen the proverbial "writing on the wall," began an aggressive campaign in 1941 to build up the Allied transport capability. In so doing he transformed the concept of women in the work place; a notion that quickly caught fire, and was spurred on by popular images such as "Wendy the Welder", and "Rosie the Riveter." Roosevelt's idea worked brilliantly, stirring the emotions of Americans nationwide and resulting in an outpouring of support.

Figure 3. Rosie the Riveter

The first of the Liberty cargo ships were launched that September and by war's end American shipyards had produced over 2,700 sister ships of similar design. The manufacturing process became so efficient that even during the darkest months of 1942 where German U-boats claimed 1.3 million tons and thousands of lives; still the US was able to replace the merchant vessels sunk by enemy actions. (Murray and Millet, p. 258)

The key to this prodigious rate of production was found in the plan of modular design and the manner in which they were assembled. Cargo vessels were prefabricated in sections which then enabled the final assembly to proceed with unprecedented speed. Additionally, the US had a sizable and willing workforce of spouses and under and overage men. In essence, the whole of America pitched in to aid the war effort. These facts coupled with ADM Dönitz's weak initial salvo in the commerce war, enabled the US to jump-start its ship-building industry early and ultimately meet the needs of the Allied shipping pool. (Murray and Millet, p. 259)

(Not-so) Jointness

"Individually, we are one drop. Together we are an ocean."
~Ryunosuke Satoro

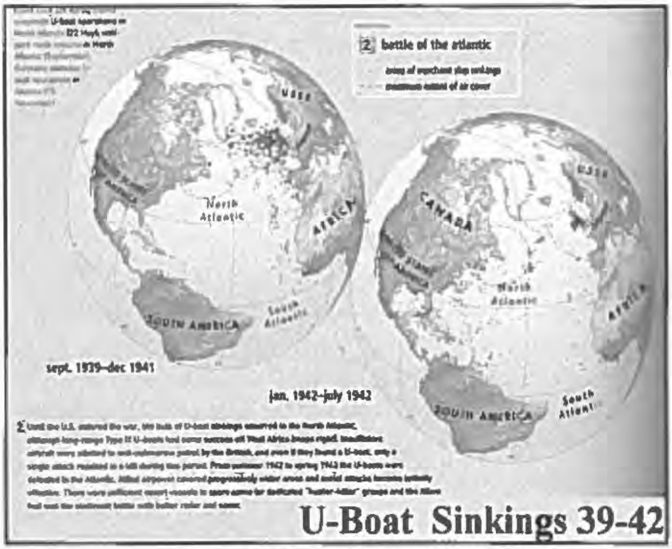

Figure 4. Merchant vessels sunk

Initially both Great Britain and the United States suffered from a division of and intolerance for their respective air and surface units. Unfortunately, this was a mindset shared by ADM King, CNO and Commander in Chief of the United States Fleet, and resulted in millions of tons of war material lost…not to mention much friction between the Americans and their British counterparts. The true root of the issue lay in the jealous distribution of duties and zealous protection of each individual's sphere of influence. For the Americans, control of convoys and the various escort vessels was severely disjointed. For example, the long range maritime patrol aircraft needed to provide air escort for convoys were owned by the Army Air Force, but the mission and hence responsibility for providing said support was wholly the Navy's. This inter-service squabbling was also reflected in the

Royal Navy and Air Force. In fact, it was not until the last months of 1942 that the RAF Coastal Command even began to provide air escort for the beleaguered convoys. (Murray and Millet, p. 236)

This sort of tension could also be found between ADM King and the British as a whole. Arguably an Anglophobic and hard man, King disagreed with the notion of a convoy due largely in part to a past failed attempt (specifically, the American-Canadian North Atlantic convoy in 1941), but also perhaps because the British so forcefully heralded its effectiveness. Hence, his dictum, "inadequately escorted convoys are worse than none" prevailed until the incredible losses sustained in 1942 convinced him otherwise. (Baer, p. 196)

What makes this a factor in Alliance victory? Consider the following: King's stubborn refusal to implement established and effective convoy doctrine during the early years of WWII encouraged ADM Dönitz to continue U-boat operations with little to no tactical or doctrinal evolution. Hence, once ADM King recognized his error, the sudden and swift move to standardize this form of transport throughout the US merchant and naval fleet virtually paralyzed Germany's U-boat fleet. One also must not overlook the value of "shared" air cover over the North Atlantic, as evidenced in mid 1943 when US B-24 Liberator's and Britain's S.25 Sunderland closed the air escort gap and contributed to the sinking of 135 U-boats in three months alone. (Murray and Millett, p. 256)

A Technological Revolution

"Necessity is the mother of invention..."

~Plato

From an operational viewpoint very little had changed in the way of anti-submarine warfare at the beginning of WWII. Though the British had learned a few lessons from WWI regarding this battle beneath the seas, at that time the technology had not truly progressed to the point of effective applications for countering this new threat. ADM Dönitz was a remarkable U-boat commander and pioneer in devising new tactics for their use, but he largely ignored the importance of technology. (Baer, p. 191)

What helped salvage this theatre of war for the Allies was the sudden, nearly frantic scramble for technological innovation which gave the Allies the advantage it sorely needed. Pioneering scientists and military personnel, primarily from Great Britain, answered this call spectacularly in the form of airborne RADAR, improved SONAR, torpedo countermeasures, radio direction finding (D/F) equipment and the advent of signals intelligence.

Though initially met with little success, the ability of Allied commanders to locate and track German U-boats via their radio communications quickly proved vital to the war effort. This was because in February of 1942, the Enigma code—which had originally been deciphered at Bletchley Park, was rendered temporarily unusable with the addition of a fourth wheel. Hence, SIGINT became the primary means of tracking German U-boat operations. (Murray and Millet, p. 252) Perhaps less eloquent, but equally important were the advancements made to SONAR, which enabled Allied forces to locate submerged submarines, the British 271M radar, to pinpoint surfaced U-boats, and finally, improved yield depth charges, to ultimately put the attacking U-boat on the bottom.

While the ebb and flow of *political* pressure did have an effect on the US ultimately adopting Great Britain's convoy and ASW tactics, one simply cannot deny the role changing technology played in shaping those very same tactics, techniques, and procedures. While the Americans and Brits adapted strategy and utilized cutting edge technology to counter the U-boat threat, Dönitz simply moved his wolf-packs to easier

Figure 5. Allied HF/DR antennae

hunting grounds (specifically the Caribbean). This coupled with his lackadaisical approach to technological innovation put Germany at a severe disadvantage and would ultimately pay the price with her national blood and treasure. (Murray and Millett, p.256)

Conclusion

There are many other factors that contributed to Allied victory in the Battle of the Atlantic; however it was the strategic insight afforded by the unique organization of Allied intelligence and control departments and the goading of the ponderous American industrial engine that ultimately won the day. The necessity of inter-agency and intra-national allies working together and standing united in the face of an implacable foe was illustrated first by their initial failure to do so (and subsequent tragedy of 1942,) as well as the follow-on success-story years of 1943 and 1944. Germany's high court blunders certainly facilitated this particular issue as well. Finally, while a nation must never place all of their eggs in the technology basket, one cannot discount the importance of innovation and advancement in the art of warfare.

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THE SUBMARINE COMMUNITY

THAT'S THE WAY HE WAS
VICE ADMIRAL FRANK T. WATKINS
SUBMARINER

by CAPT Tom Watkins, USN (Ret)

He served our nation for 38 years following his commissioning with the US Naval Academy class of 1922. He rose from Ensign to Vice Admiral with typical assignments and ever increasing responsibilities along the way. He retired at his last duty station in Seattle, Washington and died 20 years later. Yet there are no streets named after him, no buildings bearing his name, no memorial in his honor–and that's the way he'd want it. And since he was buried at sea, it took some doing even to get his name on a niche in the Naval Academy Columbarium. He was my father.

I remember taking leave to visit my folks toward the end of Dad's life. One day he suddenly looked up from the newspaper at breakfast and said, "Hey, Tom, why don't you write my biography!" Just as suddenly I found myself laughing out loud and saying "Why don't you write your OWN biography. I'm still working for a living, and you're playing ACEY-DUCEY at the local clubhouse." Then we both laughed, and that was as close as he ever got to leaving something written and tangible for his grandchildren.

But that's the way he was, the way he wanted it. In every sense of the word he had an eminently successful naval career. Moreover, he deserves much credit for the development and employment of the submarine that led to America's victory over Japan. He was awarded both the Bronze Star Medal and the Legion of Merit. Yet he seemed to consider all that to be past and unimportant to the here and now.

I remember at his retirement he made a remark to me that seems characteristic of him. He told me that when someone gets to feeling indispensable, he should immerse his hand in a bucket of water. Then note the zero effect on the water when his hand is removed.

Dad was an accomplished letter writer. In the days before word processors, he could take pen in hand and write a beautiful, succinct, and well organized letter, and then sign and mail it. No roughs, no revisions, it was perfect the first time! He also had a locker full of stories he used to tell when he got going, and they got better, funnier, and more outlandish with each telling. For both these above reasons his lack of records is unfortunate. So let me fill you in on a few things he didn't say.

Dad was born in a Mormon community in Utah, but found the match with navy life difficult, and he later became an Episcopalian. My grandparents had the lack of formal education typical of the west's early settlers. But they saw that Dad and his siblings went to college–Dad to the US Naval Academy.

After an initial tour on USS MISSISSIPPI (BB-23), a battleship home ported in Long Beach, CA, he came back to Utah, married my Mom, and reported to Submarine School in New London, Connecticut. I remember hearing some hilarious stories of their early life together–Mom came from a wealthy family and had never learned to cook!

In a very real sense Dad grew up with submarines. What I mean is that he was very much part of the group of submariners that perfected and tested submarine developments, the ones that led ultimately to the Fleet Type Submarine which was so successful against Japanese shipping in WWII. He served in a series of S-boats, eventually commanding the S-29. His duties took him to Coco Solo, Panama and then to Pearl Harbor where he served for many years.

Submarines were his life, if he wasn't actually at sea or getting ready to go to sea, then he and Mom were socializing with those same submariners. As prohibition ended in 1933, I'm sure there were some wild adventures ashore, but the total effect was a close band of submariners united in their quest to develop a better submersible warship for our nation.

He was gone a lot. I remember a two year period during which he commanded USS CACHALOT (SS-170), he traveled the oceans of the world testing engines and equipment from the tropics to the frozen north. Seems like his home port was anywhere he moored. Mom kept track of his schedules and tried to be there when he came ashore. My brother and I stayed in a California boarding school for those years.

I know Dad felt a sense of urgency to this submarine development effort, as Hitler was moving across Europe and Japan was expanding its empire in the western Pacific. Dad knew we'd be drawn into war eventually, in spite of our neutrality, and we were going to need a more capable submarine in our navy.

Being an off-and-on father to two adventurous sons wasn't easy for Dad, or for us either. When Dad came home he assumed head of the household again, precipitating a goodly amount of friction with his two boys. We were used to lots of freedom, especially as we learned to manipulate, to a certain degree, our good hearted mother. We loved seeing Dad come home when he could, but it made family life a mixed bag for us. Seeing him leave again was always sad, of course, but there were fewer rules to follow with him gone.

Eventually he was ordered ashore, to the Bureau of Ships in Washington, DC. From the Submarine Desk he was able to follow up on and implement some of the ideas and findings advocated by his band of brother submariners in Pearl Harbor. He was home at night and we had a family again–for awhile, that is.

By this time Britain was at war with Germany. It was not long before Dad was sent to London as Submarine Liaison Officer to the British Submarine Force. I had a box camera and before he left I took a photo of him in front of our house. He was in his LCDR uniform except that he wore a metal hat that reminded me of the helmets worn by US doughboys of WWI. And slung under his arm was his gas mask. England was at war, and so was Dad!

We saw Dad off to war and heard later that he had *a blonde in his lap* during his flight to London. The blonde, of course, was Dad's code word for an official package: a locked canvas pouch containing classified material being sent to England's government from America's government. As a safety precaution, the pouch was handcuffed to Dad's wrist and the key awaited his arrival in London.

From that day on Dad and Mom were on the far ends of a stream of V-MAIL letters. He had reported in to the American Embassy in London, and that became his office. However, London was being bombed nightly by the Axis bombers so it was not a place for a good night's sleep.

The submarine officers were invited to stay at an English estate outside London, called Newpipers. That became their informal headquarters. All letters were censored, and much of what Dad did was classified. That eliminated much of what he'd like to tell us, and instead we learned a lot about life at Newpipers.

Soon Dad's submarine liaison duties had him reporting to the British Naval Base at Gibraltar, to ride a British submarine in the Mediterranean. At the time there was some question as to what his POW status would be should he be captured by the Germans, since theoretically America was Neutral!

It was much later that we learned how very *green* the British crew was–they were inexperienced at operating their submarine, and now they were taking it to war. But as luck would have it, Dad, and the sub, survived the patrol, and weeks later moored safely at Alexandria, Egypt. Dad headed back to London.

Once Dad was back home from England, life settled down to *normal* for us for awhile. He commuted to his office on Constitution Avenue but was home for dinner most every night. But there were also some rumblings of big things to come–from our house in Arlington we could hear pile drivers going night and day as they worked on a new military center to be called *The Pentagon*.

Then there was that quiet Sunday afternoon. Dad, my brother Jack, and I were in the back yard gardening, when Mom burst out of the back door sobbing and crying "The Japanese have attacked Pearl Harbor." We all gathered around the radio to learn what details we could.

Monday morning all those civilian commuters became military commuters in uniform. Little by little we learned just how badly the battle fleet at Pearl Harbor had been damaged by the

Japanese—fortunately submarines at the Submarine Base had been ignored.

In early Spring Dad's new orders had us on the move again across the continent, as he headed for his new assignment: Commander Submarine Division 101 in Pearl Harbor. The other three of us rented a house in Palo Alto–it was about as close to Pearl Harbor that the Navy would permit dependents.

We saw Dad off from Hunter's Point on the Submarine Tender USS SPERRY (AS-12), as I remember, heading for Hawaii. We were back to V-Mail communications again. During his two year assignment he was constantly at sea as he trained and tested each of his submarine crews before their patrols took them into Japanese waters.

With a special OK from Admiral Lockwood, COMSUBPAC, he even made one patrol himself, in command of USS FLYING FISH (SS-229). For his successful patrol Dad was awarded the Bronze Star with Combat "V." He also became eligible for the Submarine Combat Patrol Pin which he wore proudly for the rest of his career.

Tragically he lost one of his submarines when it failed to return from patrol: USS WAHOO (SS 238), its crew of 81 and her Commanding Officer, *Mush* Morton. These young men were his *boys* and he felt the loss heavily. Dad wrote a personal letter to the families of every officer and enlisted man in her crew.

For the record Dad's Submarine Force did itself proud in the Pacific. They succeeded in cutting off Japan from its supplies by devastating Japan's merchant fleet. Some subs, like WAHOO, actually sank entire enemy convoys and arrived back at Pearl with a *Clean Sweep* broom tied to a periscope. All that submarine development work leading up to the war resulted in a front line Fleet Type Submarine fully capable of taking the war to the enemy, and sinking their ships in their own back yard. The efforts of Dad's Pearl Harbor submariners really paid off. The down side was the loss of 52 US submarines, and that hurt a lot.

The last year of the war found Dad, now a Captain, back in Washington for duty at the Bureau of Naval Personnel. Then it was back to Pearl again, this time as Chief of Staff to

COMSUBPAC. Mom and Dad had quarters in the Sub Base housing at Makalapa, and it was like the good old days again, as navy families enjoyed peacetime life in Hawaii.

The Navy established a General Line School after the war as a curriculum of refresher courses for Naval Reserve Officers desiring to become Regular Navy. It was located in the famous resort hotel Del Monte, in Monterey, California, and Dad was its Commanding Officer. He and Mom fell in love with Monterey and the affection was mutual. That was a good thing since the Navy was about to buy Del Monte.

One of Dad's many stories described his experience of handing Sam Morse, owner of Del Monte Properties, the biggest check he had ever seen. That check purchased for the Navy the Del Monte Properties, and it soon became the new campus of the Naval Postgraduate School, as it relocated from Annapolis.

Several events took place in Dad's life as I became involved in my first sea duty upon my graduation from the Naval Academy. He commanded the new *pocket battleship* USS GUAM (CB-2) for a short tour, bringing it from the Western Pacific through the Canal for ultimate decommissioning in New Jersey. He was selected for Rear Admiral, and ordered to command the Atlantic Mine Force–he and Mom joining in the southern social life of Charleston, SC.

Then it was back to his beloved submarines in New London. It was as COMSUBLANT that he sent USS NAUTILUS to sea for the first time. He and his USNA classmate, RADM Rickover, sharing the limelight, and diplomatically agreeing to just where the boundaries of *Rick's* nuclear plant authority began and ended.

I was a student at the Postgraduate School when Dad became Commander Anti-Submarine Force in Norfolk as a Vice Admiral. I guess it was a *it takes one to know one* policy that sets a submariner into perfecting ways to improve Submarine Hunter-Killer Groups. He was also in Command of the US Tenth Fleet.

At this same time my father in law, VADM *Count* Austin also had a fleet command in the Pacific. A fleet commanders' conference brought them both to Monterey and presented my children an unexpected visit with both sets of grandparents.

At a family dinner I overheard a heated discussion on the controversial nature of ADM Rickover. Dad's view was that, controversial or not, *Rick* had great influence with Congress and could get the Navy the nuclear submarine fleet we needed. As always the development of ever more capable submarines was all important to my father.

Dad gave a helping hand to many people during his long naval career. He made special exceptions to rules when he thought a person deserved it. He used his influence to steer other deserving people in new directions. While some senior officers have been known for *ending careers*, Dad was known for just the opposite. He went out of his way in advising, encouraging and assisting outstanding officers toward more brilliant careers. And I never heard anything but high praise for my father from people who worked for him.

As Dad approached retirement, he and Mom hoped for duty in the San Francisco Bay Area, as that had become our family's emotional home ever since we lived there during WWII. However, the 12th Naval District Commandant billet was filled ... but the 13th Naval District was available.

Over the next few years my folks fell in love with the beautiful Pacific Northwest. Dad eventually retired from Commandant 13th Naval District–he and Mom moving into a gracious home in Seattle. There he continued to represent the best of the Navy as a member of the International Rotary Club, and he served on numerous boards and in other community organizations. He also accepted a position at the University of Washington for awhile, working toward increasing their grants and their participation in research.

I would be remiss should I not give tribute to my mother, who played an indispensable roll in Dad's career–he could not have done it all without her, and he knew that too. She not only made a home for him, and us kids, at multiple locations, but she was beloved as *Peg* Watkins, his devoted wife and social hostess, planning and supervising social events, creating a welcoming environment at home, and promoting a cohesive atmosphere for submarine families. Her world included young families of deployed submarine wardroom officers, and she gathered them in and saw to their welfare for many long and lonely periods. Through letters and hundreds of Christmas Cards, they each maintained their contact with distant friends long after they retired.

Mom's maiden name was Margaret Ruth Orem, her father was a well known Utah railroad owner–the city of Orem honors his name. She stood 5 feet two and although she dedicated her life to making a home for Dad, he knew he could push her just so far. Many humorous stories depict them as the comic strip couple, *THE LOCKHORNS* at times. However conflicts were often ended suddenly when Mom had *had enough!* and put her foot down. She was also the go between Dad and us boys, often explaining that he really does love us, and what he meant to say was ....

Dad spent lots of days exploring Puget Sound by yacht, yet he never became a boat owner himself. He told me once that he saw no reason to own a boat when so many of his friends did own them, and wanted him along as a shipmate. Knowing my Dad's experience at sea and his willingness to help, I know why he was in such demand.

Dad died rather suddenly at 81 years of an aneurism on his abdominal aorta, and I never got to say goodbye. But I searched through his papers and found his final wishes written in his own handwriting: "to be buried at sea from a US submarine."

USS CAVALLA (SSN-684), while operating submerged in the Pacific Ocean, piped his ashes over the side–they fired them into the deep sea from a torpedo tube. Thus Dad joined the young submariners he sent to sea during the war–the ones who never came home, the ones who are still on patrol. I know he felt that to be most appropriate. He asked for nothing more. That's the way he was, the way he wanted it.

So now you know.■

DON'T PAY BY PERSONAL CHECK

by Mrs. Patricia J. Bush

It was a weekday about 6 pm. It was 1964. I was in the kitchen in my rented Newport News, Virginia, bungalow, thinking of what I could throw together for my kids for dinner. My 9-year old daughter was moaning over her homework and the other, my 7-year old son, was in the back yard playing "I throw, you catch" with Molly, our dog. We were in Newport News because my husband, James T. Bush, was assigned as Executive Officer to the JOHN C. CALHOUN, SSBN 630, under construction at Newport News Shipbuilding and Drydock.

The doorbell rang. I went to the door and opened it and two men in civilian clothes, quite ordinary looking, one shorter and fatter, pushed past me, flashed what I presumed were badges, and walked straight into the living room on the left. The shorter fatter one said something that sounded like Latin. "What did you say?" said I. His unbelievable response was, "What's the matter, lady, you're not an American?" And even more unbelievable was his next utterance, "Lady, we have a warrant for your arrest." "For what?" "For not paying the fine for yer traffic violation in Yorktown September 16th." "But I paid it." "But lady, you were told ya had ta pay by cash or money order, and ya sent a personal check. We haf ta take ya ta jail." "But" said I, "what will happen to the children?" "They'll be taken inta care." "Well then, what about the dog?" That seemed to stump them. "Well", I said, "my husband's submarine is on sea trials right now, but he'll be home tomorrow. How about you come back tomorrow to take me to jail, and then he can take care of the kids and the dog." The taller thinner up-to-now silent one asked to use the phone and made a call. He then said, "OK. We'll be back tomorrow about the same time." They left. I noticed in an unmarked car. I fumed. "This is outrageous. I'm damn well going to jail. I'm going to phone the newspaper and tell them how a navy wife whose husband was at sea was arrested for paying with a personal check. That'll fix 'em."

How did this happen? Well, my parents were living on the Rappahannock River about an hour's drive from Newport News. As Jim was at sea, I was taking the kids and dog to visit them for the weekend. This required going through Yorktown and crossing the bridge over the river. As we were about 10 minutes from Yorktown on a two lane road, the car directly ahead of me pulled over on the right shoulder in order to go around a car which was waiting for an oncoming car to turn left. I slowed down and followed him around on the shoulder. I had gone no more than 100 feet when I and the car ahead of me were pulled over by a cop. We were both given citations for reckless driving and told we could go immediately to the court at Yorktown and immediately pay an unbelievably high fine, pay the fine within 15 days, or come to court the following Friday morning to protest. I immediately said I would come to court. I did so, and the seemingly kind judge listened to my story, agreed that my crime was not reckless driving, and reduced my citation to improper passing. I was told I could pay the reduced fine by cash immediately or mail in a cashier's check within three days. I didn't have the cash.

I went home. I had never obtained a cashier's check in my life. I associated them with the method sailors use to send money home. This was not something officers did. I said to myself, "A personal check is legal tender. I'm not going to even find out how to get a cashier's check. I'm busy. I'm mailing in a personal check." And so I did.

The next afternoon, Jim came home and I told him the story and that I expected him to take care of the home front while I was in jail. His view, quite misguided I thought, was that I should have paid by the cashier's check and that I should do what was asked so as to avoid incarceration (and I thought any embarrassment to the U.S. Navy). He said he needed a shower and wanted to have his uniform on when the cops came. So up he went up to the bathroom which was right at the top of the stairs leading up from the front door. The doorbell rang and I opened the door to the two cops, again in plain clothes. At the same time, Jim opened the bathroom door at the top of the stairs. He was wearing only a towel! The cops stared up at him. I struggled to maintain a serious demeanor and told the cops my husband would be right down. I ushered them into the living room. Molly growled a little. "Good dog" I thought to myself.

Down came Jim in his blues with stripes and ribbons. Within five minutes he told them that he would obtain a cashier's check and mail it in the very next day. Wasn't there something that could be done? The cops conversed with each other and the taller thinner one said he would call the judge. He did. Jim spoke with the judge. The cop spoke with the judge. The cops left. To the best of my knowledge, Jim paid my fine the next day with a cashier's check.

I still wonder what it would have been like to go to jail and to see a front page story with my photo in the newspaper, "Navy officer's wife jailed for paying traffic fine with personal check."■

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BOOK REVIEWS

U-BOAT WAR

by Lothar-Günther Buchheim

Published 1978 by Alfred A. Knopf, Inc.[1]
(1978: distributed by Random House)
ISBN-10:0394414373

Review by Captain Dave Smith, USN (Ret)

For those of us assigned to a SubLant Guppy II in the 1950's, how can we forget those Atlantic crossings–mountainous seas and immersion suits that always seemed to leak in spite of the *O* ring seals for glove-to-sleeve and boot-to-pantleg. However it is doubtful that any of us know of photographs being taken during those adventurous times. U-Boat War will bring back all of those memories.

Lothar-Günther Buchheim served as a Lieutenant in the German Navy. Early in WWII, at the age of 23, he was assigned to U-96 as a war correspondent and tasked, for propaganda purposes, to document the reality of war from the aspect of submarine life. Although he was an artist and not a photographer, he states in his introduction that "every aspect, every detail counted, bore witness to the reality of war, for unless I captured it on film it was irretrievably gone." Thus, he acquired a camera and took about 5,000 photographs. In U-Boat War he presents about 200 selected photographs that support the text in an amazing manner. The most impressive photographs are those taken from the bridge. One must wonder how his camera survived the adverse conditions–and how he did not get washed overboard while taking some of those shots. Inside U-96 he photographed the crew in every compartment and

[1] An earlier work, *Das Boot*, published in 1973, became arguably one of the best submarine movies.

during almost every type of event–eating, sleeping, working torpedoes, being depth-charged and operating the controls of most of the machinery. The expressions on the faces of the crew convey submarine life and all of its challenging reality.

The author wrote this book before publication of The Secret In Building 26, and thus before the declassification of the information regarding how we broke the German code for their Enigma machines. Thus the author's comments on the loss of so many U-Boats adds to the knowledge as to why the Allied forces were so successful for so long.

While the majority of the book is the author's view of WWII, from 1941 until the end, the last few pages present The Submarine War; A Historical Essay, by the distinguished German historian Michael Salewski. The reader gains not only a moving awareness of submarine life but also an interesting overview of the High Command's policies in pursuing submarine warfare during WWII.■

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STRUGGLE FOR THE MIDDLE SEA THE GREAT NAVIES AT WAR IN THE MEDITERRANEAN 1940-1945

by Mr. Vincent P. O'Hara

Naval Institute Press, ISBN 9781591146483

Reviewed by Captain L. B. Hebbard, Jr., USN (Ret)

This is a very comprehensive review of the Naval war in the Mediterranean Sea during World War II. In particular the actions of the Italian Navy showed much more capability and an aggressive nature not previously attributed to the Italians. Fuel shortages played a very significant role in limiting their contribution to the Axis cause. Movement of supplies to North Africa was impressive.

Like the Italians, the willingness of the French Navy to conduct operations, significant offensive operations, had not been appreciated. Previously believing that French units remained tied up in port after the surrender of France to Germany, is shown to be quite plainly false.

The duplicity of the Vichy French government, trying to play both sides for French advantage was never appreciated. A willingness of the Vichy government to join the Axis cause had not been previously considered.

The effectiveness of mine fields on naval actions was significantly more potent than one would have expected. The failure of the British to achieve hits with numerous surface torpedo attacks was quite astounding. As the war progressed, the accuracy of the British Naval gunners improved markedly. It seemed quite below the standards expected of the Brits at the start of the war.

Although the action described for the class of ships called *Hunts* was mentioned several times, the comparison to a U S Navy type vessel was not explained, or listed in the Appendix. Also, the extremely fine print and poor color differentiation, made the numerous charts very hard to interpret.

All in all, a very thorough and educational read.■

DOLPHIN SCHOLARSHIP FOUNDATION SELECTS 2010 SCHOLARS

Dolphin Scholarship Foundation (DSF) announces the selection of 25 outstanding high school and college students as the **2010 Dolphin Scholars**. Each Dolphin Scholar receives $3,400 per year which is potentially renewable for up to four years of undergraduate study at an accredited 4 year college or university, for a possible total individual award of $13,600. For the 2019-2011 academic year, DSF will fund a total of 127 scholarships for an annual program total of $431,800.

The 2010 Dolphin Scholars were selected from over almost 400 initial applications. Final selection was based on three equal criteria: academic proficiency, financial need, and commitment and excellence in school and community activities. Members of the military and civilian community comprised the Selection Board, including Mr. John L. Haines, Jr., the First Dolphin Scholar; Dr. Dean Dunn, Dolphin Scholar 1973-1976; Dr. Jane Duffey, Headmaster, Norfolk Christian School, the daughter of DSF Founder Martha Grenfell; and Mrs. Mimi Donnelly, Chairman of the DSF Board. Of the twenty-five 2010 Dolphin Scholars, 19 were high school seniors and 5 are current college students, 8 male and 17 female. Ten of the submarine sponsors are from the enlisted community and 15 are submarine officers. Eight Scholars ranked in the top 1% of their graduation classes.

The following high school seniors were selected as 2010 Dolphin Scholars:

Name / *High School*	*Sponsor*
Adam R. Filipowicz Princess Anne High School, Virginia Beach, VA	STSC(SS) Ronald H. Filipowicz, USN (Ret.)
Alexander S. Hudson Centerburg High School, Centerburg, OH	HMCM(SS) Randall S. Hudson, USN (Ret.)
Ashleigh M. Van Metre Bishop England High School, Daniel Island, SC	CDR Christopher R. Van Metre, USN (Ret.)
Corinne E. Clinch Phoebus High School, Hampton, VA	LCDR Kevin D. Clinch, USN (Ret.)
David M. Kriete, Jr. Oscar F. Smith High School, Chesapeake, VA	CAPT David M. Kriete, USN
Erika R. Emch Basha High School, Chandler, AZ	MMC(SS) John S. Emch, USN (Ret.)
Kaitlin A. Mikatarian Ocean Lakes High School, Virginia Beach, VA	CAPT Douglas W. Mikatarian, USN
Kaitlin M. Smits Bellevue East High School, Bellevue, NE	CDR Theodore V. Smits, USN (Ret.)
Kristen K. Bateman Clear Creek High School, League City, TX	LCDR Craig A. Bateman, USN (Ret.)
Lauren L. Cosgriff Stephen Decatur High School, Berlin, MD	CDR Robert E. Cosgriff, USN (Ret.)
Melanie M. Merrick Oscar F. Smith High School, Chesapeake, VA	CDR Mark H. Merrick, USN
Michael J. Harper home school, Annapolis, MD	CDR Mark J. Harper, USNR (Ret.)
Michael J. Sheffey, Jr. Ragsdale High School, Jamestown, NC	EMC(SS) Michael J. Sheffey, Sr. USN (Ret.)
Nicole M. McCaffrey Livermore High School, Livermore, CA	CAPT Thomas E. McCaffrey, USN (Ret.)

Name / *High School*	*Sponsor*
Sean M. Cockey Iolani School, Honolulu, HI	CAPT Michael K. Cockey, USN
Tabitha R. Glinski Camden County High School, Kingsland, GA	FTC(SS) Ryan S. Glinski, USN
Taylor V. Locks Riverbend High School, Fredericksburg, VA	CAPT John T. Locks, USN (Ret.)
Yuko M. Gruber Carolina Forest High School, Myrtle Beach, SC	ETCM(SS) William J. Gruber, USN (Ret.)

The following undergraduate college students were selected as 2010 Dolphin Scholars:

Name / *College*	*Sponsor*
Christopher A. Rayle Taylor University, Upland, IN	ETC(SS) David A. Rayle, USNR (Ret.)
Gabrielle A. Jagen Baylor University, Waco, TX	TM1(SS) Theodore A. Jagen, USN (Discharged)
Kelsey M. Moran Tulane University, New Orleans, LA	CDR Michael D. Moran, USN (Ret.)
Morgan A. DeLuca Rochester Institute of Technology, Rochester, NY	EMC(SS) Michael A. DeLuca, USN (Ret.)
Nathaniel D. Green Xavier University, Cincinnati, OH	ETCM(SS) David W. Green, USN (Ret.)
Samantha J. Merwin Dartmouth College, Hanover, NH	CDR Michael L. Merwin, USN (Ret.)
Shayna J. Kniseley Old Dominion University, Norfolk, VA	MMCS(SS) Daniel R. Kniseley, USN (Ret.)

The following students are considered Honorary Dolphin Scholars; they were selected but declined the Dolphin Scholarship:

Name / *High School*	*Sponsor*
James M. Mackovjak Central Kitsap High School, Silverdale, WA	CDR David P. Mackovjack, USN (Ret.)
John M. Mackovjak Central Kitsap High School, Silverdale, WA	CDR David P. Mackovjack, USN (Ret.)
Anna C. Burnham York Catholic High School, York, PA	CDR Timothy L. Burnham, USN (Ret.)

Congratulations to the new Dolphin Scholars! They join a distinguished group of more than 1,000 outstanding students who have received over eight million dollars in financial assistance for undergraduate study since 1961. The Foundation was organized and initially funded by submarine wives' clubs, and celebrates ***"50 Years of Scholarships"*** thanks to the continued generous support from the entire Submarine community.

2010 NROTC FREDERICK B. WARDER AWARD FOR OUTSTANDING ACHIEVEMENT

Auburn University	Officer Candidate George Thompson
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College of the Holy Cross	Midshipman Stephen Smith
Cornell University	Midshipman Alexander Hydrean
Georgia Institute of Technology	Midshipman Kyle Davis
Illinois Institute of Technology	Midshipman Christopher Pope
Iowa State University	Officer Candidate John Miske
Marquette University	Midshipman Ryan McNichols
Massachusetts Institute of Technology	Midshipman Kevin Plumer
Miami University	Midshipman Tyler Hochschwender
North Carolina State University	Officer Candidate James Nevins
Northwestern University	Midshipman Joseph McElroy
Ohio State University	Midshipman John Schaeffer, II
Old Dominion University	Midshipman Earl Hill
Oregon State University	Officer Candidate Matthew Divittore
Pennsylvania State University	Midshipman Eric Larson
Purdue University	Officer Candidate Robert Jackson
Rensselaer Polytechnic Institute	Midshipman Jacob Newell
Rice University	Midshipman Joshua Kirlin
San Diego State University	Midshipman Michael Adcock
SUNY Maritime College	Officer Candidate Alexander Corpuz
Texas A&M University	Midshipman Jordan Klein
The Citadel	Officer Candidate Joshua Bergeron
University of Arizona	Officer Candidate Oliver Zufelt
University of Colorado	SSGT Sean Lee
University of Idaho	Officer Candidate Mathie Romine
University of Illinois	Officer Candidate Andrew Riegert
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University of Mississippi	Midshipman Dennis Guy
University of Missouri	Midshipman Alan McGinnis
University of New Mexico	Midshipman Christopher Derego
University of Notre Dame	Midshipman Brian Huff
University of Oklahoma	Midshipman Seth Gay
University of Rochester	Midshipman Matthew Rockwell
University of South Carolina	Officer Candidate Joshua Williams
University of South Florida	Midshipman Ho Le
University of Southern California	Midshipman Vincent Mejia
University of Utah	Midshipman Eric Spencer
University of Virginia	Midshipman Michael Stromeyer
University of Washington	Midshipman Cody Little
Vanderbilt University	Midshipman Fletcher Lewis
Villanova University	Midshipman Christopher Schneider
Virginia Military Institute	Midshipman Jorge Tellez
Virginia Tech	Midshipman Steven Wright

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Benefactors for More Than Five Years

Business Resources, Inc.
Dresser-Rand
iRobot Maritime System
L-3 Communications Corporation
Micropore, Inc.
Nuclear Fuel Services, Inc.
OceanWorks International, Inc.
Oil States Industries/Aerospace Products Division
PaciPinkerton Government Services, Inc.
Progeny Systems Corporation
SSS Clutch Company, Inc.
Superbolt, Inc.
Whitney, Bradley & Brown, Inc.

Additional Benefactors

3 Phoenix, Inc. (New in 2009)
Advanced Technology Institute
AMI International (New in 2009)
CACI International Inc (New in 2009)
Cunico Corporation
DRS Sonar Systems, LLC
Dynamic Controls, Ltd.
Epsilon Systems Solutions, Inc.
Ettem USA, Inc.
EVT LLC (New in 2010)
General Atomics
General Dynamics
IBM Global Business Services, Public Sector
In-Depth Engineering Corporation (New in 2009)
Imes
L-3 Chesapeake Sciences Corporation
L-3 Communications Aerospace Electronics (New in 2010)
L-3 Communications, Space and Navigation Division (New in 2009)
Murray Guard, Inc. (New in 2009)
Oceaneering International, Inc.
Siemens PLM Software (New in 2009)
Trelleborg Offshore Boston
TSM Corporation
VCR, Inc.