Excerpt from the book

Transparent Oceans: The Defeat of the Soviet Submarine Force

by

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CHAPTER ONE
Introduction

The Threat[1]

The advent of the nuclear submarine was a formidable new threat to the Free World. It was much faster than earlier submarines, much quieter, seemingly undetectable, and carried substantial and continually improving weapons. Essentially two types of submarines were developed: the attack submarine and the missile-carrying submarine. The attack submarine was designed to attack merchant ships, surface warships, and enemy submarines. It had a long history of success in both World War I and World War II. The supply life line between the United States and England was almost severed by German diesel submarines during both of the World Wars. The Japanese merchant traffic within the Greater East Asian Co-Prosperity Sphere was almost completely destroyed by American diesel submarines operating in the Western Pacific during WWII. The development of the nuclear submarine made the attack submarine more deadly than its predecessors. The Soviet Union, with the largest submarine force in the world, clearly had in its hands a potential major threat to free world commerce.

The missile-carrying submarine was designed to position itself in the ocean and, upon receipt of the appropriate command, launch its missiles quickly against a previously designated target. Initially, the missiles were not armed with nuclear warheads and could only travel short distances (approximately 100 miles). In a short period of time, the application of advances in technology allowed the missiles to travel much longer ranges and carried nuclear warheads. The mission of nuclear ballistic missiles is to destroy large areas, major installations, or cities.

All ballistic missiles are powered by their engines during the initial phase of their flight path. They lift off from their launch point, and fly, under power, into the atmosphere. At some point, their engines shut off, and the missiles follow a path that is influenced primarily by the force of gravity. This path is a ballistic trajectory. The path of a ballistic missile is very similar, except in scale, to that of a thrown ball. The path followed by both the ball and the ballistic missile is determined by their initial angle to the horizontal and their initial velocity. These two properties uniquely determine the path. The main

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[1]See Appendix D, Glossary, for a definition of all technical terms

external force that is exerted upon the missile (ball) is gravity. This force slowly retards the initial vertical speed and causes the missile to curve over the earth and then return to the ground to hit a specified target. By working the problem backward, we can specify a particular point that we want to hit; then, adjust the required initial launch angle for a given initial velocity.

There is a major problem with the ballistic missiles that are used by the attacking force. Once the incoming missiles are detected by radar or other similar devices, the defense force computers can calculate the trajectory and the speed of the incoming missiles. Anti-ballistic missiles may then be fired to any point along the trajectory, arriving at the desired point at the same time as the incoming missile. Assuming everything works correctly, the incoming missile will then be destroyed. The problem of having two missiles arrive at the same spot in the atmosphere at the same time is not particularly difficult. Developing the radar detection systems, and coordinating with the launch of the anti-ballistic missiles is a difficult, but not impossible technical problem. The entire problem is solvable because ballistic missiles follow predictable paths. While ballistic missiles are extremely fast, radar and computers are much faster.

The development of the cruise missile complicated the problem of missile defense. The path of a cruise missile is not predictable from basic physics. A cruise missile can be launched and then, using internal computer calculations and sensors, fly a path that can be adjusted along the way. The path variations may be pre-programmed or, by using advanced logic and on-board sensors, select between several different possible adjustable paths that lead to several possible end points (targets).

Destroying cruise missiles in flight is extremely difficult. A better and possibly simpler approach was to destroy the missile-carrying submarines before they could launch their missiles. In order to provide a timely defense, it is necessary to detect the missile carrying submarines prior to missile launch and be able to destroy them, essentially instantly, on command from the National Command Authority, resident in Washington DC.

> In the early days of the Cold War (circa 1955), Soviet missile submarines had to come close to the United States because the range of the missiles was quite short. With each passing year, the missiles could be launched from progressively farther away. In the last years of the Cold War, Soviet missile boats could launch their missiles from several thousand miles away, thus allowing the Soviets to launch their missiles from waters immediately contiguous to the Soviet Union.

The oceans cover approximately 70% of the earth’s surface, so US attack submarines had to be distributed throughout the oceans of the world, all the time. The US attack submarines had to detect, localize, classify, and be prepared to kill the Soviet missile carrying submarines on command, in a very short period of time. Aside from the communication issues, which were major in themselves, the problem of anti-submarine warfare became the crux of the missile defense problem.

A Note on Submarines at the Turn of the Century

John Phillip Holland's original invention of the submarine was in 1877. The first submarine purchased by the U.S. Navy was Holland's sixth submarine. It was commissioned as the USS *Holland* and designated the SS-1[2] .Submarines were built by most of the larger seafaring nations. It was recognized quite early that the submarine offered many operational opportunities as a new Navy platform; it was a threat of unparalleled danger. Its development was pursued with great vigor by the world's premier navies.

World War I saw operating submarines become reality. Germany's use of unrestricted submarine warfare was considered "unsportsmanlike." At that time it was still considered that warfare was to be conducted according to time-honored rules. The idea that ships could be attacked without first being given warning was simply considered improper, even if it was highly effective. Until the allies formed convoys, the submarines had the upper hand.

Convoys consist of a relatively large number of ships, sailing together. They can all be protected by a small number of warships. If the convoy is attacked, the warships can provide defense and counter-attack. Also, in the event of an attack, the ships of the convoy scatter in all directions, leaving the submarine only one or two victims. Convoying has always been proven successful, even from the time of antiquity.

Submarines of the World War I era, however, had one particular difficulty: they really didn't work well submerged! True, they could submerge and then resurface, but they really didn't operate well while they were under water. Submarines also had other problems. Their sonars were primitive and the displays even more so. Living conditions on board the so-called "pig-boats" were appalling. Their operating ranges were short, and the favorite method of attack was on the surface. The WWI submarine was really a submersible surface ship that could resurface. Nevertheless, they caused great concern among the allies because of the substantial negative effect they had on seagoing commerce.

The fall of France early in World War II allowed the Germans to acquire and use French Atlantic ports. Use of these ports substantially reduced the

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[2]http://www.geocities.com/gwmccue/index.htm

transit times to the North Atlantic—consider that St. Nazaire is much closer to the Atlantic than Wilhelmshaven. When the German submarines left Wilhelmshaven they could sortie to the Atlantic from Germany either by traversing the English Channel (highly risky) or traveling through the Baltic, traverse the North Sea, circle Scotland and Ireland, and finally enter the North Atlantic (much less risky, but very long). Departing from St. Nazaire allowed them direct access to the Bay of Biscay, which was almost within striking distance of the Western Approaches to English ports. The use of St. Nazaire allowed much longer times in the combat area.

World War II saw the submarine threat become highly effective, and almost catastrophic for the allies. The equipment developed during the period between World Wars I and II allowed significant improvements in submarine capabilities, range of operations, and living conditions. The principal constraint imposed on World War II submarines was their need to be frequently re-supplied with armaments, fuel, and food. Increasing the size of the submarines allowed them to carry more armaments, more fuel, and more food. Larger WWII submarines could remain at sea for longer periods and range much farther from friendly ports their smaller WWI predecessors.

The speed of World War II German submarines was approximately 12 to 14 knots on the surface, but much slower when submerged. While the quality of the German submarines was much higher than their World War I predecessors, they still were essentially surface ships that submerged and resurfaced. They generally attacked their targets on the surface during the night and submerged during the day.

> Diesel engines require two items to operate: fuel and air. Thus, it was impossible to operate diesel engines while the submarine was submerged. The submarine was under battery power while submerged. When the snorkel was invented later in WWII, diesel engines could operate while the submarine was submerged by taking needed combustion air through the snorkel. The submarine could then operate its diesel engines while submerged at shallow depths (keel was about 45 feet below the sea surface) with the snorkel raised above the sea

The German submarine operated in one of two modes: on the surface using their diesel engines or submerged using battery power. While they operated on the surface, they replenished their inside air, which became stale very quickly in the confines of the closed submarine, and recharged their batteries.

The United States Antisubmarine Warfare (ASW) forces initially had little capability to detect submarines until an attack took place. The operative phrase was “Flaming Datum.” When a surface ship was either torpedoed or fired upon with the submarine deck gun, an attack was clearly underway. This action caused the naval surface escorts to begin an intensive search for the surfaced submarine. Searchlights and binoculars were the principal means of detection. For submerged enemy submarines, the only detection equipment available to the Allied navies was the very rudimentary sonar which had been in use since World War I.

A tremendous step forward was the introduction of surface ship mounted radar, early in World War II. Radar, even its infancy, allowed surfaced submarines to be detected with relative ease. During the WWII era, radar was big and ungainly. It could only be operated from surface ships, but it could detect targets on the water, i.e., surfaced submarines. The rapid growth of the use of radar by surface ships forced the German submarines to begin to operate more time submerged. This requirement to remain submerged for longer periods of time caused their range to be restricted. Their maximum speed was substantially limited, and they had to surface more frequently to recharge their batteries. Operating on the surface became a dangerous thing to do. As a counter to the Allies radar, Germans invented a radar detection system that informed the submarine that a radar was operating in their vicinity. This radar detection system provided some increased warning time to the Germans so they could take evasive action and re-submerge.

Radar continued to develop rapidly. Soon radar was made sufficiently small and light so that it could be used on airplanes. This advancement made life for the submarine even more perilous. While the submarines had a radar detection system, the airplane could detect them sooner and attack much faster than the submarine could escape from the attack by submerging. Even if the submarine could submerge prior to attack by the aircraft, it could only attempt to reach safety at relatively slow speeds (several knots) while the aircraft, which had noted the spot where the submarine submerged, could move at several *hundred* knots.

In the early 1942, things were not going well for the submarine and, in a short time, became worse. Detecting a surfaced submarine, which was a large object, became commonplace and easy. When the Germans invented the snorkel, however, only a relatively small tube broke the sea surface and made detection of a submarine much more difficult.

Allied engineers were set to work on using radar to detect the relatively small snorkel tube that broke the sea surface. They were intent on developing and building a radar system that operated at a particular frequency whose wavelength was about the size of the projecting snorkel. If the reflecting device is about the same size as the incoming wavelength then there is maximum reflection. The development of radar operating at the desired frequency was quickly solved under the pressures of wartime requirements. The importance of solving the detection of snorkeling submarines had life-and-death implications; the German submarine had to be defeated. These pressures, and the contributions of the technical community produced a working radar in a short time, and soon a snorkeling submarine could be easily detected.

This series of events was unfavorable for the German submariners. The detection and subsequent kill rate of German submarines increased alarmingly. Although the Germans had invented a radar detection system for surface ship radars, they never realized that their snorkeling submarines were being detected by airborne radar tuned to detect their snorkels.

The use of radars, both surface ship and air borne, made the life of surfaced German submarine very hazardous. If a German submarine managed to avoid detection prior to attacking the surface ships, once the attack began all parties knew that a submarine was around. After its first attack, a German submarine was forced to submerge. It then found itself under heavy attack from naval surface forces using their active sonars. The sonar transmitter, located under the keel of the surface ship, sent out an acoustic signal ("pinged") and waited for the reflected echo. If no echo was returned, then they sent another ping and the search continued. The ranges between the surface ships and their submarine prey was generally less than 1 mile, or 2000 yards.

The receiving sensors (hydrophones) could be steered mechanically by the sonarman. If an echo was returned from a submerged target,[3] then the sonarman could tell the captain which direction to steer the ship. As the distance between the attacking surface ship and submerged submarine became shorter, the interval between the transmitted ping and the received echo became smaller. At some point, the sonarman informed the captain of the relative position and estimated depth of the submarine, and a barrage of depth charges ("ash cans") would ensue.

> The significance of this discussion is that the submarines were detected in two ways:
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> - by radar when they were on the surface or sub-merged and using their snorkels, which also broke the surface of the water, and
> - by using active sonar with the returning echo from the acoustic signal reflecting from the submarine.

[3]See Appendix F, The Basics, for details.

This type of detection process has many possibilities of error, such as determining the bearing of the returning echo or the submarine's depth. While it seems quite straightforward to detect and kill a submarine, that was not the case. Substantial skill, much practice and, to some extent, luck, were required.

Many people with different skills were involved in at-tempting to detect, localize, classify, and kill a submarine. Generally, they were all on one surface ship or a single aircraft. In some instances, two or more surface ships worked together to prosecute a submarine. In other instances, a surface ship worked with an aircraft; however, these instances were rare. When two or more surface ships worked together, they were always close to each other. Each ship could see the other, and they had a feeling on how they were acting as a team. They coordinated their activities using radio.

The significance of the ASW problem during WWII caused many organizations to focus on it. At Harvard, a group was dedicated to acoustics. Mr. Ted Hunt, one of the members of that group, made substantial advances in the science of underwater acoustics. Hydrophones were built and tested. Materials were investigated to ascertain their electromechanical properties. Some mathematical work was done on the problem of underwater sound propagation. These focused efforts helped immeasurably in developing the art and science of underwater acoustics and its applications to solving the ASW problem.

After World War II, members of the Harvard group followed several academic disciplines at different universities. Some of the group went to AT&T, where they continued to pursue their efforts in underwater acoustics.

The end of World War II saw the successes of the ASW forces. They had developed and applied scientific methods to several different aspects of the problem with great success. The development of radar had forced the submarines to operate submerged. Short-range, high-frequency active acoustics worked; submerged submarines could be detected at relatively short ranges, e.g., a few thousand yards.

The allied ASW forces were pleased with their success, but the more thoughtful leaders recognized some ominous developments in the submarine world. The Soviets had captured the new Type XXI submarines from the defeated German forces. Those submarines were substantially better than the main submarines used by Germany throughout most of World War II. They could remain submerged longer, they were faster, and they had longer ranges. These leaders realized that a Cold War might develop and that the Soviets would then have a submarine force-in-being. It appeared that the ASW forces could not rest on their laurels; substantial advances in ASW capabilities would have to continue.

Chapter Two
The Cold War and Antisubmarine Warfare

General Comments

The Cold War (1946–1989) has substantial precedent in written history. Tensions between nations have existed for thousands of years, and actual combat between nations has lasted for substantially longer periods than the Cold War between the United States and Russia.

During modern history, however, there have been few protracted periods where the nations of the world have divided themselves into armed camps for such a long time. Further, due to the skill and persistence of the scientific community, weapons of terror were and still are completely capable of eliminating life as we know it on our entire planet.

During the period of extended tension, the United States as the leader of the Free World and the Soviet Union as the leader of the Communist World, faced each other with antagonism and fury that were barely contained. However, as we know, the Soviet camp disintegrated in 1989. The Cold War was declared officially over; the United States and the Free World had won.

But did a specific country win the Cold War? Can a specific organization be singled out as having won the Cold War? A case could be made that the Manhattan Project, which developed the Atomic Bomb, was perhaps the one project that eventually resulted in the success of the allies in defeating Japan during World War II. (Germany had already surrendered by the time the A-bomb was used).

I contend, with a certain amount of tongue in cheek, that winning of the Cold War was materially affected by an organization called the Long Range Acoustic Propagation Project (LRAPP). The LRAPP organization was, and remains, virtually unknown to almost everyone, including almost the entire U.S. Navy.

The differences between the two projects are substantial. The Manhattan Project cost billions of dollars, involved tens of thousands of people operating at secret sites, for a relatively short period of time: 5 years. LRAPP spent considerably less than $300 million, never involved more than 200 people, and existed for approximately 20 years. The Manhattan Project had the support of the President of the United States, as well as essentially unlimited funds and bureaucratic control over its own destiny. LRAPP was unknown to almost everyone, particularly at the senior levels of the U.S.

Government, and had no bureaucratic control over its destiny. Yet the comparisons between the two programs, if measured by their contributions to the successful conclusion of World War II and the Cold War, are startlingly similar.

The Cold War was fought on a myriad of fronts. These fronts can be lumped together in such broad generic categorizations as ideological, political, economic, and technical, but not military. Confrontations in the sense of actual military battles did not occur between the principal leaders of the two major camps. Such confrontations were left to their subordinate partners. However, in one military area, and in one military area alone, the United States fought the Soviet Union in a military sense (with the sole proviso that no weapons were actually fired) on a 24-hour-a-day-basis. This battle occurred in the broad area of undersea warfare, specifically in the narrow area of Antisubmarine Warfare (ASW).

From the beginning of the Cold War in the late 1940s until the collapse of the former Soviet Union in 1989, the U.S. Navy fought Soviet Navy submarines on a daily basis. In this titanic struggle, all the resources of both military organizations dueled against each other. At the end of each day, the competing forces knew who had won. Sometimes it was the U.S. Navy, and sometimes it was the Soviet Navy. New equipment was constantly being developed; new tactics were continually being generated and tested under conditions that differed from combat in only one aspect: no shots were actually fired. However, the entire process of detection, classification, localization, and establishment of a fire-control solution was attempted and frequently achieved by each side.

> In the history of the world, many games have been invented. In the military world the concept of games is used for training purposes. Training is given to the individual military person in each of the armed services. Then training is given to larger organizations, increasing in size up to full armies. All military organizations maintain the ancient belief, "You fight as you train." During the severe stress of combat there is no time to become creative and imaginative. In fact, if deviations from established procedures are attempted during actual combat, they invariably lead to disaster.

One result of war games is to establish training procedures that will lead to successful combat, when and if that need ever occurs, against anticipated enemy capabilities. War games themselves, and their logical extensions, military exercises, are held within the military services. In certain scenarios, there are joint exercises where components of different military branches practice together. Generally, however, military exercises are held within a specific service, e.g., a naval exercise is held by designated components of naval operating forces.

In a military exercise, the role of the opponent is played by specially designated forces. These forces use the known or assumed tactics of the opposition; such information comes from the intelligence arms of the military forces. The salient point is that the opposing forces are played by substitutes. It is a constant and major concern among the commanders of the military forces that they are training their forces to fight against opponents who may use quite different tactics if actual combat takes place. They are never quite sure that the military hardware developed and used by the potential enemy will perform or be employed as predicted by the intelligence community. Military surprises are never pleasant, and frequently result in unanticipated casualties to both men and equipment.

None of the military services of the United States during the Cold War ever tested themselves against their Soviet counterparts, except the part of the U.S. Navy that was responsible for undersea warfare. During the entire Cold War, the U.S. Navy participated in operations throughout the oceans of the world against their Soviet counterparts on a daily basis.

The Game

In the history of the world, seldom has there been a game as demanding and exciting as ASW. The game was played by thousands of people, military and civilian, on both sides on a daily basis for the entire duration of the Cold War. The equipment was the finest to be developed by each side. No effort was spared in using national resources to develop a team that could defeat the other. The actual test of the tactics and equipment occurred in daily operations between the U.S. Navy and the Soviet Navy.

As participants in any other complex game, the teams needed training. If actual combat had occurred, there would be no opportunity to try different tactics on another day. The loss of men and equipment would have been catastrophic to the losing side. The fate of the war would be decided and the history of the world would turn to one side or another. The United States national leadership required the U.S. Navy to develop tactics and equipment that could instantly kill Soviet submarines on command.

Early in the Cold War senior Navy leadership recognized that undersea warfare would be one of the keys to the success of the United States in its confrontation with the Soviet Union. Both previous world wars had demonstrated the amazing power of the submarine: the first and most successful stealth platform[4]. A perfect stealth platform is essentially

[4] A platform in the Navy is a surface ship, an airplane, or a submarine.

undetectable. A submarine is virtually undetectable, and the quieter it becomes, the less detectable it is. The development of the nuclear submarine with its increased endurance, ability to stay submerged for long periods of time, and substantial speed under water increased its potential impact on the conduct of the war. The development of nuclear missiles that could be launched at a moment's notice from anywhere in the world's oceans from hidden and undetectable platforms was the principal threat faced by the United States.

Essentially a weapon platform, the nuclear missile submarine had evolved so it could hold sufficient weapons that, if used, could obliterate all life on the planet. The missiles were capable of being launched in a very short time—on the order of minutes. The U.S. Navy recognized that they needed to develop a capability that could detect, classify, localize, and prepare to kill Soviet submarines before they could launch their nuclear missiles. Since Soviet submarines could be ordered to launch their missiles at any time from the Soviet Command Center in Moscow, it was imperative that the U.S. Navy have the capability to destroy the Soviet missile-carrying submarines from the instant they left their home port for a 60-day patrol until they returned. Never had such a requirement been levied by any nation on their military forces in the history of the world. The task seemed impossible, so the U.S. Navy considered the problem and immediately adopted a bureaucratic approach.

As a reaction to a deteriorating situation, the Navy formed a new group, the Director of Antisubmarine Warfare (designated as OP-095 within the administrative structure). The first commander of OP-095 was Vice Admiral (VADM) Charles B. Martell, who was personally selected by then-Secretary of the Navy, Mr. Paul Nitze.[5]

A Lesson on How the U.S. Navy is Organized

It is important to understand how the U.S. Navy was organized in 1967. That was the time when the initial events in this story took place. At the present time, to some extent, the Navy continues to be organized the same way. At its foundation, the Navy is organized along *platform* lines. The people who operate such platforms devote their careers to the development, testing, and operation of specific platforms. The platform is what fascinates the devoted officers and enlisted personnel of the Navy. These men (and later women) choose their area of focus early in their career and, with only rare exceptions, remain in their field of specialization throughout their careers. Submarine officers are devoted to submarines. It is unusual for a submarine officer to be associated with aircraft or other platforms instead

[5]Interview with RADM Ed Snyder, USN (retired).

of submarines. Such exceptions do occur but generally above the individual platform command level.

The key point is that the Navy is organized along platform and not functional lines. All platforms have homes, and organizations that support them. There are schools that teach naval personnel about their platforms. The Navy is focused on understanding the characteristics of its platforms.

But, ASW is a function. It has no home nor supporting organization. The function of ASW is to use platforms of different types. The complexity of the ASW problem is substantial and requires special training to understand the different aspects of the problem, as well as the special needs of each facet of the problem. These different facets can be addressed using the special capabilities of different platforms, but at different times.

> The formation of OP-095 was unique within the Navy, and the choice of VADM Martell was fortuitous. He immediately recognized that the bedrock for possible success in dealing with a virtually impossible problem would be science.

VADM Martell intuited specifically that the detection of submarines would have to be based upon the improved understanding of the physics of underwater sound propaga-tion. He turned to the scientific resources within the Navy, which were embodied in the Office of Naval Research (ONR). He recruited Dr. J. Brackett Hersey from the Woods Hole Oceanographic Institution to lead the effort. Dr. Hersey was a recognized expert in the complex field of underwater acoustic propagation.

VADM Martell needed a project that would be under the direct control of Dr. Hersey, and he convinced Dr. Hersey to come to Washington, D.C., to manage it. The project would organize and develop the scientific tools and information necessary to deal with underwater acoustic propagation over long ranges. Detection of Soviet submarines would initially have to be across both the Pacific and Atlantic Oceans. By any measure, these enormous distances would necessarily entail the understanding of long-range acoustic propagation. The Long Range Acoustic Propagation Project, LRAPP, was established within and reported to ONR; overall tasking and prioritization was received from OP-095.

This tale describes the generation, existence, and demise of LRAPP and its successors. The story tells the complex series of events that took place from 1967 to 1987. It is arranged in roughly chronological order and will describe the role of several professional communities that almost never deal with one another except through coercion or happenstance. To appreciate this complex tale, it will help if the reader has a modest understanding of the bureaucracy of the U.S. Navy and its components, as well as the larger world of the scientific community. In the course of this book, the reader will meet several key individuals who possessed the foresight and determination that enabled LRAPP to have a positive effect out of all proportion to the funds involved. It was the contribution of LRAPP and its people that provided the understanding of the physics that controlled ASW. These people integrated their science and technology with professional sailors, and the two groups, operating together, solved the ASW problem. Finally, the reader will understand the crucial roles of several hundred people, all of whom contributed to the success of LRAPP in helping to win the Cold War.