COLD WAR ACOUSTICS

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INTRODUCTION

In the context of the theme of this meeting, an appropriate subtitle might be "A Bridge from the Past".

Circumstances around the end of World War II and the early post-war years conspired to precipitate a surprisingly large burst of research activity in acoustics that lasted about 50 years. I expect that many acousticians working in other branches of the field have wondered what all the underwater acoustics effort was about. I hope this paper will help to explain.

Certainly there has been military interest in underwater acoustics ever since Canadian-born Reginald Fessenden demonstrated an early underwater echo location system shortly following the sinking of the TITANIC. Both passive and active sonar were used during World War I to find submarines and this work was re-born with the onset of World War II. Yet even during WWII, research efforts in underwater acoustics fell far short of the level of effort yet to come. One of the truths of the WWII experience was that active sonar fell far short of expectations in dealing with submarines. The big breakthroughs in winning the Battle of the Atlantic were the breaking the German naval code, radio direction-finding on an ocean-basin scale, and the invention and application of RADAR.

So what happened during the Cold War? I'll try to answer that question, but please understand that this is just one man's opinion, and not the result of extensive historical investigation.

KEY FACTORS

I believe there were three main circumstances—perhaps four—that triggered the events that were to follow. I will outline each of these factors, indicate how they interacted, and then relate a bit about the historical consequences. While my prime point of view is that of a Canadian, I expect that this contest was quite symmetric: the view from the Warsaw Pact countries was probably remarkably similar.

1. <u>The State of German Technology</u>. The collapse of Hitler's Germany revealed to "The Allies"—including Britain, the USA, the USSR and Canada—the surprisingly advanced state of German military technology in a number of areas. And the Allies did what they could to absorb this knowledge while at the same time depriving Germany of it. The significant technologies relevant to this story are rocketry and a fundamental transformation in Submarines. Until the end of WWII, submarines were basically small surface warships that could make themselves hard to find by diving under the water for relatively short periods of time. The invention of the snorkel and early forms of air-independent propulsion—nuclear power is one, but there were and are others—transformed the submarine into an underwater warship that sometimes had to come to the surface. Furthermore, a craft designed primarily to operate fully submerged (rather than designed for stability on the ocean surface) could be much faster. And rocket technology would give this new generation of submarines long range weapons: ultimately weapons that could reach almost any city in the world from a launch point in the ocean.

2. <u>The State of Sonar</u>. As I have already stated, sonar had not really proven to be all that effective. It was really more of a deterrent: something that might scare off the submarines. Yet sound was just about the only hope for detecting these new more capable naval craft. WWII experience with passive sonar was promising, as was allied experience in using small explosives—and sonar—to find downed air crew. New oceanographic knowledge—spurred by the poor experience with sonar—helped to explain what was going wrong and how sonars might be fixed. There was cause to believe that sonar could be made to work.

3. <u>The Commencement of the Cold War.</u> At the end of WWII, the allies were on moderately friendly terms, though opinions certainly varied. The revelations of Igor Gouzenko (serving with the USSR Embassy in Ottawa) demonstrated, however, that the USSR regarded the capitalist allies very much as potential enemies. The revelations also strongly suggested a very aggressive posture for a Communist domination of post-WWII society. Furthermore both sides in this new contest had access to the German technology and there was a strong fear the development work would continue. And, of course, it did. And so defences also needed to be developed to counter these new threats.

4. <u>The Advent of things Nuclear</u>—explosives and propulsion—can certainly be regarded as another major influence. I tend to regard them as more of a "multiplier" factor. Nuclear propulsion speeded the transition to near full independence from the atmosphere. And nuclear warheads for rocket-propelled missiles made those rockets

much more menacing. But I think that even without the nuclear age, submarines and missiles would still have posed a threat that merited attention.

THE REACTION

The actions that followed went something like this.

Fast, missile-capable nuclear submarines were developed and deployed by both sides. They were deployed full-time off our coastlines. We in turn undertook to determine where every one was and to be in position to neutralize it if that should become necessary. The net result was that the "Cold War", while no shots were fired, was nevertheless a very active, every-day, and highly resource-intensive affair that lasted for about four decades.

While acoustic detection of submarines is not the only system that works, it certainly is one of the more effective ways, and probably the most cost-effective way, to do the job.

In addition to matters directly related to sonar, one needed to be able to move pursuing systems at a pace that could 'keep up'. Aircraft were a suitable solution—they had already proven effective in WWII—but for a time fast surface warships were also seriously considered for this job. The Canadian hydrofoil program leading to the FHE-400 was part of this effort.

Active sonars mounted on the hulls of surface ships did not work well in the North Atlantic. The cause was sound refraction due to typical temperature and salinity conditions in the ocean, coupled with the fact that sound velocity increases with pressure and hence depth, if all other factors remain unchanged. Solar warming of water near the surface tends to cause a downward bending of the sound rays, though wind-driven mixing of near-surface water can lead to upward bending of the rays. The net result is typically short ranges for typical active sonar systems. Yet the uniform deeper waters coupled with the pressure effect and warmer water near the surface also permit very effective long-range propagation at frequencies below one or two kilohertz (well below typical WWII active sonar frequencies).

The obvious solutions to the submarine detection problem then are:

1. Place the active sonar system deeper than the bottom of a surface ship by placing it in a towed submerged vehicle: The Variable Depth Sonar. (Even, perhaps, one deployed from a fixed-wing airplane!) Placing the sonar very deep—miles deep—in the ocean looked promising and was deemed feasible for large warships, but for destroyer-sized ships that length of cable proved to be a pretty effective sea anchor.

2. Use passive listening at lower frequencies. From late in WWII this was done by using freely-drifting "sonobuoys" that suspend a hydrophone at moderate depth and radio the sonar data to an aircraft, ship or ashore. Later we learned how to tow low frequency hydrophones behind a ship without suffering too much noise in so doing. (Actually the oil exploration companies did it first, but their streamers were too noisy to use at desired warship speeds. Then again, such streamers were first tried for military purposes during WWI.) Throughout the Cold War period, the race was on to build ever quieter submarines and ever more sensitive detection systems to find them.

3. Place the hydrophones on the continental margins and cable the signals ashore. And do this extensively all along our coastlines.

4. Lower the frequencies used for active sonar. This is not as simple as it might first seem. Consider briefly that lowering frequencies means making things bigger and heavier - for the same design, weight will increase as the cube of the factor by which frequency is lowered! So a reduction in sonar frequency from 10 KHz to 1 KHz might be expected to result in a 1000-fold increase in the weight of the sonar transducers.

5. And, of course, one can do most of these things better from another submarine than from a surface ship.

6. Another enduring concern throughout the 20th century was how to locate and avoid sea mines. As the mines are generally located underwater, acoustics again comes to the fore.

The acoustic anti-submarine efforts also led to intensive efforts to understand the ocean environment - an effort that has essentially taken on a life of its own, with many side benefits.

Another related issue of Canadian concern was the possibility that missile-launching submarines might use the Canadian Arctic as a launch area. This concern sparked sonar and oceanographic interest in our northern waters.

Submarines did not constitute the only Cold War threat, of course. Similar cold war battles also took place in the air, on the ground in Europe, and in many warmer skirmishes elsewhere.

CONCLUDING REMARKS

With the end of the Cold War, military submarines remain a concern, but they do not pose the enduring threat that they once did. Today there are other military concerns —such as terrorism—that occupy our defence planners' thoughts. There undoubtedly remain many potential military applications of acoustics, but acoustics does not occupy the place of prominence that it did during the Cold War.