MILE STONES

Early anti-submarine warfare

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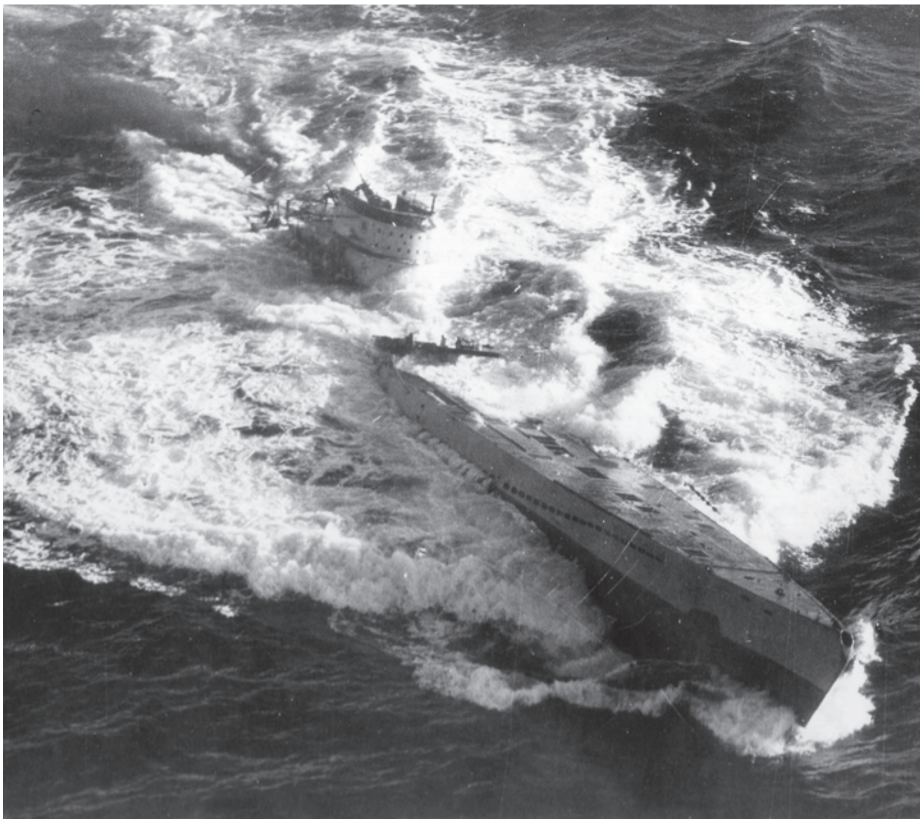
The first conflict in which Anti Submarine Warfare became a priority was the Great War, between 1914 and 1918. The Kaiser's fleet of U-boats was employed to great effect, interdicting British shipping lanes, as part of a broader attempt to blockade the British Isles and isolate Britain from its colonies, which provided both raw materials and troop reinforcements for the war effort on the continent. As the United States became progressively embroiled in the conflict, shipping lanes to the Americas became a target.

It is worth observing that the May 1915 sinking of the RMS Lusitania by U-20, with the loss of 1,200 lives, became a propaganda coup for pro-war campaigners in the United States and is often credited with being a key factor in the United States' 1917 entry to the war aligned with the British. With the world's largest fractional percentage of German immigrants and their descendants, the United States was under considerable domestic pressure not to become involved.

The scale of the Great War U-boat campaign may be modest by later standards, but it did set the path for much of naval warfare over the following nine decades and beyond. Cited statistics include 5,000 vessels sunk accounting for 12,000,000 tons of displacement, 15,000 people killed in U-boat attacks, with Germany deploying 372 U-boats, of which 178 were sunk, mostly by the Royal Navy.

The enormous effort and marginal success rate against the U-boats produced enormous pressure to develop equipment to fight the U-boats, especially sensors, and this was the beginning of a continuous technological arms race which continues to this day. Two case studies are well worth closer study, which are sonar and radar employed in early ASW operations.



Type IXC/40 boat U-185, under the command of KapitanLeutnant August Maus, sinking after being depth charged by TBM Avengers of the USS Core on the 24th August, 1943. The U-185 was attempting to rescue the crew of the crippled U-604 but was found by US Navy aircraft and in two consective engagements, damaged and then sunk.

Early Passive and Active Sonar Technology

Sonar technology, which employs hydrophones to detect sound emissions from submarines, or sound reflections off submarines, remains the mainstay of ASW sensor technology employed to prosecute attacks on submerged submarines.

The earliest and most common passive sonar installations used a pair of hydrophones under the bow of the vessel, providing in effect a "stereo" acoustic signal to the hydrophone operator's headset. The operator would use experience to estimate range by loudness, with the stereo effect providing direction finding. Based mostly on period analogue telephone technology, such systems had poor sensitivity and direction finding accuracy, and much depended upon the talent and experience of the operator, who effectively had to carry the calibration information for the system in his head.

In pursuit of a contact with turning screws, the RPM provided an indication of the speed of the contact, together with subtle Doppler shifts – most signals were in the hundreds of Hertz frequency range. Typical pursuits involved having the operator call out steering corrections and range estimates until the vessel was pointing at the contact, at which point a depth charge run could be performed.

An important advance later in the war was the introduction of steerable hydrophones, whereby a short horizontal boom with hydrophones was mounted under the vessel, and remotely steerable through a 360 degree arc. This allowed the operator to perform bearing measurements without vessel heading changes.

This technology progressively evolved through the 1930s and 1940s. Later designs employed arrays of up to two dozen piezo-electric crystal or electro-dynamic moving coil hydrophones, and vacuum tube analogue electronics were employed to perform angle measurement by comparing signals produced by each element. Additional hydrophones were employed as noise cancellers, feeding an out-of-phase copy of the ship's own noise output into the receivers to null out the ship's own signature, which would otherwise drown out a faint submarine signature. Submarines were also equipped with much the same technology, to evade other submarines, evade escorts, and hunt for targets.

The technology of active sonar, or ASDIC (Anti-submarine Detection Investigation Committee) in period British nomenclature, lagged behind passive detection technologies, as it was more technologically challenging. An active sonar needed to transmit, in a controlled fashion, a pulsed sound signal which would propagate outward until it bounced off another object be it a target or a seabed, or a "biologic" as in school of fish, cetacean or other organism. While some viable trials and experiments were performed late in the war, ASDIC did not become an operational capability until the interwar period.

By the time the Battle of the Atlantic was in full swing, ASDIC systems were widely deployed on Royal Navy and other Commonwealth navy escorts. A good example of a period system was the ASDIC 144Q system, operationally deployed in 1943. The transducer array was installed in a streamlined pod under the hull of the warship, and was steerable in azimuth. The primary sensor produced a conical 16 degree "pencil beam" which was steerable in azimuth, and range gated for 1,000 and 2,500 yards. It transmitted pulses at nine selectable acoustic carrier frequencies between 14 and 22 kiloHertz, in 1 kiloHertz increments. Two additional sonar transceivers were integrated into this system.

The "Q" attachment produced a vertical fan shaped beam of around 65 x 5 degrees of arc, and was designed to track a target in azimuth, but lacked a depth finding capability. It was range gated to 1,200 yards, and steerable through 360 degrees in azimuth, operating at 38.5 kiloHertz. The "Q" beam could thus be employed to find the bearing of a target regardless of its depth.

An additional capability integrated into this system was the Type 147 "Sword", which produced a fan shaped depth finding beam of similar geometry to the "Q" beam.

This multiple beam arrangement allowed the use of the relatively inaccurate but sensitive primary pencil beam to acquire a target at range, and as the escort closed on the target, the more precise fan shaped beams could be employed to effect more exact angle measurements to determine bearing and depth.

Contemporary active sonar arrays employ fixed rather than mechanically steered tranducers, employ phased array techniques to form transmit and receive beams in arbitrary directions within the angular coverage of the array.

ASDIC and its American siblings proved to be a critical technology in ASW operations, and remain so today.

Early Anti-Submarine Warfare Radar Technology

Surface search radar was the "other" pivotal technology which won the Battle of the Atlantic. Its development followed a far more tortuous path than ASDIC/Sonar systems, since radars for maritime search purposes directly competed for development and production resources with radars intended for night fighters, and later heavy bombers. The result of this competition was that programs were started and stopped, as short term priorities and bureaucratic politics caused resources to be shuffled.

The first maritime search radar to be built in useful numbers was the ASV Mark II, which was carried on a wide range of maritime aircraft, including the Sunderland and Catalina flying boats, and maritime variants of the Whitley, Wellington, Warwick, Halifax and Liberator, all converted from bomber variants.

This ungainly 1.7 metre VHF-band design employed wing and nose mounted Yagi antennas and a characteristic row of upper fuselage antennas. The first U-boat attack was effected in late 1940. The ASV Mark II permitted daylight attacks on surfaced U-boats, while they recharged their batteries, and while it could find U-boats at night it was not accurate enough to perform blind deliveries at night.

The Kriegsmarine responded to the increasing loss rates in the U-boat fleet by installing the FuMB 1 Metox 600A, developed after a Coastal Command Wellington fell into German hands in Africa and its ASV Mark I was dissected. The Metox produced a high false alarm rate, but even so, rapidly reversed losses in the U-boat fleet.

The British response to the Metox was to deploy the 10 centimetre S-band ASV Mark III radar, initially fitted to Coastal Command Wellingtons, using a nose mounted steerable paraboloid antenna. In early to mid 1943, a small number of ASV Mark III aircraft flew ASW patrols in the Bay of Biscay, and since the Metox was blind in the S-band, achieved a high success rate. An impulsive directive for U-boats to engage the Coastal Command aircraft using their deck guns resulted in the loss of 56 U-boats in just over two months.

While the Kriegsmarine developed and deployed the S-band FuG 350 Naxos I warning receiver to defeat the ASV Mark III, the British deployed the S-band ASV Mark VI with selectable power settings intended to deceive the U-boat operators by reducing power to suggest the aircraft had not acquired the target.

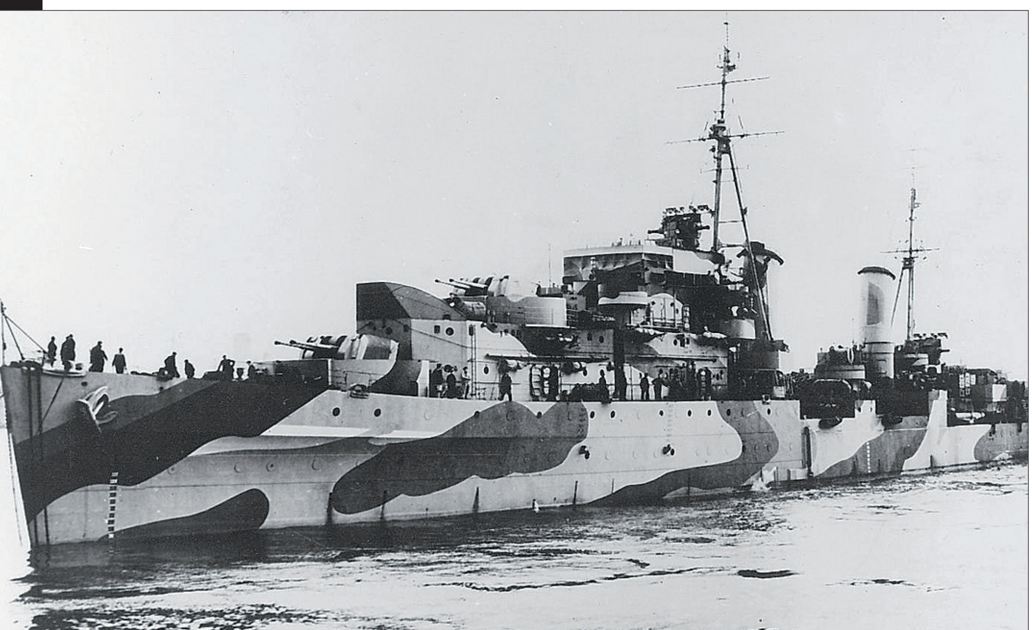
The next step in this cycle of measures and counter-measures was the introduction of the ASV Mark VII, operating at 3 centimetres in the X-band. The Mark VII was based on the technology in the H2S blind bombing radar, carried by Royal Air Force heavy bombers.

By late 1944 the Kriegsmarine's U-boat effort began to collapse, as Allied ground forces overran ports along the Atlantic coast. Around one half of the U-boat fleet at that stage were fitted with snorkels, which effectively defeated the ASV Mark III and VI radars.

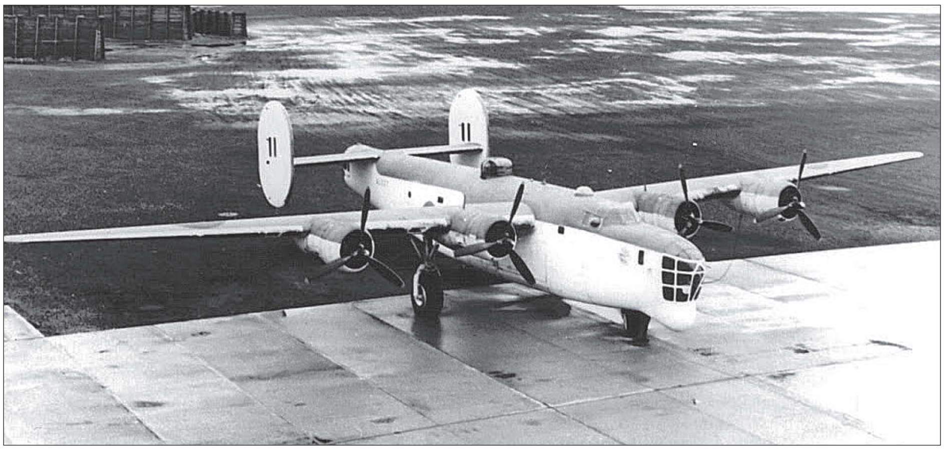
The Americans suffered heavy losses to coastal shipping by U-boat attacks and deployed a large number of patrol aircraft as a result, operated by the Army Air Corps and Navy.

The first ASW radar deployed was the 10 centimetre S-band SCR-517, derived from the SCR-520 air intercept radar, and fitted to modified Army Air Corps B-24 patrol bombers from early 1942. These were also supplied to the Royal Air Force as the ASV Mark V radar.

The US Navy deployed a large number of ASG or AN/APS-2 10 centimetre S-band search radars on maritime patrol aircraft, including the PBY Catalina, PBM Mariner, PV-1 Ventura and PB4Y-2 Privateer – in converted bombers the APS-2 antenna was usually lowered through a ventral turret well, or faired into the nose. These aircraft were used to fight U-boats along the Atlantic coastline, and Japanese submarines across the Pacific theatre.



ASDIC equipped escorts were a critical component of the Allied convoy effort. Depicted is HMS Charybdis which was sunk by a U-boat torpedo.



An early model Coastal Command Liberator Mk.II based on the B-24D, equipped with the British four gun dorsal turret, and a US built SCR-517 ASV Mark V S-band radar system under a large chin radome. This aircraft operated by RAF 120 SQN survived the war, only to be destroyed in a landing accident.

A Perspective on Early ASW Technique

In perspective, the technological battle between the Allies and Kriegsmarine was unprecedented in breadth and depth, and displayed a rate of evolution not seen until the electronic battles over Vietnam two decades later.

As in many other areas of military technology, much of what transpired during the subsequent Cold War period amounted to the exploitation of 1940s technology, and its further evolution and refinement.

A contemporary sonar, maritime radar, radar warning receiver, sonobuoy, magnetic anomaly detector, or diesel exhaust detector will be immeasurably more capable and technologically sophisticated in comparison with its 1940s era ancestor. Yet what it is, and how it is employed, differs little in fundamentals from what was devised seventy years ago.

Much less appreciated is that the Battle of the Atlantic involved the first large scale use of operational analysis techniques, where the Allies recruited a respectable number of mathematicians and other scientists to analyse and study operational effectiveness of various systems, but also operational technique, such as what were the best search patterns for a maritime patrol aircraft to fly to maximise the odds of catching a U-boat.

Because the Battle of the Atlantic is so well documented, it is very easy to observe the cyclic pattern of shipping losses and U-boat losses, as each side deployed new technology or technique, and the other side adapted by deploying a countermeasure or changing technology and technique.

It would be reasonable to describe the 1940s as a “revolutionary” period in submarine warfare and ASW, while the Cold War was an “evolutionary” period, and the post Cold War era a “stagnant” period. There has been very little substantial technological evolution in submarine technology or ASW since the end of the Cold War, with the most important advances being incremental, and mostly related to the movement away from legacy analogue electronics to modern high performance digital systems.

With the currently growing proliferation of modern and very quiet submarines globally, and some very potent and technologically advanced anti-shipping weapons intended to arm them available, there are good strategic reasons to recapitalise ASW fleets and do so very thoroughly. No less importantly, serious thinking in technological strategy is required, since we are beginning to observe creative and independent technological evolution in nations which were not part of the technological arms races of World War II and the Cold War. Not to do so could see unpleasant future surprises no different to those which confronted the Allies when the Battle of the Atlantic started seven decades ago.

Type XB boat U-118 under attack by US Navy TBM Avenger aircraft near the Canary Islands, 12th June, 1943. It sank with 43 crew killed.