IV

THE FUTURE OF ASW

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" Anti-Submarine Warfare is a core enduring naval competency that will be a vital mission in the 21st Century."

Admiral J.L. Johnson

Chief of Naval Operations, USN

Introduction

A nation can be economically strong and independent if it possesses the capability to protect its maritime interests on, over, and below the seas. The undeniable deterrent effect of possessing a modern submarine force is driving the rapid developments in the field of undersea warfare. No denying the fact then that Anti-Submarine Warfare (ASW) is arguably one of the Navy's most important core competencies. Its entry was thrust upon the naval community as a result of man's tireless pursuit to win wars at all costs. The introduction of the Bushnell-Turtle during the American Civil War was probably the turning point in modem naval warfare, which necessitated the birth of Anti-Submarine Warfare as a new branch of naval war fighting.

At the turn of the 20th Century, submarines were little more than curiosities, fit only for harbour defence. By the early 1900's the submarine had graduated into becoming a coastal defence unit. In the early days, the biggest stumbling block to submarine development was the propulsion system, and consequently the platform's endurance and size (weapon carrying capacity). Advent of the nuclear propelled submarine and submarine-launched missiles in the mid 1960's was a Revolution in Military Affairs (RMA). It removed the limitations in submarine tasking, which had hitherto been restricted to that of launching torpedo attacks on hostile naval surface vessels and maritime logistics traffic. Overnight, submarine utility became much more dynamic and imbued the already potent undersea platform with the ability to directly strike at targets in the heart of the enemy's homeland. Also, submarines could now target surface battle groups with impunity, at ranges far beyond those which had been possible with traditional submarine weaponry.

Modern naval operations are conducted on and below the sea surface and in the air. It may also, at times spill over onto land. In future, the domain of space may also be increasingly used to fight battles originating from the sea. Undersea operations are underscored by the preponderance of stealth and surprise. They influence events in all the five domains, because of their propensity to cause maximum impact with minimum accompanying risk to the perpetrator. The inherent traits of submarine warfare, veil under-sea operations in a cloak of low visibility and high secrecy, make them least understood and frequently undervalued. In an age of all pervasive space-based hostile surveillance, submarines probably remain the only almost invisible weapons platform.

Acoustic Primacy Underwater

Though technology has taken giant strides over all dimensions of warfare in the last century, acoustics still remains the foundation for both submarine and anti-submarine warfare. Sound propagation and reception holds the key to undersea operations and still remains the single most significant element upon which all undersea warfare activity depends. Given the inconsistencies of the sea medium, submarine detection remains an enigma. When initially developed, the submarine's security lay below the surface where it was not seen. However, today, a submarine's security is inextricably linked to emissions and its ability to remain unheard.

The primary technical challenge in undersea warfare remains the requirement to detect increasingly quieter submarines. Submarine detection is only the start point for anti-submarine warfare. Effective weapons and fire-control, accompanied by credible self-defence capabilities are all essentials for anti-submarine warfare. Notwithstanding various key requirements, shortfalls are present in all of these areas. However, the common factor binding most of the short comings involve detection limitations.

Underwater noise is a double-edged sword in undersea warfare, plaguing both the hunter and the hunted, whichever way one looks at it. Propellers, hull and machinery are the three main sources of radiated noise emanating from platforms both surface and sub-surface. Each platform emits its own unique combination of noise, which is termed as its 'signature'. Modern undersea warfare, therefore, lays emphasis on developing innovative methods to suppress underwater noise caused by propeller cavitation, hull flow noise and machinery noise. In general, acoustic signatures receive the largest attention because sound is the most preferred energy source for detecting a dived submarine. Signature management therefore involves the process for achieving an optimum combination of various factors, which include choice of hull shapes, materials used and external and internal treatments. Ongoing researches in the direction of anechoic tiling, flexible machinery mountings and different kinds of propulsions have succeeded in making both the submarines and the ASW platforms stealthy adversaries.

ASW Platforms

From a submariner's point of view, there are only two kinds of ships plying the oceans, namely submarines and their targets. However, the party undersea is being increasingly spoilt by the entry of a third kind of ship on the oceans viz the 'submarine hunter-killer'. Today's ASW platforms use a combination of surface, sub-surface and air based technologies and platforms in their fight for supremacy. Interestingly, space based technology is also emerging as a significant factor in ASW.

Surface Ships

The surface ASW combatant is currently the mainstay of Anti-Submarine Warfare because of its ability to accommodate a large variety of sensors onboard. Ship-borne remotely piloted vehicles (RPVs) are beginning to show an increased presence in ASW operations as are integral airbome platforms. The Hull Mounted sonar is giving way to the more effective Towed Array Active / Passive sonars which have returned vastly improved detection ranges.

The specialist ASW ship is not only very complex in design but also very expensive to build. This is a direct fall-out of the need to adhere to stringent technical parameters needed to reduce noise emission levels without sacrificing the ability to operate at variable speeds over extended periods. The onboard sonar suite fitted thereafter, dictates the effectiveness of the ship in operations. The configuration of future sonar suites would incorporate add-ons like self noise analyser and XBT recording systems and the trend is biased towards:-

- Active low/medium frequency hull-mounted sonar.
- Very low frequency, deep diving, active towed array sonar with inbuilt torpedo alert system.
- Active low-frequency variable depth sonar.

Aircraft

Airborne ASW platforms are the ultimate adversary for submarines due to the inability of the subsurface platform to target them. Further, the separation of operating medium affords stealth to the airborne platform and keeps the submarine from effectively accomplishing its mission. Helicopters, though more potent than fixed wing ASW platforms, suffer from the serious disadvantage of reduced endurance. However, this has been overcome to some extent by deploying helicopters from small platforms. The ASW helicopter effectively uses sonobuoys and on-board sensors, including dipping sonars, to prosecute undersea contacts. When deployed from ASW surface platforms, the mother vessel lends active support to the helicopter in detection and prosecution of the submarine, thus making the team an extremely potent combination. New vertical takeoff and landing (VTOL) aircraft, adapted to suit ASW requirements have the potential to overcome speed and endurance limitations of helicopters.

Space Based Sensors

The utility of space-based sensors has not yet been fully exploited since this technology is in its infancy. Emerging technologies may yet unlock means of reading various hydrodynamic disturbances created by the movement of submerged platforms through water. Whatever may be the original purpose of space-based sensors, the information garnered from them would in future form an integral component of data used to build up the undersea picture.

Submarines

Not surprisingly, these are the ideal Anti-Submarine Warfare platforms, since they would operate in the same medium and have similar characteristics as their quarry. The Submarine - Submarine Killers (SSK) could be either conventional or nuclear-powered with their primary adversary being the bigger and noisier Inter Continental Ballistic Missile (ICBM) carrying SSBN. This is because, using SSK submarines to hunt conventional diesel- electric submarines is not a preferred mode of operation in view of the limited detection ranges, which would thwart effective targeting due to the inherent danger to the firing submarine. The Virginia class SSNs being built for the US Navy is the most futuristic undersea platform on the anvil and has been especially designed for littoral warfare. These submarines are very silent even at the speed of 25 kt underwater and are capable of carrying a 50 man special operations team, fire Tomahawk missiles and also carry a remotely operated vehicle for Mine Counter Measure (MCM) duties. This class of submarines is envisaged to be the backbone of US Navy's undersea operations in the foreseeable future.

UUVs

Unmanned Underwater Vehicles (UUVs) will play an increasingly greater role in ASW. Unmanned air, surface, subsurface, drifting, and fixed platforms will act together in a highly integrated network to try and mitigate the ASW problems. The driving force behind the proliferation of UUVs and sensors across the undersea battle-space would be the increased reliability and miniaturisation of the vehicles and sensors and the advantages this would provide in terms of reduced risks.

Submarine Tasking

The traditional Cold War submarine tasking pattern called for diesel-electric submarines to be deployed at approaches to harbours, at choke points and for clandestine operations close to the coast. SSNs were preferred for mid-ocean deployment with fluid tasking ranging from interdiction of convoys and Carrier Battle Groups (CBGs) to escorting of high value surface vessels and the SSK role. On the other hand, ICBM carrying SSBNs were pre-positioned and hidden from the omniscient satellites under the polar ice caps and ice floes to enable a credible second strike capability in the event of the 'balloon going up'.

With the collapse of the erstwhile Soviet Union and the consequent change in world order, the heated arms race has cooled down substantially. The focus of naval operations has shifted from the blue waters to the littorals and hence future conflicts would involve initial ASW engagements in the littorals. In view of the wide disparity in force capabilities, the USN is realising that it is unlikely to face major opposition at mid- sea in the near-future and would have to carry the battle to the enemy's doorstep. This change in strategic concept is driving its current naval acquisitions and designs programmes. The NATO navies are following suit, since most would align as allies to achieve a common goal or else would need to be able to counter such forces in their own defence.

Littoral regions comprise the entire depth spectrum ranging from deep to shallow. A characteristic that is commonly assigned to littoral waters, however, is complexity. This is brought about by the much shorter scales of variability in both space and time compared to the deep waters of the open ocean. Important features of the littoral regions include changing bottom topography, tides, irregular and tide-produced internal waves, diurnal variations, and a cluttered acoustic and visual background. All these factors tend to make littoral ASW operations difficult. Therefore, a prerequisite for effective littoral warfare is a detailed knowledge and understanding of the maritime environment that exists in this region.

Future ASW engagements in the littorals would, in all probability, form an integral part of larger operations and would in most cases precede the transiting of heavy-lift follow-on forces through straits and choke points or the landing of forces ashore. Submarines and mines offer practical and economically viable means that an enemy can use to interrupt the flow of joint forces. Naval forces of the future must be able to sanitise the intended battle space of the threat posed by hostile submarines to allow for follow-on operations. ASW also plays a key role in the strategic military posture of a nation, since most of the credible nuclear striking power in the world is based at sea. Offensive ASW action, therefore, in many situations would be time critical and to be effective, the designated forces would require to be empowered with state of the art system capabilities that facilitate accurate remote sensing, targeting, and effective employment of weapons.

Naval operations in the future would be all about supporting the land battle. Technology will drive advances in war fighting and old wine like 'opposed amphibious landings' and the concept of blitzkrieg[1] would be sold in new bottles under labels like 'Operational Manoeuvre From the Sea '(OMFTS). Underpinning all naval operations would, however, be the undeniable fact and the future of warfare at sea will hinge on controlling the undersea battle-space.

Naval Mines

No discussion on Anti-Submarine Warfare would be complete without exploring the threat posed by naval mines to undersea operations. These 'weapons that wait' are the most cost effective sea denial naval weapons invented by man. The mine is not only a weapon of attrition but also has a deterrent effect on the enemy's will to deploy his naval forces. The naval mine is a formidable weapon against both ships and submarines and can be deployed in shallow as well as deep waters. Their low maintenance cost and long shelf life make them ideal acquisitions for cash strapped littoral nations.

Frontline navies of the future will have to maintain sea control in support of national objectives, so as to be able to operate freely across all the oceans and restricted sea spaces and finally be able to project power ashore when required. Unless effectively countered, mines will restrict, if not prevent, accomplishment of such missions. The MCM component of future navies will no longer operate as a specialist Task Group on call, but would form an integral component of the Task Force itself and be able to move and operate at speeds commensurate with such concepts.

Although mines are comparatively cheap and simple in design, the increasing sophistication of modern mines, especially in terms of their fusing methods and reduction in signature, is making them difficult to counter. The plastic-hulled Manta and the wedge-shaped Swedish Rockan GMI-100 are examples of mines with reduced signatures that are difficult to detect. In recent years, mine design has undergone a revolution, with modern mines carrying progressively increased quantities of explosive charge afforded by miniaturization of their actuation electronics. At the same time, the anti-sweeping in-built logic has become more complex and the lethality range has gone up from a few tens of feet athwart ship to nearly half a mile because of mobile warheads. Evolving technology will only introduce more complex mines into the undersea battle space.

Offensive ASW mining concepts of the future envisage whole minefields capable of remote command-on and command-off control and of changing sensitivity settings, sensor combinations, counter measures logic, and even location on remote command. Complete systems, incorporating seabed sensors in conjunction with remotely activated unmanned underwater vehicles armed with propelled mines, would further safeguard significant volumes of water for the nations, which can afford to install such comprehensive systems. Future mine designs would include;-

(a) Self-burying mine, capable of degrading the performance of current mine hunting sonar and thus force dependence on slower mine sweeping techniques.

(b) Introduction of alternating magnetic (AM), underwater electric potential (UEP), and possibly, pure pressure mine sensors.

(c) Introduction of distributed sensor minefields in which the long-range multiple-shot kill component is located at a single point within or about the field.

(d) Mines specifically targeted against MCM platforms, including helicopters.

The concepts and advances in mining as part of ASW enumerated above are well within the reach of current technology and such mines would be seen in the near future. The requirement to counter developments in mine technology is obvious. Such concerns have spurred tremendous growth in MCM techniques, with mine detection assuming primacy. Synthetic Aperture Sonar (SAS), Buried Object Scanning Sonar (BOSS) and Autonomous Underwater Vehicles (AUVs) are some of the recent developments in this direction. It has become obvious in recent times that the cost of defeating a modern minefield is becoming prohibitively expensive as compared to laying one. In future, it may not be economically or operationally feasible for a large force to successfully negotiate a mined area using traditional MCM methods, given the constraints of time and efforts. Hence, to obviate time consuming procedures required for effective mine sweeping, a new thought process is rapidly gaining currency with naval strategists. For all the advances in mining capability, future MCM forces may just settle for applying low cost 'brute power' to detonate or blast mine fields in totality rather than target individual mines.

Torpedoes

Torpedo is the preferred weapon across the spectrum of ASW platforms. Its uniqueness lies in the fact that unlike any other weapon, it can be delivered by air, surface and sub-surface platforms. To be able to achieve this, the torpedo dimensions have been standardised to a great extent. Most ships and submarines use Heavy Weight Torpedoes (HWT) of standard 533 mm calibre, 7m length, overall weight < 15 tons and containing approximately 200 Kg of explosive. ASW aircraft and some ships are fitted to deliver Light Weight Torpedoes (LWT) of 324 mm calibre, 4m length overall weight <400 Kg and carrying 40 Kg of explosives. Exceptions to this are four generations of 400 mm Swedish torpedoes and the 650mm calibre torpedoes designed specifically for some of the bigger Russian submarines.

The thumb rule regarding speed is that a torpedo should be capable of speeds in excess of 50% more than that of the intended target to have a credible kill probability. The electrical propulsion system has been the most important development in modern torpedoes as it has contributed to vastly improved homing and a more silent run at higher speeds. Torpedo homing is one of either: -

- Active-passive
- Wake homing
- Wake nibbling
- Wire Guidance

Modern Wire Guided Torpedoes (WGT) ensures a kill probability in excess of 90 percent as compared to 50 -60 percent for autonomous torpedoes. Latest generation of HWT are normally wire-guided as a necessity to overcome high self-noise due to high speeds. This mode of homing guidance allows the torpedo to be brought close enough to the target for the torpedo's homing system to take over and home on autonomously. Fibre optic cables are now replacing wire cables for use in the guidance system since the former facilitates greater quantum of two way information transfer at faster speeds.

Increasingly, modem HWT are being pitted against submarine launched missiles, which have a longer range and faster speeds. However, they suffer from inherent disadvantages such as giving away the submarine's position during launch, requirement of consort for targeting beyond onboard sensor range, less lethality and susceptibility to counter measures.

Light Weight Torpedoes have the capability of autonomous switching between multiple speed regimes, which may vary between 25 - 75 kt. Operating depths of these orpedoes are between 0 -1100m. Modern LWTs include the A244S and MU-90 from Italy, Stingray from UK, TP-46 from Sweden and Mk-46, Mk-54 and Mk-50 from USA. The Stingray is equipped with an onboard computer to carry out autonomous acquisition, classification and tracking of targets. It uses multi-mode, multi-beam sonar to achieve this versatility. The Mk-50 and U-90 are Advanced Light Weight Torpedoes (ALWTs), quiet with a shaped charge and capable of speeds in excess of 50 kt. The light weight hybrid torpedo (LHT) Mk-54 Mod- 0, developed by the US Navy, integrates the sonar system and advanced software algorithm of Mk-50 torpedo with the warhead and propulsion system of the Mk-46 torpedo.

The dominating underwater weapons currently include the Spearfish and Tigerfish torpedoes with the British Navy, Huntor and ADCAP with the USN, Seehecht with the Germans and F-17 with the French. The ADCAP version of US Mk-48 can operate at depths up to 800m and at speeds between 45 -55 kt, at a maximum range of 50 nm. The German Seahake DM2A4 can attain speeds of up to 45 kt and range of 50 km. The futuristic Italian Black Shark A-184 Advanced WGT uses a new homing head as 'Advanced System Transmission and Receiving architecture (ASTRA)', with multi- beam planar array and digital pulse compression technique providing 3-D homing capability and speeds up to 50 kt.

Other ASW Weapons - SUGWs

Apart from torpedoes, a host of torpedo derivatives and other underwater weapons also make the undersea arena increasingly lethal. Surface-to-Underwater Guided Weapons (SUGWs) are lightweight missiles, which are used as long-range torpedo delivery systems and carry LWT to the general vicinity of a target and then release them to conduct an autonomous search and attack. Anti-Submarine Rockets (ASROCs) like the USN -VLA, French -Malafon and Soviet - Isakra are some examples of similar weapons. On the other hand, SUBROCs are unguided submarine rockets, which carry depth charges as their payload and are fired from torpedo tubes in the direction of the target predicted by the sonar. The UUM-125A, Sea Lance has an alternate homing head in the form of a homing torpedo and can attack targets over the horizon at ranges up to 100 nm.

LCAWs

Germany and Norway are developing Low Cost Anti-Submarine Weapons (LCAWs), which are cheaper than LWTs and can hence be used in large numbers against low-confidence targets - specially suited for littoral warfare. These weapons can also be air launched. These use a combination of active side-scan sonar sensor for searching and active nose array sonar for homing.

Supercavitating Weapons

The supercavitating torpedo first appeared in 1977 as the Russian Shkval, which was unguided and had a speed of 5OO Kmph and range of 12 Km. Though shrouded in secrecy, subsequent improvements in technology and homing are believed to have resulted in the Shkval II being a guided weapon capable of multiple speed regimes with a top speed of 720 Kmph and a range of 100 Km. The German Barracuda torpedo is believed to be a guided weapon with speed up to 800 Kmph. As a continuation of the supercavitating projectile technology, a sub- surface gun system using Adaptable High Speed Underwater Munitions (AHSUM) is being developed, which would fire 'kinetic-kill' bullets from streamlined turrets/guns installed in the submerged hull of submarines / ships / towed mine counter sleds.

Conclusion

Growth in submarine development and production translates into increased opposition to naval surface forces from sub-surface threat in future conflicts. This position would take the form of sea denial, and would revolve around non-detection of the submarine. A small number of such submarines, even if they are not the state-of- the art, would result in disrupted operations for opposing maritime forces.

For the foreseeable future, the potential undersea operational theatres are littoral. Therefore, the option of setting up permanent seabed array systems in a potential enemy's area of interest would be difficult to execute. However, establishing ASW control in the area of interest prior to introduction of major naval forces would be necessary and will call for covertly deployable array systems with sufficiently long coverage range and lifetimes. The Advanced Deployable System (ADS) and the Fixed Distributed System (FDS) are bottom systems that suit the purpose, but need to include vertical apertures. Where the time frame is insufficient for deploying such elaborate systems, a futuristic version of the high-gain sonobuoy-type array system, Star Tracking Rocket Altitude Positioning (STRAP) and Vertical Line Array Difar (VLAD) systems designed by the US Navy would be used.

Improved means of detection, closely followed by quieting and stealth have always been the goals to attain in ASW technology. However, similar emphasis has not been given to undersea countermeasures and this field is poised to witness a flurry of developments as it has the potential for effective low cost defence. On the other hand, there is unlikely to be a proliferation in sonar hardware due to the high cost involved in their design, testing, and induction.

The shape of future undersea warfare is difficult to predict since the entire framework depends on how fast the related technology evolves. Like space, the undersea arena is yet to be explored and mastered. It is therefore obvious that the future holds great challenges in this region and one can expect to see revolutionary inventions in the mid-term. In the next 25 years, it is expected that 75 percent of the submarines, apart from those with Russia and the US, would incorporate advanced capabilities. Most of the non-nuclear submarines will have air-independent propulsion systems that allow more than 30 days of true submerged endurance. Quieting technology will make these submarines difficult to locate and track even with the latest ASW equipment, and the weapon systems onboard would rival those of their surface counterparts.

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