Survivability Considerations for the Future Submarine

Submarines exist because submerged operation affords a measure of stealthiness that surface vessels can never achieve. The result of this is that ASW sensors have evolved continuously over the last century.

At this time the single biggest long term risk to submarines, in terms of basic technology, are neither advancing supercavitating 200 knot torpedoes or persistent Remotely Piloted Vehicles. The greatest risk arises from exponential growth in commodity digital computers, as these permit the use of sophisticated software algorithms for sifting faint submarine noises from acoustic clutter, finding submarine wakes in radar sea surface clutter, and networking/fusing data from multiple sensors to find correlations between extremely faint signatures, be they acoustic, radar, chemical or thermal.

Two decades ago submarines were primarily hunted by their acoustic signatures, using passive and active sonar, and by the radar signatures of their masts when snorkelling or using a periscope to target an attack. Emerging sensor technologies such as synthetic aperture radar optimised for detecting the surface wakes of submerged submarines will over time significantly increase the risk of detection at shallow depths. The popularity of Air Independent Propulsion (AIP) reflects this reality – future submarines will have to spend more time at greater depths and slower speeds to survive. Under hostile airborne or satellite radar coverage, snorkelling will be only marginally better than surfaced operation.

The increasing use of batteries of vertical cruise missile launch tubes in attack submarines and missile submarines, in preference to firing and reloading from torpedo tubes is no differently a reflection on the reality, that missile launches are ‘indiscretions’ which betray the position of the submarine to hostile sonar and once the missiles are airborne, radar. The faster all of the missiles can be launched, the better, as it gives the submarine commander more time to put distance between the launch point and the submarine, when the opponent does react.

The mathematics of submarine survivability follow the same pattern as with stealth aircraft. Even if the vehicle can survive most encounters with hostile defences, the more frequent the encounters, the lower the cumulative probability of surviving a sortie.

This will be a critical issue in the definition of the new submarine class, as key choices such as the role of the submarine, and its propulsion package, will have to be made against projected ASW sensor capabilities of two or more decades hence, rather than contemporary ASW capabilities. Short term choices will prove fatal in the long term, where rapid evolution of ASW sensors can be expected. In many respects, survivability against future ASW sensors, rather than political ideology, should be the determinant of whether the future submarine employs nuclear or non-nuclear propulsion.
The Roles of the New Submarine

As noted, the future role of the Collins replacement has not been explored well in the ongoing submarine debate. Decades ago the role of submarines could be easily defined, as they were built to be attack submarines, with a hunter-killer role against hostile submarines and surface ships, or they were built as launch platforms for ballistic missiles. The results were four basic classes of submarine – diesel-electric powered attack submarines or SSKs armed with torpedos, nuclear powered attack submarines or SSNs armed with torpedos, diesel-electric powered ballistic missile submarines or SSBS armed with ballistic missiles and torpedoes for self-defence, and nuclear powered ballistic missile submarines or SSGNs armed with ballistic missiles and torpedoes for self defence. The imperative in attack submarines was low signature, but also speed in nuclear powered boats, while the imperative in SSN/SSBN classes was extremely low signatures. Stealth remains the central imperative in all submarines, regardless of category. These four classes of submarine remain numerically dominant in the current world. The largest SSBNs are in the 18,000 – 24,000 tonne range, while SSNs typically span the 2,600 – 14,000 tonne range. SSKs remain one of the most numerous categories, ranging in displacement up to 3,300 tonnes. Other categories have evolved in parallel. The most important of these, built in respectable numbers by the Soviets, were cruise missile armed diesel-electric SSGs and nuclear powered SSGNs. The intent of these designs was to stalk or ambush CVBGs, SAGs and convoys, and unleash ambush CVBGs, SAGs and convoys, and unleash)

The US Navy addressed this limitation by rebuilding four Ohio SSBNs into SSGNs each carrying up to 154 Tomahawks. Even so, these vessels are used primarily for ‘first day of the war’ attacks, to surprise the opponent and cause disruption and damage to critical assets – they are not intended

Invariably the size and cost of submarines is closely linked to their role and weapons payload. By far the largest submarines are SSBNs and SSGNs, as their missile payloads are reflected in large internal volume and displacement. In SSNs, weapon payload is also reflected in displacement and cost – the recent trend to arm traditional SSNs with vertically launched cruise missiles typically impacts displacement and/or torpedo reload capacity. In diesel-electric boats, the range and persistence of the boat becomes a major factor impacting displacement and cost, as range/persistence performance is gained by carrying more fuel. The advent of AIP is again reflected in displacement and cost, as an additional hull section is typically required to carry oxidiser and/or fuel for the AIP system, and reactors to use the oxidiser and/or fuel. At some point nuclear propulsion becomes the better choice, as the size/displacement/cost penalty of a non-nuclear propulsion package for a given weapon payload and range/persistence becomes prohibitive.

The central question for the ADF will be that of what role the future submarines are to perform, whether the intended 12 boats or a smaller number are to be procured. The Collins SSKs are traditional attack submarines by design, armed with a fairly standard payload of 22 torpedoes or Harpoon ASCMs, all launched from six 21 inch bow tubes, but built for range and persistence, with a nominal endurance of 70 days or operating radius in excess of 4,500 nautical miles, the latter reflecting their strategic role. The Collins like all SSKs is primarily an ambush hunter, as it lacks the submerged speed and endurance to escort a SAG or stalk a hostile SAG or CVBG travelling at dash speeds. The primary role of the Collins class is strategic denial of key regional shipping lanes and chokepoints, by ambushing hostile surface shipping and submarines, and mining sea lanes, chokepoints and port entrances, with secondary roles of ISR and deploying and recovering special forces. The Collins is not equipped with land attack cruise missiles, despite a persistent decades-long advocacy campaign by the Navy League and other submarine force advocates.

The issues of whether the future submarine should be equipped to launch land attack cruise missiles is one which should be carefully studied, as it has major cost and survivability implications. An argument commonly raised by submarine advocates is that Australia should deploy a land attack cruise missile on its submarine force, as a substitute for the use of air power as a cruise missile delivery system. The difficulties any experienced missile warfare strategist or operations analyst will observe immediately are the dual problems of ‘weight of fire’ and ‘magazine depth’. Cruise missiles have limited killing power, and at best compare to a 1,000 lb air delivered bomb. The United States has performed numerous cruise missile bombadments since 1991. Typically targets such as airfields require dozens of cruise missile hits to effect significant damage, no differently than in air raids where packages of aircraft drop dozens of guided bombs. A single submarine armed with a dozen cruise missiles provides at best a harassment or ‘pinprick’ capability – the same as a raid by one cruise missile armed B-52H, three F-111s, or six F/A-18s with tankers. To cripple a military or large civil / dual use airfield would require two SSG/SSGN each with 24 cruise missiles. A large fixed Surface to Air Missile site would require at least one submarine armed with 24 cruise missiles, or two armed with 12 each. The difficulty is that once the missiles are expended, the boats have to transit to a safe area at tens of knots, evading defences, to reload from a tender or a safe harbour. As a result, reattacks may be days or weeks apart, compared to air power which can reattack in a matter of hours. The US Navy addressed this limitation by rebuilding four Ohio SSBNs into SSGNs each carrying up to 154 Tomahawks. Even so, these vessels are used primarily for ‘first day of the war’ attacks, to surprise the opponent and cause disruption and damage to critical assets – they are not intended.

HMBS Waller and a US Navy Ohio class SSGN.

The exceptionally fast Soviet Akula class SSN was a benchmark in attack submarines.

The primary role of the Collins class SSKs is ASW/ASuW.
to compete with air power.

An important factor is the proliferation of ‘Counter-PGM’ weapon systems, like the Russian 9K66 Pantsir S1 or Chinese LD-2000, intended to kill incoming cruise missiles as they approach their targets. Such systems will drive up the number of cruise missile rounds required for effect, in turn driving up the number of cruise missiles to be launched. A launch of six cruise missiles against a ‘Counter-PGM’ battery defended target could see no effect, with all rounds shot down. The game then becomes how to saturate the defending battery with more rounds than it can handle, exacerbating the ‘weight of fire’ and ‘magazine depth’ problems.

Another key issue for land attack is the problem of ISR capability for targeting and damage assessment, in dealing with mobile or relocatable targets, both of which have been major issues in bombardment campaigns since 1991. Submarines are wholly reliant on aircraft for fire control; their sonar systems have a fixed launch array, while a submarine launched expendable autonomous UAV is feasible, its launch increases risk of exposure, and would require satellite relay for data-linking beyond 400 nautical miles. No amount of vocal advocacy or wishful thinking by submarine supporters can fix the ‘weight of fire’, ‘magazine depth’ and time critical ISR problems – submarine launched cruise missiles are highly valuable supplements to air power for bombardment of fixed targets, but are simply not viable in any sustained campaign where persistent bombardment of targets for weeks or months is required to produce effect, or mobile targets are involved. Claims otherwise cannot be substantiated by operational analysis or historical precedent.

The same is not true if the target is a CVBG, SAG or convoy, and the cruise missiles are antishipping weapons. Lacking the hardness of reinforced concrete land structures, and capability for rapid repair of heavy damage, surface shipping is particularly vulnerable to saturation missile attacks, which an SSG/SSGN can autonomously target using passive sonar. A saturation attack with two dozen supersonic ASCMs will cause mayhem in any concentrated group of surface vessels, be they warships or a convoy of transports. The Soviets would not have so heavily invested in the regional weapon system'. The same is not true if the target is a CVBG, SAG or convoy, and the cruise missiles are antishipping weapons. Lacking the hardness of reinforced concrete land structures, and capability for rapid repair of heavy damage, surface shipping is particularly vulnerable to saturation missile attacks, which an SSG/SSGN can autonomously target using passive sonar. A saturation attack with two dozen supersonic ASCMs will cause mayhem in any concentrated group of surface vessels, be they warships or a convoy of transports. The Soviets would not have so heavily invested in the regional weapon system'.

The Ohio class SSGN is a conversion from an SSBN, armed with up to 154 Tomahawk cruise missiles, in six round launchers which are inserted into former Trident SLBM tubes.

Launch of a Block IV Tomahawk SLCM.

USS Santa Fe displaying its twelve open vertical launch tubes for SLCMs. Later Virginia class boats use a six round launcher arrangement adapted from the Ohio SSGN design, with two large doors.