Killing the Vampire

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The history of naval warfare chronicles the evolutionary process in weapons development and the parallel development of defensive measures to counter the threat. The last century started out with a technological contest between large guns and armour plating, followed by the emergence of carrier-based dive bombers and torpedo bombers, balanced by anti-aircraft guns and carrier based interceptor aircraft. The latter decades staged an ongoing contest between the developers of anti-ship cruise missiles (ASCM), countered by Anti-Ship Missile Defence systems (ASMD) and electronic countermeasures.

In the first decade of this century, the technological contest continues, with the advantage now held by the offensive players. Whether the defensive players manage to produce an effective response to the current generation of supersonic ASCMs remains to be seen.

Playing Offensive – The Cold War Era

The first anti-ship cruise missiles emerged during the 1950s, as the lessons of World War II naval operations were digested. By far the most lethal anti-shipping weapons deployed during the 1940s were the German Hs-293 and Fritz-X guided bombs, and the Japanese kamikaze pilots. This experience effectively set the pattern for the subsequent 70 years.

The Soviets started the Cold War with a brown water surface navy devoid of the aircraft carrier fleet, which did not emerge in credible form until the 1980s. As a result the Soviets pursued a strongly asymmetrical strategy relative to their NATO opponents, who deployed many carriers of widely ranging capabilities.

From the outset the Soviets focused their effort into developing ASCMs, and every weapon type in production today can show a lineage directly or indirectly back to the 1950s. Two distinct categories of ASCM evolved, surface and sub-surface launched, and air-launched by long-range bomber aircraft.

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The Soviets emulated the maritime strategy of Nazi Germany, and there is good evidence to support this claim. The Kriegsmarine operated a large fleet of U-boots along with fast and heavily armed surface combatants, while the Luftwaffe deployed smart bomb equipped FW-200 Condor and He-177 long range bombers and Ju-88 and Do-217 medium range bombers for maritime interdiction.

Canberra based CEA Technologies are about to commence sea trials of their X-band active array Anti Ship Missile Defence radar package for the ANZAC frigates. The CEAPAR/CEAMOUNT provides integrated search, track, engagement and CW illumination functions for the ESSM missile. The Australian developed CEA design is in many respects more capable than the US SPY-3 and UE APAR radars, and is specifically designed to overcome the vulnerability of existing shipboard systems to saturation attacks by supersonic sea skimmers such as the Sunburn, Stallion or Sizzler.

Just as the Third Reich sought to strangle the Allied trans-Atlantic resupply effort during the 1940s, so the Soviets planned to interdict reinforcements and resupply of NATO forces from the US. For the Soviet Voenno-Morskiy Flot (V-MF) the cardinal battle was geographically constrained, as it was for Germany during the 1940s.

The result of this Soviet maritime doctrine was the evolution of a diverse array of large, fast, highly lethal and sophisticated ASCMs. This process started during the 1940s and continued until the USSR collapsed in 1991.

As the end of the Cold War neared, Soviet designers produced two final heavyweight weapons, both of which remain in production today: the Mach 2.2 P-80 Zubr/P-270 Moskit or SS-N-22 Sunburn family of the missiles, and the Mach 2.6 P-800 Onyx/Yakhont or SS-N-26 Stallion family of ASCMs.

Western ASCMs followed a fundamentally different path, reflecting the fundamentally different paradigm of navies in which heavy munitions were delivered primarily by carrier based aircraft initially armed with dumb bombs and later smart bombs.

Two designs continue to dominate Western naval inventories. These are the 1970s developed subsonic French AM/MM.38/39/40 Exocet and US AGM/BGM/UGM-84 Harpoon missiles. Curiously the Soviets emulated these weapons with the 3M24/Kh-35 Uran or SS-N-25 Switchblade, colloquially named the "Harpoonski". It also survived the end of the Cold War.

The only major departure from this model was the US Navy's RGM/BGM-109B Tomahawk Anti-Ship Missile (TASM), modeled on the Harpoon but with a bigger warhead and ~300 nautical mile range.

Playing Offensive – The Post Cold War Era

The end of the Cold War saw a collapse in Soviet, US and NATO budgets and a resulting contraction in force structures and development funds. While Western navies continued with the Harpoon and Exocet, progressively evolving new variants, the Russians consolidated all development and export marketing into a handful of designs. Post 1991 the US Navy's TASM war stock was rebuilt into TLAMs

and dropped on Iraq and Yugoslavia in subsequent conflicts.
The P-270 Moskit / Sunburn was adapted for air launch and coastal batteries, and sold to the PLA-N to arm its Sovremenniy class DDGs. It remains in the market, available for surface combatants or as a centerline store for the Flanker fighter.
The P-800 Yakhont was licenced to India, which is now manufacturing an improved variant, the Brahmos, adapted for launch from surface combatants, coastal batteries, aircraft, and with a submarine launch variant in development.
The 3M24/Kh-35 Harpoonski remains in the market, available for warships, fixed and rotary wing aircraft, and the Bal E coastal battery system.
Three entirely Russian missiles emerged during this period. The lesser of these is an anti-shipping variant of the Kh-59M series ASM, developed for China. The Kh-59MK is supplemented by a supersonic ASCM variant of the Kh-31 / AS-17 Krypton, the Kh-31A. More significant is the Novator 3M54 Club or SS-N-27 Sizzler family of missiles, modeled on the stillborn 1980s US Navy turbojet powered Tomahawk MRASM, but further evolved, and available in ship, sub and air launched variants.
The basic 3M54E1 Sizzler is an analogue to the US Navy TASM, and the 3M14E Sizzler an analogue to the TLAM cruise missile. The 3M54E Sizzler is unique and in a class of its own, combining a Tomahawk-like cruise airframe with a rocket propelled thrust vectoring sea skimming Mach 2.7+ terminal kill stage. The US Navy is currently contracting for the development of a drone target to emulate this weapon which is widely considered to be capable of defeating most if not all Western defensive systems.
In parallel with Russian ASCM developments, China has continued its development of ASCMs along three parallel tracks. One involves rocket and turbojet analogues to the Harpoon/Exocet, another turbojet and fan powered analogues to the TASM, and the final prong being further evolution of its turbojet Styx/Silkworm derivatives.

Playing Defensive

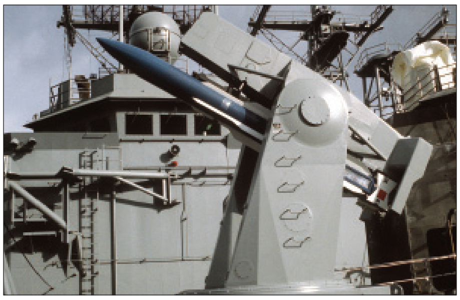
At the most fundamental level the attacker's game is maximizing the probability of scoring a hit and maximizing damage effect if a hit is achieved. The defender's game is minimizing the odds of being hit, by denying launch opportunities and killing inbound missiles, and if hit surviving the damage.
Naval air and missile defences inevitably evolve to overcome anti-shipping weapons, and the game has always been one of producing defensive fire capable of stopping incoming weapons before impact. While it is fashionable in naval analytical circles to argue the virtues of damage control systems in warships and their ability to overcome damage, the reality of every single successful ASCM shot against a warship or transport since 1967 has been runaway fires resulting usually in the eventual sinking of the victim vessel, or significant damage and loss of life. The pragmatic reality is that avoiding being hit is the smarter strategy.
When the Soviets deployed the Styx, Shaddock, Kipper and Kelt, the primary US Navy long-range Surface to Air Missile was the Bendix RIM-8 Talos, a large 100 nautical mile range 3,000 lb Mach 2.5 ramjet missile with beam riding guidance in early variants, and continuous wave semi-active radar homing in later variants – the launch vessel illuminating the incoming missile until impact. The Talos remained in use until the late 1970s.
Soviet tactics rapidly evolved, following detailed operational analysis, which showed that the best approach to defeating US Navy defences was to salvo a sufficient number of ASCMs to overcome the defensive fire from escorting missile cruisers and picket destroyers. This set the parameters for a technological contest which continues to this day.
ASCM shooters maximize their advantage by shooting as large a salvo as can be carried, by deploying missiles with high cruise speed to minimise available SAM firing opportunities, and low cruise altitudes to minimise warning time to the victim while maximizing the warhead size carried. A desirable byproduct of these parameters is that the kinetic energy at impact of a supersonic ASCM massing several tonnes may be enough in itself to cut a small warship in half.
The 1960s generation of Soviet ASCMs typically flew high or medium altitude trajectories, diving down on the victim warship. This was largely the byproduct of midcourse guidance system limitations, and reliance on datalink steering from the launch vessel or Bear D targeting aircraft. As a result the ASCMs could be detected early in flight and repeat firing opportunities presented to defending warships.
The US Navy responded to the growing Soviet ASCM threat initially by adding additional layered defences, and by launching the Aegis program which resulted in the massive SPY-1 Aegis phased array air defence radar and the RIM-66 SM-2 Standard missiles.
By 1966 the RIM-7E Sea Sparrow began to deploy as a point defence missile, this semi-active homing weapon being almost identical to the AIM-7E carried by US fighter aircraft. The RIM-7 remains in use today, with the most recent variants being the monopulse RIM-7M and P. RIM-7 box launchers became a ubiquitous feature of US aircraft carriers, amphibious ships and some transports.
The Royal Navy deployed its Armstrong Whitworth GWS.1 and .2 Sea Slug missile almost concurrently with the US Talos series, this beam riding missile being comparable to early Talos variants. By the 1970s the Sea Slug was progressively replaced by the GWS.30 Sea Dart, with semi-active homing.
The principal focus in the technological contest until the end of the Cold War was in saturating the opponent with numbers of missiles, and making the missiles ever faster and longer ranging to improve the number of firing opportunities.
This reasoning drove the Soviets by the 1980s to the ultimate 18,000 tonne class Oscar SSGN carrying 24 Granit ASCMs, and the 28,000 tonne class Kirov battlecruiser carrying 20 Granit ASCMs – the aim was to deliver an overwhelming saturation attack on an opposing battle group.
The first CG-47 Aegis "Ticonderoga' class cruiser, the USS Ticonderoga (CG 47) entered service in 1983, armed with RIM-66 SM-2 Standard SAMs. The stated intent of the Aegis was to counter saturation attacks by Soviet ASCM firing bombers, SSGNs, CGs and DDGs. The Ticonderoga class used four SPG-62 X-band illuminators under the control of the Aegis system – in a typical engagement, Standard missiles would fly out to their assigned targets under midcourse datalink control, with the Aegis system scheduling and slewing the illuminators to paint the target for the last few seconds of terminal homing. This allowed many more targets to be engaged compared to earlier SAM systems, where the illuminator was committed to a target from SAM launch to impact.

RIM-2 Terrier.

RIM-8 Talos.

Mechanically steered X-band illuminators to support missile shots have until recently been a common design feature in air defence destroyers and cruisers.

RIM-7 Sea Sparrow.



RIM-24 Tartar.

RIM-67 Standard.

RIM-162 ESSM

GWS-25 Sea Wolf

RIM-116 RAM

P-270 Moskit / Sunburn.

P-800 Yakhont / Stallion.

3M54E Klub / supersonic Sizzler.

Air Launch supersonic Sizzler.

The Aegis was an essential counter to the Soviet AVMF which could muster around 200 AS-4 firing Backfires and similar number of AS-6 armed Badgers, in addition to the legacy Echo and Juliet SSG/SSGNs, and the newer Papa, Charlie and Oscar SSGNs. An engagement between the Soviet V-MF and US CVBG could have seen hundreds of ASCMs launched in synchronized attacks.

The deployment of Aegis was paralleled by further point defence weapons, intended to soak up ASCMs which penetrated the medium and long range SAM defences. The Royal Navy deployed the innovative BAe GWS.25 Sea Wolf missile, a fully automatic radar directed command link guided missile capable of killing artillery shells in flight, the weapon proving highly lethal in the 1982 Falklands campaign. The US Navy deployed the Phalanx CIWS, a close loop tracking radar directed 6 barrel 20 mm Gatling gun. It was soon followed by the conceptually similar Dutch 30 mm Goalkeeper, and the Soviet AK-630 30 mm gun.

The latter decades of the Cold War saw a progressive shift in ASCM design away from high altitude diving attacks, toward sea skimming terminal trajectories. This had two benefits, in limiting warning time with ASCM detection as it emerged over the horizon, and in presenting a more difficult radar clutter environment for defensive systems. This has been an evolutionary adaptation by ASCM designers to the Aegis system, forcing it into engagement cycles where the time between initial ASCM detection and impact is measured in less than a minute.

The statistical realities of missile defence engagements are that at least two SAMs must be salvoed on average for each incoming ASCM to be killed, and these SAMs must be guided to impact. In the era of Mach 3 ASCMs diving down from 70,000 feet, there was usually time to perform sequential launches, ie if the first SAM did not kill, a second one could still be launched and guided.

In the contemporary era of Mach 2.2 to 2.9 sea-skimming ASCMs popping up over the horizon 15 to 25 nautical miles away, the SAMs must be salvoed almost concurrently. If the first round misses, there's not time for a second launch and flyout. The principal problem is then that three or four mechanically steered illuminators, such as the SPG-62, can only cope with a limited number of inbound ASCMs before it becomes mechanically impossible to keep up.

At this point in time an attacker who can salvo half a dozen or more supersonic sea skimmers against an Aegis class vessel is likely to achieve a kill. The exact number will depend on the ASCM type, engagement geometries, and effectiveness of other defensive systems. The US Navy has publicly acknowledged that the supersonic SS-N-27 Sizzler variant presents a genuine problem, which will require new technology to overcome.

The US/NATO response to the shift to supersonic sea skimmers has been twofold. The RIM-162 Evolved Sea Sparrow Missile (ESSM) SAM was developed, intended to allow rapid sequential firings to stop saturation attacks. This thrust vectoring missile is built for vertical box launchers, and pitches over once clear of the ship to dive on the inbound ASCM.

The other developmental track has been the adaptation of X-band fighter AESA radar technology to provide fast acquisition, tracking and guidance support, such as illumination, for SAMs such as the ESSM. The European APAR and US SPY-3 are the primary programs, the latter intended to be retrofitted to a wide range of surface combatants but also larger warships and transports.

In Australia, CEA are now testing the CEAFAR (six arrays) and CEAMOUNT (four arrays) AESA suite for this purpose, intended to equip the ANZAC frigates to support the ESSM weapon system.

Until AESA systems, such as the CEAFAR/CEAMOUNT, APAR or SPY-3, and SAMs such as the ESSM are deployed in significant numbers, the advantage in the maritime missile warfare game will continue to lie with the attacker.

The long term future will see reduced signature ASCMs that are harder to detect, with more autonomous fire and forget SAM seekers, and the advent of new point defence weapons such as High Energy Lasers. The balance between the attacker and defender will continue swing back and forth, as these technologies are progressively deployed, and progressively overcome.

Milestones in this issue includes further discussion of early Soviet ASCMs.

Soviet ASCM development

The massive supersonic P-700 Granit / SS-N-19 Shipwreck was the last of the heavyweight Cold War era supersonic ASCMs to enter service. It remains in service on the Oscar II SSGNs and a wide range of surface combatants. It is the immediate ancestor of the current SS-N-26 Yakhont/Brahmos series.

Soviet Anti Ship Cruise Missiles (ASCM) remain today the benchmark in this diverse category of weapons. Many Cold War era weapons remain in production, mostly enhanced with more recent technology, and many more types remain in operational service with navies of former Soviet satellite nations, former allies or former recipients of military aid. Consequently, a naval force going in harm's way today and in the future stands very good odds of encountering many of these ASCM types, or their offspring, in combat.

The first Soviet ASCM was the rudimentary P-1 deployed on a number of larger surface warships. It was eclipsed by the now ubiquitous P-15 Termit or SS-N-2 Styx, which remains one of the most widely deployed anti-shipping weapons of all times, carried by surface combatants and missile boats. These missiles were also adapted for mobile coastal batteries and for aerial launch by the Chinese, who still manufacture variants of this design.

The Styx and its younger supersonic sub/ship launched sibling, the P-35 or SS-N-3 Shaddock, spurred the development of a generation of new defensive systems. The P-35, carried by Echo SSGN or Juliet SSGs, required the submarine to surface to raise its conformal tube launchers. A Tu-95RTs Bear D aircraft relayed midcourse guidance commands. The Shaddock was also widely deployed on major surface combatants. It was clearly inspired by the stillborn US Navy Regulus II missile.

The ASCM fundamentally changed the character of naval combat, clearly shown in 1967 with the sinking of the Israeli destroyer Eilat, hit by Styx missiles fired from Soviet-supplied fast missile boats. Four years later, the Indian Navy created havoc with the same weapon system – sinking three Pakistani warships and severely damaging two more. The age of missile combat in maritime warfare had dawned.

In parallel with the Styx and Shaddock, the Soviets developed a range of new air launched ASCMs to support their growing force of Tu-16 Badger anti-shipping missile carrier aircraft. The first such ASCM, the cumbersome KS-1 Kometa / AS-1 Kennel, was rapidly superceded by the much more capable Raduga K-10S Luga-S / AS-2 Kipper cruise missile and the massive 180 kiloWatt YeN Puff Ball attack radar used to acquire targets and guide the supersonic turbojet powered missile. The Kipper remained in service as an ECM drone well after it was replaced by newer ASCMs.

By 1961 the K-10 had been superceded by the slower but more compact KSR-2 / AS-5 Kelt, which used a similar liquid rocket engine as the Styx. A Badger could carry a pair of Kelts, doubling the effective firepower. By the mid 1960s the KSR-2 evolved into the KSR-11 with an anti-radiation homing seeker.

In parallel with these specialized ASCMs, the Soviets developed the strategic nuclear-armed Raduga Kh-22 Burya or AS-4 Kitchen, a massive 7 tonne Mach 2.8 missile to be carried by the supersonic Tu-22 Blinder. By the late 1960s this missile, inspired by the British Blue Steel, was adapted for the ASCM role with active radar or anti-radiation seekers. It became the primary weapon arming the Tu-22M Backfire and Tu-95K-22 Bear G maritime interdiction aircraft. It was soon followed by the scaled down KSR-5 Kingfish ASCM for the Badger.

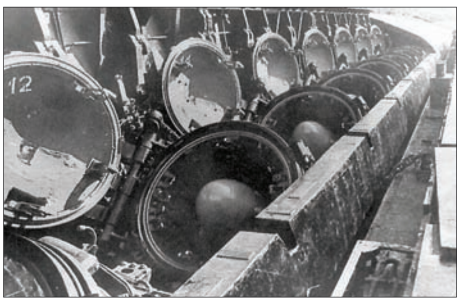
While the Styx armed mostly fast missile boats it was widely exported to Soviet clients in the Third World. The Soviet V-MF armed its capital ships and SSGNs with an array of increasingly lethal ASCMs, all evolved from the concept of the P-35 Shaddock.

The intended replacement for the P-35 was the supersonic P-70 Ametyst or SS-N-7 Starbright, deployed on Charlie SSGNs, and the first ASCM that could be launched from a submerged position. It was supplemented by the subsonic P-120 Malakhit or SS-N-9 Siren, deployed on Corvettes and the Papa demonstrator SSGN. The 1960s designs remained in use until the 1980s.

The V-MF's planners were not satisfied with the lethality or survivability of these weapons, and by the mid 1970s sought the development of the P-700 Granit or SS-N-19 Shipwreck, intended as the primary armament for the massive Oscar class SSGN. This 7 tonne launch weight 300 nautical mile range Mach 2.5 turbojet missile was deployed also on the Kirov class battlecruisers and Type 1143.5 Kuznetsov class aircraft carrier. Concurrently, they sought a replacement for the P-70 and P-120 in the P-1000 Vulkan or SS-N-21 Sampson. This missile most closely resembles the Shaddock/Sandbox family, but is more compact.

The 1980s P-750 Meteorit or SS-N-24 Scorpion/AS-19 was stillborn, an intended Mach 3 replacement for the air launched Kh-22 Kitchen and Shaddock/Sandbox.

P-500 Bazalt / Sandbox.



P-700 Granit launchers on Oscar SSGN.

P-1000 Vulkan / Sampson.