

Evolving naval anti-ship weapons threat

Dr Carlo Kopp

The reality of the last two decades has been the increasing capability of weapon systems developed specifically to kill modern surface warships. The current supersonic sea skimming Anti-Ship Cruise Missile (ASCM) threat will soon be supplemented by Anti Ship Ballistic Missile (ASBM) systems, further complicating the challenge of operating naval forces in blue water or brown water operating environments.

The evolution of ASCMs is by no means complete and there is considerable growth potential in this family of weapons.

The end of the Cold War ensued two decades of ASCM development, set by three Soviet ASCM designs. These were the P-700 Granit / SS-N-19 Shipwreck deployed on a number of Soviet cruiser classes and the Echo II SSGN, the P-270 Moskit / SS-N-22 Sunburn and the P-800 Yakhont / SS-N-26 Stallion, also deployed on the Sovremenniy class DDG and adapted for sub, air and ground launch.

These large supersonic missiles would initially climb to a medium or high cruise altitude, accelerate to high supersonic speeds, and as they approached their target they would descend to a sea skimming altitude for terminal phase homing at Mach 2 class speeds. Additional modes in all three missiles permitted profiles flown wholly at low altitudes, trading significant range to keep the missiles below the radar horizon of defending warships for most of their trajectories.

Sea-skimming attacks present challenges for all naval air and missile defence systems, as the inbound missiles do not become visible to defensive radar or other sensors until they reach the radar horizon of the antenna system used. Depending on the size of the vessel and antenna elevation this varies between 10 and 25 nautical miles. This compresses the time available for defensive fire and re-attack if the initial attempt fails – severely, in comparison with earlier Cold War era ASCMs, which flew shallow diving terminal homing trajectories from medium or high altitudes. In comparison, ‘classic’ Cold War era weapons such as the Kh-22 Burya / AS-4 Kitchen and KSR-5 / AS-6 Kingfish flew at midcourse altitudes of 50,000 to 70,000 ft AMSL, allowing detection at ranges of around 250 nautical miles or more.

The time available to effect a defensive missile shot was thus compressed five to tenfold, with the shift to sea skimming ASCM trajectories, all else being equal. This strategy aimed to saturate the fire control systems of warships under attack, which have to acquire and track the inbound missiles, assign X-band illuminators to each, launch and guide out defensive missiles, illuminate for terminal missile homing, and then repeat this cycle again if the initial shot failed, and do so before the inbound



The DF-21 IRBM is the basis of the PLA's new ASBM weapon.

missiles get inside the minimum engagement distance of the warship's weapon system.

The game of the attacker is to find the best combination of ASCM speed and numbers to overwhelm the defences of the victim warship.

Since the end of the Cold War the Sunburn and Stallion have matured and been exported, with the Indian Brahmos ASCM / LACM a licensed and improved variant of the latter. Since then, the P-900 / 3M54E Klub/Kalibr / SS-N-27 Sizzler has deployed; this missile even more challenging as the rocket propelled terminal kill stage of the primary variant flies at a sea skimming speed cited variously between Mach 2.7 and 2.9. This is roughly four times faster than legacy subsonic ASCMs such as the Exocet and Harpoon, thereby cutting available response times for warship defensive systems fourfold.

Sea skimming terminal trajectories offer other advantages over late detection and tracking, as for much of the terminal trajectory the defending

warship's radars must separate the small radar return from the inbound missile, which may have a frontal radar cross section as low as 0.1 square metres, from the wavetop clutter which is typically more pronounced with increasing sea state. This is a challenging task even for a good pulse Doppler radar signal processor, and typically requires more dwell time by the radar on a given azimuth to extract a good quality radar track. Refractive atmospheric effects at low altitudes resulting from varying humidity and temperature profiles with increasing altitude, especially common in the tropics, can further complicate the problem by bending the radar beam upward or downward.

Some years ago DefenceToday published a basic analysis, which showed that a saturation attack with around ten supersonic sea skimming ASCMs would overwhelm a SPY-1 Aegis weapon system with mechanically steered illuminators and semi-active homing SAMs. Given that Soviet/Russian operational doctrine exported with training



Early variants of the DF-21 were based on China's JL-1 SLBM design.



packages for these ASCMs mandates saturation attacks with a dozen or more such missiles per target warship, the operational problem is worse than that modeled. The prospect of facing 12 – 16 ASCMs is so far outside of what is mathematically feasible for such a system that the argument is moot. The ship dies.

What are the expected trends in ASCM evolution over the coming two decades?

Increased ASCM speed. India is currently experimenting with the Brahmos missile to make it fly much faster. Propellant and engine evolution is likely to result in hypersonic ASCM designs emerging over the next two decades.

Reduced ASCM radar signatures. Stealth shaping rules are now sufficiently well understood that an ASCM with a frontal radar cross-section of well below 0.1 square metres is achievable.

Multimode ASCM terminal seekers. A number of current ASCMs already have multimode terminal guidance schemes. In fact, the 1970s P-120 Malakhit / SS-N-9 Siren used a dual mode infrared homing and active radar guidance package, and the current P-800 Yakhont / Brahmos / SS-N-26 series Granit-Elektron seeker is a combined active radar and passive anti-radiation homing design.

ASCM EWSP packages. Late Cold War Soviet ASCMs such as the P-500 Bazalt / P-1000 Vulkan / SS-N-12 Sandbox carried active jamming equipment intended to frustrate tracking by NATO warship fire control radars. The effect of such systems would be enhanced by radar signature reduction of the missile. Importantly, the high cost of modern surface warships, even destroyers and frigates, along with the exceptionally high cost of major capital ships such as aircraft carriers and amphibious ships makes an ASCM cost in the millions of dollars entirely justifiable.

The US Navy's candid public comments some years ago to the effect, "we have no good means of stopping the SS-N-27 Sizzler", should be taken seriously. The ASCM threat is not going to evolve backwards into slower and dumber weapons.

Anti Ship Ballistic Missiles (ASBM) are the latest weapons to produce public controversy in the United States, and for good reason.

The first terminally guided ballistic missile to enter operational service was the US Army's MGM-31C Pershing II IRBM, built with a Goodyear MARV (Manoeuvring Re-entry Vehicle) terminal stage, equipped with an active radar terminal seeker and Radar Area Correlator (RADAC) guidance similar in concept to the optical correlator used in the BGM-109 Tomahawk Land Attack Missile. This weapon would use the radar to image the terrain below it

as it descended, and then correlated the imaged radar map with a stored digital map of the terrain to produce a position error measurement, then used to guide the terminal MARV stage with high accuracy.

The Soviets were impressed with the Pershing RADAC design and sought to develop an optical scene correlator design for use in their ballistic missiles. The end of the Cold War disrupted these plans.

The Russians have since the end of the Cold War fielded this technology in mass produced KAB-500Kr and KAB-1500Kr electro-optically guided smart bombs, and more recently in the 9M72 Iskander M/E Tactical Ballistic Missile.

An ASBM was also developed by the Soviets during the 1970s. This weapon was the R-27K designated by NATO as the SS-N-X-13, and based on the R-27 / SS-N-6 Serb liquid propellant SLBM. This missile was only ever deployed on a single modified Golf class SSBN, which was equipped with the Kasatka fire control system capable of accepting targeting data from RORSATs (Radar Ocean Reconnaissance Satellites). Given the period during which this system was developed, the guidance package for the missile would be very limited by contemporary standards. Most sources credit the R-27K / SS-N-X-13 with a passive anti-radiation homing seeker and nuclear warhead.

During the 1990s reports intermittently emerged on Russian websites that an optical correlator based seeker was being developed for the SS-N-6 Serb for use as an ASBM, and that the technology had been sold to China. These claims were never confirmed.

Reports that the PLA was developing ASBM technology started appearing some years ago, but the existence of this weapon was not confirmed until recently.

Most sources agree that the Chinese ASBM is based upon a terminally guided variant of the DF-21 / CSS-5, which is a 1,000 nautical mile range class IRBM derived from the JL-1 series solid rocket propelled SLBM carried by PLA-N SLBMs. The DF-21 is carried by a towed TEL and is highly mobile, an ASBM variant would likely be deployed in exactly the same fashion, as mobile TELs are extremely difficult to locate and target prior to missile launch. There does not appear to be a strong consensus in open sources on whether the DF-21 SLBM uses a radar or an optical seeker. There is a strong consensus that the DF-21 SLBM is intended as an anti-access weapon, to keep US Navy carrier battle groups outside China's first and second island chains.

The DF-21 IRBM is a difficult missile to stop using a tactical or theatre ABM system due to its high re-entry velocity, as it sits at the outer performance envelope of contemporary ATBM systems. A bigger concern is that DF-21 ASBMs could be salvaged to produce multiple round saturation attacks against naval task forces. There will be practical limits to how many concurrent engagements against ASBMs can be handled by a single ABM system such as the SPY-1 Aegis. The high re-entry velocity of such targets demands a high update rate during tracking, and this in turn consumes per target some share of the total tracking time available from each Aegis system. There will be, as with supersonic ASCMs, some hard limit beyond which these systems are overwhelmed.

While existing warship defensive systems with ABM capability will have no difficulty in engaging small numbers of such weapons, saturation attacks change the whole strategic dynamic.

Compared to ASCM attacks, ASBM attacks offer more warning time as the ionization trail of the MARV is readily detected by radar. On the other hand, ASBMs are significantly faster making them more challenging targets to intercept. While ASCMs can still be engaged by close in gun systems or lasers once inside the minimal engagement distance of defensive missiles, ASBMs are much too difficult a target for such terminal defences – their speed alone requires exceptionally high tracking rate performance for an effective intercept.

From a lethality perspective, even an ASBM armed with an inert concrete warhead presents as a highly lethal projectile, given the exceptional terminal velocity at impact. The kinetic energy at impact of a single ASBM MARV is roughly 10 to 20 times greater than that of a concrete piercing guided bomb.

While opportunities may exist to jam a RADAC style seeker, the propensity to combine passive anti-radiation homing seeker technology into existing ASCM active radar seekers make this a marginally viable strategy in the long term. The cost of an ASBM and its targets make the installation of sophisticated multi-mode seekers entirely justifiable.

It therefore comes as no surprise that China's deployment of the DF-21 ASBM has produced a very loud public debate in the United States.

Anti-shipping weapons technology and shipboard defences have been locked into an evolutionary arms race for two millennia now, and the latest cycle is currently favouring the attacker. How soon credible defensive technologies can be deployed remains to be seen.