Future AEW&C capabilities for Maritime Warfare

Dr Carlo Kopp

E-2D Advanced Hawkeye prototype.

Airborne Early Warning and Control (AEW&C) capability has been a critical feature of maritime warfare since its introduction in 1946. With shipboard radar range against low flying aircraft and Anti-Ship Cruise Missiles (ASCM) limited typically to around 25 nautical miles, and dependent on sea states, AEW&C systems that project detection capabilities at greater ranges are therefore critical to the survivability of surface combatants.

The first AEW&C system to operationally deploy in 1946, the Grumman TBM-3W "Cadillac" with an AN/APS-20 search radar, was equipped with then state-of-the-art datalink equipment to relay the acquired radar picture to surface warship Combat Information Centres (CIC). While the technique used to build AEW&C systems has evolved immensely since 1945, when initial trials began, the basic concept of an airborne radar system with datalinks down to surface warships remains unchanged.

From the outset, maritime AEW&C capabilities were divided between the use of shipboard systems and land-based systems. While shipboard systems were always available for use, as part of a carrier air wing, they were usually limited in station altitude and thus detection range and coverage, as well as suffering from much lower on station endurance.

The evolution of AEW&C capabilities for maritime use has reflected this division for the past 66 years, although navies have now relegated the land-based role to air forces, reflecting the realities of progressive force structure and budget shrinkages over time, and the geographical circumstances of most conflicts where wide area AEW&C capabilities were mostly required within reasonable distances of available land bases. The only circumstances where land based wide area AEW&C support has been absent are blue water operations such as planned Cold War era US Navy CVBG sorties against Soviet bastions, planned North Atlantic convoy escort operations, or distant interventions such as Operation Corporate to retake the Falkland Islands, in 1982.

The importance of maritime AEW&C capabilities has increased considerably, since the advent of sea skimming ASCMs during the 1960s. With the global proliferation of mostly Russian and Chinese built ASCMs, many supersonic, and suitable for launch from aircraft, submarines, surface combatants and highly mobile land based batteries, ASCM attacks are the most likely manner in which a surface fleet will be engaged, whether it is in littorals or blue water operations.

There is a deeply held belief at present that ASCM attacks are uniquely a feature of high intensity conflict between advanced peer competitor nations. This belief is as well entrenched as the early 1940s notion that aircraft could not sink battleships, or the 1960s notion that sea-skimming ASCMs did not work.

The first of these beliefs collapsed in December 1941 when Japanese land-based torpedo bombers sank the 'Prince of Wales' and 'Repulse' off the coast of Malaya. The second of these beliefs should have collapsed in 1967, when the Israeli destroyer 'Eilat' was sunk by four Soviet supplied Styx ASCMs launched by a Soviet supplied fast missile boat, but it was not until the much publicised Exocet attacks on the British fleet off the Falklands in 1982 that significant investments were made into defend against sea skimming ASCMs.

Shenyang J-31 stealth fighter, the proliferation of stealth complicates maritime air defence as it typically defeats many types of radar.

The circular ventral antenna on this E-2D belongs to the Cooperative Engagement Capability system, which permits the E-2D to function as an Over-The-Horizon targeting system for SAM shots.

E-2D crew stations.

The reality of pervasive ASCM use remains to be accepted, despite the successful use of a Chinese built, Iranian supplied Saccade ASCM, launched off the back of a truck, by Hezbollah insurgents against INS 'Hanit', an Israeli Saar 5 missile boat, in 2006.

Only a handful of Western surface combatants are robustly equipped for the defeat of saturation ASCM attacks. There has been large scale investment by Western navies in the long range high altitude optimised SPY-1 Aegis family of systems, which have limited capabilities against saturation and/or supersonic sea skimming ASCM attacks.

The challenge presented by saturation attacks using sea-skimming ASCMs is not a trivial one, primarily due to the radar horizon limitations of shipboard radars. This provides only a very limited time window measured in tens of seconds, to detect the missiles as they pop-up over the horizon, track and identify the missiles, and salvo defensive missile fire before the ASCMs close. While radar-directed guns such as the Phalanx CIWS and Goalkeeper series can be highly effective, they are limited to one target at a time, which is a major problem with multiple inbound ASCMs.

Ultimately, trying to stop saturation ASCM attacks in the endgame is a high risk high investment game, where fire control system saturation will eventually occur as the enemy increases the ASCM salvo size. This is an inevitability. Another consideration is that ASCM vendors will invest effort in making ASCMs harder to detect and kill. Soviet innovations in this area included titanium armour over vulnerable ASCM areas, and the installation of active radar jamming equipment in the ASCMs, to confuse fire control radars and missile seekers. The addition of stealth shaping and radar absorbent materials and coatings on ASCMs is only a matter of time now.

The consequence of pervasive use of advanced ASCMs is an increasing need to defeat ASCM launch platforms before they can release their lethal payload, that is "shoot the archer, not the arrow", and where this is not feasible, engage and destroy ASCMs in "over-the-horizon" engagements.

Contemporary Maritime AEW&C Capabilities

Throughout the Cold War period, maritime AEW&C capabilities were used primarily to defeat aircraft carrying ASCMs, as AEW&C platform radar performance was often marginal against low flying ASCMs.

A major challenge in this game is building a radar compact enough for carriage by a small shipboard aircraft or a large shipboard helicopter, yet one that provides good detection performance against aircraft and ASCMs at all altitudes under all weather conditions.

The advent of globalised stealth, exemplified by the Russian PAK-FA and Chinese J-20 and J-31 fighters, adds another complexity to this problem.

Choice of the radar operating band and thus wavelength is a major issue, as it has impacts on both performance and, importantly for small platforms, the physical size of the antenna. While a land based AEW&C system has some flexibility in this respect, as the airframe is physically larger, for shipboard systems this is inevitably a challenging task.

The often heard view that "all size issues will be easily resolved in the future due to exponential growth in electronics" is sadly nonsense, despite its popularity. Current maritime airborne early warning radars for shipboard use, of which there are only a handful, are broadly split into two categories.

The biggest and most capable by far is the AN/APY-9 / ADS-18 carried by the new E-2D Advanced Hawkeye. This is a modern solid state phased array digital radar, which although mechanically scanned in azimuth, provides also electronic beamsteering through a limited range. The E-2D is currently operated by US Navy only.

The next tier down is the Russian NNIIRT E-801M Oko carried beneath the Kamov Ka-31 Helix AEW&C helicopter. This is large rotating radar, which folds flat under the helicopter for cruise, landing and takeoffs. The unusual arrangement is claimed to present problems with vibration during operation, as the antenna rotates through 360 degrees as the helicopter orbits on station. Operators include Russia, India, and a small number were procured by China.

The only remaining shipboard AEW&C radar in operational use is the Thales Searchwater 2000AEW, carried by the Royal Navy's Westland Sea King ASaC.7 helicopter, installed as a block upgrade from the earlier Thorn-EMI ARI 5930/3 Searchwater radar, itself an adaptation of an existing surface search radar in the wake of the Falklands conflict, to equip Invincible class STOVL carriers. This radar is essentially an adaptation of an ASW radar built for maritime patrol applications. Its performance against stealthy targets will be inherently poor. A variant of this radar has been proposed for the Agusta Westland EH-101 Merlin helicopter, to replace the elderly Sea King ASaC.7.

The Chinese PLA Navy is currently developing an AEW&C system for the Varyag, based on an arrangement conceptually similar to the Searchwater system. The host vehicle is the Chengzhe Z-8, which is a licence built Aérospatiale SA 321 Super Frelon, used until recently for ASW, SAR and assault roles by several navies.

The Future: Shooting Over The Horizon

The problems inherent in defeating saturation attacks by sea skimming ASCMs, especially supersonic weapons, will yield major operational rewards for navies which develop the capability to effectively target Surface Air Missiles (SAM) against low flying targets beyond the radar horizon.

This is a challenging task, as it requires tight integration between the warship and an airborne targeting platform, such as an AEW&C system. The

clockwise from above:

Chinese Z-8 Super Frelon AEW&C concept.

RAAF Wedgetail AEW&C.

Royal Navy Sea King AEW.7.

Russian Navy Kamov Ka-31 Helix AEW with the E-801M Oko radar deployed.

airborne platform must detect, track and sort the targets, relay very accurate position and velocity data to the warship deploying the SAMs, and then provide continuous real time target tracking updates as the SAMs fly out to engage the targets. The demands upon both radar and datalink capabilities are challenging.

The most advanced program in this area at this time is the US Navy Naval Integrated Fire Control –Counter Air (NIFC-CA) program, which is to "Provides Engage-On-Remote and OTH capability to counter manned aircraft and cruise missiles", "Link E-2D elevated sensor to Aegis ships and Navy fighter aircraft to expand Air Defense battlespace." and to "Utilize full kinematic range of active missiles." *(www.dtic.mil/ndia/2011IAMD/Pandolfe.pdf)*

The critical enabler for this program is the new RIM-174 Standard Extended Range Active Missile (ERAM) or "SM-6", which combines the two stage airframe of the RIM-156 SM-2 Extended Range Block IV or SM-2ER/B.IV SAM with a variant of the active radar seeker employed in the AIM-120C AMRAAM Air-Air Missile. *(http://www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1200&ct=2).* The first production missile deployed in 2011 to the US Navy.

The US Navy have conducted at least two successful trials of the NIFC-CA capability. In a September 2012 trial, the Over-The-Horizon sensor was an X-band radar carried by a US Army JLENS (Joint Land Attack Cruise Missile Elevated Netted Sensor System) tethered aerostat. *(http://www.navy.mil/submit/display.asp?story_id=69829).* The cruise missile type target was tracked by the JLENS radar, and tracking data was relayed using the US Navy CEC (Cooperative Engagement Capability) datalink to an Aegis weapon system, which fired an SM-6 and destroyed the target at an unspecified range, over land. This followed earlier trials, in which an E-2D Advanced Hawkeye performed as the airborne sensor component in the system, utilising its CEC antenna to relay tracking data to an Aegis system, to engage and destroy a cruise missile target Over-The-Horizon, over land using an SM-6 SAM.

The NIFC-CA capability is an important step forward, but it is also currently a niche capability specifically intended to engage distant targets using a large and expensive two stage long range SAM. While the capability would be viable for defeating a standoff seas skimming ASCM attack, the capability confronts the "magazine depth" problem, as only a limited payload of SM-6 SAMs would be carried by an Aegis CG or DDG. The system is also architected around the CEC system, which is currently deployed in significant quantity only by the US Navy, including CEC installations on E-2C and E-2D AEW&C aircraft. The cost of a single SM-6 round may be greater than the cost of many ASCMs it would be used to defeat, and the economics are not a war-winning prospect.

The long delayed JLENS tethered Over-The-Horizon radar was intended to provide US Army Patriot batteries, and US Navy warships defending beachheads, with an affordable capability to detect and attack cruise missiles. JLENS was cancelled in recent budgetary cuts.

What the NIFC-CA effort does show is the long term path forward for dealing with saturation ASCM attacks, which is exploiting an airborne sensor system, advanced datalink system, and active radar seeker equipped SAMs to soak up an inbound wave of ASCMs before they reach the radar horizon and endgame defences of the warship.

There is little doubt that if the intent is to salvo multiple SAMs at any range against a saturation ASCM, active radar seeker equipped SAMs will be a necessity. There can also be little doubt that some kind of AEW&C capability will be essential for surface action groups in contemporary and future conflict.

For Australia, the possession of the 'Wedgetail' provides exactly such an AEW&C capability, with a radar well suited to this regime of operation. While the Hobart class AWDs are to be equipped with the CEC system, for RAN surface combatants to engage ASCMs in Over-The-Horizon attacks will require integration of the CEC system also on the Wedgetail AEW&C aircraft, and other RAN surface combatants. *(http://www.ausawd.com/content.aspx?p=97).*

The technically challenging problem will be in providing a shipboard AEW&C and Over-The-Horizon targeting capability, given the challenging radar performance demands involved. While evolution of existing helicopter ASW/ASuW radars would provide a limited capability, this is unlikely to be credible with more advanced ASCM threats.

In conclusion, the means now exists to significantly improve surface fleet survivability against saturation ASCM attacks using AEW&C capabilities for Over-The-Horizon SAM targeting, but the equipment is costly and will further drive up the expense in surface fleet procurements and sustainment.

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