The changing world of maritime patrol

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Boeing's MMA proposal is based on the 737-800 airframe, with a heavier -900 series wing. The fuselage is extensively modified to accommodate a sonobuoy bay and internal weapon bay. Pylons are used for the external carriage of weapons such as the Harpoon missile. Photo: Boeing

The world of Long Range Maritime Patrol is undergoing the biggest technological and operational changes seen since its inception during the 1940s. These changes are a reflection of evolving roles and missions, and growth in a range of new technologies, especially long endurance UAVs and ISR sensors. Over the next two decades we can expect to see the evolution of a quite different paradigm to that we have known for six decades.

Operational drivers of change

The 'classical' paradigm of maritime patrol, which we see in Australia's AP-3C Orion fleet, has seen progressive incremental evolution in technology and technique since 1942, when maritime patrol forces first became significant components of Western force structures.

The earliest origins of modern maritime patrol lie in the German Luftwaffe's Fw-200 Condor fleet used during the Battle for the Atlantic. Individual Condors, working with diesel-electric submarines and 'wolfpacks' inflicted enormous attrition upon the Allied merchant shipping fleet and it was clear that escort vessels simply could not provide the protection required. The four engine FW-200 Condors, modified from commercial transports, flew from bases in France and Norway and attacked surface shipping with bombs and cannon. The mere 15 aircraft of I/KG 40 sank 90,000 tons of shipping over a 3 month period in 1940.

Britain's response was to build up Coastal Command, starting with expansion of its fleet of Sunderland flying boats, introducing the US Catalina, and redeploying obsoleted Bomber Command Whitleys, Wellingtons and later Warwicks. Coastal Command continued to grow, adopting the US B-17 as the Fortress GR.II and the GR.I/V/VI variants of the Liberator to expand fleet numbers. The decisive technological innovation was the adoption of surface search radars which could detect shipping and surfaced U-boots. The Kriegsmarine's response was to invent the snorkel, but it too was detectable by radar. Coastal Command hunted down the U-boots, blockade running German transports, and opportunities permitting, the elusive FW-200 fleet. This model was quickly adopted by the US Navy in the Atlantic and later Pacific, with the

We have yet to see the full impact of HALE UAVs such as the RQ-4 Global Hawk on the maritime patrol roles and missions environment. With superior footprint coverage and persistence, UAVs offer some attractive capabilities absent in 'classical' manned patrol aircraft. Photo: Northrop Grumman

slow and clumsy Catalinas soon supplanted by the PB4Y-1, a rebadged B-24D/J, and later its offspring the single tail PB4Y-2 Privateer.

The Cold War era saw incremental evolution of this model, with maritime patrol fleets dominated by recycled heavy bombers like the Lancaster / Shackleton, and the Lockheed P-2V Neptune, built until the early 1960s. Equipped with surface search radar, magnetic anomaly detection equipment and sonobuoys, the P-2V Neptune defined the maritime patrol model used until quite recently.

During this era the principal role of maritime patrol forces was to hunt down Soviet submarines, be they SSKs, SSGs, SSBs, SSBNs, SSGNs or SSNs. Opportunities permitting, Soviet surface assets would also be engaged and destroyed. This era saw the emergence of the ubiquitous P-3 Orion, derived from the Lockheed Electra transport, while the RAF fielded the Nimrod, derived from the Comet transport, and France/Germany the Atlantique, the only one purpose built for maritime patrol. All three of these types are apt to remain in service over the next two decades.

By the end of the Cold War the role of maritime patrol aircraft remained firmly centred in maritime reconnaissance, surveillance, ASuW (surface strike) and ASW. Sensor suites typically included radar with Inverse Synthetic Aperture Radar (ISAR) modes for shipping identification, thermal imagers for close in identification, Electronic Support Measures (ESM) for sniffing out surface radar emissions, diesel fume detection apparatus to sniff out snorkelling SSKs, Magnetic Anomaly Detectors (MAD) to detect submerged subs, and suites of active and passive sonobuoys. Weapons included typically homing torpedoes, depth charges, naval mines and anti-ship cruise missiles such as the Harpoon or Exocet. These aircraft evolved into a 'Swiss Army Knife' package of sensors and weapons.

After the Soviets collapsed and globalisation took hold, significant changes began to emerge in the roles and missions demanded of maritime patrol fleets. Maritime sovereignty missions increased in prominence as drug runners, gun runners, people smugglers and other violators of national borders increased activity levels. As Western navies shifted from 'blue water' operations to 'littoral' or 'brown water' operations, maritime patrol aircraft were further pressured to expand their roles. Terrorism and rogue states engaged in drug running and illegal exports of ballistic missiles, and Weapons of Mass Destruction technology have put further pressure on maritime patrol fleets.

In many respects the threat presented by the Soviet Voenno-Morskiy Flot was highly predictable in its evolution. Today maritime patrol aircraft face a reality in which their 'classical' roles of ASW/ASuW remain, albeit flown less frequently, and a wide range of electronic, radar and optical ISR roles have been added, encompassing quasi-military maritime sovereignty tasks and broader intelligence gathering roles. While maritime patrol remains an 'armed ISR' role, the ISR component continues to grow in importance but the weapon delivery component must remain.

Future growth will continue in the ISR domain as opponents learn to evade established sensors and patrol techniques. The US Navy has experimented extensively with the use of the carrier-borne S-3B and the land based P-3 as land ISR platforms equipped with Ground Moving Target Indicator / Synthetic Aperture Radar (GMTI/SAR) packages, such as the Ku-band APY-6, essentially duplicating the capabilities of the massive US Air Force E-8C JSTARS over a much smaller footprint. Such a system can perform all weather realtime ISR over both landmasses and oceans.

An opponent such as a terrorist group, smuggling insurgents and weapons in congested littoral or archipelagic waterways, can employ camouflage, deception and concealment to evade conventional ISR systems. No differently people/arms/narcotics smugglers can play the same game.

ASuW strike capabilities will remain centred in anti-shipping missiles like the Harpoon, although increasing long range defensive missile capabilities on warships will over time force the adoption of longer ranging and stealthier missiles. Land strike capabilities will remain for all practical purposes in the 'target of opportunity long range shot' domain as maritime aircraft are not survivable in the face of long range SAMs and modern fighters.

The recent DoD decision to use the AP-3C as a primary front line strike asset is predicated on the absence of any opposing air defence capabilities.

The longer term reality is that maritime patrol forces will need to be increasingly diverse in their capabilities, be it in terms of the ISR suites carried or the weapons delivered. Therefore future maritime patrol aircraft will need tremendous capacity for evolution in systems and weapons. Concurrently, persistence and cost of operations will continue to be a key priority.

Technological drivers of change

The technological changes we are seeing in the maritime patrol world are in many respects more dramatic than during any previous period of evolution. These changes fall into the domain of ISR systems, and increasingly the exploitation of High Altitude Long Endurance (HALE) UAV technology.

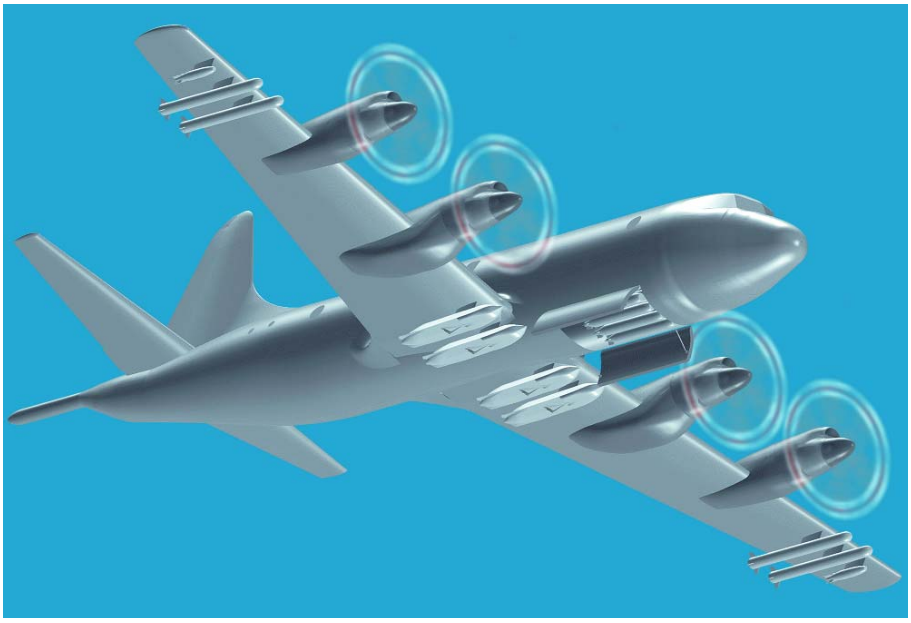
A maritime patrol ISR package will require considerable breadth across the spectrum of roles to be covered, and fleets with mixes of variously 'customised' platforms are a very likely prospect.

In radar technology we are likely to see the progressive adoption of surface search radars derived from mid range fighter radars, as the economics of mechanically scanned dedicated maritime radars become unsustainable.

Modern fighter AESA radars like the APG-79, APG-80 and JSF radar will be built in hundreds or thousands, and will deliver better power-aperture performance than traditional maritime radars. They will also include delivery modes for a wide range of standoff weapons, GMTI/SAR modes, and Maritime MTI/ISAR modes.

In addition, many maritime aircraft will acquire dedicated, typically

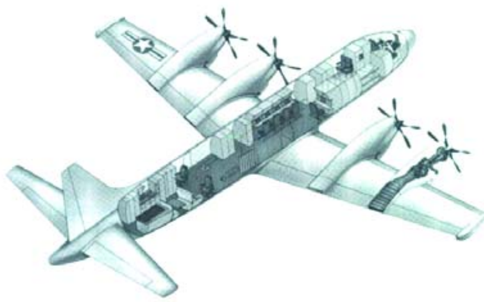
Lockheed-Martin's MMA proposal is likely to draw heavily on the effort invested into the stillborn P-7A LRAACA program, intended to replace the P-3C over a decade ago. The LRAACA was around 30,000 lb heavier than the P-3C. Photo: Lockheed



sidelooking, GMTI/MMTI/SAR radars to provide longer range surface mapping and small moving ground/maritime/air target detection and tracking thus providing capabilities in the JSTARS/ASTOR domain. Users like Australia confronted with littoral/archipelagic environments will be under much pressure to become early adopters of this technology.

In passive electronic detection technology, we will see increasing pressure to provide electronic and signals intelligence suites, capable of precise geo-location of radar and communications emitters, but also providing for signals intelligence gathering and near real time analysis. A terrorist using a satellite phone from a junk or barge hidden in archipelagic waters would make a good case study target emitter - the location, unique signature of the satphone, and contents of the conversation all represent intelligence of value. Most current ESM systems are capable of geo-location through consecutive bearing measurements - longer term pressure will grow for genuine fast Emitter Location System capabilities to be added - be it Differential Doppler, Differential Time of Arrival, Phase Rate of Change or hybrid hardware. Vendors of ESM/ELS equipment will find a lucrative market over time in maritime patrol.

The RAAF faces some interesting technological, budgetary and force structuring challenges over the coming decade if it is to continue to provide world class maritime patrol capabilities.



Optical sensors will also increase in importance, as these can be vital to effecting identification of surface contacts and also land targets. The longwave scanning thermal imagers which dominate current fleets will be displaced by multispectral Focal Plane Arrays, in the thermal imaging bands QWIP technology will dominate, while commercial colour High Definition TV imaging devices will be adopted very widely - high resolution daylight colour imagery can be vital in counter-terrorist and national sovereignty roles. More specialised tools like hyperspectral imagers are also likely to appear as these provide unique identification capabilities absent in three colour or single colour imagers.

ASW sensors are not an area of aggressive growth at this time, but as quiet diesel electric subs proliferate in less stable parts of the world, pressure will exist to improve shallow water detection capabilities. MAD technologies like SQUID sensors may see increasing use. Smarter sonobuoys with powerful digital signal processing chips - using COTS technology - will become a growth market. We may also see the revival of diesel exhaust fume sniffers - albeit implemented with LIDAR technology permitting standoff ranges of many miles.

Mission consoles will over time shift away from the established specialised designs toward common digital consoles using large colour LCD or plasma displays. The two drivers will be cost reduction through common hardware, and role flexibility demanded of the system. An aircraft equipped with a dozen ISR sensors will not have the space for dedicated sensor consoles - common consoles with unique software will be the only way to rapidly reconfigure the aircraft across dramatically divergent roles - more so if the role shift happens during a sortie.

Future maritime mission computer packages are apt to follow the model we see now in the RAAF's Wedgetail AEW&C - racked COTS computing equipment permitting incremental growth in computing power, and rapid turnover of onboard computers to stay abreast of Moore's Law. We are likely to see large onboard intelligence databases stored on such systems - digital elevation maps, electronic signature information and other aids to target geolocation and identification.

Maritime aircraft will increasingly require digital datalinks to integrate with other ISR assets and strike aircraft it might direct in higher threat environments. Satellite communications are a must for the aircraft's basic roles, and the presence of both will over time lead to the inevitable step of turning the maritime patrol aircraft into a digital voice and data communications relay hub. With the size, internal volume, power and cooling capacity to support high speed satcom links and relay hardware, this is an inevitability. The 'smart tanker' hardware developed for the US Air Force is apt to be an early candidate.

The cost of future maritime patrol aircraft will be dominated by the highly flexible and capable, but complex ISR/ASW suites. Weapons systems will be digital Mil-Std-1760 schemes, permitting the addition of virtually all guided munitions in the inventory.

Aside from ISR suite technologies, the other large driver of change will be the adoption of HALE UAV technology. Originally designed for long range and persistent targeting ISR over land, UAVs have rapidly attracted the interest of maritime patrol strategists and planners.

Maritime patrol operations have historically been expensive and remain so, as large aircraft with complex systems and large crews must remain aloft for very long sorties. Australia's AP-3C Wing has been the most expensive of all the RAAF's force elements to operate, as the nature of the role and the size of the platform and crew cannot be escaped.

For many of the roles a maritime patrol force must perform the 'classical' large manned aircraft is an unavoidable reality. Prosecuting a submerged submarine, laying naval mines or harassing a Surface Action Group with missile shots are roles which are incompatible with HALE UAVs. Conversely, long endurance patrols over ocean searching for surface contacts fit very nicely against the capabilities of ISR oriented HALE UAVs. Refinements in radar and ESM modes to accommodate maritime targets are the principal deviations from the conventional land oriented ISR capabilities.

The ADF's interest in the Northrop-Grumman RQ-4 Global Hawk HALE UAV, and the US Navy's BAMS (Broad Area Maritime Surveillance) effort, centred on the RQ-4 and new enlarged RQ-1 Predator ER variants are good examples.

The idea of a mixed force of 'classical' maritime patrol aircraft and HALE UAVs is simple - the UAVs absorb the tedious wide area patrol sorties, while the maritime patrol aircraft are employed for more complex low altitude sorties in which a surface or sub-surface contact must be identified and if required, prosecuted. The UAV's ISR suite is optimised for long range wide area surface contact detection, primarily using radar, ESM and high gain optical sensors. The manned patrol aircraft carries these and other sensors, and of course weapons.

In practice such a force would shift a significant proportion of its total hours across to the UAV component, reducing fatigue life consumption, personnel and airframe support costs incurred on the more expensive and complex manned component. HALE UAVs are not a cheap solution in their own right, the ISR package can be very expensive, the ground support stations are inherently expensive, and the hidden cost of satellite bandwidth must be factored in. The economic advantage in the HALE UAV derives from its persistence, as a larger fraction of its sortie time can be actively used for ISR work, and the simpler airframe, which demands less maintenance than a militarised airliner airframe exposed to low altitude turbulent flight. Unlike manned aircraft which incur a large number of crew hours in transit, a HALE UAV ground station crew's transit time from the base to the console is measured in minutes.

HALE UAVs are not a panacea, but offer a highly valuable complementary capability to the manned maritime patrol aircraft.

On board a US Navy P3-C Orion.

Australia's

Australia's AP-3C Orions are expected to run out of fatigue life later in the next decade. Replacement of the two squadrons will present genuine budgetary challenges given the large impact of currently planned JSF acquisition.
Photo: RAAF

options

The RAAF's AP-3C Orion fleet is expected to run out of fatigue life between 2015 and 2020, if current DoD statements are accurate. Australia has a range of options it could pursue to maintain this vital capability. A key issue for Australia in the longer term will be the direction which is taken by the US Navy with its BAMS and Multimission Maritime Aircraft (MMA) P-3C replacement program.

The MMA program is expected to be a fly off between a Lockheed-Martin proposal, based on a P-3 derivative, and Boeing's new entrant in the game, a derivative of the 737-800, similar to the RAAF's Wedgetail.

Few details were available at the time of writing on the LM proposal. LM invested a large amount a decade ago into the P-7A LRAACA (Long Range Air ASW-Capable Aircraft) intended then to replace the P-3C fleet. The LRAACA was a new build P-3 derivative, with a large composite material airframe fraction and new engines. It is likely that the LM MMA proposal will build on experience with the LRAACA and later P-3C upgrades developed since then. The LM MMA is expected to be cheaper to operate than the P-3C, with range and speed improvements.

Boeing's MMA in many respects follows LM's evolutionary path from the Electra to the Orion - a successful commercial airframe is evolved into a maritime patrol aircraft. The baseline 737-800 is used as the starting point, with a later -900 series wing, external pylons for stores, a fuselage weapon bay and an ISR suite added. This militarised 737-800 will be larger and heavier than a P-3C, but with a greater payload capability, more internal volume and greater long term mission growth potential.

If we assume similar mission package capabilities, then the principal distinction between the turboprop LM proposal and the turbofan Boeing proposal will lie in their transit speeds and surface search patrol altitudes and footprints. The Boeing MMA will transit faster and cover a larger sensor footprint from a higher altitude yielding a productivity advantage over the altitude limited turboprop. P-3 advocates have focussed on the low altitude performance of the Boeing MMA - Boeing vigorously argue the merits of their design in low altitude operations.

The pragmatic reality is that Australia is likely to follow the US Navy's path simply to exploit the economies of scale which accrue. The bigger issue for the RAAF in the near term is controlling the timelines in which the AP-3C will be replaced, to avoid yet another budgetary spike. The original AIR 6000 plan was to buy blocks of first F/A-18A and later F-111 replacements over a two decade period to spread the expense over time. This was abandoned with the JSF decision last year, compressing the replacement into the next decade. The recent decision to dump the F-111 early is apt to result in further budgetary timeline compression as F/A-18A fatigue life expiry coincides with expected JSF delivery delays. It would thus be very difficult to replace 20 AP-3Cs with new aircraft in the 2015 to 2025 period.

The RAAF's options will revolve around ways to extend AP-3C fleet fatigue and corrosion life past 2020 - be it by appropriate structural rebuilds or the introduction of a HALE UAV like the Global Hawk to reduce the rate of airframe life consumption. It is unlikely that the demand for maritime patrol hours will abate in coming years. An issue will remain how to economically add additional ISR sensors - industry proposals like the weapon bay mounted MMSP/CMAP could prove very useful.

The RAAF faces some interesting technological, budgetary and force structuring challenges over the coming decade if it is to continue to provide world class maritime patrol capabilities. How well these are addressed remains to be seen.