Wedgetail - Australia's "Pocket AWACS" (*Australian Aviation*, June 1999, p 26-29.)

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October 5, 2000

1 Introduction

In the nearer future Australian taxpayers should know which of the three Wedgetail bidders will be contracted to supply the ADF's new Airborne Early Warning & Control (AEW&C) system. Without any doubt, this will be the most expensive and complex platform ever acquired and operated by the ADF, and a decisive battle management asset in any future conflict.

The strategic importance of the Wedgetail program to the ADF cannot be overstated - it is the single most important purchase the ADF will have made in the last five decades.

For the first ever time, the ADF will have the ability to surveil, command, control and coordinate a joint air/sea/land battle in real time. Until now, whatever capabilities the ADF had to conduct such engagements were dependent upon pooling information from diverse sources, which presents formidable difficulties if a rapid operational level or tactical level response is required. A picture of the battlespace would need to be compiled from a large number of reconnaissance "snapshots", few of which could be delivered let alone assembled into a cohesive picture in real time.

Wedgetail combines a long range surveillance radar, a secondary radar (IFF/SSR), passive detection surveillance receivers, tactical/strategic voice and data communications systems and air traffic control facility, all in one platform capable of virtually unlimited rapid long range deployment with inflight refuelling. As such it is both a surveillance and realtime reconnaissance asset, as well as a command and control platform, thus producing in effect a complete battle management system.

While Wedgetail may appear to be a RAAF specific asset, this is a common misconception carried over from previous decades. Any battle conducted in the defence of the air sea gap, or as part of an expeditionary force, will necessarily involve assets from all three services. Seeing the big picture as it happens, and coordinating the assets of all three services, are necessary and essential preconditions for a successful outcome. Kim Beasley's now prophetic words of more than a decade ago: "With it [AEW&C] you win, without it you lose" should not be lost upon any observer. The ADF is a small defence force, and to be effective it must be able to apply every asset it has to best advantage. Wedgetail is the critical enabling capability for this.

Whilst it was fashionable over a decade ago to argue the case for AEW&C vs the case for JORN, the ADF has correctly decided that the two assets are complementary in capabilities, rather than competitive. There is no zero sum game in these capabilities. JORN provides a very long range "tripwire" capability, Wedgetail provides an in theatre battle management capability.

There are fundamental differences in these capabilities. JORN has limited resolution, blind time windows due ionospheric conditions, no known heightfinding capability, and no ability to identify non-cooperating tracks from their signatures. It does have superlative area coverage, with a total footprint which could only be matched by multiple microwave radar equipped low orbit satellites.

Wedgetail's footprint is limited by station altitude and sensor performance. About 150-250 NMI for surface and low flying targets limited by station altitude and the geometry of a curved earth, and much further for medium to high altitude targets, limited by the choice of radar. Wedgetail however has the ability to resolve targets with very high accuracy, identify and sort these targets, and control air and surface assets.

The "traditional" picture of an AEW&C platform being a dedicated air defence asset is an artifact of past times. The abilities provided by modern AEW&C systems encompass the detection, identification and tracking of both airborne and sea surface targets by radar and passive ESM detection, and friendly air/sea/land assets equipped with suitable onboard transponders or datalink terminals. The only capability missing is the JSTARS style high resolution SAR surface mapping and GMTI surface target tracking, both of which are secondary capabilities in the regional geographical environment, dominated by littoral scenarios (and both of which may be growth options given declining long term costs in computer hardware).

In the context of an air-sea battle, a modern AEW&C asset like Wedgetail provides the essential capability to control the deployment of defensive assets to best advantage against an attacker in aircraft or surface ships, frustrating their manoeuvre strategy. CAPs and SAGs can be positioned to best advantage to block an opponent. No less importantly, it allows the best deployment of offensive

assets to bypass an opponent's defensive deployment. In practical terms, this means a strike package can be routed around a defensive CAP, denying them the geometry to close to an engagement. SAGs can be provided with a wide area picture allowing them the choice of engagement geometry, or the choice of avoiding engagement if required.

No less importantly, the ADF now acquires the ability to precisely coordinate RAAF and RAN combat assets at a broader operational level. An opposing SAG can be concurrently engaged by air and naval assets, making things extremely difficult for an opponent. Saturation ASM attacks by RAAF assets can be followed up by close in mopping up by RAN surface assets.

Land battle and littoral scenarios benefit no less from the presence of a modern AEW&C asset. Hostile air defences, CAPs and helicopters are stripped of concealment by terrain and may be engaged by RAAF assets. Army helicopters may be routed around air defences, just as strike packages performing battlefield air interdiction may be positioned to best advantage.

The only defence against a coordinated and capable force under the watchful eye of an AEW&C platform, is to have a better AEW&C platform, and a better battle strategy.

The deployment of Wedgetail by the ADF will carry with it essential strategic complexities. As the single highest value asset in the battlespace, it will become the primary target of any opponent, who will go to any lengths to kill it if he understands its importance. Kamikaze special forces and fighter aircraft attacks should be expected, as well as long range anti-radiation missile attacks, should the opponent have that level of sophistication.

An opponent with nuclear capability could be expected to use a nuclear armed ballistic missile to kill an asset of such value, should their position be sufficiently precarious.

The consequence of deploying an AEW&C capability is that an in depth defensive strategy must be employed to prevent its loss in combat. Operating bases will need to be well defended on the ground, and fighter CAPs available in the numbers and lethality required to stop a kamikaze attack or saturation fighter attack dead.

This issue has its advantages strategically, insofar as it forces an opponent to channel his effort in a specific fashion, thereby making his behaviour more predictable. Just as the mighty 8th used its B-17s and B-24s to lure the Luftwaffe into a suicidal battle with its fighters, so an AEW&C platform can place an opponent in the position where he must pour his vital assets into an attempt to kill it.

One of the curious aspects of Desert Storm was that the anticipated kamikaze attacks by afterburning Foxbats against the most exposed E-3 AWACS aircraft never eventuated. The Iraqis never grasped the importance of the AWACS.

2 Pocket AWACS - A New Category of AEW&C Aircraft

Australia's Wedgetail is the first of a new generation of AEW&C aircraft, which could most aptly be described as a "pocket AWACS".

Traditionally AEW&C aircraft could be divided into small, short range systems, capable of tracking modest numbers of targets at modest ranges, and large, long range systems, designed to track large numbers of targets at long ranges.

The classical examples of the former were the E-2B/C, the Shackleton AEW, and the various lightweight naval systems carried by helicopters and fixed wing naval aircraft. A more recent example is the Erieye system, an early Wedgetail bidder. Such AEW&C assets were designed for modest or low threat density environments, short or modest endurance, and essentially tasked with providing air defence coverage over a modest footprint. Defending a CVBG would be the classical example, or providing air defence coverage in tight Middle Eastern or Scandinavian geographies.

Such systems are characteristically light in terms of onboard command and control capabilities, and are typically closely linked into a surface air defence environment. The E-2C datalinking its situational picture into the CIC of an Aegis cruiser, or the Erieye datalinking into the dense Swedish IADS, represent the essential paradigm of such systems.

The USAF were the first to go the route of large systems with complete onboard battle management capability, designed to cover the largest possible footprint and provide the complete capability to independently manage an air battle from the cabin of the aircraft. While the various EC/RC-121 variants were the first step in this direction, the E-3A AWACS was the first true example. Designed to win the NATO vs Warpac air battle, the E-3A had unprecedented endurance, radar range, and importantly, the ability to track very large numbers of targets. The latter in turn meant a large number of operator consoles, and large package of communications and datalink channels, pushing up the complexity and cost of ownership of the system.

The ADF was however caught in a dilemma of strategic geography, a factor which has hampered its long standing interest in acquiring an AEW&C capability. Large distances, huge areas to cover, with potential opponents in more recent times acquiring some very high performance aircraft. Yet, the same geographical context resulting in a much lower density of targets in any feasible regional scenarios.

Opting for the "affordable" low end choices of the E-2C or like systems, it gets the appropriate size of target tracking capability and communications package,

but is constrained to a much smaller coverage footprint, and a turboprop airframe with inadequate range and endurance. Without a supporting surface based air defence system, the limited C3 capability of a three operator airframe meant that the system would simply not fulfill the inherent requirements of the ADF's situation.

Opting for the "unaffordable" top end choice of the E-3B, the ADF gets the required coverage footprint, airframe endurance and range, and capability of onboard C3 systems to do what is required. The snag is that the baseline E-3B was so much excess target tracking and C3 capability, that it is overkill for the scenario. Total cost therefore precludes deployment of numbers which are genuinely useful.

During the mid-eighties Boeing did its best to tempt the RAAF with a "cut down" E-3B variant, with a reduced number of consoles, single rather than dual redundant radar, and reduced capability C3 suite. The system was in many respects a good fit for the Australian scenario, but was still penalised in cost insofar as many parts of the system were standard E-3 components, in a system sized to be much bigger. The overhead of supporting the older technology B-707/C-137 airframe would seriously bite into any economies gained on the mission package.

Lockheed and Grumman during this period made the first steps in the direction of a mid range system. Lockheed proposed variants of the E-2C APS-125 UHF band radar, with modest new technology consoles, fitted to the C-130H or P-3C airframes. These ultimately became the basis of US Customs and Coast Guard systems used for drug interdiction operations. Grumman proposed a C-130 solution using a palletised E-2C mid fuselage section, wiring harnesses, consoles and seats all bundled into one package.

While both of these proposals came closer to the ADF's needs, they were to some degree penalised by the limited on station altitude and speed of the turboprop airframes of that generation, and the limitations of the -125 radar, carefully optimised for the naval air defence environment. With limited overland capability, and limited footprint, the repackaged mid-life E-2C system on a standard turboprop airframe fell a little short of what was really needed by the ADF.

A factor of some importance was that in all instances, the gaps between capability and cost of this generation of proposals would have significantly compromised any competitive bidding process.

The nineties brought about important changes in available technology for mid range AEW&C systems. Westinghouse commenced the development and early testing of its MESA phased array, originally designed as a low cost podded solution for the C-130 airframe. Elta in Israel designed and built the Phalcon phased array, opting for a cumbersome sidelooking fuselage box arrangement on the B-707 airframe. The technology base was becoming available for a very

modern package on a modestly sized airframe. Lockheed, amalgamating with Martin-Marietta, continued to build upon the original APS-125/C-130 package, and further developed the capabilities of their original baseline system.

Another no less important development in technology was the rapidly declining cost of high performance computers, and the increasing availability of ruggedised milspec variants of commercial Unix/X11 computers. This in turn allowed a potent yet lightweight onboard mission package, and capable digital consoles, at a very modest cost against the heavy custom built IBM mainframe derived systems on the original E-3A/B.

When the ADF initiated the AIR 5077 Wedgetail program to acquire an AEW&C capability, a wide range of proposals appeared. Critical and unique requirements of AIR 5077 were high radar performance, 360 degree coverage, integrated ESM, onboard defensive countermeasures, affordable ruggedised COTS computers, and a mid range airframe size. The first "Pocket AWACS" was created as a concept by the AIR 5077 project team. To their credit, they took the strategic perspective on technology and opted to include the relatively immature technology of fixed phased arrays, an alternative with considerable long term technology growth potential against the established mechanically rotated antenna.

Phased arrays offer potentially "Aegis-like" scan and tracking capabilities, the potential for exceptional ECCM capabilities against conventional antennas, no moving parts, and exceptional reliability by virtue of independent transmit/receive modules.

An interesting side note was that the model established by the Wedgetail team has come under serious discussion in USAF circles as an "expeditionary force" substitute for the heavyweight E-3. An expeditionary force comprising one or two composite wings would become much more flexible with its own 2-3 aircraft AEW&C detachment, an option difficult to provide with the support intensive and numbers limited E-3C. The "Pocket AWACS" may therefore prove to be a major long term production item for winning bidder, be it in the export market, or potentially the US market.

The AIR 5077 team shortlisted three proposals, and awarded Initial Design Activity contracts to three teams, as a risk reduction measure. In this fashion the three bidders were funded to produce much more detailed proposals than would have been otherwise judged prudent in a zero sum game of this scale.

Two of the proposals are based upon medium/high PRF pulse Doppler phased array radars and turbofan powered commercial airframes. One proposal is a low risk fallback, technologically, using a rotating mechanically azimuth steered antenna and a turboprop airframe, albeit using the latest technology in many areas of the design.

The largest proposal is that of the Raytheon Systems Company, based upon

the Elta Phalcon radar and the Airbus A310 widebody airframe. This system is "conventional" in configuration, in that it uses a rotodome like, yet fixed radome above the fuselage, which contains the three sided L/D band phased array and IFF antennas. Each array covers a 120 degree sector. The ESM is fitted to wingtip pods.

The proposal marries a minimal risk phased array configuration, with guaranteed high antenna performance through 360 degrees, with a very large and mature airframe for a maximum of onboard systems growth and crew comfort on long endurance missions. Its principal limitation against the other bidders is likely to be in the all up costs, and operating costs, of a large widebody airframe.

The proposal was clearly sized about the requirement for best possible all-azimuth radar performance, with antenna aperture size (determining range and angular resolution for a given level of receiver and transmitter performance) driving the radome size, in turn driving the airframe size, for specified performance.

The most technologically innovative proposal is that of the Boeing led team, built around an evolved variant of the now Northrop-Grumman MESA radar and the Boeing B-737-700 narrowbody airframe. The Boeing/N-G Wedgetail is "unconventional" insofar as it uses a unique antenna design. Sidelooking coverage for two 120 degree sectors is provided by the L/D-band MESA in a dorsal fin structure, while nose and tail coverage over 60 degree sectors is provided by an electronically steered "tophat" end-fire array mounted in a surfboard shaped radome above the MESA arrays. Angular resolution of the "tophat" array varies from several degrees over the nose and tail, improving by a factor of four as the beam is steered to 30 degrees off the antenna boresight. ESM is carried in wingtip pods.

The Boeing/N-G proposal incurs higher risk against the Raytheon/Elta proposal, insofar as it employs a more complex antenna arrangement, which has not been used in any other design. However, the payoff is in a much smaller, lighter and lower drag antenna installation, which allows for a smaller and cheaper narrowbody airframe. With the installed base of 737s, the stretched -700 is about as economically supportable as a narrowbody gets.

The simplest comparison of the configurations of the two phased array based solutions is that one incurs lower risk in antenna integration and complexity at the cost of a bigger and more expensive widebody platform. Determining the scale of the cost vs risk issues is impossible without a deeper evaluation of both proposals, and full access to technical data, neither of which are options for a public discussion.

The third contender is the Lockheed-Martin/Northrop-Grumman team, with the C-130J-30 based proposal, using the AURA solid state transmitter derivative mechanically steered UHF radar, based upon the Yagi array antenna technology of the E-2C APS-125/145. Interesting, marketing literature for the system cites

electronic beam steering, which it is safe to assume is being used for ECCM and heightfinding purposes.

The L-M/N-G proposal is the lowest risk of the three bids, in terms of antenna technology (with the caveat that in a system of such complexity as Wedgetail, risk is not confined to the antenna alone !). However, it also offers little in the way of long term technological growth potential within the basic antenna technology. The trade in judging this antenna arrangement, other than raw performance, lies in near term capability and risk against long term capability and risk. At the point of initial service entry, this arrangement clearly runs the lowest risk of not meeting performance requirements, accepting that in 5-10 years time the antenna will no longer hold this advantage against the now less mature phased arrays.

In terms of footprint for long endurance on station operation, the turboprop is typically penalised against a turbofan by increasing power demands and thus gas burn with increasing station altitude. The lower you are, the closer the radar horizon. Without detailed data on the signal processing techniques used in the radar it is impossible to judge the long range look down performance against the pulse Doppler proposals. Assuming that the radar can deliver the goods in this respect, then the issue of lookdown range to the horizon is then determined by the on station time and altitude parameters of the C-130J-30 airframe. Comparisons against the C-130H are not relevant given the much higher installed power of the C-130J.

It is the only bid based upon an existing RAAF in service airframe, which the bidder indeed argues strenuously.

Given the sheer complexity of all three Wedgetail bids, and overall assessment of relative risk is not feasible without full access to supporting data. The software and integration issues for all three proposals have similar potential to incur development risks. If your antenna is lower risk than another bidder's offer, is your software, your consoles, your integration also of lower risk ?

This lightweight discussion of relative system attributes underscores the difficulties which the AIR 5077 team, and DSTO, will face in assessing the three bids. All bids are based on variants of very mature airframes, all bids involve very complex system level designs, with high levels of integration. Assessment of total system capabilities will be a challenging task.

What is certain is that the service introduction of the Wedgetail will propel the ADF into the leading edge of battle management technology, and will provide it with a decisive near to medium term capability advantage over other wider regional players.