AWACS AND AEROSTATS: ROLES AND MISSIONS

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Modernisation and development are the processes of evolution. While scientists across the globe have made our lives comfortable by providing more efficient gadgetry and machinery, the innovations in the field of weaponry and their delivery systems have left the Air Defence (AD) planners working overtime to find suitable solutions to counter this development. Advancements have led to development of aircraft flying at high speeds and ultra low levels. Modern precision navigational systems help these aircraft navigate through hills to reach their designated targets and deliver their weapon loads with pinpoint accuracy.

The oldest adage from the dawn of air combat is, *"He, who spots first, has the advantage"*. The premise holds good to this day, even while technology continues to advance at a rapid pace. Air defence by definition is reactive and is directly dependent upon the availability of early warning to the air defence forces. All efforts are, therefore, on to increase the extent of early warning to the troops and decision matrix. While the reaction time is being curtailed by using computerised networks with modern generation data handling systems, the early warning is planned to be enhanced by induction of aerostats or Airborne Warning and Control System (AWACS).

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RADARS

Early writers of air power had emphatically prophesied the invulnerability and destructive capability of the manned bomber. It is true that in the absence of any early warning, by the time an enemy aircraft was detected either audibly or the visually, it was too late for the fighter aircraft on the ground to get airborne and hope to carry out a successful intercept. What they had, perhaps, not anticipated was the invention of the radar.

The initial developments in radar technology started way back in 1887 when the German physicist Heinrich Hertz began experimenting with radio waves in his laboratory. He found that radio waves could be transmitted through different types of materials, and were reflected by others, such as conductors and dielectrics. The existence of electromagnetic waves was predicted earlier by the Scottish physicist James Clerk Maxwell, but it was Hertz who first succeeded in generating and detecting radio waves.

The history of radar began in the 1900s when engineers invented simple uni-directional ranging devices. The technique developed through the 1920s and 1930s, led to the introduction of the first early warning radar networks just before the start of World War II. At the start of World War II, both the United Kingdom and Germany knew of each other's ongoing efforts in their "battle of the beams". Both nations were intensely interested in the other's developments in the field. By the time of the Battle of Britain, both sides were deploying radar units and control stations as part of integrated air defence capability. Progress during the war was rapid; by the end, the United States widely deployed radars that fit in a single semi-trailer.[1] It would be interesting to study the work done by some countries in the development of the radar.

Dutch Early Radars. Dutch scientists Weiler and Gratema were inspired by queries about "death rays" from their military, to start developing radar. They were well advanced by May 1940, and had built four working prototypes of centimetric gunlaying[2] radar operating at a wavelength of 50 cm and a

1. From www.en.wikipedia.org/wiki/history of radar accessed on January 15, 2009
2. "Gun laying is the process of aiming an artillery piece. The term is also applied to describe the process of aiming smaller calibre weapons by radar or computer control. The gun is typically traversed - rotated in a horizontal plane in order to gain a line of sight to the target; and elevated - moved in the vertical plane, to range it to the target", reference: http://en.wikipedia.org/wiki/Gun_laying

practical range of 20 km.[3]

UK. Shortly before the outbreak of World War II, several radar stations known as Chain Home (CH) were constructed along the south and east coasts of Britain. These radars operated at a frequency of 20 to 30 MHz (15 to 10 m) wavelength) and peak power of 350 kilowatts (KW). CH proved highly effective during the Battle of Britain, and is often credited with allowing the Royal Air Force (RAF) to defeat the much larger Luftwaffe forces. Whereas the Luftwaffe had to hunt all over to find the RAF fighters, the RAF knew exactly where the Luftwaffe bombers were, and could converge all their available fighters on them. In modern terminology, CH was a force multiplier, allowing the RAF fighters to operate more effectively as if they were a much larger force operating at the same effectiveness as the Germans. In order to avoid the CH system, the Luftwaffe adopted other tactics. One was to approach Britain at very low levels, below the sight line of the radar stations. This was countered to some degree with a series of shorter range stations built right on the coast, known as Chain Home Low (CHL).

Similar systems were later adapted with a new display to produce the Ground Controlled Intercept (GCI) stations in January 1941. In these systems, the antenna was rotated mechanically, followed by the display on the operator's console. That is, instead of a single line across the bottom of the display from left to right, the line was rotated around the screen at the same speed as the antenna was turning. The result was a 2-D display of the air around the station, with the operator in the middle, with all the aircraft appearing as dots in the proper location in space. These so-called Plan Position Indicators (PPI) dramatically simplified the amount of work needed to track a target on the operator's part. Such a system with a rotating, or sweeping line is what most people continue to associate with a radar display.

Germany. German developments mirrored those in the United Kingdom, but it appears radar received a much lower priority until later in the war. The Freya radar was, in fact, much more sophisticated than its CH counterpart

3. From http://reference.findtarget.com/search/History percent20of percent20radar accessed on February 6, 2009.

and by operating in the 1.2 metre wavelength (as opposed to ten times that for the CH) around 250 MHz, the Freya was much smaller and yet offered better resolution. As regards the PPI systems, it was quite some time before the Luftwaffe had a command and control system nearly as sophisticated as the British one.

US. After early work on radar by the US, conducted in the Twenties at the Naval Research Laboratories, Robert Page[4] successfully demonstrated a pulsed radar experiment in 1934. When the British and US began technology exchanges in 1940, the British were surprised to learn they were not unique in their possession of practical pulse radar technology. The US Navy's pulse radar system, the CXAM radar, was found to be very similar in capability to their Chain Home technology.[5] On entry to World War II, the army and navy had first generation working radar units in frontline units. The army's type SCR-270 radar detected the Japanese planes attacking Pearl Harbour at a range of 132 miles. Although the US had developed pulsed radar systems independent of the British, as had the Germans, there were serious weaknesses in their efforts — the greatest of which was the lack of integration of radar into a unified air defence system.

Japan. Well prior to World War II, Japan had knowledgeable researchers in the technologies necessary for radar but due to lack of appreciation of radar's potential, and rivalry between army, navy and civilian research groups, Japanese technology was three to five years behind that of the US during the war. Although progress was rapid after the value of radar was better appreciated, research continued to be impeded by inter-Service rivalry, and new units, though capable, were too late to influence the outcome of the war. Radar was used by the army for gun laying and aircraft detection, and by the navy for detection of air and sea threats on all major capital ships,

4. Dr. Robert M. Page (1903-1992), Eden Prairie, Minnesota. Retired as Director of Research, US Naval Research Laboratory 1966.
5. "The CXAM is listed (in 'U.S. Radar, Operational Characteristics of Radar Classified by Tactical Application') as being able to detect a single aircraft at 50 miles and to detect large ships at 14 miles. Other sources list CXAM detection range on aircraft out to 100 miles. *Lexington*'s CXAM-1 detected the incoming Japanese carrier aircraft strike at a range of 68 miles during the battle of the Coral Sea", from http://en.wikipedia.org/wiki/CXAM_radar, accessed on March 3, 2009.

including use of centimetric units in 1944.

Canada. Little radar research was done in Canada prior to the start of World War II. However, in 1939, the National Research Council of Canada was tasked with developing a Canadian designed radar system, which was eventually deployed on Royal Canadian Navy ships, thereby putting Canada in the forefront of naval radar deployment.[6]

> *Radar was probably the biggest force multiplier of World War II and the raison* d'être *for the British success in the Battle of Britain.*
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> — Gp Capt Atul Kr Singh[7]

The place of radar in the larger story of science and technology is argued differently by different authors. Radar, far more than the atomic bomb, contributed to Allied victory in World War II.[8] The development of radar during the 1930s transferred aerial warfare from an imprecise adventure into science. At a stroke, the accurate detection of a hostile formation in bad weather and at night became a practical reality. Radar technology has come of age and specific role-oriented radars have replaced the general purpose detection radars. The Indian Air Force (IAF) has a healthy mix of radars which include radars with three-dimensional and two-dimensional coverage capabilities, static and mobile versions as well as long range and limited range systems. The various radars in the IAF can broadly be classified into high/medium level radars and low level radars.

High/Medium Level Radars. The high/medium level radars have long range detection capability ranging from 300 to 450 km; they may be either static or transportable. These radars have an array of systems and Electronic Counter-Counter-Measures (ECCM) techniques. The data handling is either automatic or semi-automatic, so as to have real/near real-time information.

6. ASDIC, Radar and IFF Systems Aboard HMCS HAIDA - Part 8 of 10, accessed through Wikipedia.
7. Group Captain Atul Kumar Singh, *Transformation of Air Defence in Asia*, (New Delhi: Knowledge World, 2008), ch. 2.
8. D.K. van Keuren, "Science Goes to War: The Radiation Laboratory, Radar, and Their Technological Consequences," *Reviews in American History*, 25: 1977, pp. 643--647.

These radars require very high power for their operation. The various high/medium altitude radars available with the IAF are the THD 1955, PSM 33 and TRS 2215, etc.

Low Looking (LL) Radars. The present day low level attacks and tactics by enemy fighters/armed helicopters have given the need for low looking radars. These radars have the capability to detect aircraft/armed helicopters/surface-to-surface missiles at ranges of 90 to 150 km. These are mobile or highly transportable radars with minimum site requirements, which can operate in various places at short notice. The data handling system could be automatic or semi-automatic. The various low lookup radars of the IAF are the ST-68U/UM, Indra I/Indra II, etc.

History has shown us that the ground-based radars have several inherent weaknesses, which are listed below:

- Essentially radar propagation is along Line of Sight (LoS) though radar horizon is more distant than the optical horizon. However, ground-based radar systems still cannot look very far.
- Some of the mobile radars are bulky and require a lot of time to deploy. A few of these mobile versions are unsuitable for all kinds of terrain and all weather operations.
- The targets coming at low level are picked up at very short ranges of 30-40 km, resulting in less reaction time to the AD system.
- Besides low flying, the capabilities of radars can further be degraded by employment of Electronic Warfare (EW) measures. These, in fact, are reaching high levels of sophistication. Ground-based radars are generally static, semi-mobile or mobile and can be located through electronic intelligence and Electronic Support Measures (ESM). The use of Remotely Piloted Vehicles (RPVs) has proved singularly effective in this role, especially since it reduces the risk to manned aircraft during this critical phase of operations. Once the radars are located, they can be neutralised by a hard kill or a soft kill.
- The problem of identification is the most difficult one to solve. Identification of Friend or Foe (IFF) equipment has a large number of shortcomings and

problems.

- Most of them are susceptible to enemy jamming and deception measures.
- Ground-based non-Moving Target Indicator (MTI) radars are restricted due to their siting in the use of some frequencies, for which they receive permanent echoes from terrain features.
- The radar sites are known features and thus prime targets of the enemy.
- There are still some gaps in the LL radar cover along the borders with our neighbours.

Of these, the first two limitations i.e. detection limited to LoS and mobile versions not being fit for all terrain and areas are the major factors that limit the deployment. This results in gaps in the low level detection, especially in hilly terrain.

AEROSTATS

It is said that Napoleon had expressed a need to be able to "look over the hills" and this could be taken as one of the early instances of the requirement for early warning. The French revolutionary armies used balloons as observation posts for their artillery in 1794. In the following century, the Union armies used them in the American Civil War.[9] In fact, balloons can be considered to be the forefathers of modern aerostats. The first balloon flight was demonstrated by the Montgolfier brothers on June 5, 1783. Later that year, they sent up the first balloon crew — a sheep, a rooster, and a duck[10]. Jean-François became the first human to ascend in a balloon on November 21, 1783. The need to preempt the enemy led to the utilisation of balloons for reconnaissance and these were used extensively during the American Civil War.

The persistent demand for low cost surveillance led to radars being fitted to tethered balloons. These were called "aerostats". The term has its origins

9. Air Vice Marshal R.A. Mason, *Air Power: An Overview of Roles* (New Delhi: Ritana Books, 1987), chapter 2.
10. http://en.wikipedia.org/wiki/Montgolfier_brothers

Special fabric surface minimises the snow and ice loading on the aerostats during winter seasons and the ability to withstand bullet holes and cuts in their fabrics proves that aerostats are not as fragile as they appear.

from the Greek words *aēr* meaning air and *statos* meaning standing[11]. The first modern aerostat is the Tethered Aerostat Radar System which was deployed by the United States in 1980. It is used for low level air surveillance to prevent air space violation and to intercept drug trafficking. This aerostat carries the Lockheed Martin L-88 surveillance radar as its primary payload. Among the later aerostats is the Marine Airborne Re-Transmission System (MARTS) which is equipped with transponders for Enhanced Position Locating and Reporting radios. It provides a 24-hour relay within a radius of 125 km for up to 15 days from 3,000 ft. The first MARTS system was deployed in Iraq in early 2005[12].

Capabilities

Modern aerostats have a low level detection range of about 350 km when hoisted to 15,000 ft. These platforms have a deployment period of approximately 30 days at a time. The on station time of aerostats is limited primarily due to loss of helium pressure and maintenance activities. Special fabric surface minimises the snow and ice loading on the aerostats during winter seasons and the ability to withstand bullet holes and cuts in their fabrics proves that aerostats are not as fragile as they appear. Aerostats are capable of withstanding several hundred bullet hits before deflating gradually and undergoing a controlled degradation. Similarly, missiles designed to fuse on a hard surface would pass directly through the balloon structure. Aerostat systems support a wide variety of electronic payload, including Airborne Early Warning (AEW) radar with integrated IFF, Signal Intelligence (SIGINT) and electro-optical payloads, besides operating as radio relays. The payload weight varies from 225 kg (500 lb) for small size aerostats to 2,300 kg (5,000 lb)

11. http://en.wikipedia.org/wiki/Aerostat
12. From *Directory of US Military Rockets and Missiles*, accessed through the link http://www.designation-systems.net/dusrm/app4/aerostats.html, on November 12, 2008.

for the TARS system[13].

Although the original aerostat radars were developed for aircraft targets, presently technology has developed to a state where boats and even cars and trucks can be detected. Generally, mission application of aerostats platforms is regarded as the border surveillance type, however, its role as AEW for navy surface ships cannot be over-emphasised. Taking into consideration the perceived threats from the northwest, ship-based aerostats in the northwestern seas would give us immense benefit in early warning. These ship-based aerostats could also be used in conjunction with other surveillance platforms for our maritime reconnaissance requirements and surveillance of our Sea Lines of Communication (SLOCs).

Since the aerostat's primary mission is normally to detect low altitude low speed targets, most of its energy is focussed below the horizontal.

Advantages

Aerostats offer the advantage of enhanced LoS due to their altitude. The added advantage of aerostat-mounted radars is their increased vertical coverage due to multipath reflections from the surface. Since the aerostat's primary mission is normally to detect low altitude low speed targets, most of its energy is focussed below the horizontal. Hence, multipath reflections from the surface can significantly increase the vertical coverage of the radar and targets well above the main beam are frequently detected due to surface reflections. An inherent limitation in ground-based low-looking radars is the restricted radar coverage due to shadowing by mountains and hills. Higher operating altitudes of the aerostats reduce the amount of shadowing. Generally, the aerostat can accommodate large parabolic antennae within the windscreen without serious loss of aerodynamic performance, again contributing to enhanced radar coverage.

Aerostats present a cost-effective option for long endurance Intelligence, Surveillance, Reconnaissance (ISR) and early warning capabilities as compared

13. Ibid.

It costs about $26,500/hour to operate a Global Hawk Unmanned Aerial Vehicle (UAV), $18,000/hour to operate a Hawkeye AEW and just $610/hour to operate an aerostat.

to other aerial platforms. The life-cycle cost of aerostat operation is approximately one-third that of fixed wing early warning aircraft. Smaller mobile aerostats like the American Rapidly Elevated Aerostat Platform, can be launched within five minutes. Larger aerostat systems require about 45 minutes for deployment. Launch and recovery operations for large aerostats require only a few ground handlers. Modern helium filled aerostats can stay aloft for extended periods of time and they have demonstrated mission availability of 95 percent and higher when weather and scheduled maintenance times are excluded. And, now, coming to one main consideration – the operating cost. It costs about $26,500/hour to operate a Global Hawk Unmanned Aerial Vehicle (UAV), $18,000/hour to operate a Hawkeye AEW and just $610/hour to operate an aerostat.[14]

Limitations

Aerostat operations would require the development of extensive infrastructure to accommodate launch and tether facilities, ground segment, and storage facilities for helium. Large size aerostats also pose ground handling problems. Although aerostats can operate in winds up to 80 knots in a deployed state, they are adversely affected by winds of more than 50 knots during the launch and recovery phase. In the event of inclement weather, winching down an aerostat system could take up to two hours for large size aerostats. Besides, the payload of an aerostat can be affected by lightning strikes.

The ground installations, particularly the mooring system, are vulnerable to air-to-surface weapons. Additionally, safeguards have to be provided against Special Forces operations. Aerostats are, therefore, deployed at a

14. Dr Vijay Sakhuja, "Airships are Back", Guest Column of *Salute* magazine, dated February 21, 2009.

distance of 100 to 150 km from the borders to achieve a balance between the required radar cover and depth against hostile threats.

ANALYSES OF AWACS ROLES

> *Radar had the effect of forcing air operations down to lower levels to stay below the radar horizon and thus evade detection… an airborne platform thereby nullifying the benefits of a low-level approach has been perhaps, the single, greatest force-multiplier in air operations.*[15]

The invention of the radar provided the much needed early warning to defending forces. However, its limitations spurred the way for the development of the 'airborne' radar or the radar held aloft in an aerial platform, viz the aerostats and other AEW platforms. These platforms subsequently led to the modern day AWACS, which sought to overcome the few drawbacks of radars and aerostats. AWACS has been touted as a great force multiplier and it has proved its capability on many an occasion. What, therefore, are the roles for AWACS? Where does the operational role finish and strategic importance begin to take over? Are there areas of overlap and do both roles overshadow each other to some extent? AWACS can be utilised for a variety of roles in many different situations which are covered in the following paragraphs.

Operational Roles

- **Radar Cover and Tactical Control of Offensive Missions.** Radar cover of ground-based radars is restricted by line of sight and consequently the ability to pick-up low-level targets flying at 100 metres (300 feet) is restricted to 45-50 km, whereas a single AWACS provides a seamless low and medium level cover up to 400 km or more. Flying at 30,000 feet, and approximately 100-150 km inside own territory, AWACS can provide 250 km of early warning and control capability in enemy territory for six to eight hours. The extent of radar cover from low to medium and high

15. Squadron Leader Ajay Singh, "The Air War with AWACS Symmetry", *The Indian Defence Review*, © 1995 by Lancer Publishers & Distributors, downloaded www.bharat-rakshak.com/LANCER/index.html

altitudes would facilitate effective employment of fighter sweeps and free escorts for conduct of air dominance operations in enemy territory.

- **Strike Control.** One of the biggest advantages of the airborne radar platform is the ability to warn and control own strike missions in the adversary's territory, which hitherto was not possible owing to line of sight constraints of ground-based radars. Under positive radar cover, friendly strike missions can fly at medium levels, thus, avoiding three-tier low-level radar cover of Mobile Pulse Doppler Radars (MPDRs) which are restricted to 4.5 km (15,000 feet) in elevation coverage. This would also render en-route Short Range Air Defence Systems (SHORADS) deployed in the Tactical Battle Area (TBA) ineffective because most of these weapon systems have a slant range of 2.5 to 3 km (8,000 to 10,000 feet). Medium level ingress would afford prompt threat warning, larger radius of action, more freedom to manoeuvre, better endurance for strike aircraft and reduced exposure to enemy ground-based air defences.

  It can also warn the friendly strike of enemy Surface-to-Air Missile (SAM) threats by sensing their emitters. Also, the strike aircraft can be assisted in its navigation to the target through safe corridors, avoiding the enemy radar pick-up zone. The AWACS can assist in the RV of the refueller aircraft with the strike aircraft during air-to-air refuelling.
- **Low/Medium Level Ingress.** The sole purpose of low-level flight profiles is to avoid and delay the detection by air defence radars and give minimal reaction time to anti-aircraft weapons, where the fighter aircraft flies at 50 to 100 metres (150 to 300 feet) above ground level (AGL). The gap free low level radar cover extending 250 km or more in the adversary's territory would afford instant detection, greater reaction time and swift offensive action by fighter sweep, free escorts or tied escorts, thereby rendering the low-level ingress tactics redundant. Pakistan's lack of geographical depth would place all its main and satellite airfields within the detection ranges of AWACS.
- **Defence in Depth.** AWACS would assist in early detection and interception, maintain continuity in application of firepower and afford

opportunity for multiple interceptions, thus, imposing greater attrition and providing the classical defence in depth. Enhanced early warning and gap free radar cover would facilitate the area defence concept which affords optimal exploitation of speed, mobility, flexibility and firepower of fighter aircraft and greater freedom of action for terminal weapons deployed at vital areas/vital points (VA/VPs). As an offshoot of greater early warning during AWACS operations, aircraft on ORP and terminal defence weapons would be able to maintain a more realistic state of readiness and avoid prolonged State of Readiness I / II.

- **Air Battle Management and Target Designation.** AWACS executes the air battle management in real-time in coordination with ground-based/ship-borne air defence systems, Multi-Role Air Superiority Fighters (MRASFs), a combination of electronic warfare and strike aircraft and other combat air support operations like aerial refuelling. This provides it the capability to do real-time allocation and reallocation of weapon systems against enemy assets.[16] This capability can be gainfully exploited for real-time target allocation, and shrinking the sensor-to-shooter loop, to achieve the objectives with minimal force and time.
- **Air Space Management over Tactical Battle Area.** The problem of air space management emanates from the delayed /no detection and identification of tracks, very little reaction time and unreliable chain of communication. AWACS with onboard long range HF/V/UHF RT and large detection ranges could perform the function of battlefield management. Detection ranges beyond horizon, early radio contact, medium level approach and timely communication give options of exercising positive control over AD weapons in the TBA, maximise their freedom of action and reduce the chances of fratricide. Higher and larger vertical slabs would be available for helicopter operations of the IAF and Army, transport

16 "In April 1996, rebel Chechen President Dudayev was assassinated with the help of a Russian A-50 AWACS operating over Chechnya. Capable of monitoring communication frequencies, an A-50 located the President's cellular phone frequency and the target data was relayed to a Su-25 ground attack aircraft armed with laser and TV guided bombs, which attacked the precise location to complete the mission," Timothy L. Thomas in "Air Operations in Low Intensity Conflict: A Case of Chechnya," *Airpower Journal*, Winter 1997, p.54.

Permanent solutions for integrated radar network, composite air picture and fibre optics communication links would streamline the battlefield air space management.

support operations, Special Heliborne Operations (SHBO) and Combat Search and Rescue (CSAR). The permanent solutions for integrated radar network, composite air picture and fibre optics communication links would streamline the battlefield air space management. Even then, the air space management might continue to pose the challenges experienced by the technologically superior Coalition forces. In the Iraq War of 2003, a US A-10 attacked and killed nine US Marines on March 23 and a US F-16 CJ fired on a Patriot missile battery on March 24, 2003.[17] Since the invasion in 2003, there have been at least five collisions between UAVs and manned aircraft. After decades of experience in joint operations, the fundamental differences on methods of air space control continue to exist between the US Army and US Air Force (USAF).[18] Magnification of this problem is on the cards if proliferation of UAVs in the forms of mini and micro UAVs is permitted without proper monitoring and/or establishing the requisite Standard Operating Procedures (SOPs).

- **Silent/Passive Intercept.** AWACS can provide a silent intercept to the modern day fighter aircraft like the Su-30 class, through the Operational Data Link (ODL). AWACS picks up the target and this target information is passed on to the fighter, through text or radar picture. The fighter would not need to switch on its own airborne radar till a weapon solution is achieved, thereby concealing its approach till the last stage.
- **Rescue and Recovery.** With state-of-the-art mapping and navigation system onboard, AWACS can pinpoint locations accurately. Thus, it can help to locate and recover any friendly aircraft to its parent base or to the nearest airfield. Helicopters on SAR missions may be directed to their destinations. In CSAR missions, the AWACS aircraft is the hub of all

17. Anthony H. Cordesman, *The Iraq War: Strategy, Tactics and Military Lessons,* (Natraj Publishers Dehradun, 2006), pp. 239-240.
18. Gayle S. Putrich, *Unmanned and Dangerous*, available on www.defensenews.com, dated June 11, 2007.

activities. The airborne mission commander can be on board an AWACS aircraft and can control the whole mission. The aircraft can relay information between the Joint Air Defence Centre (JADC), on-scene commander and rescue forces. Further, AWACS can simultaneously coordinate a number of search missions.

- **Electronic Intelligence.** The SIGINT system on board AWACS can receive, analyse and locate radar and communication frequencies at ranges much greater than the radar range of 400 km. This would supplement the existing intelligence infrastructure. AWACS could transfer SIGINT data either directly or through the Ground Exploitation System (GES) to command and control centres for real-time analysis and decision-making. The enemy's electronic Order of Battle (ORBAT) can be updated for planning of air operations and the real-time radar picture can be correlated with electronic ORBAT.
- **Air Intelligence.** Monitoring and analysing of the adversary's air activity is an ongoing process during peace and during operations. Information on the adversary's capabilities and analysis of such information [known as General Hostile Area (GHA) analysis in the parlance of the Indian Control and Reporting (C & R) organisation] during flying training and known periods of air exercises would give a very good insight into the enemy's tactics and capabilities. AWACS can monitor air activity up to 350 km or more during peace-time (because they can fly closer to the international border) and 250 km or more during war-time (for safety reasons, these platforms would operate at least 100-150 km inside own territory). The air activity, when correlated with radar and radio activity monitored by SIGINT systems, would form definite patterns of tactics and manoeuvres practised by adversary.

Strategic Roles

As a tool of power projection, the US has used AWACS for coercive politics on many occasions. "…the US has made increasing use of AWACS for political purposes, leading in fact to some people coining the term **'AWACS diplomacy'** to describe the phenomenon."[19] The USAF has employed AWACS in different roles and for different purposes extending from purely defensive operations to coercive diplomacy and implementation of international sanctions, some of the examples are quoted below:

- Deployment of AWACS to maintain North American air sovereignty in Alaska and as part of NORAD.
- Deployment of E-3A Sentry in Saudi Arabia in March 1979 in the context of the conflict in Yemen.
- Deployment of AWACS in Saudi Arabia, Turkey, Bosnia for enforcing international sanctions.
- Deployment in Egypt in October 1981 (in the immediate aftermath of the assassination of President Anwar Sadat) and again in February 1983 (to forestall through coercive politics the allegedly impending Libyan backed coup attempt in Sudan).
- Deployment of E-3C Sentry in Operation Desert Storm (1991) for weapon control, battlefield management and surveillance and ESM and in Operation Iraqi Freedom in 2003 in similar roles.

- **Air Dominance Operations.** AWACS could be used to achieve air dominance over the adversary's air space and in a joint battle with the army and navy to attain time critical military objectives. Initiative, surprise, concentration of firepower, shock effect and attaining operational advantage over adversaries would remain the guiding principles for utilisation of AWACS. Therefore, it will be prudent to identify the specific areas of strategic value for AWACS utilisation in operational plans and in joint planning by the three Services.[20] The command and control of the air

19. Air Commodore Jasjit Singh, *AWACS: The New Destabiliser* (New Delhi: Lancer Press, 1987), p. 33
20 "… All these sensors and combat assets, both ground-based and airborne will be networked and this will give us the requisite capability to dominate the airspace", Air Chief Marshal F.H. Major in an interview in *Force*, vol 6, no. 6, February 2009, p.21.

battle management function would be carried out by AWACS over land or over sea in coordination with ground-based/shipborne air defence systems.

- **Command and Control Centre.** In peace-time as well as war-time, AWACS remains an instrument of power projection and force application. As an airborne command and control centre, AWACS, along with MRASF could be utilised for coercive diplomacy or sending vital politico-military signals or to actually open a new front of war and take the adversary by surprise. For example, a high intensity air battle may be in progress in a given theatre, and to dilute the adversary's resources and attention, integrated force projection of AWACS, Air-to-Air Refuelling (AAR) MRASF is brought to bear on our adversary by carrying out a heavyweight air attack in a different sector, thereby taking the enemy by surprise and seizing the initiative.
- **Disaster Management.** AWACS has played a vital role in surveillance, aircraft control and regulating the air effort in mitigation of natural calamities like earthquake, hurricanes, tsunamis, etc, to fill the void created by the inability of ground-based systems to move in quickly and operate from difficult terrain and poor infrastructure post natural disasters. In such circumstances, AWACS operating over a given area can coordinate and regulate air traffic to ensure safety and efficient flow of humanitarian assistance. After the devastating earthquake in Pakistan on October 8, 2005, as an element of the North Atlantic Treaty Organisation (NATO) Response Force, AWACS missions performed air assistance for humanitarian efforts and similar relief was provided to victims of Hurricane Katrina in New Orleans, Louisiana, in 2005.[21]
- **Air Battle Management.** The strategic importance of AWACS emanates from its ability to extend multiple functions like early warning, surveillance, ESM, command and control, SIGINT and battle management from one airborne platform. It affords the capability to single-handedly conduct air operations over geographically dispersed locations and diversified terrain. Defending India's land frontier that measures more than 15,000

21. "AWACS: NATO's Eye in the Sky", from http://www.nato.int/docu/awacs/awacs-e.pdf

km, which it shares with seven countries, including a small segment with Afghanistan (106 km) in northern Jammu and Kashmir[22], and a coastline of 7,516 km with a total of 1,197 island territories in the Bay of Bengal and the Arabian Sea,[23] by ground-based radars is neither practical nor cost-effective. AWACS would overcome the limitations of ground-based radars and function with relatively improved efficiency from the plains of Punjab, Rajasthan, coastal areas and over the Indian Ocean. This capability affords significant strategic advantage of conducting air operations over any area of national interest.

- **Prioritisation of Operations.** A large number of AWACS would be required to cover such a vast expanse of land, coastline and island territories. AWACS cannot be apportioned in a particular role; in a given theatre, it can support a variety of operations over a single mission. The demand to availability ratio for AWACS will always remain critical, considering the vast geographical expanse and distances between possible theatres of operations in India. Considering the limited numbers, AWACS will remain a strategic asset directly under the control of Air Headquarters (Air HQ) and the operational demands of Command HQ would have to be prioritised considering the overall military objectives and time critical operations.
- **AWACS in Nuclear Strategy.** Strategically, another very important and critical role for AWACS could be envisaged in unconventional warfare. Considering India's "no first use" policy, Indian nuclear strategists have to reconcile to absorbing the first strike and launching a punitive retaliatory strike within a reasonable time-frame. In this case, the first imperative would be to safeguard our weapons and delivery systems. The aerial delivery of nuclear weapons is the most viable option to create a desired impact at a given time and place. Although it is understood that after absorbing the first strike, the balance of air dominance will shift in favour of the adversary and own strike capabilities may face tough resistance,

22. Brig Gurmeet Kanwal, "India's Borders", accessed through http://www.indiandefencereview.com/?p=379
23. http://india.gov.in/sectors/defence/indian_navy.php, accessed in January 2009.

that is where the integration and networking of force multipliers is to be exploited. Such contingencies must be considered in our counter-strike strategies. AWACS, integrated with other force multiplying platforms, could play a strategically vital role in guiding and positioning our delivery vehicles over selected target areas, and also ensuring that such strikes go through unhindered.

- **AWACS for Continental Air Force.** The Indian Air Force is being shaped to expand from a subcontinental to a continental air force, which would be capable of safeguarding national interests and economic assets over a larger area of national interest in the Indian Ocean, Central Asian and Southeast Asian regions. In this process of evolution, the importance of an air expeditionary force needs no emphasis. For an expeditionary air force, AWACS would perform the role of an airborne command and control centre, for handling the contingencies beyond own territory/territorial waters, similar to the landing at Male airfield (Maldives in 1988), amidst the uncertainty about the status of the airfield, or protection of aircraft and ships evacuating the Indian population during the Gulf War (1991).

COMPARISON OF AWACS WITH GROUND-BASED RADARS AND AEROSTATS

Having understood the origin and the characteristics and advantages of AWACS and aerostats, it is indeed very clear that ground-based radars have a limited capability. The ground-based radars are also affected in the coverage by the curvature of the earth, thus, providing the critical gap below the radar horizon. Radar detects low-level targets at very limited range, thus, reducing the reaction time to activate the AD systems to neutralise the high-speed aircraft threat. At the same time, in the past decade or so, advances in electronic warfare have seriously threatened the efficacy of such radars. During peace-time, very little of the opponent's air activity can be monitored by ground-based radars. During war, the existence of the radar gap at low altitudes has traditionally brought the air warfare zone to lower heights. Since World War II, AD systems in all countries have been essentially orientated towards a low level altitude air warfare environment.

On the other hand, airborne surveillance and tracking radars significantly increase the capability to track low flying aircraft, as well as negate most of the hostile electronic warfare capability. AWACS detects the threat at large distances, thus, increasing reaction time to neutralise the threat far away from the target. Not only is the target detected but the real-time data is transferred to ground-based AD systems which are integrated with AWACS.

A ground-based radar cannot detect an aircraft approximately 100 metres high until it approaches a range of 45 km, due to LoS limitation. On the other hand, the same aircraft can be detected at ranges of 400 km by the AWACS, flying at 9 km altitude. The targets at higher altitude can be detected at even greater ranges with improved clutter reduction facility. AWACS has the capability to control the air battle in the entire air envelope. In 1982, during the air battles over Lebanon's Bekaa Valley, the Hawkeye (E-2C) and Israeli Air Force gained distinction for synergistic control and coordination of air operations. One needs to note that the shooting down of 86 fighters with the loss of only one aircraft was due to surveillance and control through the E-2C stationed over the Mediterranean Sea.[24]

Aerostats can also perform continuous surveillance with minimum control capability. The aim is to increase the reaction time by increasing the early warning in order to neutralise or divert the incoming enemy threat. They are capable of detecting targets at a range of 150 to 200 nautical miles (nm), which is a significant increase in range compared to existing land-based radar equipment.

India has a vast air space to provide surveillance to our own aircraft as well as to guard the sky against any possible intrusion and violation of the air space. This demands a large inventory of radar and communication equipment and an extensive network of the Air Defence Ground Environment System (ADGES). The western front alone demands simultaneous operation of a large number of medium and high looking radars to provide surveillance to friendly air movements as well as to provide air defence watch from dawn to dusk.

24. Edwin Leigh Armistead, *AWACS and HAWKEYES* (St. Paul, USA: MBI Publishing Company).

In the case of any adverse political or military signal from across the border, they resort to round the clock watch. This demands extensive utilisation of the existing AD resources and high state of maintenance and serviceability. Their job can be made easy and be augmented by employing AWACS. For economy of effort, AWACS can be selectively used in conjunction with aerostat radars and the already existing ground-based radars to supplement each other. A similar arrangement could be worked out for the surveillance of the northeastern frontier and the peninsular area.

While operating at 30,000 ft and 100-150 km inside the international border (IB), the AWACS radar can cover upto 250 km inside the enemy territory. During the course of its normal surveillance, it can help us to monitor and analyse the enemy tactics and capabilities. Further, AWACS can intercept and detect almost all types of enemy radar and radio transmissions. Online data link with the ground stations can provide real-time study and intelligence from these radiations. However, dedicated Electronic Intelligence (ELINT) missions may be undertaken if the situation so demands. Thus, AWACS can supplement the existing ELINT and recce aircraft squadrons. Specific ESM equipment may be fitted on board the aerostat to search, detect and intercept enemy electro-magnetic (EM) radiation. Thus, a judicious use of AWACS can highly augment our intelligence capability.

During war-time, AWACS will act as the single largest airborne operations room, controlling and coordinating all the air activity in its area of pick-up. When linked up with ground-based ADGES through voice and datalink, it would act as an extended but superior platform of AD operations. Because of its height of operations, the inherent increase in radar pick-up range and radio/telephony (R/T) communications will curtail all the limitations of the ground-based system. The basic functions of active air defence, namely detection, identification and interception will not be restricted to the terminal phases of the enemy air strike. The basic drawback of air defence, namely a reactive operation, will shed much of its drawbacks, as the reaction time would be increased. The enemy threat can be neutralised well ahead of the VA/VPs. Further, AWACS can control the free escorts and the fighter sweeps, thereby taking the battle into the enemy territory. With all these attributes provided by the AWACS/AEW&C platforms, air defence does not remain purely 'reactionary'. As a matter of fact, we now need to accept that the air defence component of air power has an offensive content, and the more properly we exercise this option, the more AD will contribute to counter-air (aircraft) operations.

Despite numerous advantages, the AWACS also has some limitations, which are:

- **Height Errors.** Due to the antenna thickness, the beam is not very sharp. This results in errors in elevation, which at times could be very large. This limitation would be overcome in an Integrated Air Command and Control System (IACCS) environment where a number of sensors would be linked through the ODL. The inputs from various sensors can be co-related to get the correct height of the target.
- **Limitation as an Independent Command and Control Hub.** If the AWACS operates as an independent Command and Control (C2) centre, in an IACCS environment, then the limited number of workstations on board the aircraft poses a constraint.
- **AWACS in Mountains.** Effectiveness of radar, airborne or ground-based, in mountainous terrain is restricted by terrain masking. All radars, including AWACS, work on the line of sight principle and are prone to radar shadows owing to terrain masking. Although as compared to ground-based radars, AWACS overcome the constraints of line of sight and provide higher detection probability at farther ranges, the performance of AWACS would also be restricted. While it is true that in mountainous terrain, aircraft would invariably take advantage of terrain masking and follow the valleys to avoid radar detection and give as little early warning as possible, it is also true that such an approach is predictable. Smaller sensors like mobile observation posts and UAVs could be deployed to cover the approaches to these valleys. AWACS could be used more advantageously in conjunction with smaller ground-based radars like Low Level Light Weight Radars (LLLWR), ST-68 and

other GCI units integrated on a network to provide a composite air picture.

- **Protection of AWACS.** AWACS, being a strategic asset, would be the prime target for any adversary and would need to be protected adequately at all times – be it in the air or on the ground. It is a considered opinion that a large number of fighter aircraft would be tied down for protection of this high value asset, thus, negating the advantages of AWACS. The effort diverted to protect AWACS and its associated infrastructure would also offset/negate the force multiplier effect which could be accrued.

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  AWACS can easily be detected by enemy radars due to its height of operation but the onboard systems would give it adequate warning to take defensive action. The increasing number of long range SAMs has bolstered the case for engagement of AWACS. Although these are very live issues, they do not seem to be a cause for undue alarm because these missile systems have not been proven so far.
- **Data Transmission.** AWACS would operate over a large geographical expanse and data would need to flow seamlessly. The large amount of data transfer between the AWACS and other AD elements requires a very robust ground communications network. The operationalisation of IACCS on AFNET will overcome this limitation.
- **Aircrew Limitations.** Due to the large loiter time, which can be further enhanced with air-to-air refuelling, pilot fatigue is a consideration. Aero-medical indoctrination of the crew to operate in confined spaces for prolonged durations, could address this problem.
- **Unserviceability in the Air.** In case of any unserviceability of the system in the air, the downtime will be higher as compared to ground-based radars wherein the radar can be rectified faster. A radar transmitter failure would result in aborting the AWACS mission as it would not be possible

to replace this on-board.

- **Blind Zone.** There is a cone of blind zone above and below the platform, which can be exploited by the adversary. AWACS is a dynamic platform and would be operating inside our air space; hence, this blind zone might not seem to be of great importance. Additionally, this blind zone would keep shifting with the movement of AWACS, thereby, not giving a chance to the adversary to factor exploitation of this zone at the planning stage. The blind zone would be a limitation only in case the threat develops below the aircraft or passes underneath the AWACS platform. In such a scenario, the pick-up from other sensors like ground-based radars or aerostats would be taken on the IACCS network to complete the intercept.
- **Loss of Surprise.** The pattern followed by AWACS, observed by the adversary over a period of time, would be a dead giveaway. Thereafter, they could resort to taking protective measures, be it in terms of ECM, ECCM, ESM or Communication Support Measures (CSM) as soon as an AWACS is identified as being airborne. This would result in loss of force multiplication effect of the AWACS. This limitation can be overcome by carrying out minimum R/T takeoffs and frequently changing the pattern flown by the AWACS.
- **IFF.** The problem of identification is the most difficult one to solve. IFF equipment has a large number of shortcomings and problems. The IFF Mark-10, fitted on almost all our aircraft and compatible with AD sensors, is outdated. The newer generation IFF Mark-12 might be the answer to this problem but there are issues on its procurement, installation on all types of aircraft and integration with the AD sensors in the C&R chain. For a long time to come, the only reliable identification method will continue to be based on track history. This requires an extensive overlapping radar coverage without gaps. While such coverage is feasible with regard to medium and high altitude air activity, at low level, the limited range of radars would necessitate a very large number of such radars. A comparative study has revealed that about 50 low-level radars would be required to cover an area equivalent to the area covered by one AWACS.

CONCLUSION

Success in any air defence engagement depends on the ability to detect a raid as soon as possible. The extent of early warning available is the prime objective around which the defender force builds its defensive strategy. The order of the day is "real-time" information. Sufficient early warning is required to neutralise surprise attack. As the efficiency of radars and AD systems increased, attacking aircraft were progressively forced to lower and lower altitudes for penetration and attack so as to evade detection till as late as possible, thereby reducing reaction time available for the defences.

The limitations of the ground-based radars and the introduction of early warning have generated pressures for other tactical solutions against penetration of high speed, hostile strike aircraft. AWACS is used for surveillance and to provide aerial target information of high speed aircraft flying at low / medium altitudes. The evolution of AWACS and other AEW assets has forced a reevaluation of the core concept of 'reactionary' air defence and blurred the line between defensive and offensive operations. AWACS is a formidable component of the air defence system, and doctrines have to be suitably modified to offensive defence. There is a need to shift focus from air space denial to air space control as a means of achieving tactical objectives.

Airborne early warning systems provide better track histories by virtue of improved coverage against low flying aircraft, and, thus, provide a more reliable identification of tracks. The real answer to the tactical problems of air operations being executed at low levels lies in an integrated command and control system of which AEW systems constitute the key element. AWACS alone cannot win wars—it is has to be integrated with other interoperable war fighting components and employed aggressively for optimal exploitation. AEW systems cannot replace the ground-based radar network due to their inherent limitations. They must, therefore, form a complementary, though increasingly, important and indispensable element in the control, reporting and response system vital for conducting air operations in the modern environment.