THAT FIRST LOOK

Airborne early warning is a critical capability, but it took a while to get it in the force.

By Walter J. Boyne

FOR modern military forces, the significance of airborne early warning was clear right from the beginning. In World War I, visual detection in the daylight hours did not exceed 15 miles. Even in the late 1930s, defending forces heard attacking aircraft long before they saw them. This situation, in the view of military leaders, was intolerable.

The first attempts to see "over the next hill" featured balloons and then observation aircraft. These became useful in the World War, despite limits imposed by night and poor weather. Primitive listening devices, used in cooperation with ground observers, helped detect raids by Zeppelins and bombers.

Invention of radar on the eve of World War II caused a radical shift in the balance of power in the air. By 1940, radar could spot incoming aircraft at a distance of more than 100 miles. Early detection gave defenders much more time to organize their air defenses and to intercept attacking airplanes. The famous English "Chain Home" radar system was vital to the Royal Air Force's victory in the Battle of Britain.

Yet the power of radar, by itself, wasn't sufficient. Ground-based systems had a vulnerability that could be ruthlessly exploited by opponents, and air forces learned to do so in the years following World War II. Because its beams travel only in straight lines, radar's detection capabilities could be blocked with the proper tactics. Aircraft could hug the ground and take advantage of the curvature of the Earth, getting close to transmitters before popping up to attack. Reaction time was greatly shortened.

Thus, getting radars airborne, where they would not be limited by line-of-sight obstacles, became a key objective. Indeed, the US already had embarked on this task in the final few months of World War II, when it put primitive airborne radar sets into night fighters. They were of limited utility.

Not until the 1960s did electronics miniaturization make it possible for a single airframe to transport a powerful search radar plus computers to differentiate between moving aircraft and ground clutter. The aircraft would also contain communication equipment sophisticated enough to give commanders a real-time view of the battlespace.

However, that's getting ahead of the story.

The Beginning

In early 1944, studies by Navy Capt. Frank Akers and Lt. Cmdr. Lloyd V. Berkner of the US Navy's Bureau of Aeronautics focused on an airborne aerial warning system. The two naval officers, working with the Radiation Laboratory of the Massachusetts Institute of Technology, helped the nation build the first production AEW system in only 13 months.

The capability of the new airborne radar equipment, designated APS-20, was even more remarkable than its speed of delivery. The system was used with little modification for many years in a wide variety of airframes and applications.

The APS-20 was tested initially in the TBM-3W, a version of the Avenger torpedo airplane. The radar's eight-by-

USAF's first airborne early warning aircraft—the RC-121, shown here, was used extensively in the Vietnam War.

three-foot paraboloid dish antenna was housed in a huge ventral dome. The need for greater range and endurance—as well as some command and control capability—led to the APS-20 being installed in the PB-1W. Some 25 of these converted B-17Gs were delivered.

The new radar system began one revolution in warfare while suggesting yet another. The first—airborne early warning—immediately allowed fleet commanders to see hostile forces long before they could attack. The second revolution—service as an airborne combat information center—was foreseen but not realized for many years.

The APS-20 provided a search capability two to six times greater than that of ship-based radar, depending on the target, but the system also had developmental and technical teething issues. The aircraft had a radar receiver and IFF (identification friend or foe) receiver and a complex synchronizer. The two-man crew used three radar consoles to correlate information. Instead of today's familiar array of symbols, returns on the radar screens were yellow flashes, jokingly termed "fluorescent bananas." These were tracked by grease pencil, and establishing a target's course and speed took as much as three minutes.

The other half of the system was on board ships, where the additional space, power, and cooling capacity allowed it to be much more elaborate. The shipboard equipment included a radar relay service to the combat information centers on other ships, conveying data on units of the fleet as well as on unidentified targets.

In the early years of the Cold War, the Soviet Union developed a fleet of several hundred Tupolev Tu-4 bombers, giving Moscow the power to launch a massive nuclear attack. The United States needed an air defense system to detect such an attack in its early stages and muster the weaponry to defeat it. (See "A Line in the Ice," February 2004, p. 64.)

This system, strung out across the US, Canada, and Greenland, was largely in place by the mid-1950s. As expensive, extensive, and effective as these land-based radar lines were, they could be outflanked by attacks coming across the ocean. The need for picket ships and early warning aircraft was clear.

Navy Initiative

In the early 1950s, the Navy accepted the challenge of an AEW barrier by acquiring 142 WV-2 Warning Stars. The APS-20 radar was housed in a plastic radome underneath the aircraft and was supplemented by a height-finding radar.

The Air Force followed suit, adapting the WV-2 to its needs and naming it the RC-121C, USAF's first AEW aircraft. Ten of these were delivered in late 1953 and were used with Navy radar picket ships as an extension of the US Continental Air Defense System. Within two years, the Air Force's AEW force had grown to six squadrons and 50 aircraft operating in two wings.

Duty on board the RC-121 was arduous. Crews were nominally five officers and 13 enlisted personnel, but they could be more than doubled for longer missions.

Tracking the APS-20's fluorescent bananas was demanding, and operators at the five radar consoles were relieved often during a 16-hour mission. Because of the need to maintain a constant defense, takeoff and on-station times were made largely without regard to prevailing weather conditions. Some 60 percent of the barrier missions were flown in icing conditions, while 50 percent encountered storm-force winds. Engine malfunctions and fires were common, as were hydraulic leaks. These often occurred when the aircraft were on station, hundreds of miles out to sea. Over the years, at least 50 crew members were lost supporting this massive early warning effort. (See "The Fall of the Warning Stars," April 2005, p. 78.)

By the 1960s, it was apparent that the principal Soviet threat was from ICBMs. The combined maintenance problems of the Super Constellation and the increasingly antiquated APS-20 produced calls for a new system.

The Navy selected the E-1B as an "interim" aircraft, one that served for 20 years. Known colloquially as the "Willy Fudd" or the "Stoof with a Roof," the E-1B used the APS-82 radar installed in a fixed, air-foil-shaped housing mounted over the fuselage. Later came the E-2 Hawkeye, equipped with a rotating radar dome over the fuselage.

The Air Force continued to use its redesignated EC-121s to track and recover space vehicles and provide command and control for nuclear tests. Other duties included shepherding fighter aircraft on long over-water deployments, filling in for inoperative land-based radar sites, and acting as a control vehicle for Air Force One. The EC-121 was especially effective during the 1962 Cuban Missile Crisis, helping U-2s avoid MiG attacks.

Vietnam Pressures

The Vietnam War forced a different American approach; the EC-121s were pressed into service to augment surface-based radar. Aircraft based in Taiwan, South Vietnam, and Thailand rotated into and out of the theater on a continuous basis, flying combat missions until 1973. During that time they provided control to 210,000 aircraft, issued 3,297 threat warnings, and assisted in the rescues of more than 80 downed aircrew members.

EC-121s flew a race-track orbit over the Gulf of Tonkin, with initial emphasis on monitoring enemy air activity and controlling US fighter aircraft in the area. Duties were expanded to include battle management of combat air patrol, strike and support missions, coordinating search and rescue operations, controlling air refueling operations, and acting as an airborne radio relay for poststrike reports.

By 1967, the EC-121s were operating over Laos, to provide navigational

USN photo by Photographer's Mate 3rd Class Jonathan Chandler

A Navy E-2 Hawkeye awaits takeoff from USS* Kittyhawk *in the South China Sea in December 2005. The E-2 replaced the E-1 and provides an all-weather AEW and command and control function.

assistance to US aircraft and to prevent incursions across the border to China. Later these aircraft moved closer to North Vietnam, where—operating under the call sign Disco—they directed airborne intercepts against North Vietnamese fighters.

The veteran EC-121 crews wrung all they could from their outdated equipment, which had difficulty discriminating aircraft from the clutter of the Vietnamese land mass. On July 10, 1965, Disco vectored two F-4 Phantoms in an attack that shot down two MiG-17s. It was the first radar-assisted kill of the war.

The 552nd Airborne Early Warning and Control Wing—first activated at McClellan AFB, Calif.—won six Air Force Outstanding Unit Awards, including two for valor, for its operations in the Vietnam War. Perhaps even more important, the antiquated, oil-leaking, prone-to-failure EC-121s validated the need for a new AEW aircraft.

The Navy's Hawkeye went through a long development period but finally emerged as an exceptionally capable AEW aircraft. However, it was too small and short-ranged to fulfill Air Force requirements. Meanwhile, upgrades had turned the EC-121 into an AEW system that could also serve as a command and control aircraft.

A new Airborne Warning and Control System program office established the ground rules for a long, complex competition for both airframe and radar manufacturers. The 707 won the airframe competition on July 10, 1970. The APY-1 radar was declared the winner in 1972, and the official AWACS production effort began on Jan. 26, 1973.

Almost from its inception, the AWACS program came under scathing attacks. The *New Republic* famously labeled it in April 1974 as "The Plane That Would Not Die." The magazine stated that the AWACS looked like a "mushroom with elephantiasis," a reference to the 30-foot diameter rotating radar dome stationed 11 feet above the aircraft's fuselage.

The General Accounting Office—now the Government Accountability Office—leveled criticism of its own. One GAO report questioned the ability of the AWACS to operate in a hostile environment, while another criticized the ability of the AWACS to function in the face of Soviet electronic jamming equipment. Much of the hostility was generated by the fact that the AWACS was the first weapon system to cost $100 million a copy.

On July 1, 1976, the Air Force moved the 552nd AEW&C Wing to Tinker AFB, Okla. The 552nd (now the 552nd Air Control Wing) served in many operations and wars over the next three decades.

The First E-3

The first production E-3 was rolled out in October 1976, only 23 months after Boeing was ordered to proceed. The following March, the first aircraft was delivered to Tinker. There, Gen. Robert J. Dixon, commander of Tactical Air Command, christened the E-3 the "Sentry."

The Air Force hoped to buy 42 E-3s, but budgetary restrictions reduced this to 33, the last them delivered in 1984. The E-3 fleet is far smaller than the scores of EC-121s that it replaced. Outfitted with 14 computer and radar workstations, the modern AWACS carries 20 to 30 mission crew members and four flight crew.

The E-3 crews see the airspace and can notify friendly aircraft where the enemy is—and direct him there. "I love the mission. I love the fact that we're the eyes and ears," said Airman Nicholas Cotter, a radar technician with the 552nd Air Control Wing.

The Sentry's higher altitude capability endowed its superior radar with a far greater range. The much greater available electrical power permitted additional equipment to be installed as it was developed. With its million-watt Doppler radar system, the AWACS was the first successful example of look-down, shoot-down capability. It is particularly useful against low-flying, earth-hugging air targets, and is capable of precision tracking and control of both airborne and maritime targets while remaining highly resistant to electronic countermeasures.

Northrop Grumman photo

The E-8C Joint Surveillance Target Attack Radar System airplane, shown here landing, detects and tracks targets on the ground.

The APY-1 radar was exceedingly complicated by today's standards, containing some 78,000 parts. It offered a range of 250 miles, however, and could distinguish aircraft tracks from ground clutter. It could operate in five different modes, including detecting targets at low altitudes, detecting targets and their elevation, looking beyond the horizon for long-range surveillance, with receivers only for passive surveillance, and in test and maintenance mode.

For the operators, the most obvious improvement was the introduction of symbols on the radar screens rather than the raw data of fluorescent flashes. To offset fears about its ability to operate in the face of Soviet jamming, the Sentry's radar operators had their own sophisticated electronic countermeasures equipment.

DOD photo by TSgt. Olivo Reynaldo

USN photo by Jonathan Chandler

Maintenance personnel service E-3 Sentry Airborne Warning and Control System aircraft on the flight line at Tinker AFB, Okla., in 1984.

New Era

The AWACS signaled a new era in the concept of airborne battle management even as it became the flagship of aerial diplomacy. The 552nd's E-3s were at once perceived as essential to any combat operation and were immediately in constant demand for training exercises. Missions ranged from passive duties such as surveying border disputes between North and South Yemen to battle action in Grenada, Panama, the Middle East, and the Balkans.

The 552nd particularly distinguished itself during Operations Desert Shield and Desert Storm, flying more than 7,000 combat hours and controlling 31,924 strike sorties. In addition, the AWACS controlled 20,401 air refueling sorties where tankers offloaded 178 million gallons of gas to 60,453 receivers.

When the Gulf War ended, the E-3s were essential to peacekeeping in Operations Provide Comfort, Northern Watch, and Southern Watch.

In 1995, NATO E-3s monitored the 3,515 NATO sorties in Operation Deliberate Force.

When the Air and Space Expeditionary Force became USAF's standard deployment system, the 552nd was well-positioned to support it, despite the relatively small number of aircraft in its fleet. The wing's long experience in sending small numbers of E-3s to all corners of the globe for long periods of time served the wing well, enabling it to meet each major requirement as it happened. An unrelenting acceleration in operations tempo became a way of life for the 552nd.

In 1999, more than a score of E-3s took part in Operations Allied Force, flying 500 missions averaging almost ten hours each. The AWACS contributed to the destruction of about 85 percent of the Yugoslav Air Force's fighters.

The terrorist attacks on Sept. 11, 2001 brought new work to the 552nd. Tasked to protect the airspace over North America, the wing flew hundreds of missions as part of Operation Noble Eagle. Yet the demand for AWACS support worldwide was so great that five NATO E-3s had to be summoned to assist in defending the United States. These NATO birds flew more than 360 missions as part of Operation Eagle Assist.

Operation Enduring Freedom and Operation Iraqi Freedom have brought home the importance of the AWACS as a force multiplier. In both of these campaigns, the E-3s, the epitome of the low-density, high-demand assets, have been key instruments in establishing air dominance.

It is a testament to the AWACS that it can ably perform both the early warning mission to defend the skies and as a battle management force multiplier during air wars. The E-3s possess the requisite long loiter time, extraordinary communication capability, long-range radar, and, most of all, the ability to integrate information derived from satellites with ground- and air-based assets.

The AWACS continues to be a keystone in the United States' military capability, and it now has an almost exact counterpart for ground operations in the E-8C Joint Surveillance Target Attack Radar System. Also a modified 707, Joint STARS detects and tracks targets on the ground.

The history of AWACS has been that of continual improvement through upgrade programs, and this will continue into the future.

As the 707-320 airframe is no longer in production, however, future AWACS, will have to be based on more modern airframes. For example, the four AWACS aircraft purchased by the Japanese Air Self-Defense Force are based on the 767.

Other examples of AWACS variants, with alternate electronic systems and smaller airframes, are being put forward in various countries around the world.

In the United States, it may be that the functions of AWACS and Joint STARS eventually will be combined in a single aircraft—one that might even have a tanker capability. Alternatively, future airborne warning and control functions may be divided among a whole range of assets, including manned and unmanned types, located on the ground, in the air, or in space. These developments are perhaps two decades in the future, and until then, there will be no letup in demands for AWACS services. ■

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