= Boeing E @-@ 3 Sentry =

The Boeing E @-@ 3 Sentry , commonly known as AWACS , is an airborne early warning and control (AEW & C) aircraft developed by Boeing as the prime contractor . Derived from the Boeing 707 , it provides all @-@ weather surveillance , command , control , and communications , and is used by the United States Air Force , NATO , Royal Air Force , French Air Force , and Royal Saudi Air Force . The E @-@ 3 is distinguished by the distinctive rotating radar dome above the fuselage . Production ended in 1992 after 68 aircraft had been built .

In the mid @-@ 1960s , the US Air Force (USAF) was seeking an aircraft to replace its piston @-@ engined Lockheed EC @-@ 121 Warning Star , which had seen service for over a decade . After issuing preliminary development contracts to three companies , the USAF picked Boeing to construct two airframes to test Westinghouse Electric and Hughes 's competing radars . Both radars used pulse @-@ Doppler technology , with Westinghouse 's design emerging as the contract winner . Testing on the first production E @-@ 3 began in October 1975 .

The first USAF E @-@ 3 was delivered in March 1977 , and during the next seven years , a total of 34 aircraft were manufactured . NATO , as a single identity , also had 18 aircraft manufactured , basing them in Germany . The E @-@ 3 was also sold to the United Kingdom (seven) and France (four) and Saudi Arabia (five , plus eight E @-@ 3 @-@ derived tanker aircraft) . In 1991 , when the last aircraft had been delivered , E @-@ 3s participated in Operation Desert Storm , playing a crucial role of directing coalition aircraft against the enemy . Throughout the aircraft 's service life , numerous upgrades were performed to enhance its capabilities . In 1996 , Westinghouse Electric was acquired by Northrop before being renamed Northrop Grumman Electronic Systems , which currently supports the E @-@ 3 's radar .

= = Development = =

= = = Background = = =

In 1963 , the USAF asked for proposals for an Airborne Warning and Control System (AWACS) to replace its EC @-@ 121 Warning Stars , which had served in the airborne early warning role for over a decade . The new aircraft would take advantage of improvements in radar technology which allowed airborne radars to " look down " and detect low @-@ flying aircraft (see Look @-@ down / shoot @-@ down) , even over land , which was previously impractical due to ground clutter Contracts were issued to Boeing , Douglas , and Lockheed , the latter being eliminated in July 1966 . In 1967 , a parallel program was put into place to develop the radar , with Westinghouse Electric and the Hughes Aircraft being asked to compete in producing the radar system . In 1968 , it was referred to as Overland Radar Technology (ORT) during development tests on the modified EC @-@ 121Q . The Westinghouse radar antenna was going to be used by whichever company won the radar competition , since Westinghouse had pioneered in the design of high @-@ power RF phase @-@ shifters .

Boeing initially proposed a purpose @-@ built aircraft , but tests indicated it would not outperform the already @-@ operational 707 , so the latter was chosen , instead . To increase endurance , this design was to be powered by eight General Electric TF34s , or carrying its radar in a rotating dome mounted at the top of a forward @-@ swept tail , above the fuselage . Boeing was selected ahead of McDonnell Douglas 's DC @-@ 8 @-@ based proposal in July 1970 . Initial orders were placed for two aircraft , designated EC @-@ 137D as test beds to evaluate the two competing radars . As the test @-@ beds did not need the same 14 @-@ hour endurance demanded of the production aircraft , the EC @-@ 137s retained the Pratt & Whitney JT3D commercial engines , and a later reduction in endurance requirement led to retaining the normal engines in production .

The first EC @-@ 137 made its maiden flight on 9 February 1972 , with the fly @-@ off between the two radars taking place during March ? July that year . Favorable test results led to the selection of Westinghouse 's radar for the production aircraft . Hughes 's radar was initially thought to be a

certain winner , simply because much of its design was also going into the new F @-@ 15 Eagle 's radar program . The Westinghouse radar used a pipelined fast fourier transform (FFT) to digitally resolve 128 Doppler frequencies , while Hughes 's radars used analog filters based on the design for the F @-@ 15 fighter . Westinghouse 's engineering team won this competition by using a programmable 18 @-@ bit computer whose software could be modified before each mission . This computer was the AN / AYK @-@ 8 design from the B @-@ 57G program , and designated AYK @-@ 8 @-@ EP1 for its much expanded memory . This radar also multiplexed a beyond @-@ the @-@ horizon (BTH) pulse mode that could complement the pulse @-@ Doppler radar mode . This proved to be beneficial especially when the BTH mode is used to detect ships at sea when the radar beam is directed below the horizon .

= = = Full @-@ scale development = = =

Approval was given on 26 January 1973 for full @-@ scale development of the AWACS system . To allow further development of the aircraft 's systems , orders were placed for three preproduction aircraft , the first of which performed its maiden flight in February 1975 . To save costs , the endurance requirements were relaxed , allowing the new aircraft to retain the four JT3D (US Military designation TF33) engines . IBM and Hazeltine were selected to develop the mission computer and display system . The IBM computer receiving the designation 4PI , and the software is written in JOVIAL . A Semi @-@ Automatic Ground Environment (SAGE) or back @-@ up interceptor control (BUIC) operator would immediately be at home with the track displays and tabular displays , but differences in symbology would create compatibility problems in tactical ground radar systems in Iceland , Europe , and Korea over Link @-@ 11 (TADIL @-@ A) .

Modifications to the Boeing 707 for the E @-@ 3 Sentry included a rotating radar dome , single @-@ point ground refueling , air refueling , and a bail @-@ out tunnel or chute . The original design had two (one forward , and one aft) , but the aft bail @-@ out chute was deleted to cut mounting costs . Engineering , test and evaluation began on the first E @-@ 3 Sentry in October 1975 . Between 1977 and 1992 , a total of 68 E @-@ 3s were built .

= = = Future status = = =

Because the Boeing 707 is no longer in production , the E @-@ 3 mission package has been fitted into the Boeing E @-@ 767 for the Japan Air Self Defense Forces . The E @-@ 10 MC2A was intended to replace USAF E @-@ 3s ? along with the RC @-@ 135 and the E @-@ 8 , but the E @-@ 10 program was canceled by the Department of Defense . The USAF is now performing a series of incremental improvements , mainly to avionics , to bring the E @-@ 3 up to current standards of performance . Boeing is flight @-@ testing its Block 40 / 45 E @-@ 3s . This modified E @-@ 3 contains upgrades of the mission crew and air battle management sections , as well as significantly upgraded electronic equipment .

Another program that the Air Force is considering is the " Avionics Modernization Program " (AMP) . AMP would equip the E @-@ 3s with glass cockpits . The Air Force also wants modified E @-@ 3s with jet engines that are more reliable than the original ones , and also with at least 19 % higher fuel efficiencies . New turbofan engines would give these E @-@ 3s longer ranges , longer time @-@ on @-@ station , and a shorter critical runway length . If the modification is carried out , the E @-@ 3s could take off with full fuel loads using runways only 10 @,@ 000 ft (3 @,@ 000 m) long , and also at higher ambient temperatures and lower barometric pressures , such as from bases in mountainous areas . Now that the E @-@ 8 Joint STARS are being fitted with the new Pratt & Whitney JT8D @-@ 219 turbofans , which are stated as having one @-@ half the cost of the competing engine , the CFM56 , the Air Force is again studying the possibility of replacing the E @-@ 3 's original turbofan engines with more @-@ efficient ones .

Upgrading NATO 's E @-@ 3 fleet is complicated by the heterogeneity of the fleet 's equipment . Each NATO member 's E @-@ 3 aircraft are configured differently , and NATO has not finalized upgrade or replacement plans . The airplanes themselves can be flown to 2050 with appropriate

maintenance , but as the world @-@ wide fleet of 707 aircraft dwindles , supporting the E @-@ 3 becomes more difficult .

= = Design = =

= = = Overview = = =

The E @-@ 3 Sentry 's airframe is a modified Boeing 707 @-@ 320B Advanced model . USAF and NATO E @-@ 3s have an unrefueled range of some 4 @,@ 000 mi (6 @,@ 400 km) or eight hours of flying . The newer E @-@ 3 versions bought by France , Saudi Arabia , and the UK are equipped with newer CFM56 @-@ 2 turbofan engines , and these can fly for about 11 hours or about 5 @,@ 000 mi (8 @,@ 000 km) . The Sentry 's range and on @-@ station time can be increased through air @-@ to @-@ air refueling and the crews can work in shifts by the use of an on @-@ board crew rest and meals area .

When deployed , the E @-@ 3 monitors an assigned area of the battlefield and provides information for commanders of air operations to gain and maintain control of the battle ; while as an air defense asset , E @-@ 3s can detect , identify , and track airborne enemy forces far from the boundaries of the U.S. or NATO countries and can direct fighter @-@ interceptor aircraft to these targets . In support of air @-@ to @-@ ground operations , the E @-@ 3 can provide direct information needed for interdiction , reconnaissance , airlift , and close @-@ air support for friendly ground forces .

= = = Avionics = = =

The unpressurized rotodome is 30 feet (9 @.@ 1 m) in diameter , six feet (1 @.@ 8 m) thick at the center , and is held 11 feet (3 @.@ 4 m) above the fuselage by two struts . It is tilted down at the front to reduce its aerodynamic drag , which lessens its detrimental effect on take @-@ offs and endurance (which is corrected electronically by both the radar and secondary surveillance radar antenna phase shifters) . The dome uses both bleed air and cooling doors to remove the heat generated by electronic and mechanical equipment . The hydraulically rotated antenna system permits the Westinghouse Corporation 's AN / APY @-@ 1 and AN / APY @-@ 2 passive electronically scanned array radar system to provide surveillance from the Earth 's surface up into the stratosphere , over land or water .

Other major subsystems in the E @-@ 3 Sentry are navigation , communications , and computers . Consoles display computer @-@ processed data in graphic and tabular format on video screens . Console operators perform surveillance , identification , weapons control , battle management and communications functions . The radar and computer subsystems on the E @-@ 3 can gather and present broad and detailed battlefield information . This includes position and tracking information on enemy aircraft and ships , and location and status of friendly aircraft and naval vessels . The information can be sent to major command and control centers in rear areas or aboard ships . In times of crisis , data can be forwarded to the National Command Authority in the U.S. via RC @-@ 135 or naval aircraft carrier task forces .

Electrical generators mounted on each of the E @-@ 3 's four engines provide the one megawatt of electrical power that is required by the E @-@ 3 's radars and other electronics . Its pulse @-@ Doppler radar (PD) has a range of more than 250 mi (400 km) for low @-@ flying targets at its operating altitude , and the pulse (BTH) radar has a range of approximately 400 mi (650 km) for aircraft flying at medium to high altitudes . The radar , combined with an SSR , provides a look down capability , to detect , identify , and track low @-@ flying aircraft , while eliminating ground clutter (radar) returns .

= = = Upgrades = = =

Starting in 1987 , USAF E @-@ 3s were upgraded under the " Block 30 / 35 Modification Program " to enhance the E @-@ 3 's capabilities . On 30 October 2001 , final airframe to be upgraded under this program was rolled out . Several major enhancements were made , firstly the installation of electronic support measures (ESM) and an electronic surveillance capability , for both active and passive means of detection . Also , Joint Tactical Information Distribution System (JTIDS) was installed , which provides rapid and secure communication for transmitting information , including target positions and identification data , to other friendly platforms . Global Positioning System (GPS) capability was also added . Onboard computers were also overhauled to accommodate JTIDS , Link @-@ 16 , the new ESM systems and to provide for future enhancements .

The Radar System Improvement Program (RSIP) was a joint US / NATO development program . RSIP enhances the operational capability of the E @-@ 3 radars ' electronic countermeasures , and dramatically improve the system 's reliability , maintainability , and availability . Essentially , this program replaced the older transistor @-@ transistor logic (TTL) and emitter @-@ coupled logic (MECL) electronic components , long @-@ since out of production , with off @-@ the @-@ shelf digital computers that utilised a High @-@ level programming language instead of assembly language . Significant improvement came from replacing the old 8 @-@ bit FFT with 24 @-@ bit FFTs , and the 12 @-@ bit A / D (Sign + 12 @-@ bits) with a 15 @-@ bit A / D (Sign + 15 @-@ bits) . These hardware and software modifications improve the E @-@ 3 radars ' performance , providing enhanced detection with an emphasis towards low radar cross @-@ section (RCS) targets .

The RAF had also joined the USAF in adding RSIP to upgrade the E @-@ 3 's radars . The retrofitting of the E @-@ 3 squadrons were completed in December 2000 . Along with the RSIP upgrade was installation of the Global Positioning System / Inertial Navigation Systems which dramatically improve positioning accuracy . In 2002 , Boeing was awarded a contract to add RSIP to the small French AWACS squadron . Installation was completed in 2006 .

= = Operational history = =

In March 1977 , the 552nd Airborne Warning and Control Wing (now the 552d Air Control Wing) at Tinker AFB , Oklahoma received the first E @-@ 3 aircraft , commanded by Major James R. Sterk . The 34th and last USAF Sentry was delivered in June 1984 . In March 1996 , the USAF activated the 513th Air Control Group (513 ACG) , an ACC @-@ gained Air Force Reserve Command (AFRC) AWACS unit under the Reserve Associate Program . Collocated with the 552 ACW at Tinker AFB , the 513 ACG which performs similar duties on active duty E @-@ 3 aircraft shared with the 552 ACW .

The USAF has a total of thirty @-@ one E @-@ 3s in active service . Twenty @-@ seven are stationed at Tinker AFB and belong to the Air Combat Command (ACC) . Four are assigned to the Pacific Air Forces (PACAF) and stationed at Kadena AB , Okinawa and Elmendorf AFB , Alaska . One aircraft (TS @-@ 3) was assigned to Boeing for testing and development (retired / scrapped June 2012) .

In 1977 , Iran placed an order for ten E @-@ 3s , however this order was cancelled following the 1979 revolution .

NATO acquired 18 E @-@ 3As and support equipment for a NATO air defense force . Since all aircraft must be registered with a certain country , the decision was made to register the 18 NATO Sentries with Luxembourg , a NATO member that previously did not have any air force . The first NATO E @-@ 3 was delivered in January 1982 . The eighteen E @-@ 3s were operated by Number 1 , 2 and 3 Squadrons of NATO 's E @-@ 3 Component , based at NATO Air Base Geilenkirchen . Presently , 17 NATO E @-@ 3As are in the inventory , since one E @-@ 3 was lost in a crash .

The United Kingdom and France are not part of the NATO E @-@ 3A Component , instead procuring E @-@ 3 aircraft through a joint project . The UK and France operate their E @-@ 3 aircraft independently of each other and of NATO . The UK operates six aircraft (with a seventh now retired) and France operates four aircraft , all fitted with the newer CFM56 @-@ 2 engines . The

British requirement came about following the cancellation of the British Aerospace Nimrod AEW3 project to replace the Avro Shackleton AEW2 during the 1980s . The UK E @-@ 3 order was placed in February 1987 , with deliveries starting in 1990 . The other operator of the type , delivered between June 1986 and September 1987 , is Saudi Arabia which operates five aircraft , all fitted with CFM56 @-@ 2 engines . This particular sale was hotly contested between the Reagan administration and opponents of the sale .

E @-@ 3 Sentry aircraft were among the first to deploy during Operation Desert Shield , where they immediately established as an around @-@ the @-@ clock radar screen to defend against Iraqi forces . During Operation Desert Storm , E @-@ 3s flew 379 missions and logged 5 @,@ 052 hours of on @-@ station time . The data collection capability of the E @-@ 3 radar and computer subsystems allowed an entire air war to be recorded for the first time in history . In addition to providing senior leadership with time @-@ critical information on the actions of enemy forces , E @-@ 3 controllers assisted in 38 of the 41 air @-@ to @-@ air kills recorded during the conflict .

NATO E @-@ 3s joined their USAF colleagues for joint air defense as part of Operation Eagle Assist in the wake of the September 11 , 2001 terrorist attacks on the World Trade Center towers and the Pentagon .

NATO and RAF E @-@ 3s participated in the international military operation in Libya .

On 27 January 2015 , the RAF deployed an E @-@ 3D Sentry to Cyprus in support of U.S.-led coalition airstrikes against Islamic State militants in Iraq and Syria . The Sentry joins RAF Panavia Tornado , MQ @-@ 9 Reaper , and AirTanker Voyager aircraft performing or supporting almost daily strikes against militants .

On 23 June 2015 , the first of the original 18 NATO E @-@ 3A AWACS aircraft to retire , arrived at Davis @-@ Monthan AFB near Tucson , AZ . The aircraft , LX @-@ N 90449 , will be placed in parts reclamation storage where critical parts will be removed by NATO technicians to support their remaining fleet of 16 Boeing E @-@ 3A aircraft . It had accumulated 22 @,@ 206 flight hours between 19 August 1983 and 13 May 2015 and operated out of twenty @-@ one different countries in support of NATO operational activities . The aircraft was due in mid @-@ July 2015 for a six @-@ year cycle Depot Level Maintenance (DLM) inspection which would have been very costly . Without the inspection , the aircraft would no longer be allowed to fly . The so @-@ called " 449 Retirement Project " will result in reclamation of critical parts with a value of upwards of $ 40 @,@ 000 @,@ 000 . Some of the parts to be removed are no longer on the market or have become very expensive .

On 18 November 2015 , an E @-@ 3G was deployed to the Middle East to begin " immediately " flying combat missions in support of Operation Inherent Resolve against ISIL , marking the first combat deployment of the upgraded AWAC Block 40 / 45 . The $ 2 @.@ 7 billion development effort started in 2003 , with the first five aircraft achieving initial operational capability (IOC) in July 2015 . The Block 40 / 45 upgrade is the most extensive the E @-@ 3 has undergone , replacing its 1970s computer technology with an early 2000s standard and including a deployable ground system that receives , processes , and disseminates data . The Air Force plans to convert 24 AWACS to E @-@ 3G standard , while retiring seven from the fleet to avoid upgrade costs and harvest out @-@ of @-@ production components .

= = Variants = =

EC @-@ 137D

Two prototype AWACS aircraft with JT3D engines , one fitted with a Westinghouse Electric radar and the other with a Hughes Aircraft Company radar . Both converted to E @-@ 3A standard with TF33 engines .

E @-@ 3A

Production aircraft with TF33 engines and AN / APY @-@ 1 radar , 24 built for USAF later converted to E @-@ 3B standard , total of 34 ordered but the last 9 completed as E @-@ 3C . One additional aircraft retained by Boeing for testing , 18 built for NATO with TF33 engines and five for Saudi Arabia with CFM56 engines .

KE @-@ 3A

These are not AWACS aircraft but CFM56 powered tankers based on the E @-@ 3 design . Eight were sold to Saudi Arabia .

E @-@ 3B

E @-@ 3As with improvements , 24 conversions .

E @-@ 3C

Production aircraft with AN / APY @-@ 2 radar , additional electronic consoles and system improvements , ten built .

JE @-@ 3C

One E @-@ 3A aircraft used by Boeing for trials later redesignated E @-@ 3C .

E @-@ 3D

Production aircraft for the Royal Air Force to E @-@ 3C standard with CFM56 engines and British modifications designated Sentry AEW.1 , seven built .

E @-@ 3F

Production aircraft for the French Air Force to E @-@ 3C standard with CFM56 engines and French modifications , four built .

E @-@ 3G

USAF Block 40 / 45 modification . Includes hardware and software upgrades to improve communications , computer processing power , threat tracking , and others , and automates some previously manual functions . IOC reached in July 2015 .

= = Operators = =

= = = Current operators = = =

France

The French Air Force purchased four E @-@ 3F aircraft similar to the British E @-@ 3D aircraft .

All planes are assigned to the Escadron de Détection et de Commandement Aéroporté (ECDA , Air detection and command squadron) and are based at Avord Air Base .

NATO

Based in Geilenkirchen , Germany , 18 E @-@ 3 AWACS were purchased ? one lost in Greece . All of these aircraft are officially registered as aircraft of Luxembourg , a NATO member with no other air force . Responsible for monitoring airspace for NATO operations around the world .

Aircrew Training Squadron

Flying Squadron 1

Flying Squadron 2

Flying Squadron 3 disbanded 2015

Saudi Arabia

The Royal Saudi Air Force purchased five E @-@ 3A aircraft and eight KE @-@ 3A tanker aircraft in 1983 .

No. 18 Squadron

United Kingdom

The Royal Air Force purchased seven E @-@ 3Ds by October 1987 . All seven are still in service ; six are operational and one is used for training . The aircraft are designated Sentry AEW.1.

No. 8 Squadron

No. 23 Squadron ? (disbanded in 2009)

No. 54 Squadron

United States of America

The United States Air Force currently has 32 E @-@ 3s .

Tactical Air Command 1976 ? 92

Air Combat Command 1992 ? present

552d Air Control Wing ? Tinker Air Force Base , Oklahoma

960th Airborne Air Control Squadron 2001 ? present (NAS Keflavik , Iceland 1979 ? 92)
963d Airborne Air Control Squadron 1976 ? present
964th Airborne Air Control Squadron 1977 ? present
965th Airborne Air Control Squadron 1978 ? 79 , 1984 ? present
966th Airborne Air Control Squadron 1976 ? present
380th Air Expeditionary Wing ? Al Dhafra Air Base , United Arab Emirates
968th Expeditionary Airborne Air Control Squadron 2002 @-@ 2003 , 2013 @-@ present
Air Force Reserve Command
513th Air Control Group (Associate) ? Tinker AFB , Oklahoma
970th Airborne Air Control Squadron 1996 ? present
Pacific Air Forces
3d Wing ? Elmendorf AFB , Alaska
962d Airborne Air Control Squadron 1986 ? present
18th Wing ? Kadena AB , Japan
961st Airborne Air Control Squadron 1979 ? present

= = Incidents and accidents = =

The E @-@ 3 has been involved in three hull @-@ loss accidents , and one radar antenna destroyed during RSIP development (see photo under Avionics) .
On 22 September 1995 , a U.S. Air Force E @-@ 3 Sentry (callsign Yukla 27 , serial number 77 @-@ 0354) , crashed shortly after take off from Elmendorf AFB , Alaska . The plane lost power to both left side engines after these engines ingested several Canada geese during takeoff . The aircraft went down about 2 miles (3 @.@ 2 km) northeast of the runway , killing all 24 crew members on board .
On 14 July 1996 , a NATO E @-@ 3A , LX @-@ N90457 , c / n 22852 , ex @-@ 79 @-@ 0457 , overran the runway and dipped into the sea on takeoff from Preveza AB , Preveza , Greece . The fuselage broke into two , destroying the aircraft , but there were no casualties among the 16 crew members on board . It allegedly suffered a birdstrike during take off , but no evidence of a birdstrike was found .
On 28 August 2009 , a USAF E @-@ 3C , 83 @-@ 0008 , was severely damaged while landing at Nellis Air Force Base , after experiencing a nose @-@ wheel failure . The failure resulted in a fire that caused a reported US $ 100 million in damage . The accident was determined to be pilot error : at an altitude of about 100 feet (30 m) , both the co @-@ pilot , and the pilot , lost track of their height above ground . The aircraft struck the ground with such force that the nose wheel strut broke . The aircraft slid along the runway for 4 @,@ 500 feet (1 @,@ 400 m) .

= = Specifications (USAF / NATO) = =

Data from Globalsecurity.org
General characteristics
Crew : Flight crew : 4 (aircraft commander , pilot , navigator , flight engineer)
Mission crew : 13 ? 19
Length : 152 ft 11 in (46 @.@ 61 m)
Wingspan : 145 ft 9 in (44 @.@ 42 m)
Height : 41 ft 4 in (12 @.@ 6 m)
Wing area : 3 @,@ 050 ft2 (283 @.@ 4 m2)
Empty weight : 185 @,@ 000 lb (73 @,@ 480 kg)
Loaded weight : 344 @,@ 000 lb (with aerial refueling) (156 @,@ 036 kg)
Max. takeoff weight : 347 @,@ 000 lb (157 @.@ 397 kg)
Powerplant : 4 × Pratt and Whitney TF33 @-@ PW @-@ 100A turbofan , 21 @,@ 500 lbf (93 kN) each
Performance

Maximum speed : 530 mph (855 km / h , 461 knots)
Range : 4 @,@ 000 nmi (7 @,@ 400 km) (8 hr)
Service ceiling : 41 @,@ 000 ft (12 @,@ 500 m)