

Eyes of the Fleet

US Navy E-2 Hawkeye

The Northrop Grumman E-2 Hawkeye series has served the US Navy as an all-weather, tactical airborne early warning and control system (AEW&CS) for more than 55 years. As **Tom Kaminski** reports, recent upgrades will keep it in service for decades to come



Developed in response to a 1956 requirement for a carrier-based aircraft that could carry an Airborne Tactical Data System (ATDS) to “provide early warning, threat analysis, and control of counteraction against air and surface targets”, the Hawkeye continues to serve as an airborne surveillance and battle management command and control (BMC2) platform. Its ability to detect and track targets, process and transmit data, and control engagements also allows the aircraft to be tasked with secondary roles such as air traffic management, search and rescue, communications relay, and drug interdiction.

The US Navy Bureau of Aeronautics selected the Grumman Aircraft Engineering Corporation to design and build the carrier-based airborne early warning and

control aircraft in March 1957. Grumman had previously developed the earlier WF-2 Tracer from its TF-1 carrier-on-board delivery aircraft. On October 21, 1960, the model G-123 flew for the first time in Bethpage, New York, as the W2F-1. The aerodynamic prototype was followed by a second fully equipped example that flew on April 19, 1961. Known affectionately as the ‘Hummer’, due to the distinctive sound of its twin turboprop engines, the Hawkeye has been fielded in four major variants that comprise the E-2A, E-2B, E-2C and E-2D.

It entered operational service with carrier airborne early warning squadron VAW-11 under the designation E-2A on January 19, 1964. Its first combat deployment began when VAW-11 Detachment C embarked the USS *Kitty Hawk* (CVA 63) which left

San Diego on October 19, 1965 headed for Southeast Asia. Production concluded with the final E-2A delivery in February 1967 and totalled 59 aircraft.

Powered by two 4,050shp Allison T56-A-8/8A turboprop engines, the E-2A’s most notable feature was a 24ft diameter AN/APA-143 rotodome that housed the antenna arrays for the General Electric AN/APS-96 radar and the AN/APX-7 identification friend or foe (IFF) system. Rotating at a speed of six rpm, it provided 360° coverage around the aircraft. The E-2A also featured an automatic flight control system and was equipped with a CP-588 airborne computer. Its ATDS was designed to acquire, transmit and exchange information and targeting data with warships equipped with the Naval Tactical Data System.



Above: The Hawkeye's Combat Information Center provides three identical mission system operator positions for the Radar Operator (RO), Combat Information Center Officer (CICO) and the Air Control Officer (ACO) US Navy/MCS Kyle D. Gahlau



Main photo: VAW-116 'Sun Kings' E-2C, BuNo 165649, is one of 27 Hawkeye 2000 variants delivered to the US Navy between 2002 and 2009. US Navy/Lt(jg)Toby Rollenhagen

Reliability issues with computer and other systems resulted in modifications that updated 51 E-2As to the E-2B configuration. First flown on February 20, 1969 and initially deployed with VAW-114 aboard the *Kitty Hawk* in November 1970, the E-2B featured a new Litton L-304 digital computer and upgraded avionics. The conversion programme was completed in December 1971. The 'Bravo' was phased out of operational fleet service by 1985 but continued to serve the Naval Reserve until VAW-88 retired its E-2Bs at NAS Miramar, California, in October 1986.

E-2 CHARLIE

Produced in five sub-variants, the E-2C has had the largest production run, comprising 183 aircraft for the US Navy and 36 that

were sold to international customers. Work on the E-2C began in June 1968, when Grumman was awarded an \$11.9m contract to develop the AN/APS-111 radar. Based on the earlier AN/APS-96, the AN/APS-111 was designed by General Electric and underwent testing aboard an E-2A from 1965 to 1967.

Two early E-2As became the E-2C prototypes and were assigned the designations YE-2C and NE-2C. Powered by 4,860shp Allison T56-A-422 engines, the first prototype flew on January 20, 1971. Physical differences between the E-2C and the earlier E-2A/B included a longer, sleeker nose and fairings on the outboard vertical fins and aft fuselage that housed antennas for the Litton AN/ALR-59 Passive Detection System (PDS). The system provided 360° passive precision direction finding, ranging,

and identification of electronic emitters. The design also incorporated a larger vapour cycle radiator on the upper fuselage, aft of the cockpit, used for cooling the avionics.

Production E-2C deliveries began on September 23, 1972 and the baseline version entered service with VAW-123 in November 1973, but VAW-113 was the first to deploy aboard the USS *Saratoga* (CV 60) in September 1974. The E-2C was powered by 4,910shp T56-A-425 engines and carried the AN/APS-120 radar. Developed from the earlier AN/APS-111, it improved detection of aerial targets against sea and land returns. The E-2C retained the E-2B's Litton L-304 computer but the AN/ASN-92 Carrier Aircraft Inertial Navigation System (CAINS) replaced the earlier AN/ASN-36 INS.

Introduced with the 35th E-2C (BuNo 160415) in 1976, the digital AN/APS-125 Advanced Radar Processing System was less vulnerable to jamming and could detect fighter-size targets and cruise missiles at ranges up to 200nm and 125nm respectively. Additionally, it incorporated improved electronic counter-countermeasures (ECCM) capabilities.

Beginning in 1987, several early E-2Cs were operated by the US Customs Service and the US Coast Guard, under loan from the US Navy. Each agency initially operated two E-2Cs to support counter narcotics operations, funded under the Anti-Drug Abuse Act of 1986. The Customs aircraft were turned over to the Coast Guard in 1989 and continued in service until October 1991.

First installed on aircraft A-79 (BuNo 161346), the AN/APS-138 radar and the Total Radar Aperture Control-A antenna improved the radar's effectiveness in detecting small targets, especially over land. Grumman produced 52 aircraft in this configuration, which was later referred to as Group 0, including 35 to the US Navy and 17 to international customers.

The Group I that followed featured the AN/APS-139 radar. It increased cruise missile detection range to 160nm and improved surface detection in high sea state/clutter and against countermeasures. Group I also introduced the 5,100shp T56-A-427 engines and the improved Litton AN/ALR-73 PDS, which was first installed on A-69 (BuNo 161229). First evaluated on aircraft A-34 (BuNo 160012) in April 1986, the -427 delivered a 24% increase in power and reduced fuel consumption by 12%. Just 18 Group I E-2Cs were produced beginning with aircraft A-122 (BuNo 163029), and the variant entered operational service with VAW-112 on August 8, 1989. Hawkeye A-123 (BuNo 163535) was the first production model with the new engines and it served as a dedicated test asset for its entire career.

Group II Hawkeyes retained the T56-A-427 engines, but featured 11in colour tactical displays, a more powerful computer and AN/APS-145 radar. The latter system was first tested aboard aircraft A-92 (BuNo 161784). In addition to increasing ►



The prototype Hawkeye first flew on October 21, 1961, under the designation W2F-1. Assigned Bureau Number 148147, it was later modified to become the prototype C-2A carrier on-board delivery (COD) prototype Northrop Grumman

radar range by 40% and surveillance space volume by 96%, the new version could simultaneously monitor, track and display more than 2,000 target tracks. The radar could also locate and track naval targets, including large ships, fast patrol craft and stationary platforms in most sea states.

The Joint Tactical Information Distribution System (JTIDS) was also fielded on Group II aircraft. Flight-testing of this data link system began in February 1990. Group IIs also gained a wideband/narrowband secure voice satellite communication (SATCOM) capability and an upgraded IFF system. Deliveries to VAW-113 began in June 1992.

The conversion of 16 Group Is to Group II configuration began on December 21, 1995 and the programme was completed in mid-2001. A Mission Computer Replacement programme provided most Group IIs with new processors. Completed in 2005 it installed the Reconfigurable Processor for Legacy Avionics Code Execution (RePLACE) computer, which reduced weight and greatly increased processing capabilities. The last Group II variant was retired from operational service in November 2019.

HAWKEYE 2000

The final E-2C variant is known as the Hawkeye 2000 (H2K) and aircraft A-130 (BuNo 163849) first flew as the production system test aircraft on June 28, 1998 and

deliveries began in October 2001. It retained the AN/APX-145 radar but, featured a GPS receiver, AN/ASN-139 CAINS II navigation system and improved AN/APX-100 IFF. An UHF SATCOM satellite communication set and a Multimission Advanced Tactical Terminal provided expanded over-the-horizon wide-band and narrow-band voice/data communications capability. Additionally, the earlier PDS was replaced by the

HAWKEYE CREW

The Hawkeye is flown by a crew of five, comprising two pilots and three Naval Flight Officers (NFOs). From front to rear, three identical mission system operator positions are provided in the CIC for the Radar Operator (RO), Combat Information Center Officer (CICO) and the Air Control Officer (ACO). The RO is the primary weapons system operator and acts as a secondary air controller. The CICO serves as the airborne mission commander and is responsible for mission planning and execution. The ACO is the primary air controller, datalink and SATCOM operator.

Lockheed Martin AN/ALQ-217A electronic support measures (ESM) system. The most pronounced changes were the integration of the mission computer upgrade (MCU) and Advanced Control Indicator Set (ACIS) and updated T56-A-427A engines.

The MCU integrated an improved commercial, off-the-shelf (COTS) based,

open-architecture Raytheon model 940 computer and the ACIS installed COTS tactical workstations, featuring 17in flat-panel active-matrix liquid-crystal displays (AMLCDs). Testing of the new computer began with the first flight from Northrop Grumman's production facility and flight test centre at St Augustine, Florida in January 1997 and concluded that July.

A contract to incorporate the MCU/ACIS in four earlier Group II E-2Cs (A-143/146) was issued earlier in September 1996 and the aircraft initially deployed with VAW-117 aboard the USS *Carl Vinson* (CVN 70) in July 2001.

The Hawkeye 2000's most advanced upgrade was the AN/USG-3 Cooperative Engagement Capability (CEC) that enabled high-capacity data exchange between the aircraft and CEC-equipped surface combatants. Along with a Cooperative Engagement Processor and a Digital Distribution System the CEC's Common Engagement Set installed a 54in electronically steered antenna on the Hawkeye's lower fuselage that enabled enhanced fleet-wide connectivity and situational awareness.

The Hawkeye 2000 was also the first production model equipped with the digitally controlled eight-bladed Hamilton Sundstrand NP2000 propeller, replacing the aircraft's mechanically controlled, four-blade Hamilton Sundstrand model 54460 propellers. The NP2000 reduced noise and vibration, improved reliability and increased maintainability. The programme was launched in 2000 and the new propeller first flew on aircraft A-123 (BuNo 163535) on April 19, 2001. Testing of the new system concluded in late-2003 and retrofits for earlier aircraft got under way in 2004.

The new version of Hawkeye joined the fleet in 2002 and was first deployed aboard the USS *Nimitz* (CVN 68) by VAW-117 in 2003. The US Navy accepted the last of 27 Hawkeye 2000s at St Augustine on September 21, 2009. The programme included two TE-2C trainers that were later upgraded to the E-2C H2K configuration, under a \$10m contract awarded in December 2010.



E-2Bs served the active fleet from 1969 to 1986 when Naval Reserve squadron VAW-88 retired its last 'Bravo'. E-2B BuNo 152476 was one of 51 E-2As converted to the later configuration Tom

Kaminski

E-2Cs currently equip three fleet squadrons and Fleet Replacement Squadron (FRS) VAW-120, which also operates a single TE-2C trainer. Hawkeyes are also assigned to the Naval Air Warfare Development Center at NAS Fallon, Nevada, and the Naval Air Warfare Center Aircraft Division's air test and evaluation squadron VX-20 at NAS Patuxent River, Maryland. Under current plans, the last E-2Cs will be retired by 2027.

OPERATIONAL MISSIONS

Like the USAF's E-3 Sentry, little has been written about Hawkeye combat operations. Although no less important than strike and fighter aircraft, both are 'unsung heroes' whose missions are overshadowed by more glamorous types.

Early E-2A/B models first supported combat operations in Southeast Asia from 1965-1972 but the Hawkeye came to the forefront in August 1981, when a VAW-124 E-2C controlled the intercept and destruction of two Libyan Su-22s by VF-41 F-14A Tomcats from the aircraft carrier USS *Nimitz* (CVN 68) over the Gulf of Sidra north of Libya.

Since then, the E-2C has supported every major combat operation that involved a US Navy carrier strike group. In October 1985, a VAW-125 E-2C tracked an EgyptAir Boeing 737 carrying the Palestinian hijackers of the Italian cruise ship *Achille Lauro* and directed F-14As from VF-74 and VF-102 to intercept the aircraft, which was forced to land at NAS Sigonella, Italy.

During April 1986's Operation El Dorado Canyon, Hawkeyes directed F-14As flying combat air patrol missions, while carrier-based strike aircraft hit terrorist-related targets in Libya. Later, on January 4, 1989, a VAW-126 E-2C controlled the intercept of a pair of Libyan MiG-23s that were then shot down by VF-32 F-14As from the USS *John F Kennedy* (CV 67) over the Mediterranean Sea, north of Tobruk, Libya.

E-2Cs provided airborne command and control for Coalition air operations directing strike and combat air patrol missions over Iraq during Operation Desert



The Baseline E-2Cs featured the AN/APS-120 and then the AN/APS-125 radar and AN/ALR-59 Passive Detection System (PDS). The E-2C entered service with VAW-123 in November 1973 and Grumman produced 69 over a ten-year period Northrop Grumman

Storm. A Hawkeye provided air control for the shoot-down of two Iraqi MiG-21s by carrier-based F/A-18Cs from VFA-81 during the first day of the conflict on January 17, 1991. Following the Gulf War, deployed Hawkeyes continued to support Operations

Later, E-2Cs from CVW-8 aboard the USS *Theodore Roosevelt* (CVN 71) served as airborne command, control and communication platforms directing strike packages containing F-14Ds and F/A-18Cs and EA-6Bs over Kosovo in 1999. The Hawkeyes acted as an interface between the Combined Air Operations Center in Vicenza, Italy, and naval air assets.

Hawkeyes have been engaged in support of Operation Enduring Freedom/Freedom's Sentinel in Afghanistan since 2001 and Operation Iraqi Freedom/New Dawn in Iraq since 2003. Ten E-2C squadrons have flown overland sorties, providing critical airborne battle and airspace management in support of attacks on enemy ground targets, close-air-support coordination, combat search and rescue control, and airspace management. They have also acted as datalink and communication relays for both land and naval forces.

In August 2003, VAW-123 became the first carrier-based Navy squadron to operate an expeditionary detachment in support of special warfare units operating in Northern Afghanistan. The squadron provided airborne command control to coalition aircraft and time-sensitive targeting coordination to special operations forces involved in Operation Mountain Resolve. ▶

PRODUCTION SITES

Hawkeyes have been produced at three different sites, at Bethpage and Calverton, New York state, and St Augustine, Florida. All E-2As and 138 E-2Cs were produced at Grumman's Bethpage facility. The closure of the runway at that site in 1990 caused production to move 50 miles east to the company's production and flight test facility at Naval Weapons Industrial Reserve Plant, Calverton, where aircraft A-139 to A-163 were produced.

Production transitioned to the St Augustine facility after the final delivery from Calverton occurred in 1994. Aircraft A-164 was rolled out in St Augustine on February 24, 1997 and all subsequent E-2C and E-2D production has been carried out at that facility, which is co-located with Northeast Florida Regional Airport.

Northern and Southern Watch over Iraq. From 1993-1995, carrier-based E-2Cs from VAW-123, VAW-124, VAW-125 and VAW-126 supported NATO operations over Bosnia and Herzegovina as part of Operation Deny Flight/Deliberate Force.



A pair of Group 0 E-2Cs from VAW-124 were among 52 produced and included 35 for the US Navy and 17 that went to international customers. The Group 0 was equipped with an updated AN/APS-138 radar system that improved its ability to detect small targets

US Navy/PH1 Ronald Beno



A Group I E-2C assigned to the 'Bear Aces' of VAW-124 lands on the USS Theodore Roosevelt in the Mediterranean Sea. Entering service in August 1989, the Group I variant featured the AN/APS-139 radar and updated AN/ALR-73 PDS US Navy/AFAA Chris Thamann

More recently, E-2Cs and E-2Ds have supported Inherent Resolve and the fight against the Islamic State in Syria and Iraq. In mid-2017, VAW-121 E-2Ds flying from the USS Nimitz (CVN 68) in the Persian Gulf, proved to be a critical element by providing early warning detection of

potential threats, air intercept control, and airspace management for coalition aircraft conducting defensive counter air (DCA) combat air patrols over friendly troops. During missions over Iraq the Advanced Hawkeyes provided radar and radio coverage of the battlespace, controlling



One of just 18 Group I E-2Cs produced and assigned to the 'Bear Aces' of VAW-124. The Group I Hawkeyes featured the AN/APS-139 radar, but most were later updated to Group II configuration. The squadron currently operates the Hawkeye 2000 variant of the E-2C from Chambers Field at Naval Station Norfolk, Virginia. VAW-124 was originally known as the 'Bullseye Hummers'. Tom Kaminski

US Navy F/A-18s and assets that included USAF F-15Es and F-22As. The missions marked the first time since the opening days of Operation Desert Storm that Hawkeyes executed the combat DCA mission.

Many E-2 missions have involved homeland and regional defence and support. Hawkeyes were active on both the US East and West coasts as part of Operation Noble Eagle, immediately following the terror attacks in September 2001.

In the aftermath of Hurricane Katrina in 2005, three Hawkeye squadrons supported search-and-rescue and civilian relief efforts including air traffic control over three states. Following a January 2010 earthquake in Haiti, Hawkeyes supported relief efforts that included air traffic control. They have also proven to be invaluable assets when actively involved in drug interdiction efforts worldwide. A major change for the Hawkeye community occurred on January 1, 2020, when the title for the VAW squadrons was changed to Airborne Command and Control Squadron.

ADVANCED HAWKEYE

In late-2001, Northrop Grumman received a \$49m pre-systems development and demonstration (SDD) contract associated with the E-2C Radar Modernization Program (RMP). A Milestone B approval to enter SDD followed in June 2003 and the contractor was awarded a \$1.9bn contract to begin development of the Advanced Hawkeye (AHE) on August 4, 2003. The E-2D mission design series designation was formally assigned in July 2004, but wasn't officially announced until March 2005.

As part of the SDD effort, \$413.5m was allocated to Lockheed Martin for development of the new UHF-band AN/APY-9 advanced electronically scanned array radar. Featuring mechanical and electronic scan capabilities, the phased-array system delivered a 250% increase in coverage over the AN/APS-145. Its

US NAVY HAWKEYE OPERATORS				
Squadron	Location	Aircraft	Command	Tail code
NAWDC 'Strike'	NAS Fallon, Nevada	E-2C	CNAF/CNAFP	-
VAW-113 'Black Eagles'	NB Ventura County - Point Mugu, California	E-2D	CACCLW	NE
VAW-115 'Liberty Bells'	NB Ventura County - Point Mugu, California	E-2C	CACCLW	NH
VAW-116 'Sun Kings'	NB Ventura County - Point Mugu, California	E-2C	CACCLW	NA
VAW-117 'Wallbangers'	NB Ventura County - Point Mugu, California	E-2D	CACCLW	NG
VAW-120 (FRS) 'Greyhawks'	Chambers Field, NS Norfolk, Virginia	E-2C/D, TE-2C	CACCLW	AD
VAW-121 'Bluetails'	Chambers Field, NS Norfolk, Virginia	E-2D	CACCLW	AG
VAW-123 'Screwtops'	Chambers Field, NS Norfolk, Virginia	E-2C	CACCLW	AC
VAW-124 'Bear Aces'	Chambers Field, NS Norfolk, Virginia	E-2C	CACCLW	AJ
VAW-125 'Tigertails'	MCAS Iwakuni, Japan	E-2D	CACCLW	NF
VAW-126 'Seahawks'	Chambers Field, NS Norfolk, Virginia	E-2D	CACCLW	AB
VX-1 'Pioneers'	NAS Patuxent River, Maryland	E-2D	COTEF	JA
VX-20 'Force'	NAS Patuxent River, Maryland	E-2C/D	NAWCAD	-

Key: CACCLW - Commander, Airborne Command and Control Logistics Wing
CNAF/CNAFP - Commander, Naval Air Force/Commander Naval Air Force Pacific
COTEF - Commander, Operational Test & Evaluation Force
NAWCAD - Naval Air Warfare Center Aircraft Division



First flown in June 1998 the E-2C Hawkeye 2000 featured numerous upgrades that included the AN/USG-3 Cooperative Engagement Capability (CEC). Northrop Grumman delivered the first of this variant in 2002 and eight-blade Hamilton Sundstrand NP2000 propellers were introduced in production in mid-2004 Northrop Grumman

maximum range extended out to around 350nm and it improved capacity, flexibility, and accuracy over land and in littoral environments. Development of the RMP and AHE systems was supported by NC-130H serial 87-0157 and E-2C A-123 (BuNo 163535), operated by VX-20.

Critical design reviews (CDR) were completed in 2005 and the first of two SDD aircraft, AA-1 (BuNo 165501), was rolled out April 30, 2007. It flew for the first time at St Augustine, on August 3, 2007. The second E-2D carried out its first flight on November 29, 2007 and the first full mission system test followed in December. Whereas the first SDD aircraft was tasked with aircraft systems testing, the second supported mission systems testing. Northrop Grumman and VX-20 flight crews flew 3,411 hours during 1,115 flights in support of SDD. More than 12,000 test points were evaluated over a five-year period.

A \$408m contract for three pilot production E-2Ds was issued in July 2007. Carrier suitability testing began on January 31, 2011, when the E-2D carried out its first landings and take-offs aboard the USS *Harry S Truman* (CVN 75).

An operational assessment was conducted by VX-1 between July and December 2010 at NAS Jacksonville, Florida, NAS Fallon, and Naval Base Ventura County - Point Mugu, California. The squadron later conducted initial operational test and evaluation (IOT&E) from February to October 2012. During IOT&E, the E-2D conducted 200 tracking events that involved drones and fighter-sized targets. Following IOT&E, VX-1 declared the E-2D was operationally "suitable and effective" and on June 11, 2009, the programme received a Milestone C approval to enter low rate initial production (LRIP). Five E-2Ds were purchased under the initial Lot 1 and 2 LRIP contracts and Lots 3 and 4 each added five more.

Delivery of a pilot production E-2D to VAW-120 occurred on July 29, 2010. Full-rate production (FRP) of 55 aircraft

was approved on February 11, 2013 and the E-2D achieved Initial Operational Capability in October 2014.

After an initial FRP contract for five aircraft, the Navy awarded Northrop Grumman a multi-year contract under which it ordered 26 Advanced Hawkeyes over a five-year period. E-2Ds are currently being procured under the second year of a 24 aircraft multi-year contract awarded in April 2019. The service's programme of record provides for 77 E-2Ds but the service's actual fleet objective is 86 aircraft. So far, more than 40 have been delivered to the fleet. Four additional aircraft were requested in Fiscal 2021. The Advanced Hawkeye completed its maiden deployment with VAW-125 aboard the USS *Theodore Roosevelt* (CVN 71) in November 2015 and six squadrons have already transitioned to the new variant.

NEW RADAR CAPABILITIES

Delivering a two-generation leap in capability over the APS-145, the E-2D's AN/APY-9 radar features both mechanical and electronic scanning modes and its ADS-18 antenna combines mechanical rotation with the ability to electronically scan the beam in azimuth.

Three operational modes comprise Advanced Airborne Early Warning Surveillance (AES), Enhanced Sector Scan (ESS) and Enhanced Tracking Sector (ETS). AES provides simultaneous 360° air and surface coverage with long-range detection of low radar cross-section targets. The antenna rotates 360° every 10 or 12 seconds. The ESS mode merges mechanical scanning with steerable electronic scanning to provide all-around coverage plus ▶



First flown on August 3, 2007, the E-2D Advanced Hawkeye features the AN/APY-9 advanced electronically scanned array radar, enhanced AN/ALQ-217A electronic support measures (ESM) system and upgraded AN/USG-3B Cooperative Engagement Capability (CEC) Northrop Grumman



An E-2D operated by air test and evaluation squadron VX-1 conducts refuelling with a KC-707 operated by Omega Aerial Refueling Services near NAS Patuxent River, Maryland. The first E-2D equipped for this was delivered to VAW-120 in September 2019 US Navy

enhanced detection and tracking in an operator-selected sector. ETS provides enhanced detection and tracking in a selected sector by stopping the antenna and scanning electronically. This mode provides a rapid search/track revisit rate and is especially useful against low-observable, small or distant targets.

The Advanced Hawkeye also features the enhanced AN/ALQ-217A ESM and advanced AN/APX-122A IFF systems, upgraded HF/VHF/UHF voice and satellite (SATCOM) communications and datalink, and a digital intercommunication system. A fully integrated digital 'glass' tactical cockpit featuring three 17in primary flight displays and two backup flight displays replaces the earlier analogue cockpit instruments.

Flight and tactical data are presented by the integrated navigation cockpit display system, which also permits the co-pilot to function as a Tactical Fourth Operator and assist the mission system operators, when not actively flying the aircraft. The E-2D's main cabin Combat Information Center features a new mission computer and tactical workstations equipped with 20in COTS

AMLCD displays. The CEC, first installed in the Hawkeye 2000, is upgraded to the AN/USG-3B configuration.

The aircraft's Rolls-Royce (Allison) 5,250shp T56-A-427A engines are equipped with uprated electrical generators and a digital Propulsion System Control Monitoring and Maintenance

initially installed in the 35th production E-2D. Retrofits to the earlier aircraft began in mid-2018.

Incremental updates to the E-2D are made as part of the Delta System Software Configuration (DSSC). The capability to refuel the Hawkeye in flight was demonstrated with a VX-20 E-2C in 2004-2005 and again in 2009. Although never implemented in the E-2C, an in-flight refuelling (IFR) system is being integrated with the E-2D as part of DSSC-3AR. A modified E-2D first received

fuel via the probe-and-drogue method from a KC-130T during testing in July 2017. Subsequent tests with the KC-135R, F/A-18E and KC-10A followed in October and December 2017, and January 2018.

The E-2D has also been fully qualified to receive fuel from a Omega Aerial Refueling Services KC-707. Extensive modifications to the cockpit, flight software, crew seats, tail rudder, fuel system, wing centre section fuel tank and external lighting are required to add the in-flight refuelling system. The capability is expected to achieve IOC and be ready for use this year. Introduced on the 46th production E-2D the in-flight refuelling

"Known affectionately as the 'Hummer', due to the distinctive sound of its twin turboprop engines, the Hawkeye has been fielded in four major variants..."

System that interfaces with the airframe, engines and propellers. Additionally, cooling capacity is increased and the fuselage and centre wing structure were designed to reduce weight and provide increased strength.

NEW CAPABILITIES

Recent upgrades have equipped the E-2D with the Automatic Identification System (AIS), which enhances maritime target combat identification capability in support of BMC2 and surface warfare missions by providing identification, course and speed of maritime surface vessels. Flight-testing was completed in 2015 and the AIS was



A VAW-126 E-2D lands aboard the aircraft carrier USS Harry S Truman. The 'Seahawks' operated the E-2A, E-2B, and the Baseline, Group 0, Group II and Hawkeye 2000 variants of the E-2C before transitioning to the Advanced Hawkeye in 2016. US Navy/MCS Rebekah A. Watkins

equipment is being retrofitted to earlier aircraft at a cost of around \$6m each. Modifications to fleet aircraft began in 2019 and VAW-120 received its first updated E-2D in September that year. The first delivery to an operational squadron occurred when VAW-126 received its first IFR-capable E-2D on July 27 this year.

Incorporation of the Embedded National Tactical Receiver (ENTR) began with the 44th E-2D and retrofit installations started in early 2019. ENTR permits the E-2D to receive real-time, emergent threat or combat identification intelligence data from national assets. It will shorten the tactical engagement timeline for Naval Integrated Fire Control-Counter Air (NIFC-CA) kill chains.

Planned upgrades, being implemented under the Operational Safety and Improvement Program will improve numerous systems and provide beyond line-of-sight (BLOS) networking and GPS-protection capabilities. Flight-testing began in 2018 and Northrop Grumman will integrate BLOS Tactical Targeting Network Technology (TTNT) and Navigation Warfare (NAVWAR) into the Advanced Hawkeye beginning with the FRP Lot 7 aircraft.

TTNT integrates Advanced Tactical Data Link (ATDL) functionality and replaces the Multifunctional Information Distribution System – Low Volume Terminal (MIDS LVT) radio with MIDS/JTRS (Joint Tactical Radio System). Incorporation of MIDS/JTRS TTNT will enable high-speed data link communication with the EA-18G and F/A-18E/F and support the NIFC-CA mission. NAVWAR provides GPS anti-jam protection, enabling operations in electronic jamming environments. Modifications are scheduled to begin



The 'Bluetails' of VAW-121 are one of six squadrons that have already converted from the E-2C to the E-2D US Navy/MC3 Amber Smalley

in 2021. In August this year, Northrop Grumman received a \$34.2m contract to start development of a cockpit redesign for the E-2D.

Northrop Grumman is also studying the feasibility of equipping the E-2D's dual SATCOM channels with the Mobile User Objective System developed by Lockheed Martin. The next-generation narrowband ultra-high frequency tactical SATCOM system will deliver advanced communications capabilities.

Advanced Hawkeye's theatre air and missile defence abilities make it a key component of the NIFC-CA concept. Further upgrades to the radar, CEC, Link

16 JTIDS and ATDL will combine to fully integrate the E-2D for the joint integrated air and missile defence role. Under the NIFC-CA concept, the aircraft's radar could potentially be used to target ship-launched Standard SM-6 missiles via the CEC data link.

Sales of E-2Ds have already been chalked up to Japan for 13, and in July this year France received US State Department approval to purchase three Advanced Hawkeyes at a cost of \$2bn.

Northrop Grumman continues to pursue international customers, while the E-2D is poised to serve the US Navy through to the middle of the century. **AN**



Under the E-2D's System Development and Demonstration (SDD) phase, Northrop Grumman produced a pair of Advanced Hawkeyes at its St Augustine, Florida facility. One of the defining features of the E-2D is the second air scoop behind the cockpit Northrop Grumman