



IN IT FOR THE LONG HAUL

As the US Air Force marks 60 years of the KC-135 and puts its new Boeing KC-46 Pegasus tanker onto a production footing, *Combat Aircraft* takes a timely look at the current USAF tanker force and potential avenues for the future.

report: **Rob Coppinger**

AT THE UK'S Royal International Air Tattoo last July, Lockheed Martin F-35 Lightning IIs and F-22 Raptors made display flights after long trans-Atlantic journeys. The tankers that kept those F-35s aloft at the end of June and beginning of July were the US Air Force's McDonnell Douglas KC-10 Extender and Boeing KC-135 Stratotanker aerial refuelers.

On June 29, two US Marine Corps F-35Bs and one Royal Air Force F-35B took off from Marine Corps Air Station Beaufort in South Carolina and landed at RAF Fairford in England. They each refueled 15 times with the help of two Extenders, in a process of aerial ballet that brings fighters and tankers into close proximity, often over remote open oceans. On June 30, three F-35As made the same journey, refueling with the help of KC-10s, which have been in service for 35 years,



and KC-135s, a tanker that has been operational for almost 60 years.

'We are capable of refueling 59 different aircraft from 35 different countries around the world using either our boom or [hose and] drogue system', KC-10 pilot Capt Mark McNaughton told *Combat Aircraft*. 'We take great pride in our ability to support our sister services and international partners.'

McNaughton comes from the 6th Air Refueling Squadron (ARS) at Travis Air Force Base, about 60 miles north-west of San Francisco, California. A KC-10 crew from Travis refueled three F-35As on their trans-Atlantic return flight from the UK in July. The previous month, the USAF had announced that Travis was one of five candidate sites for the future basing of the KC-135's replacement, the Boeing KC-46A Pegasus.

The US Department of Defense (DoD) approved the start of low-rate initial production (LRIP) of the KC-46 on August

12. The first two LRIP lots that have been approved will see 19 aircraft produced, together with associated parts, at a cost of \$2.8 billion. Initial deliveries will be to McConnell AFB, Kansas and Altus AFB, Oklahoma. The new tanker is expected to enter service next year. It could be operating from Travis as soon as October 2019.

Expected to be phased out in the next 10 years, the KC-10 entered USAF service in 1981 and 59 examples are still flying.

McNaughton has flown KC-10 missions worldwide, with a longest flight of 18.5 hours; in one sortie he offloaded 100,000lb of fuel. He said: 'We deliver fuel to the combat aircraft, who deliver the firepower to the enemy. Ultimately, if we've done our job, the air refueling activities that a fighter has participated in should be the easiest part of his or her combat mission.'

Last April, KC-10 aircrews from the 514th Air Mobility Wing, based at Joint Base

McGuire-Dix-Lakehurst, New Jersey, as part of the Air Force Reserve Command, refueled a B-52H Stratofortress while on its way to conduct air strikes against insurgents of the so-called Islamic State. The B-52 was flying from Barksdale AFB, Louisiana, to Al Udeid Air Base in Qatar.

9th ARS KC-10 boom operator TSgt Stephen Wentz explained to *CA*: 'Without tankers, rapid global mobility is impossible. You feel a sense of importance when you are the guys they are relying on to get their gas. Aerial refueling allows our aircraft to operate beyond their normal ranges.' Wentz has 'operated in multiple theaters supporting worldwide operations'. The most fuel he has offloaded in one mission is 210,000lb, and his longest flight time is 18 hours.

With such long flight times, refueling at night is inevitable. 'Both day and night pose different challenges to the air refueling mission', said McNaughton. 'Reflections of the sun off of water

A KC-135R Stratotanker from the 927th Air Refueling Wing at MacDill AFB tops up a 94th Fighter Squadron F-22 of the off the coast of Virginia.
Jamie Hunter

A KC-10A refuels an F-35B from its centerline hose. Lockheed Martin/
Michael D. Jackson



or ice can be difficult to deal with during daytime operations when the tanker is directly where the sun is in a receiver's canopy.

'At night, there is a reduction in the amount of visual references that a pilot can use to determine his position relative to the tanker. We make sure to practise day and night air refueling to be prepared for any circumstances during operations.'

Wentz doesn't have a preference for night or day missions and notes that the easiest aircraft to refuel are other KC-10s, because 'they are flown by the best tanker crews in the world!'

The KC-10 has also refueled the KC-46A. The very first KC-46A tanker, EMD-2, which made its maiden flight in September 2015, was refueled by an Extender in February this year. 'Our community is looking forward to see what capabilities the KC-46 brings to the table,' Wentz said.

The first KC-135 flew 60 years ago in August 1956 and the initial production Stratotanker arrived at Castle AFB, California in June 1957. The last KC-135 was delivered to the USAF in 1965, and today the USAF's Air Mobility Command (AMC) manages more than 400 Stratotankers, of which the Air Force Reserve and Air National Guard fly in excess of 200. The Boeing 367-80 design on which the Stratotanker was based also led to the classic Boeing 707 airliner.

Looking back at his time with the KC-135, 351st ARS KC-135 pilot Capt Bradley Sutton told CA: 'The times I will always be most fond of are supporting [the A-10 Thunderbolt II] and other fighters that are helping troops in combat. During these times, we often hear the radio chatter from the ground and hear how these receivers are directly impacting the mission by being able to stay in the air for hours on end. These moments are most memorable to me because I know that we are making a difference.' Sutton has flown over Afghanistan, Iraq, Syria, and Africa. The 351st ARS is part of the 100th Air Refueling Wing (ARW) based at RAF Mildenhall in England.

Sutton says the KC-135 has 'a reputation as being among the most uncomfortable aircraft in the fleet. That said, the squadron does have lots of extra seat cushions for us and some pilots even go above and beyond and buy their own.' Other changes are making flying the KC-135 easier. 'The upgrades I've seen over the last five years have improved safety. The brand-new autopilot, which will directly link to the flight director, is a much-needed upgrade and makes the KC-135 a lot easier to fly. In addition to a lot of other small changes, there will also be a large display replacing the engine 'steam' gauges.' Sutton's longest flight took him over the North Pole, a trip that lasted more than 13 hours.



MSGt Lawrence Nahalea also serves with the 351st ARS, but as a boom operator. The most fuel he has ever offloaded is 120,000lb in one contact to a C-5 Galaxy. His preference is for day refueling. 'Day is preferable, due to the fact that on nights without much moon illumination, depth perception can become an issue.' For Nahalea, most receiver aircraft are comparable and do not present a problem for air refueling, assuming all the flight conditions are equal. But there is one aircraft he finds challenging — the C-17 Globemaster III. He said: 'It is a big aircraft that has a large bow wave and moves just like a fighter.'

Tankers also carry cargo and personnel. Reflecting on this, Nahalea said: 'Our mission is so versatile [that] the majority of the time we are also carrying cargo and people, and our fuel loads are quite small.' The longest flight he has ever accomplished was 16.2 hours from Kadena AB in Japan to the US East Coast. But, for Nahalea, one particular sortie will always stand out: 'The very first

night over Iraq during 'Operation Iraqi Freedom'.

New blood — the KC-46 Pegasus

The KC-135's replacement-elect, the KC-46A, is based on the Boeing 767-2C airframe and emerged from the DoD's KC-X acquisition program (see accompanying boxed item). Initially, 179 examples of the Pegasus will operate with Air Mobility Command to begin replacement of the KC-135. The follow-on KC-Y and KC-Z projects will be required to fully recapitalize the USAF tanker fleet.

On September 25, 2015, the second Pegasus test aircraft completed the first ever KC-46 flight, flying from Paine Field in Everett, Washington, and landing a few hours later at Boeing Field in Seattle. The program reached its latest refueling milestone on July 15 this year. 'We joined up with a KC-10, an A-10 and an [F-16 Fighting Falcon] with a KC-46, and seeing all those airplanes in flight all around you really is a magnificent sight', Ron 'Taco'

Below: Despite the advent of the KC-46, the KC-135R will continue to operate for many years.
USAF/MSGt Shawn Monk

Bottom left to right: A KC-10 'boomer' refuels an F-15E Strike Eagle. USAF/SrA Brian Ferguson

The KC-46A 'boomer' at the remote air-refueling operator (RARO) station. Boeing

An RAF Voyager refuels a Typhoon, monitored by the mission systems operator. Jamie Hunter

'If we've done our job, the air refueling activities that a fighter has participated in should be the easiest part of his or her combat mission'

CAPT MARK McNAUGHTON





Johnson, Boeing's KC-46A chief pilot, told CA. 'We did that near Mount Rainier, which is an amazing background to be flying next to and we were doing that in pursuit of Milestone C requirements to refuel the A-10'. It was these refuelings — and more, of a C-17, AV-8B Harrier II and F/A-18 Hornet — that led to the DoD's LRIP approval.

Johnson is a 20-year USAF veteran and former B-2 Spirit flight test squadron commander. He has flown Boeing 767s, the aircraft the KC-46A is based on, for seven years with United Airlines. He was also, for 11 years, Boeing's chief commercial 767 pilot. Johnson has more than 175 hours in the KC-46 and has flown all five test aircraft.

The first and third KC-46 test ships are Boeing 767-2Cs. They are being

used for mission systems testing and for certification, according to the US government's Federal Aviation Administration (FAA). Test aircraft are flying with a boom and wing-mounted air refueling pods (WARPs) that have hose and drogue systems, to demonstrate to the FAA that the type's stability has not changed from the basic 767. The second and fourth test aircraft are configured as tankers and have carried out all the refueling flights. A fifth aircraft joined the test program in July, the first of the LRIP models. It is being used for avionics testing for now and will later be converted to a full tanker.

The USAF's KC-46A test pilot is Lt Col James Quashnock, who works with a detachment of 30 staff from the 418th Flight Test Squadron from Edwards

AFB, California. They been working with Boeing for more than three years on test preparations. Quashnock has flown all five of the aircraft in the test program. He compared the KC-46A to a car. 'The aircraft flies just really smoothly, flies like a Cadillac; it is very intuitive. I have flown quite a few different aircraft, commercial-type aircraft — 737, KC-10, DC-9 — and this aircraft flies really, really well'. Johnson has a similar view: 'The airplane feels like a 767 does; I have a lot of time in 767s. You cannot tell when the WARPs or the booms are deployed. The airplane is very stable and that is what makes a good tanker, a very stable tanker.'

Johnson likes how quiet the flight deck is — normal speaking voices can be used. He finds the 'glass' cockpit display, derived from that used in the Boeing

Top: **The second EMD KC-46 takes on fuel from a KC-10 during testing.** Boeing/ Paul Weatherman



Far left: **A KC-46 Pegasus refuels an A-10C Thunderbolt II with 1,500lb of fuel on July 15, 2016. The mission was the last of the flight tests required for the tanker's Milestone C production decision.** Boeing/John D. Parker

Left: **KC-46 refueling boom issues were discovered during testing with the C-17A. Boeing tested a fix for the axial load problem that involved the installation of hydraulic pressure relief valves. The Pegasus then carried out a successful refueling with a C-17A on July 12.** Boeing/Paul Weatherman

187-degree panoramic display. The cameras that feed the displays are set up to handle all the different light conditions from high noon to moonless night, as well as under clouds, over clouds, over cities, and over water.

'We truly designed the crew station to support the air refueling operator doing all the roles of his job,' said Sean Martin, a retired USAF air refueling operator who had a 25-year career with the USAF before joining Boeing in 2007. He has flown the KC-10 and the KC-135, and has been the chief boom operator for the KC-46A program since the outset. 'In the KC-135, for example, the 'boomer' lies down on a pallet and has a little chin rest and does his job, and in the KC-10 he has a chair that he sits on, but it is really like a stool,

literally, to sit on, and we needed a place where the boom operator could do all of the duties of an eight-hour flight. So, as a result of that we took a 787-style seat base and combined that with a 767 seat back to give them the best seat in the aircraft.'

The KC-46A has more than 150 light installations on its exterior, including the normal strobe and landing lights. Testing these lights will be part of the program for the remainder of 2016. The lights that aid refueling are known as pilot director lights. They tell the receiver aircraft pilots where they are in relation to the boom envelope; receivers on the hose and drogue system can see where they are in relation to the hose length and if it is ready for contact. These various lights have to be tested in all environmental conditions to make sure

KC-X PROGRAM HISTORY

In early 2007 the USAF released the final request for proposals (RFP) for the KC-X future tanker program. Earlier draft RFP versions had been updated to respond to concerns expressed by US Congress, the Department of Defense (DoD) and potential suppliers, to address litigation concerning large civil aircraft pending before the World Trade Organization.

On February 29, 2008 the USAF selected the Northrop Grumman and Airbus (or EADS as it was then) bid for the KC-X program, to deliver the KC-45A tanker, based on the A330 MRTT. The initial KC-45A contract provided for four system design and development (SDD) aircraft and was valued at \$1.5 billion. The first prototype of the KC-45A had completed its maiden flight on September 25, 2007. As of February 2008, the KC-45A's aerial refueling boom system (ARBS) was in flight test and had performed in-flight contacts with receiver aircraft.

Boeing made a complaint against the award and the Government Accountability Office (GAO) began to review the decision. On June 18, 2008 the GAO announced that it had found in favor of Boeing. In its statement the GAO said that Boeing had challenged the USAF's technical and cost evaluations, conduct of discussions, and source selection decision. The GAO's managing associate general counsel for procurement law, Michael R. Golden, said: 'Our review of the record led us to conclude that the Air Force had made a number of significant errors that could

have affected the outcome of what was a close competition between Boeing and Northrop Grumman. We therefore sustained Boeing's protest.'

The GAO recommended that the USAF re-open discussions with the companies, obtain revised proposals, re-evaluate the revised proposals, and make a new source-selection decision, consistent with the GAO's decision. It also specified the alleged USAF errors, which included failure to assess the relative merits of the proposals in accordance with the USAF's own evaluation criteria identified in the solicitation, and not taking into account the fact that Boeing offered to satisfy more non-mandatory technical 'requirements' than Northrop Grumman, even though the solicitation expressly requested applicants to satisfy as many of these technical 'requirements' as possible.

In September 2009, the DoD announced plans for a new RFP for another acquisition program. On February 24, 2010, the DoD released its RFP for the revised KC-X program, with a contract value estimated by the GAO at \$51.7 billion for 179 tankers. Bidding closed on July 9, 2010, with submissions from Boeing and the Northrop/EADS team again, and an additional bid from Ukrainian airframe-maker Antonov.

On February 24, 2011, Boeing was awarded the KC-X contract. The Boeing aircraft received the designation KC-46A, with four prototypes to be built under a \$3.5-billion engineering, manufacturing and development (EMD) contract.

787, easy to read. Quashnock agrees, and compares the displays with high-definition televisions and the improvement that technology delivered over cathode ray tubes. Furthermore, the flight deck has new lighting to accommodate night vision goggles (NVGs). Using airfields equipped with infra-red landing lights, the goggle-wearing pilots are able to land and take off with no other visible exterior lighting from the aircraft or airfield.

The air refueling operator's station is just outside the KC-46A's flight deck door. The single station has two chairs with both boom and WARP controls, allowing an instructor to teach in-flight. The boom and WARP controls are fly-by-wire and the operator wears 3D spectacles to allow them to see the monochromatic 3D images presented by the station's



BOOM VERSUS HOSE-AND-DROGUE

The boom is a rigid, telescopic tube that an operator on the tanker aircraft extends and inserts into a receptacle on the receiver aircraft being refueled. A single flying boom can transfer fuel at a rate of about 6,000lb per minute. However, fighter aircraft can only accept up to 3,000lb of fuel per minute. The US Air Force's original decision to field boom-equipped tankers was based on the refueling needs of long-range bombers, which required large amounts of fuel.

Until the late 1950s, all US combat aircraft used the hose and drogue system. Hose and drogue employs a flexible hose that trails from the tanker aircraft. A drogue is a small windsock at the end of the hose that stabilizes it in flight, and provides a funnel for the receiver aircraft being refueled, which inserts a probe into the hose. A single hose-and-drogue system can transfer between 1,500 and 2,000lb of fuel per minute.

All boom-equipped tankers have a single boom and refuel one aircraft at a time. Many tanker aircraft that employ the hose-and-drogue system can refuel two receiver aircraft simultaneously.



all the receiver aircraft can see them, and that the air refueling operator can see the receiver. Some of the lights are infra-red, allowing receiver aircraft pilots with NVGs to refuel in total darkness. It is a capability the older tankers do not have.

Quashnock adds: 'The KC-46 [...] can take fuel from other KC-46s and other tankers as well. I was the pilot who conducted the first receiver refueling of the KC-46 and we did that with a KC-10.'

The flight program will continue well into 2017 for certification of the various

aircraft that are to be refueled. This will require the test KC-46As to fly at different altitudes and speeds, reflecting the different refueling envelopes for the many types that have to be certified.

The KC-46A will be adopted by other air forces renewing their tanker fleets. The US DoD has recently approved the sale of four KC-46s to the Japanese government, the aircraft's first foreign sale. They will be delivered by 2020. Until then Boeing had lost all foreign competitions to Airbus and its tanker product, the Airbus A330 Multi-

Role Tanker Transport (MRTT), which in turn lost out to Boeing during the USAF's KC-X program.

The discounted challenger — A330 MRTT

While on June 29 the RAF F-35B flown by SqN Ldr Hugh Nichols was refueled by a KC-10 for its first trans-Atlantic crossing, the United Kingdom employs Airbus Voyager tankers. Voyager is the UK name for the MRTT, a heavily modified A330-200 airliner.

Top: An artist's rendition of a possible KC-Z blended wing-body configuration. Lockheed Martin

On April 15 this year, the RAF deployed a Voyager to Naval Air Station Patuxent River, Maryland in support of F-35B refueling trials. Certification of the Voyager for F-35 refueling saw 20 flights being recorded by July.

The UK placed its Voyager order in 2008 after its Future Strategic Tanker Aircraft (FSTA) process, and the first MRTT entered service with the RAF in April 2012. The country bought 14 MRTTs. It has two slightly different versions, the Voyager KC2 two-point tanker, with a Cobham Mk32B 900E pod under each wing, and the Voyager KC3, a three-point tanker with an additional centerline hose for refueling larger aircraft.

The UK was not the first country to order the MRTT. In 2004, the Australian government selected the MRTT, which it employs under the local designation KC-30A. The Royal Australian Air Force (RAAF)'s KC-30A completed F-35 refueling trials last year. It is now capable of refueling F/A-18A/Bs, F/A-18F Super Hornets, E-7A Wedgetails, C-17As and other KC-30As.

The RAAF was the first customer to take receipt of the A330 MRTT when an initial KC-30A was delivered in June 2011. The fleet is based at RAAF Base Amberley and operated by No 33 Squadron. The squadron currently operates five aircraft equipped with both a boom and underwing WARPs. Initial operating capability was reached in February 2013. The last two of the seven aircraft on order will be delivered in 2018.

According to the Australian Department of Defence, KC-30As have been deployed over Iraq since 2014 and have completed 566 sorties, delivering more than 10,000 tonnes of fuel and entering Syrian airspace five times.

The Saudi Ministry of Defense was the second buyer, placing an order for three A330 MRTTs in 2007. It then added another three aircraft to its order during 2009. All have been delivered. In 2008, the UK placed its order, as did the United Arab Emirates, which opted for three aircraft, all now delivered.

According to Airbus Defence and Space, 49 MRTTs have been sold. Of those 49, as well as the MRTT sales mentioned above, France has ordered 12 (named Phénix), Singapore six, and South Korea four. In March 2014 Airbus announced that Qatar intends to purchase two MRTTs. India selected the MRTT in January 2013,



Above: **The A330 Multi-Role Tanker Transport is designated as the KC-30A in service with the Royal Australian Air Force.**
Lockheed Martin/
Tom Reynolds

Left: **The A330 MRTT is in service with the Royal Saudi Air Force with both hose and drogue and flying boom capabilities.**
RSAF

but withdrew the tender in July 2016, citing the aircraft's high operational cost. Nevertheless, Airbus told CA: 'We are engaged with the Indian government in finding the best way to bring the A330 MRTT's capabilities to the Indian Air Force.'

South Korea's first MRTT delivery will take place in 2018; conversion of the first aircraft will begin next year. Korea's MRTTs will represent a new, standard configuration. The main changes involve revised avionics, weight reductions, aerodynamic improvements, the latest identification friend or foe (IFF) standard, an upgraded mission planning system, and an electronic flight bag.

The Netherlands and Luxembourg are buying two MRTTs that will be stationed at Eindhoven in the Netherlands for shared use. The aircraft will be delivered from 2020 as the Royal Netherlands Air Force gradually decommissions its KDC-10s. The European Organisation Conjointe de Coopération en matière d'Armement (OCCAR) and European Defence Agency (EDA) are involved in the purchase on behalf of NATO. Belgium,

Germany, Norway and Poland may join the tanker share deal in future. This joint buy is the first phase of a deal that could see up to eight tankers stationed at Eindhoven.

Under the joint tanker plan, forward operating locations are expected in Norway and Poland, as well as the Eindhoven home base. The Netherlands and Luxembourg are considering working with France and the UK, among others, for training and maintenance. Spain is also considering buying MRTTs to replace its 707s. Airbus said: 'Those discussions are at various stages and additionally other sales campaigns are under way.'

Despite this international success, it seems that the US market is dead for the A330. In September, Gen Carlton Everhart, chief of AMC, said that he did not envisage competing the KC-Y requirement and that it would simply be filled by additional KC-46s, albeit with some new technology inserted. Instead, Everhart says he is focused on a more radical KC-Z phase, which could take the form of a stealthy, blended wing-body design. ❏

KC-46 VS A330 — KEY FACTS

Boeing KC-46A	Airbus A330 MRTT
Length: 165ft 6 in (50.5m)	193ft (58.8m)
Wingspan: 157ft 8 in (48.1m)	198ft (60.3m)
Maximum take-off weight: 415,000lb (188,240kg)	514,000lb (233,000kg)
Maximum cargo capacity: 65,000lb (29,484kg)	99,000lb (45,000kg)