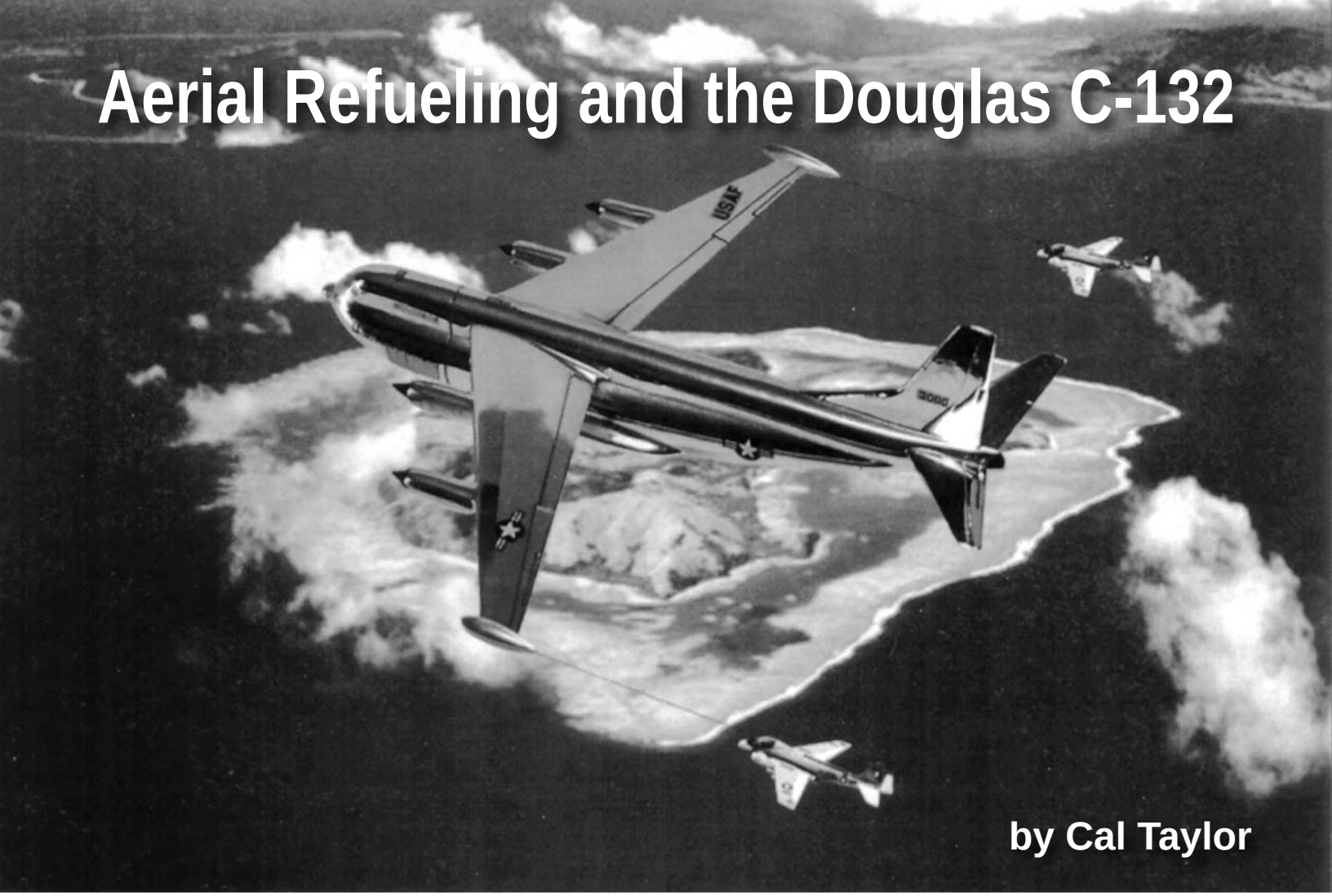
Aerial Refueling and the Douglas C-132



by Cal Taylor

A KC-132 of the 496th Air Refueling Wing at George AFB, Calif., refuels two Grumman A6-A Intruders of VA-34 based aboard USS John F. Kennedy *(CVA-67) in April 1970. (Artist's conception by Cal Taylor)*

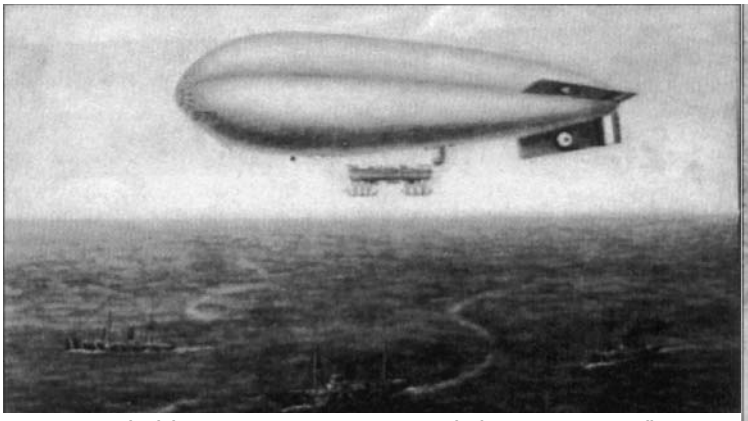
Aerial Refueling Comes of Age

By 1951, when the Air Force asked Douglas Aircraft Co. to design what eventually became the C-132, aerial refueling was already a standard part of the Air Force's operational repertoire. The Strategic Air Command (SAC) had been using B-29 tankers and receivers since 1948 and activated its first two aerial refueling squadrons on June 30, 1948. The cumbersome "looped hose" refueling system was proven, though with serious limitations, and enabled the B-50 "Lucky Lady II" to fly around the world in 94 hours and one minute. The new jet-powered Boeing B-47 bomber posed greater challenges to aerial refueling technology. The probe and drogue system, first tested in 1949, enabled a Gloster Meteor jet fighter to remain airborne for 12 hours and three minutes. Subsequently, large formations of fighters made transoceanic deployments using the system. In Korea, on July 6, 1951, aerial refueling was first used in combat, allowing fighters greater time in the combat area. Consequently, tanker aircraft that could operate at jet speeds, altitudes and off-load requirements were clearly needed. The tanker version of the Douglas C-132 was one possible answer to this requirement. A brief history of aerial refueling into the 1950s is useful to place the C-132 in context.

Why Aerial Refueling?

Aerial refueling has two primary functions. The first is to increase endurance. Second is to extend an airplane's operational range. The main distinction between the two is that an endurance flight requires only a few, perhaps one or two, tanker aircraft to keep another airplane airborne in a relatively limited geographical area. Range extension, on the other hand, calls for a much larger fleet of tankers located in several locations to support the receivers. A third variation is aimed at increased load-carrying capacity. In this application, an airplane takes off with a maximal load but insufficient fuel to reach a destination. Enroute, after more fuel has been burned off, an aerial refueling enables mission completion. In its historical development, aerial refueling worked first for endurance; range extension followed, as technical advances permitted.

In the early days of aviation, airplanes were limited simply by their primitive technology. Engines were unreliable, airframes not always robust and fuel was of variable quality. The earliest reasons for some sort of aerial refueling were simply to prove that it could be done. Later, as airplanes and engines became more reliable, there came the urge to set records, to show that it was possible to remain in flight for extended periods. Initially,



C-1 airship on WWI convoy patrol. (WWI postcard)

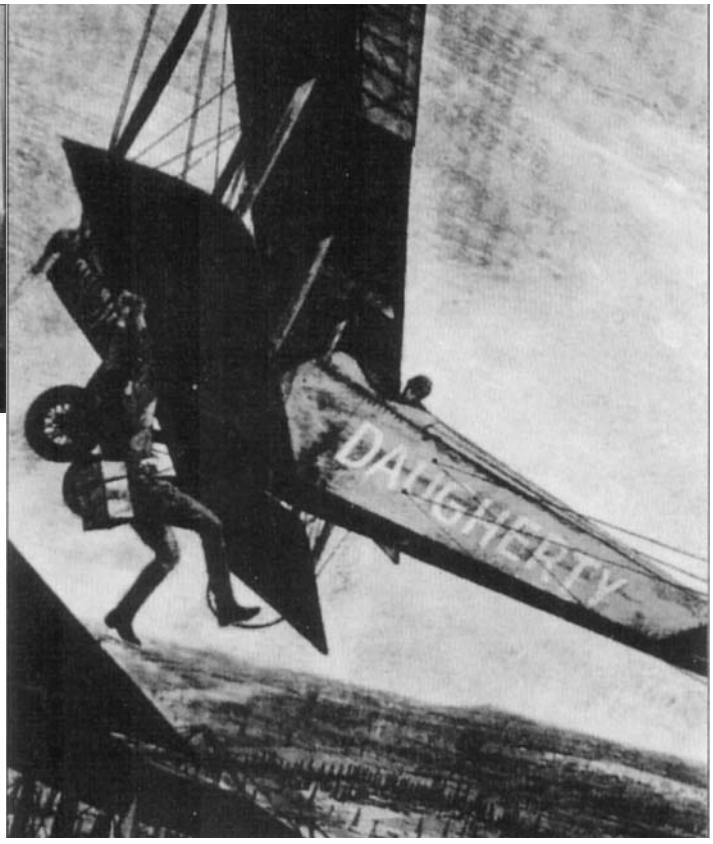
these were civilian pilots but military aerial refueling soon set its own records. Ultimately, on both the civilian and military side, there was much experimentation and testing to develop reliable methods to achieve two objectives. These were greater endurance by refueling airplanes in flight and to enable greater loads to be carried over longer distances, whether weapons or passengers and cargo.

Much progress was made in the period before the 1939 beginning of WWII. For the war years, though, emphasis was upon extending intrinsic range of fighter and bomber aircraft, though both the Americans and British considered the use of aerial refueling to enable long range attacks on Japan. Other aircraft production requirements overrode lower priorities for aircraft, equipment and training to create the necessary aerial refueling force. The Boeing B-29 was the immediate solution to long-range bombing in WWII. Once the war was over, though, experimentation and development brought rapid progress to routine operational use of aerial refueling, even in civil aviation.

Basics of Aerial Refueling

There are three basic methods to refuel airplanes in flight. The earliest and most obvious was to link a fuel source and the aircraft to be refueled with a hose. Fuel was delivered by gravity flow from the tanker to the receiver or, in one attempt, pushed up by compressed air from a floating platform to an airship hovering above. There were obvious difficulties and hazards involved when streaming a heavy hose between two airplanes flying less than 100 feet apart, even if airspeeds were only about 110 mph. Nevertheless, a variant of the hose method that had been proven by 1939 was used in the early postwar period, with B-29 tankers and B-29 and B-50 receivers. It was known as the looped-hose system.

Later came the probe and drogue system. The tanker aircraft streamed a hose that had a wide cone-shaped device at the end, with an internal valve that is opened when the receiver's probe is directed into the drogue. Fuel delivery was faster with this method than with the hose and no crew member had to be exposed to the open air and slipstream to complete the connection. As many as three receivers could be refueled concurrently, depending upon the tanker configuration. The receiver pilot had an extra burden on his flying proficiency

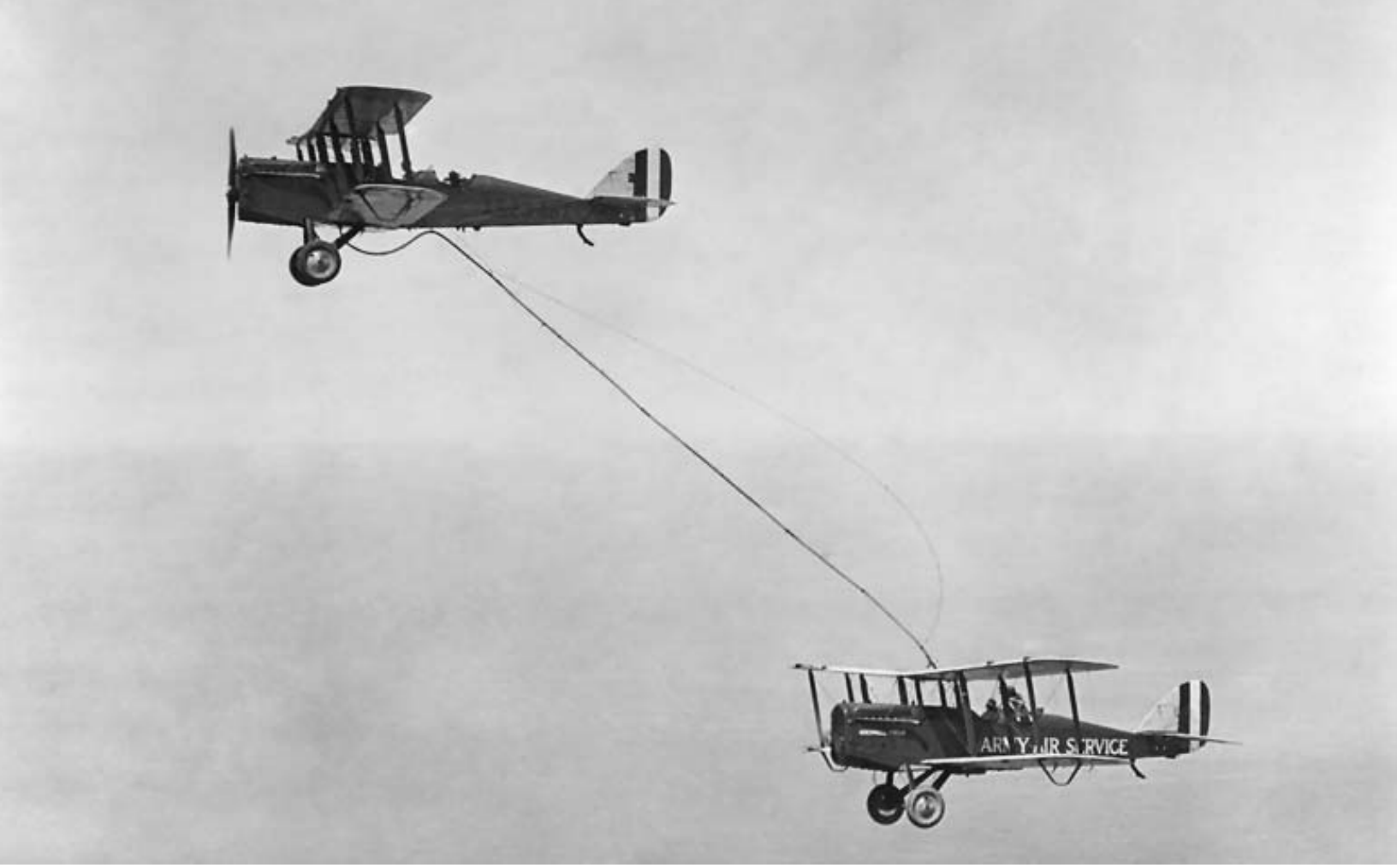


Wing walker Wesley May makes the first aerial fuel transfer at 3,500 feet over Long Beach, Calif., from an airplane flown by Howard Hawks. (Artist's conception)

when he had to direct a probe located out on the wing into the drogue that was dancing around in the sky in front of him. Night refuelings were not routinely possible.

The third procedure used a hollow metal boom extending from the tail of the tanker. The receiver would fly into position slightly aft of and below the tanker's tail, guided by radio commands and lights on the tanker. The boom operator in the tanker would direct the boom into a receptacle on the receiver, using small airfoils that enabled him to control the boom's position vertically and horizontally. Once the boom entered the eceptacle, a collet clamp closed around the nozzle and fuel flow commenced. This system could deliver fuel much faster than the others and had greater control of all parts of the process. It could also be done at jet aircraft operational airspeeds and altitudes. Still, especially with bombers or other large receivers, both crews had to deal with demanding aerodynamic interaction between two large aircraft flying less than 50 feet apart, often at night, in the clouds and weather. Though it became a standard procedure, it was never totally routine or without elements of concern.

The C-132 was designed to use the probe and drogue method. With its great fuel capacity, near-jet speeds and ability to conduct refuelings at high altitudes, it would have been invaluable in supporting movements of the fighter force. Despite its large off-load fuel capacity, the C-132 would not have been of much value to SAC. Both the B-47 and the Boeing B-52, which entered squadron service in 1956, were equipped for the flying boom method. Even considering that



Two DH-4Bs make the first Air Service refueling on June 27, 1923, at Rockwell Field, Calif. (USAAC)

fact, however, the C-132 represented nearly the maturation of aerial refueling methods and capability. Only the advent of a pure jet tanker, as embodied in Boeing's KC-135 Stratotanker, was needed to reach that level.

In the Beginning

Only 14 years after the Wright brothers' first manned flight, airplanes were flying in combat during WWI. The pressures of combat brought rapid advances in aviation technology and employment. Flight endurance was well above the early performance of the Wright Flyer and other aircraft. The Allied Forces' SPAD and Nieuport 17 and the German Fokker DR.I and D.VII all could remain airborne between 1.5 and 2 hours. Though the theater of operations was relatively small, aviators were already complaining that their range and endurance were insufficient.[1] Such interest in being able to fly farther and longer certainly persisted after the war was over.

At least one effort was made in that period to refuel an aircraft that was in flight.[2] On September 6, 1916, the Coastal Class airship C.1 was towed behind *HMS Canterbury*, a C-class light cruiser assigned to the Royal Navy's 5th Light Cruiser Squadron. Fuel was pumped from the cruiser to the airship, propelled through a long hose by compressed air. Given that Coastal Class airships had an 11-hour endurance, the objective was most likely a proof of concept test. From the point of view of crewmembers in the open cockpit, longer flight times were probably not eagerly anticipated. Known as "the ugliest dirigibles ever made," they were erratic and hard to control, often causing airsickness. Yet, the Coastal Class airships were important weapons in antisubmarine warfare.

Two years later, Stephen Kolczewsky, whose nationality is unknown, filed a patent for a method of picking up fuel from ground stations.[3] This was probably a "snag and drag" process, in which some sort of container was snatched by a hook attached to the airplane and then hauled up. An actual experiment with this method took place in 1921. Seated in the back seat of a Huff-Daland HD-4 trainer, a U.S. Navy lieutenant used a grappling hook to snag 5-gallon cans of gasoline from a float in the Potomac River.[4] In 1917, Alexander P. de Seversky, then a pilot in the Russian navy, proposed increasing the range of combat aircraft by refueling them in flight. De Seversky soon immigrated to the United States and became an engineer in the War Department. He applied for and received the world's first patent for air-to-air refueling in 1921. His method would enable "large fuel tankers to supply fuel to pursuit ships in flight." Thus was aerial refueling linked to a military operational requirement.

In 1919, the British Royal Aircraft Establishment (RAE) succeeded in transferring water via a hose from one Bristol F.2b fighter to another.[6] The RAE became, over time, the leading British government agency investigating aerial refueling. Such

Douglas C-1 refuels Fokker C-2A "Question Mark" in January 1929. (USAAC)

activity increased rapidly in many nations during the interwar period.

Aerial Refueling Gains in the Twenties

An answer without a question

In this period, aerial refueling was more actively investigated and experimented with by military and civilians alike. Aircraft technology matured significantly with greater reliability of airframes and engines. Motivations ranging from the desire to set records through military and civilian operational necessity to political concerns all focused more thought upon aerial refueling.

The year 1921 saw the first actual fuel transfer between two airplanes in flight.[7] On November 12, wing walker Wesley May strapped a 5-gallon can to his back and then climbed from a Lincoln Standard biplane to a Curtiss JN-4. He then emptied the can into the Jenny's fuel tank, not the most effective method imaginable. This effort was still well within the "stunt" category, but things were changing in the 1920s.

In 1923, two Army Air Service operations demonstrated the use of aerial refueling in extending endurance and range. The first air-to-air refueling in a practical manner occurred on June 27 at Rockwell Field, Calif., (later, North Island NAS), across the bay from San Diego.[8] Two DH-4Bs were used, one as a tanker, the other as the receiver. Crewing the tanker were pilot 1st Lt. Virgil Hine and hose-handler 1st Lt. Frank W. Seifert. In the receiver were pilot Capt. Lowell H. Smith, with 1st Lt. John Paul Richter receiving the 50 foot hose tipped with a manually-operated quick-closing valve at each end. Flying at an altitude of 500 feet, one contact was made in the six-hour 38-minute flight, passing 75 gallons of gasoline. Engine trouble on the receiver caused the flight to be terminated.

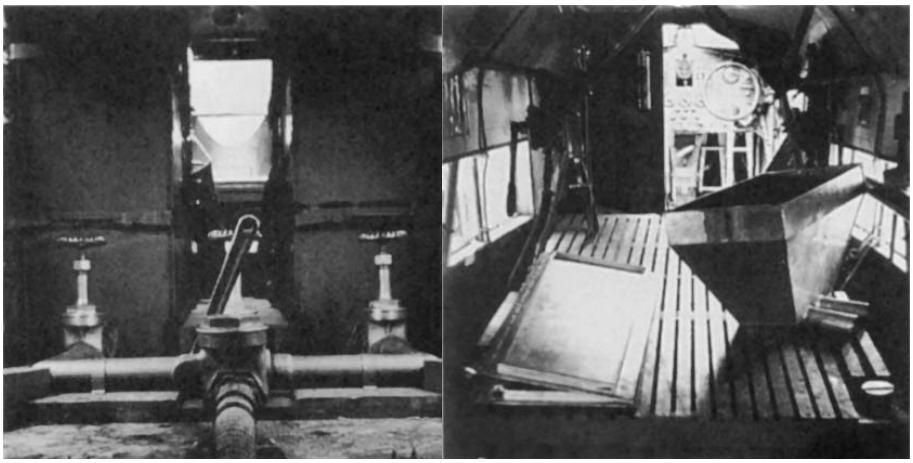
A second attempt took place on August 27 and 28, with a second refueler available. The pilot was Capt. Robert G. Erwin, with 1st Lt. Oliver R. McNeel handling the hose. The result was a flight lasting 37 hours 25 minutes and totaling 3,293 miles on a prescribed track. Fourteen contacts made the flight possible.

Two months later, Smith and Richter departed from Sumas, Wash., near the Canadian border, on a flight to show a practical application for aerial refueling. Near Eugene, Ore., they were refueled from a tanker flown by Seifert and Hine and again, near Sacramento, Calif., by Erwin and McNeel. Just over 12 hours after takeoff, Smith and Richter landed at Rockwell Field, after circling the customs house near Tijuana, Mexico. With refueling, the DH-4's 275-mile range had been quadrupled, to 1,280 miles. But the experience remained mostly in the stunt category. The Air Service in 1921 was not prepared, doctrinally or operationally, to exploit aerial refueling. Not until the end of the 1920s was there concerted effort to investigate this process.

Aerial refueling flights gain broader purpose

On June 4, 1928, aircraft of the Belgian Air Force's first Aeronautical Regiment took off to set an endurance record of 60 hours 7-1/2 minutes.[9] The aircraft used were two DeHavilland DH-4 biplanes. This event was one of two that inspired 1st Lt. Elwood Quesada to plan a similar flight. Based at Bolling Field, D.C., Quesada worked first with a U.S. Marine Corps aviator at the adjoining NAS Anacostia. Also working to enhance the line of thought was his time on a search in Labrador, to rescue the crew of the German Junkers W 33 Bremen that was the first airplane to make a successful east-to-west transatlantic flight.

With Quesada were Capt. Ira Eaker and Maj. Gen. James Fechet, head of the



LEFT: *Interior of C-1 tanker feeding "Question Mark." Three gate valves fed through a quick closing valve and a strainer before the hose. (USAAC)*

RIGHT: *In "Question Mark," the hose fed into the square funnel that directed fuel into cabin tanks beneath the duck boards. (USAAC)*

Army Air Corps. When Eaker flew over a fog layer, Quesada thought, "My God, what are we going to do if we get caught up here? . . . wouldn't it be nice if we had a gas station. We could just fly in to a gas station and fill up with gas again." Eaker, then in the office of the Assistant Secretary of War for Air, took over the project from Quesada for the Air Corps, supported by General Fechet.[10] Assist. Sec. of War F. Trubee Davidson agreed to the event only if there is a military application.[11] This planning resulted in the record-setting flight featuring the Fokker C-2A trimotor that was named "Question Mark", symbolizing the uncertainty about how long it would remain airborne.

Years later, then General Quesada recalled that the primary objective was publicity for the Air Corps. "It was exactly what [we] had in mind. The "Question Mark" had no noble purpose. It [wouldn't make] the Air Force into a great superior power that would make it unnecessary to have an army or a navy. The purpose was to attract attention."[12] That certainly was the result, with effects lasting throughout the 1930s in the United States and Great Britain.

The "Question Mark" flight involved the Fokker C-2A and two Douglas C-1 single-engine transports as tankers. A hatch was cut in the top of the Fokker's fuselage and a pair of 150-gallon tanks were installed in the cabin under a slatted platform. The tanks supplemented the 96-gallon tanks in the wings. The hose from the tanker would be directed into a large, 24 inch-square metal funnel feeding the fuselage tanks and then be hand-pumped to the wing tanks. The tankers had a pair of 150-gallon fuselage tanks with a hole in the floor through which the hose was dropped.

Crewing "Question Mark" were pilot Maj. Carl Spatz (spelling later changed to Spaatz), Ira Eaker as copilot and hose handlers 1st Lts. Harry A. Halverson and Elwood Quesada, plus SSgt. Roy W. Hooe. The crew on Tanker 1 was Capt. Ross G. Hoyt, lst Lt. Aubry C. Strickland and 2nd Lt. Irwin A Woodring. The other tanker crew included 1st Lt. Odas Moon, 2nd Lt. Joseph G. Hopkins and 2nd Lt. Andrew F. Salter.

The operation flew out of Metropolitan Airport, Van Nuys, Calif., where the weather was less foggy than at Mines Field in El Segundo. Manager Waldo Waterman used the weather as a selling point to get the Air Corps to operate at Van Nuys.[13]

The flight route was between Metropolitan Airport and Rockwell Field, 110 miles each way. Capt. Hoyt, flying Tanker 1, was based at Rockwell and 1st Lt. Moon's Tanker 2 flew from Metropolitan. Departing on January 1, 1929, "Question Mark" remained airborne for 150:40, landing on January 7. The engines had been reduced to junk because there was no way to oil the rocker arms. The tankers made 43 takeoffs (Hoyt 27 with 10 at night; Moon 16 with 2 at night). Offloads were 5,660 gallons of fuel and 245 gallons of engine oil, along with storage batteries, food, clothing, mail and congratulatory telegrams.[14] This flight inspired a growing number of air refueling events in 1929 and later years in the United States and elsewhere.

In spring 1929, the Army planned another aerial refueling flight, at Fairfield Air Depot, Dayton, Ohio, designed to further demonstrate the military utility of the process. It was done in conjunction with annual military maneuvers in eastern Ohio and western Pennsylvania. A Keystone B-3A bomber would depart Fairfield in company with a Douglas tanker. The two would fly to Washington, D.C., do a refueling, and then the bomber would fly on to New York City where it would drop a flash bomb. It would then return to Washington, refuel again and fly on to Dayton. Unfortunately, weather caused the two airplanes to become separated. The Keystone flew the entire route, unrefueled. The tanker landed at Uniontown, Penn., and got stuck in the mud. This flight marked the end of Air Corps investigation of aerial refueling for the next 12 years.[15]

Buhl Sesquiplane "Spokane Sun God" at Felts Field, Wash., which set 1929 air refueling record of 115:45 hrs over 7,220 miles. (Art Walker via NW Museum of Arts and Culture)

The publicity value of extended flight using aerial refueling was a specific objective of another 1929 event in which Capt. Ira Eaker was the pilot. His copilot and hose handler was 1st Lt. Bernard Thompson. The Pratt & Whitney (P&W) company wanted to demonstrate the reliability of its new R-1690 Hornet engine. To do so, the "Boeing-Hornet Shuttle" made a transcontinental flight on August 27, 1929, using a Boeing Model 95 mail plane.[16]

The flight departed Oakland, Calif., for Mitchel Field, Long Island, N.Y. Three refuelings eastbound were over Elko, Nev., Cheyenne, Wyo., and Mitchel Field, whence the airplane

Ken Hunter in flight on "The City of Chicago," with brother John in the copilot seat. (NASM via dmairfield.org)

headed west. The flight terminated at Cleveland, Ohio, after the tanker dropped a 5-gallon can of oil onto the receiver. Total time was 28 hours and 15 minutes. A second attempt was made on September 2, departing Mitchel Field. They reached the Oakland turnaround but the flight ended between Salt Lake City, Utah, and Cheyenne. A fuel stoppage caused the engine to quit and the airplane crashed in a canyon.

Civilians quickly picked up the challenge of flying longer or farther. In many cases, they were endurance flights over closed courses, but one flight was done for extended range. In August 1929, the Texas Oil Co. and the National Air Derby Assoc. sponsored N. B. Mamer and Art Walker in their nonstop flight from Spokane, Wash., to New York City via San Francisco and return. They flew a 1929 Buhl CA-6 Sesquiplane, modified in the usual manner with a hole cut in the top of the fuselage. The planned route was via Portland, Oakland, Reno, Salt Lake City, Cheyenne, Des Moines, Chicago, Cleveland and New York, returning over Cleveland, Chicago and St. Paul.

On August 15, Mamer and Walker departed Spokane's Felts Field, headed for Oakland and their first smooth refueling over Mills Field. From there, contacts were more challenging. The next refueling, over Rock Springs, Wyo., was at night (a first) and 8,000 feet altitude, necessitating several contacts to take on enough fuel. Pennsylvania provided rough weather four hours out of New York, where they flew over Roosevelt Field after 66 hours and 47 minutes having covered 3,600 miles in the air. Turning west, there was more hard weather before refueling over Cleveland. Forest fire smoke in Montana nearly blinded the pilots and makeshift refueling methods compounded the problem. Mamer and Walker finally landed at Spokane after 115 hours and 45 minutes airborne. The trip included the first night refueling, the first above 8,000 feet and the first nonstop transcontinental round trip.[17]

Flight endurance records continued to be broken over the next few years, most over closed courses. The number went to 420 hours, set over St. Louis in 1929 by Dale Jackson and Forrest O'Brine. Their later record of 647 hours was disqualified, because they landed one night for repairs.

In 1930, in Chicago, the four Hunter brothers, John, Kenneth, Albert and Walter, used two Stinson Detroiters for an endurance flight. The tanker was named "Big Ben" (NR5326) and the receiver was "The City of Chicago" (NR5189). The flight raised the endurance record to 553:41 hours (just over 23 days), covering about 40,000 miles.[18] Five years later, however, an air refueling endurance record was established that was not broken until 1959. In the process, a spill-free refueling nozzle was developed that remains the pattern for all subsequent equipment.

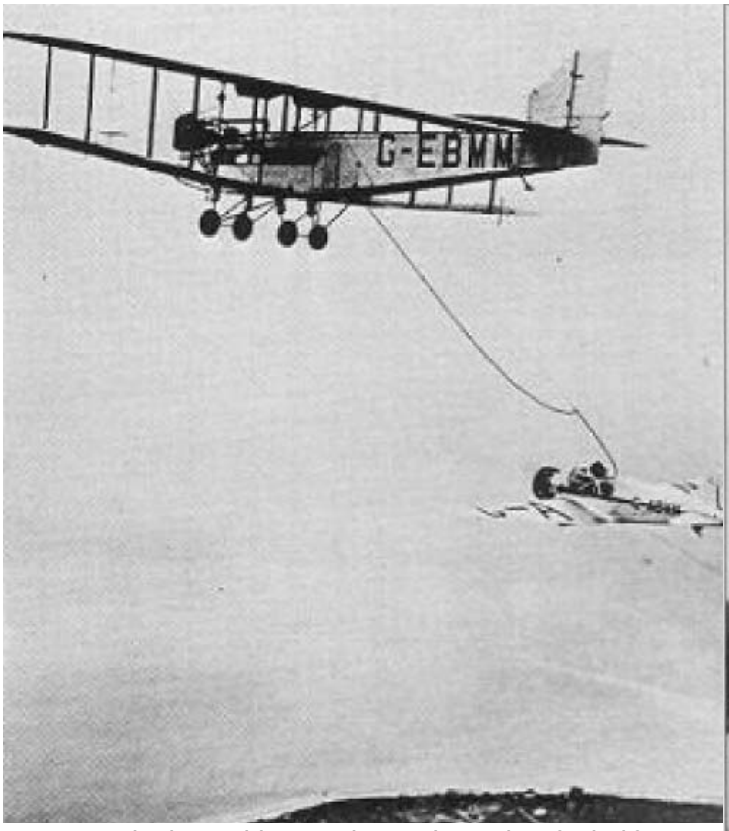
By 1935, the country was in the depths of the Great Depression. The city of Meridian, Miss., was considering closing its airport to save money. Airfield managers Fred and Al Key developed a plan to draw attention to Meridian by breaking the Hunter brothers' record. They borrowed a Curtiss Robin monoplane, naming it "Ole Miss," and modified it with a metal tube catwalk extending from the wing struts forward along the uncowled engine, to allow in-flight repairs. Together with mechanic A. D. Hunter, they invented a prototype spill-proof refueling nozzle. It had a valve on the delivery end that opened by contact with the receiver receptacle and closed if the connection was broken. This nozzle was later adopted by the U.S. Army Air Service and later modifications continue to serve modern aerial refueling.[19]

Curtiss Robin "Ole Miss" on display at the Smithsonian Air & Space Museum, showing the catwalks from which in-flight maintenance was performed during the 1935 endurance flight. (Smithsonian)

The first of three attempts took off on June 21, 1934. It was terminated after only 123 hours due to engine fires and electrical problems. A second flight in July ended at 169 hours, when a detached exhaust pipe created a fire hazard and prompted landing. Finally, the third attempt left the ground on June 4, 1935. They flew a closed course around the Meridian area at 90 to 100 mph for a total of 653:34 hours (just over 27 days), having dealt with cramped quarters, thunderstorms, an engine fire and even an abscessed tooth. *[Editor's note: the 1959 record was 64 days 22 hrs 19 min 5 sec]:*

In 438 refuelings, "Ole Miss" took on over 6,000 gallons of fuel and 300 gallons of oil. The Key brothers finally landed when the left stabilizer fittings and bell crank proved to be

Two of 10 Martin B-10B bombers in 1934 round-trip flight from Washington, D.C., to Fairbanks, Alaska, led by Lt. Col. Hap Arnold. (USAAC)



ABOVE: *Sir Alan Cobham's Airspeed AS.5 is refueled from a Handley-Page W.10 during 1934 flight. (Century of Flight)*
RIGHT*: HP.54 Harrow G-AFRL refuels Short S.30 Cabot, G-AFCU, during 1939 aerial refueling testing.*

so worn that flight control was difficult, especially during refueling. Upon landing, the airport was promptly named Keys Field.[20] The flight boosted confidence in aviation across the nation, the reasoning being that if a small airplane could stay aloft for so long, then larger commercial airplanes were even safer.

Aerial Refueling Advances

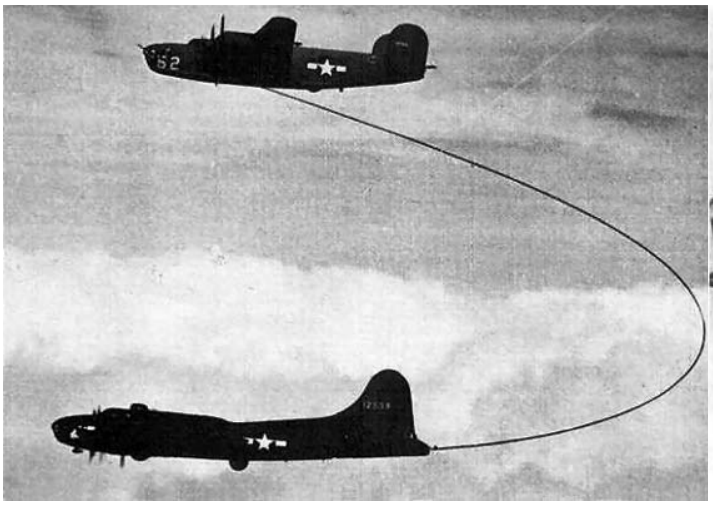
During the last decade before WWII, technical, military, economic and even political considerations moved aerial refueling from the stunt category into the area of deliberate development. The most significant advances took place in the United States and Great Britain and soon became interlocked for the next 20 years. Ironically, a rapid advance in aviation technical capability in the later 1930s actually worked against interest in aerial refueling.

In England, the Royal Aircraft Establishment (RAE) was inspired by the "Question Mark" flight to start experiments that stretched into 1937. The aircraft used were small biplanes flying at speeds of 80-90 mph. The hook-up method remained the "dangle and grab" system used by all of the predecessors. The focus was to enable an airplane to take off with a limited fuel load and then tank up in flight. Particularly with flying boats, this would lessen the structural effects of water takeoffs and landings. Based upon these experiments, L.H.B. Farrar wrote the first primer on aerial refueling.[21]

A political consideration affecting British interest in aerial refueling was because of proposed League of Nations restrictions on bomber size, so aerial refueling was a means of maximizing bomb loads. Smaller bombers would also reduce wear and tear on grass air fields of the day.[22] In the United States, though, the size of the country caused the Air Corps to look for ways to deal with its expanse. Aircraft endurance and the ability to fly long distances were direct extensions of that challenge.[23] Another challenge was the ability to protect America's long coast lines well out to sea that required aircraft with range and endurance.

At the conclusion of its testing in 1937, the Royal Air Force decided that aerial refueling had limited application for them. In the United States, too, a spurt in aviation technology made aerial refueling unnecessary for a decade, though development did not cease on either side of the Atlantic. As exemplified by the Douglas DC-2 airliner and the Martin B-10 bomber, inherent increased range and load capacity overcame much of the deficiencies that aerial refueling was intended to remedy. They were all-metal airplanes with retractable landing gear and high-lift devices. Their engines were part of a development process that quadrupled power in 10 years.

The Wright R-1820 had 675 hp in 1935, the P&W R-2800 produced 1,500 hp in 1938, Wright's R-3350 raised output to 2,300 hp. Ultimately, these engines powered the B-17 and Consolidated's B-24, both with range exceeding 2,500 miles, which were finally superseded by the B-29, contracted in 1940. It met a requirement for a 100,000 lb. bomber with a 4,000 mile range.[24] For the military in both America and England, modern aircraft were more than capable of meeting requirements for



LEFT: *USAAF 1943 refueling testing, using B-24D tanker and B-17E receiver, Eglin Field, Fla. (USAAF)*

RIGHT: *The German Luftwaffe considered using the Junkers Ju 390 as a tanker to refuel the four-engine Ju 290 bombers. (Reichluftministerium)*

operations in the theaters of concern, thus leading to less interest in aerial refueling.

Practical development in aerial refueling equipment made great strides in the 1930s, led by RAF Flt. Lt. Richard L.R. Atcherly and Sir Alan Cobham. In fact, their innovations later made their way west to the United States when the Americans got truly serious about aerial refueling.

Atcherly's great accomplishment was to develop a reliable aerial refueling system, which he eventually patented. He had observed American aerial refueling in 1929 and 1930 and judged the methods to be primitive and dangerous. During a later assignment in the Middle East, he developed his method. It placed the burden of the refueling hookup on the tanker, whose crew usually was more experienced than that of the receiver.

Both airplanes trailed cables with grapnels on the end. With the receiver maintaining straight and level flight, the tanker approached from the rear, crossing the receiver's track until the receiver's cable was hooked. Then, moving into a side-by-side formation, the receiver reeled in both cables. The refueling hose was attached to the other end of the tanker's cable. It was winched into the receiver and connected to the fueling system. During refueling, the two aircraft flew in formation, the tanker above and to the right of the receiver, with a huge bight of hose connecting them. Once refueling was complete, the receiver disconnected the hose, which the tanker reeled in. The final step was for the tanker to turn away, breaking the cable connection at a weak link.

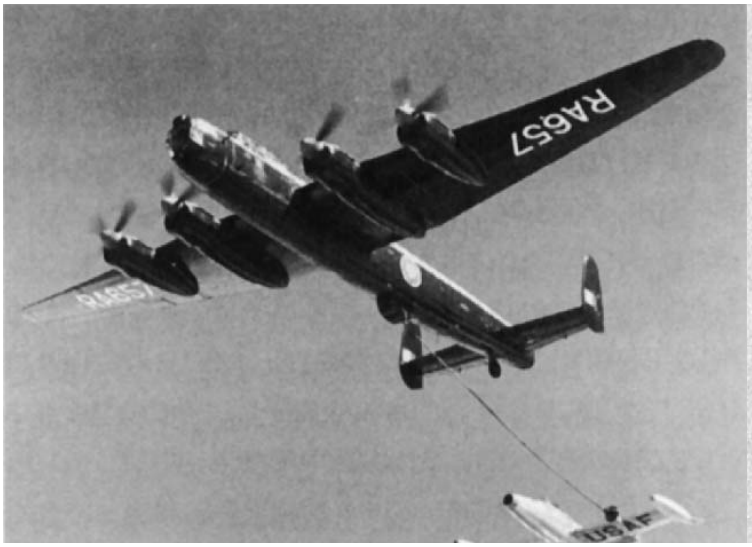
By 1937, the Atcherly system had been perfected, but the RAF did not carry things further, with more modern aircraft obviating the need for aerial refueling, as far as the RAF was concerned.[25] Civil aviation, however, as it developed longer range routes, remained concerned with how to maximize use of those routes. In 1930, Alan Cobham became very active in working to extend airliner range.

Cobham's interest in aerial refueling stemmed from his many years of aviation pioneering, much on a par with Charles Lindbergh. He had been identified with long-distance flights since the 1920s. In 1925, he surveyed air routes to the Middle East, India and Burma, as well as the London-Capetown route. The following year, he opened an air route between England and Melbourne, Australia.

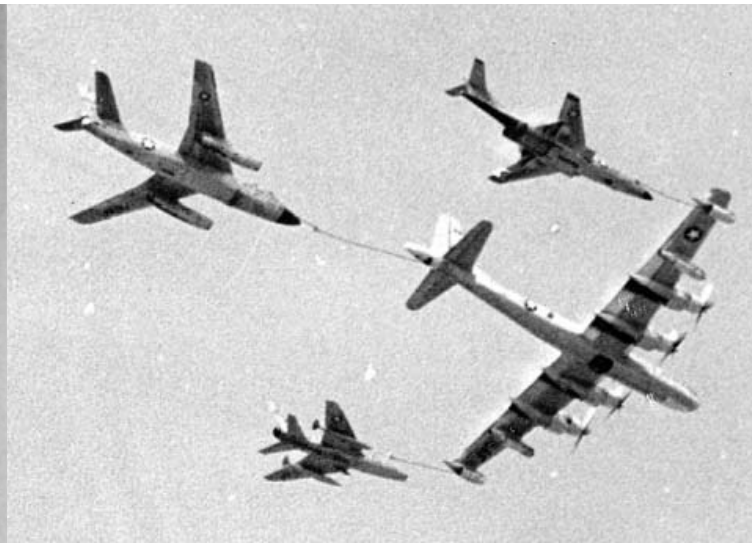
Cobham's first attempt at using aerial refueling to extend range was in 1934. His goal was to reach India from England.

The airplane was an Airspeed AS.5 Courier, the first British retractable gear airplane and the first one certified for aerial refueling. The takeoff gross weight was 3,500 pounds but maximum in-flight gross weight was 5,050 pounds. The difference was the weight of 273 gallons. Departing from Portsmouth on September 22, he took on fuel from Handley Page W.10 tankers over the English Channel and again over Malta. The contacts went well but he was forced to land in Malta after a throttle linkage broke. Though the operation failed, Cobham was still convinced of the value of aerial refueling. Consequently, he formed Flight Refueling Ltd. (FRL),[26] a company that would later be important to American postwar aerial refueling. FRL got access to aerial refueling test results at Farnborough and the loan of obsolescent RAF aircraft. Cobham was able to reconcile any conflicts with the Atcherly patents and to convince Imperial Airways that aerial refueling was useful. FRL's system, outwardly very similar to the Atcherly method with a looped hose, was different in the extent to which the small fittings and connecting devices had been worked out by 1938. Imperial Airways had a commercial motivation to look at aerial refueling. An American competitor, Pan American Airways, had been operating Sikorsky S-42 and Martin M-130 flying boats beginning in 1935. Flight testing began in the summer of 1939. Both types had transoceanic ranges and had been initially equipped for aerial refueling using the still-customary dangle and grab system. The equipment was removed, after performance proved to meet requirements. In 1938, the new Boeing B314 flying boat upped the ante with a 3,000-mile range, carrying 25 passengers and several hundred pounds of mail. Imperial's Short S.23 flying boats could not compete with such performance.

Beginning on August 5, FRL and Imperial Airways flew test missions on an experimental airmail service route between Southampton, England, and New York City, via Foynes, Ireland, Botwood, Newfoundland and Montreal. The two receivers were heavily-modified Short S.23 flying boats redesignated



Col. David Schilling refuels from a Lincoln tanker on the 1950 flight from England to the U.S. (USAF)



A KB-50J "triple nipple" refuels a B-66, an F-100D and an F-101A, sometime in the 1960s. (USAF)

S.30s after stripping out a lot of weight and strengthening them to operate at 53,000 lbs. FRL provided Handley Page HP.54 Harrow tankers at Gander, Newfoundland, and Rineana (later, known as Shannon), Ireland. Total off-load fuel was 6,840 lbs.

Refueling was not intended to make a nonstop flight from Southampton to Montreal, for the stops in Ireland and Newfoundland were necessary. The purpose was simply to fill up the S.30s after takeoff. Operations were terminated on September 30 because Botsford would soon freeze up. The plan was to resume operations in spring 1940, but the 1939 outbreak of WWII brought other concerns. Air France had also planned to use FRL's services in the Azores on a route to New York City.[27] In 1940, FRL was put out of business for a time when its tankers at Ford, Sussex, were destroyed by bombs.

The British and Americans were not alone in testing aerial refueling, though they were certainly the most advanced. During the 1930s, the Soviets tested all of the known systems without implementing any of them.[28] They resumed testing in the 1940s but not until the 1950s did it become part of the Soviet repertoire. The system used a hose looped from the starboard wing of the tanker to the port wing of the receiver. The German Luftwaffe experimented during the war to extend range of some of the fleet. A Heinkel He 111 was converted to a tanker and other proposals called for six-engine Junkers Ju 390s, the Amerika Bomber, to serve as tankers for Ju 290s. The war's progress caused these efforts to terminate as Allied forces closed in on Germany.[29]

Aerial Refueling during World War II

During WWII aircraft design priorities were on extending inherent range for both fighters and bombers. Distances in the European and North African theaters were within the range of existing aircraft, usually not more than about 600 miles, but the Pacific War stretched aircraft and aircrew capabilities to their limits. Though it was not a primary interest in the haste to meet WWII combat demands, aerial refueling continued to be evaluated.

In England the government asked for proposals to fit out the Short Stirling bomber as a receiver, but events in 1940 forestalled this. Alan Cobham tried to get the Air Ministry to equip the Short Sunderland flying boat as a receiver, which would have enabled it fly to a convoy in mid-Atlantic, cover it for one or two hours and then return to base in Ireland, Cornwall, Iceland or Newfoundland. Stirling tankers could have carried 7,000 lbs of fuel for offload and even the Armstrong-Whitworth Whitley could have delivered 3,000 lbs. Mid-ocean convoy protection would have been available well before mid-1943.[30] Such capability might have made large differences in the Battle of the Atlantic.

In America, post-Pearl Harbor conditions led the AAF to consider three aerial refueling options in dealing with Japan. The first was to launch B-17s from Midway against Japan, refueled by B-24s. A second option was to launch B-24s from Hawaii and refuel them enroute from U.S. Navy seaplanes. Finally, B-17s would tow fuel-filled gliders that would serve as tankers.[31] In all cases, times enroute probably showed planners the scope of such missions. A B-17 flight from Midway would have been nearly 13 hours one way. A B-24 flying from Hickam AFB faced a one-way time of over 19 hours. Pilots who flew 16-hour B-24 missions in the SW Pacific had to be lifted from their seats. The performance degradation of towing fuel-laden gliders would have been hugely inefficient, not even considering the primitive nature of refueling methods in the early 1940s.

In the summer of 1943, the Army Air Forces used FRL equipment in experiments to refuel a B-17 from a B-24 tanker. There were plans to develop large fleets of tankers and receivers, but production requirements and the availability of aircraft with large internal fuel capacity alleviated the need for aerial refueling.[32] The American military contacted the British and were put in touch with RAF Wing Cmdr. Hugh Johnson, who had managed the FRL tankers at Gander, Newfoundland. A B-24 took him to England, to collect all that he could from FRL for American use.

Johnson assembled FRL equipment in England, some technicians and technical drawings. Testing took place at Eglin Field, in Florida's panhandle. Johnson was in charge and technical assistance came from Percy R. Allison of the British Air Commission. Piloting the B-24 tanker was Capt. Fred C.

A Lancaster tanker refuels the Gloster Meteor fighter during a 1949 record-setting flight over southern England, using the probe and drogue method. (FRL)

Bretcher, with copilot 1st Lt. M.K. Norton. The B-17 pilots were Capt. Ralph C. Hoewing and 1st Lt. John A. Kelting. Seven flights were made, with most off-loads over 1,000 gallons. The final flight transferred 1,450 gallons.[33] Total fuel capacity of a B-17 was some 1,700 gallons, with a burn rate of 200 gallons per hour (gph).

To fly a 26-hour round trip from Midway to Tokyo and return called for at least five aerial refuelings on a route where the tankers would also have had to launch from Midway and weather could be extremely demanding. In any case, despite relatively successful tests, there was the problem of manufacturing enough refueling equipment to support several squadrons, then modifying the airplanes and training aircrews, both tanker and receiver. Departures from Hawaii would have called for missions over 38 hours long with at least eight refuelings. In this case, at least, the tankers could have been located forward, at Midway.

In 1944, as Allied forces moved closer to Japan, the Americans had the B-29. It had the range and load capacity that did not require concerns about air refueling, as far as American forces were concerned. The British, though, anticipating participation in the final assault on Japan, were not so favorably equipped. The Air Ministry in 1944 informed Alan Cobham of RAF plans to bomb Japan using aerial refueling.

In Operation Tiger Force, 600 Avro Lancaster bombers would be converted to tankers to refuel the new Lincoln bomber, which first flew in June 1944. Basing of the force was unclear, but by summer 1944, the Americans had taken Saipan, Tinian and Guam, all within B-29 range of Japan. The RAF gave Cobham free reign in obtaining resources for the project, including three bases and an aircrew training school. With the 1945 fall of Okinawa, though, Japan's main islands were within easy reach of the B-29s. The atomic bomb in August 1945 terminated all requirements for further bomber forces in the Pacific.[34] With the end of the war in both Europe and the Pacific, it was a new world in which aerial refueling became a subject of intense military and technical interest.

Postwar Civilian Testing

With the end of WWII, commercial aviation looked briefly at aerial refueling as a means to extend its capabilities. The military soon came to realize that the technique was absolutely necessary, due to postwar political realities.

On the commercial side, Alan Cobham energetically sold FRL services to the airlines. In the winter of 1946-47 came the first testing, with British South America Airways. The tankers were six Lancasters with another half-dozen serving as receivers. The aircraft were fitted with radar and transponders so that testing could simulate mid-ocean rendezvous. In total, 43 successful aerial refueling flights (26 day and 17 night) were made between Dover and Land's End, a distance of 319 miles. Enroute time would have been approximately 1.5 hours.

Overwater testing began in the spring of 1947 between London's Heathrow Airport and Kindley Field, Bermuda. The tankers were based at Santa Maria, Azores. Most refuelings were within 200 miles of Santa Maria, though at least one was 500 miles out. This leg was 3,437 miles, requiring at least 14 hours and 30 minutes flight time for the Lancaster. Seven weekly flights took place between May 28 and August 11. All flights went smoothly except for one instance of engine problems on a receiver. Westbound offloads averaged 2,230 gallons and eastbound took 1,365 gallons.

Winter testing over North Atlantic routes was done with British Overseas Airways Corporation (BOAC) aircraft, from February 4 to May 30, 1948. The tankers were Avro Lancastrians, two each based at Shannon, Ireland, and Goose Bay and Gander in Canada. The receiver was a B-24 converted to carry mail and freight. Fifteen round trips were refueled enabling the B-24 to fly the 3,240 mile route between London and Montreal nonstop. There were two westbound contacts and one eastbound. Of 45 scheduled refuelings, only three miscarried.

Despite the successes, BOAC officials ultimately decided to buy Lockheed Constellations and Boeing Stratocruisers and make stops at Gander and Prestwick, Scotland, or Shannon.

The B-50 "Lucky Lady II" refuels from a KB-29M during the 1949 round-the-world demonstration flight. The extent of the looped bight of refueling hose is clearly apparent. (USAF)

Aerial refueling was effectively dead for the airlines.[35] Somehow, one wonders what passengers would have thought to see another large airplane quite close, with a bight of hose between the two aircraft.

Air Force headquarters had gained some familiarity with FRL's equipment and methods through efforts of retired Lt. Gen. James Doolittle. At some point prior to BOAC's North Atlantic trials, Doolittle visited FRL at the behest of Shell's president, Walter Hill. He had worked before the war for Shell Oil Co., which owned 60 percent of FRL. Shell envisioned the FRL equipment offloading Shell product. At Ford Airport, Doolittle obtained a large amount of FRL aerial refueling data and a movie of its operations. This material was circulated widely throughout Air Force headquarters and shown to USAF Sec. Stuart Symington. Though Doolittle was concerned about FRL proprietary rights, Alan Cobham was delighted to have such excellent advertising.[36]

Aerial Refueling Goes All-military

Less than a year later, Alan Cobham and FRL found themselves with a customer interested in all that they had, due to the postwar political situation. As tensions grew between the United States and the U.S.S.R., the USAF became concerned about the distances to potential Soviet targets. No American bomber in full service, primarily the B-29, had the range to reach those targets. The new B-36 was slow and the first production aircraft would not fly until July 8, 1948. The B-52 was still planned for six turboprop engines and aerial refueling was already part of the operation. The B-36 was modified with a pair of J-47 turbojets under each wing tip enabling it to make the round trip to the Kremlin.

In 1947, the Aircraft and Weapons Board of the new service met for the first time. The Board recognized that only the B-36 and the B-52 could reach Soviet targets, but an aircraft range of 10,860 nm[37] was believed necessary to do so. Improved jet engine technology by 1947 had brought greater fuel efficiency, so that aircraft could attain higher speeds than with turboprops. Design refinements eliminated gun turrets, ammunition, some crew members and fire control systems. Even more important, the design range requirement was reduced to 6,950 nm that enabled structural reductions in weight to about 300,000 pounds. Aerial refueling would be used to make up the range deficiency. Through this process, the Air Force identified aerial refueling as a top priority for the bombardment force. Chief of Staff Gen. Carl Spaatz (who had piloted *"Question Mark"*) charged Gen. George Kenney and Gen. Curtis Lemay with implementation of the program on existing B-29s and B-50s, the B-52 and the B-47.[38]

FRL had visitors on March 18, 1948 - a team from the USAF. After short negotiations with Cobham, the result was two sets of FRL inflight refueling equipment, manufacturing rights for the system and a contract for FRL to provide another 40 sets plus one year's technical support. With this action, the USAF had obtained the only equipment in the world that was fully tested by the USAAF, FRL, BSAA and BOAC. Both doctrine and equipment were now in place. Domestic access to FRL equipment was assured when an American subsidiary was created, Flight Refueling, Inc. (FRI). Manufacturing took place first at Danbury, Conn., and then at Baltimore Friendship Airport, Maryland. In the end, Aeronautical Corp. of America (Aeronca) bought FRI.

The development of procedures and training followed soon.[39] For a lengthy period aerial refueling would be done using the FRL looped hose method to transfer fuel from one large aircraft to another. The process had the two airplanes flying in formation at slightly under 200 knots, with the bomber about 20 feet below and 75 feet behind and to the left of the tanker. The tanker streamed a "contact line" with a 50-lb weight on the end. The receiver trailed another cable, the "hauling line," from the refueling receptacle. A hook on

The pilot's view of the drogue just at contact. (USN)

An F-84 refuels its tip tank over Korea, using the probe and drogue method. (USAF)

its end snagged the contact line as the airplanes crossed paths. Once connected, the tanker operator connected the hauling line to the fuel hose that was then winched to the receiver. When the hose was connected to the receptacle, fuel flowed. One can only imagine the challenges of accomplishing such hookups in weather or at night.

Aircraft modification proceeded quickly. The first two FRL units went to Boeing's plant in Wichita, Kan., where they were installed on B-29s. One of the aircraft remained at Wichita and the other flew to Wright-Patterson AFB, Ohio, where it began testing in May 1948. To build the aerial refueling force, the Air Force had 80 B-29s modified into tanker-receiver pairs. The tankers were redesignated KB-29M and receivers as B-29MR. All B-50s were to be equipped as receivers, either on the production line or with field modifications.

A further structural modification that ultimately became standard on all aircraft was single-point refueling. No longer would individual tanks be filled through their own fueling port. Instead, the airplane would be filled via a single receptacle from which fuel would be pumped under positive pressure to the tanks that were part of an integrated fuel system.[40]

Organizationally, the first two aerial refueling squadrons (ARS) were formed. The 43rd ARS stood up at Davis-Monthan AFB, Ariz., and the 509th ARS was based at Walker AFB, Roswell, New Mexico. These were only the first of many to come. Six more ARS were in place by the end of 1949, another half-dozen were formed in 1950 and by July 1956, SAC had 40 full-strength refueling units averaging 21 airplanes per squadron. The tanker force peaked in 1961 when there were 651 KC-97s and 444 KC-135s (some of which were still in service in 2011).

These numbers reflected the growing requirement for tankers in that period, beginning with the first combat use in the Korean War, even while SAC bombers were being refueled to accomplish deployments to overseas bases. Large fighter formations also came to use tankers routinely during mass deployments.

During these early years, all aircraft involved had to deal with inherent deficiencies of the FRL system. The huge bight of hose between tanker and receiver was very awkward and limited to speeds below 190 knots. Inside diameter of the hose was 2.5 inches and maximum fuel flow was 110 gpm. To overcome these problems, the Air Force directed Boeing to look at alternatives. The result was what was called at first the "Boeing boom" and later was termed the flying boom. The boom was a telescoping pipe with inside diameter of 4 inches and two small airfoils ("ruddervators") near the nozzle. The boom operator, sitting in the B-29's tail turret, could fly the boom to a receiver's refueling receptacle. The early equipment delivered fuel at 700 gpm. They were tested in the fall of 1948. More than 100 KB-29Ps were modified with the boom and all new B-50Ds were to be outfitted as receivers with a built-in receptacle.[41]

Operational aerial refueling testing in December 7-8, 1948, used the looped hose method and showed transoceanic capabilities. A B-50 departed Carswell AFB, Tex., for a dummy bomb drop in Hawaii and return. One aerial refueling serviced the bomber on its westbound leg. Returning, headwinds caused excessive fuel consumption and required two refuelings to complete the flight. Nearing the California coast, the B-50 was running on fumes. After two missed contacts, the crew considered landing on a Navy flight strip on one of the Channel islands, but they connected on the third try. The second contact was over eastern California, allowing the airplane to reach Carswell. Total distance was 6,720 nm, equivalent to the B-36's range.[42]

The final proof of concept flight involved a round-the-world (RTW) demonstration flight, ordered by the Air Force at the end of 1948. In only four weeks, the nascent aerial refueling force prepared for and delivered a successful mission. Experience was still low for both tanker crews and receivers. Crews from the 509th ARS had done only a dozen contacts and 43rd crews only one. The B-50 had only a year in squadron service and their new R-4360 engines were temperamental.

The total fleet of airplanes included at least three KB29Ms at Lajes AB, Dharan, Saudi Arabia, Clark AB, Philippines, and Hickam AFB, Hawaii. Their support included C-54 and C-97 transports. Five B-50s were prepared as receivers, to be launched in succession until one made the entire RTW trip.

The first to launch from Carswell AFB was "Global Queen," on February 25, 1949. The flight ended at Lajes AB after experiencing engine trouble. "Lucky Lady II" took off the next day, the 13 crewmembers commanded by Capt. James Gallagher. All went smoothly through two refuelings

The "Boeing boom" offered greater fuel flow rates than the probe and drogue system and became the standard system for Strategic Air Command. (USAF)

A single KC-132 could have replaced the five Illinois ANG KC-97s of the 126th Air Refueling Wing that supported the first ANG F-100 transatlantic deployment. (USAF)

at each location enroute. The landing at Carswell came 94 hours and one minute later. The entire receiver crew received the Distinguished Flying Cross (DFC), but none of the tanker crews garnered awards. Gen. Curtis LeMay remarked that, now, the Air Force could deliver an atomic bomb to any place in the world.[43]

General LeMay lost no time in standing up more refueling squadrons to support SAC. He also worked on bringing in jet refueling. Less than a year after the RTW flight, the first refueling of a jet bomber took place in the fall of 1950, using the flying boom. A tanker and an RB-45C from the 91st Strategic Reconnaissance Wing, at Barksdale AFB, La., were the aircraft involved. During the succeeding 18 months, the wing refined refueling equipment, techniques and procedures, including night and instrument refueling. The importance of aerial refueling was stated by 2nd Air Force commander Maj. Gen. Frank Armstrong, when he wrote to LeMay, ". . we are continuing to build, our strategy around refueling. As of today, the 'tail is wagging the dog.'"[44]

Using the boom, fuel offload flowed at 600 gpm between the two aircraft flying at 215 knots. It was essential that there be uninterrupted communication between the two aircraft. An inadvertent extension of the boom could put the tanker into a rapid pitch-down condition with the possibility of an explosion. Boom testing at Air Materiel Command (AMC) using a B-50D receiver and a KB-29P tanker identified how much extra power was needed on the receiver while in the tanker's downwash. Testing also evaluated the most suitable altitudes, the best means of approach and aircraft position. By late 1952, the boom was installed on or planned for 116 KB-29Ps, 750 KC-97s and 213 B-50s. B-47s, B-52s and Republic F-84G and -F fighters were fitted with receptacles for the boom.[45]

In this period, the probe and drogue method was believed to be superior to the flying boom. The Wright Air Development Center (WADC) believed that the method offered greater potential and performance than the boom method. Hose reels were available that were capable of transferring 1,000 to 1,200 gpm. By 1953, the B-47, B-52 and B-36 had been successfully tested as probe and drogue tankers. However, SAC favored the boom method for the simple reason that the only logistics tanker in service for development was the KC-97, which was equipped with the boom. An essential aid to refueling of any kind was the Sperry Gyroscope Company's AN/APN 69 radar beacon that allowed the receiver to automatically detect and fly to the tanker from as far as 200 miles away.[46]

The aerial refueling world split into two camps as the result of a fly-off at Offutt AFB, Neb., February 4-7, 1951. SAC went with the flying boom while operators of smaller, more maneuverable airplanes stayed with the probe and drogue. These were Tactical Air Command (TAC), the Marines and Navy, Royal Air Force and NATO forces. Seven years later, on July 14, 1958, HQ USAF decreed boom refueling as the standard method for all USAF airplanes. This decision revoked an earlier decision, in July 1952, that probe and drogue refueling would be the Air Force standard.

Though the boom method had become the standard with SAC, the system suffered because of the inherent performance differential between the KC-97 tankers and the jet-powered B-47s. The -97 could only reach about 20,000 feet, two miles below the B-47's cruise altitude. During refueling, the bomber had to descend below 20,000 feet for the hookup. Once connected, the tanker flew in a slight dive, to help maintain maximum airspeed. Also, as the bomber took on fuel, it had to keep a higher airspeed to stay airborne, requiring even more rate of descent for the pair, connected by the refueling boom. Weather and night operations made the process even more challenging. After fueling was completed, the B-47 had to expend a large portion of the onload simply climbing back to cruise altitude.

Early on, SAC realized that a jet-powered tanker was necessary to derive the greatest efficiency from aerial refueling. Until that happened, though, the propeller-powered tankers provided yeoman service to SAC's B-47s during several years of deployments to bases in England, North Africa and other locations that put the bomber force closer to Soviet targets. The first such "reflex" deployment moved B-47s from MacDill AFB, Fla., to RAF Fairford, England. The first squadron, led by Col. Michael N.W. McCoy (namesake of McCoy AFB, Fla.), departed on June 3, 1953. By June 6, the entire 306th Bomb Wing was in place at Fairford. Ninety days later, the 305th Bomb Wing relieved them. SAC kept a wing of B-47s in England until 1958. In Morocco, reflex bombers operated

An F-84E prepares to hook up to the drogue for refueling. The probe is visible just inboard of the of the left wing tank nose. (USAF)

KC-97 tankers refueled Strategic Air Command B-47 force through the 1950s, using the flying boom. (USAF)

from Nouasseur AB, Ben Guerir AB and Sidi Slimane AB, for several years.

By the mid-1950s, aerial refueling was routine for both bombers and fighters. Whether single aircraft or entire formations, the process was carried out, even in mid-ocean. With two contacts, aerial refueling had tripled the B-47's combat radius and was a normal part of every long-distance flight. By 1956, SAC bombers were averaging 3,000 refuelings each week.[47] These were all using the flying boom, for which most fighters were not fitted. For many years, the flying boom was the standard for SAC aircraft, first, and then other large airplanes in later years. Such aircraft were not the ones toward which the C-132 services were directed and SAC had no interest in the airplane.

The other system, the probe and drogue method, became standard for fighter aircraft. This equipment was what was chosen for the refueler version of the C-132, on which Douglas Aircraft Co. began design work in January 1953. With this method, the tanker version of the C-132 would have been invaluable in supporting mass fighter deployments.

Refueling Tactical Aircraft in Flight - The C-132's Role

The growing use of the flying boom foretold the direction that the bomber world would take in aerial refueling. For most fighters of the 1950s, another method was needed, because they had no receptacle into which the flying boom could be inserted. As with FRL's looped hose method, the probe and drogue solution began in England. The C-132 would have employed this system had it gone into service.

The system involved a hose that was streamed from the tail, bomb bay or wings of the tanker aircraft. The hose ended in a large conical basket, or drogue, made of strips of heavy rubber, with a receptacle at the apex. Fighters were fitted with a long probe that was flown into the drogue. When the probe made contact, it activated clamps to hold things together.

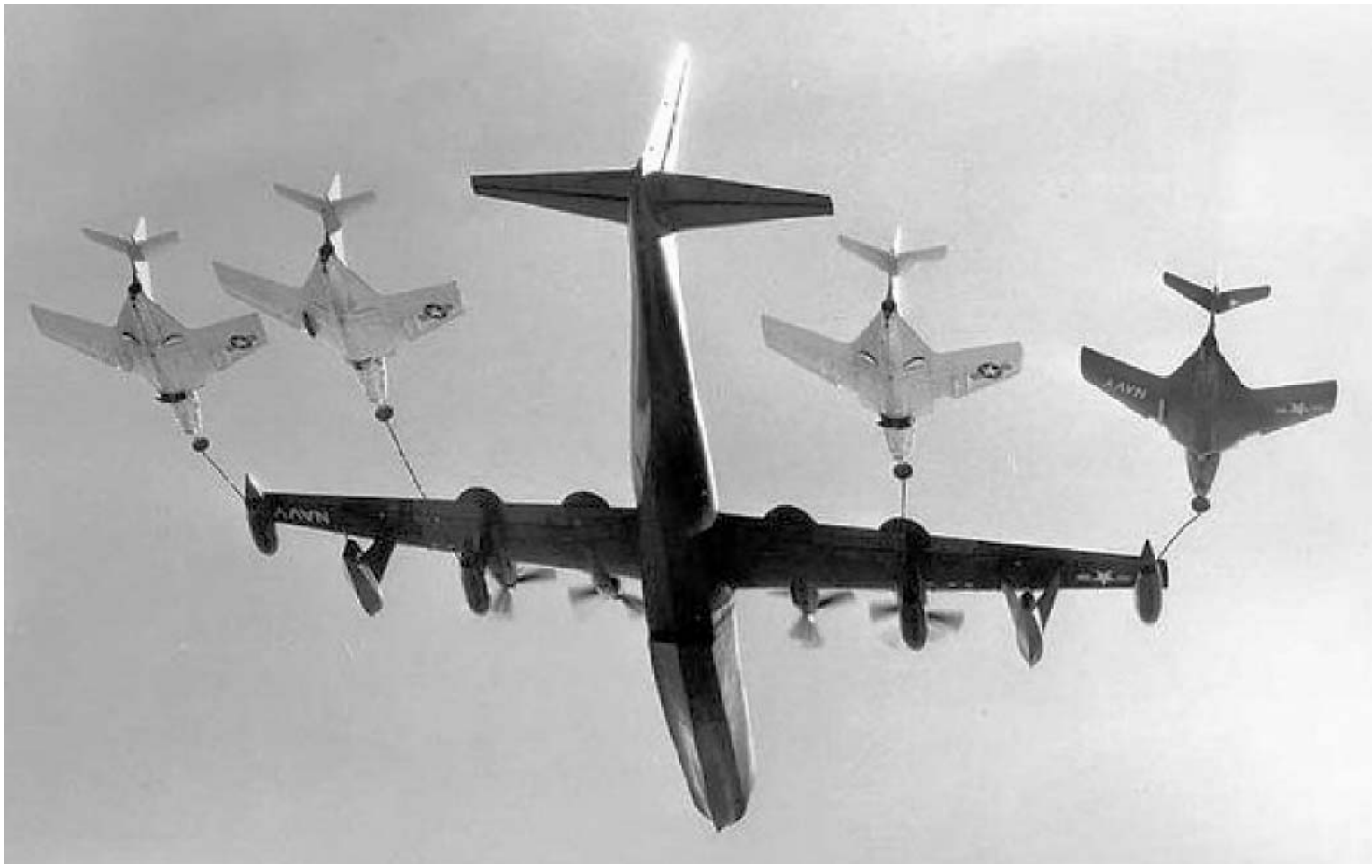
The first tests of the system were on April 4, 1949, in England. Using a Lancaster tanker, a Gloster Meteor III fighter made an unrefueled connection. Some days later, a USAF team observed another such operation. This resulted in dispatch of four B-29s and two F-84Es to England to be modified as tankers and receivers. Two B-29s had both drogues and a probe, thus becoming known as "unicorns." Another B-29, redesignated YKB-29T, was fitted with hose reels on both wings and the tail, thereby receiving the nickname "triple nipple." The F-84s received probes on the center leading edge of the left wing.[48]

FRL made further tests of the system, during 1949, setting a new record on August 7. Thomas Marks piloted the Lancaster tanker that refueled Patrick Hornidge's Gloster Meteor 10 times, keeping it airborne for 12 hours and three minutes. This was a first aerial refueling for fighters and a world flight record for fighters. Such endurance foretold what fighter pilots would experience on long deployment flights. Development on the system was essentially complete in England by September 1950. On the British Mark 14 hose unit, fuel flow was 600 gpm at airspeeds of 160 to 260 knots. It was proven in service when the modified B-29s and F-84s returned to the U.S.

Departing on September 22, 1950, Col. David Schilling (for whom Schilling AFB, Kan., is named) and Col. William Ritchie piloted the F-84s. They each made three refuelings enroute, from a Lancaster near Prestwick, Scotland, a Lincoln near Iceland and a KB-29 near Labrador. Unfortunately, Ritchie's probe was damaged in the Iceland refueling and he had to eject after the Labrador landfall due to fuel exhaustion. Schilling carried on to land his EF-84E, 49-2091, at Limestone, Me., after 10 hours and eight minutes in the air.

This was the first nonstop transatlantic flight by jet fighters with uncounted thousands to follow in the years since. By comparison, in July 1948, Schilling led a deployment of 16 F-80s from Selfridge AFB, Mich., to RAF Odiham. That operation, Fox Able One, required four fuel stops and took 10 days, due to weather and fueling delays. Fox Able Two in May 1949 required 16 days.[49] Aerial refueling definitely promised much more efficient fighter deployments.

This capability was quickly implemented, certainly with the demands of the Korean War, which began on June 25, 1950. Fighters were in high demand in that conflict. Initially, fighter operations flew out of Japanese bases. Pusan was 130 nm from southern Japan and North Korean front lines were 175 to 300 nm distant. From bases near Tokyo, distances were 540 to Pusan and 600 nm to Seoul and the 38th Parallel. These distances were at the limits of jet fighter combat radius. Some means was needed to extend the range of F-80 and F-84 fighters.



The Convair R3Y Tradewind flying boat was a U.S. Navy aerial refueling demonstration project that never went into squadron service. (USN)

Initially, the fix was to equip the fighter tip tanks with probes that the fighter could fill from KB-29 tankers. One tanker was stationed in Japan by June 1951 and the first refuelings in Korea occurred on July 6, 1951. A KB-29M orbiting off the east coast, near Wonsan, refueled four RF-80As from Taegu, 210 nm away. The contact restored their 330 nm combat radius, enabling them to photograph targets to the limits of northern Korea. The process was cumbersome, requiring the fighter to hook up, fill the left tank halfway, then the right wing completely, and finally to top off the left tank. This was done to avoid an out-of-balance situation while bringing up the fuel load to the range of 1,040 pounds to 1,690 pounds.

The first refueling of a combat mission occurred on May 29, 1952. Twelve Japan-based F-84Es were tanked up to complete an attack on Sariwon, North Korea. Perhaps the most extreme example of extended flight endurance due to aerial refueling came in September. Col. Harry Dorris in an F-80, bombed, launched rockets, strafed and flew reconnaissance on a single 14 hour and 15 minute sortie during which he refueled three times.[50]

These occasional refuelings grew into Project HIGH TIDE. Aircraft of the three squadrons in the 136th Fighter-Bomber Wing were fitted with probe-equipped tip tanks. Ten KB-29Ms that were surplus to SAC requirements were converted with hose reels and drogues and released to the project, along with the "triple nipple" YKB-29T. The three phases of the project were, first, to train the squadrons in small exercises. Then, they were deployed in combat air patrols over northern Japan, before finally sending them into combat over North Korea. The Air Force concluded that tip tank refueling was only an interim fix. What was needed was fighters with single-point refueling. Republic Aircraft already had such an aircraft in production for SAC, the F-84G.

Delivery of F-84Gs to SAC began in 1951. These aircraft had a refueling receptacle in the left wing root, making them compatible with the flying boom. They began making long-range refueled flights in 1952, the first of which was Fox Peter One, again led by Col. David Schilling. On this deployment, beginning on July 6, 1952, three squadrons of the 31st Fighter Escort Wing flew from Turner AFB, Ga., to Yokota AB, Japan, completing the operation less than two weeks after leaving Georgia. This was much faster delivery than would have been required to transport the aircraft on a carrier.

The route went from Turner to Travis AFB, Calif., and then on to Hickam AFB, Hawaii, 1,860 nm distant, with a refueling from KB-29Ps in the area of a U.S. Coast Guard cutter between California and Hawaii. Subsequent legs were shorter. Hickam to Midway was 990 nm and the hops to Wake Island, Eniwetok, Guam, Iwo Jima and Yokota were even less. Fox Peter Two, in October, moved the 27th Fighter Escort Wing to the Far East and the process soon became routine.

On the east coast, on August 20, 1953, Colonel Schilling once again endured long hours in the F-84G, when eight Turner AFB F-84s deployed to Nouasseur AB, French Morocco. Just after Schilling's section departed, Col. Thayer S. Olds led 20 more F-84s into the air bound for RAF Lakenheath. These

A 91st Air Refueling Sqdn. KB-29P from Barksdale AFB, La., refuels an RB-45C of the 91st Strategic Reconnaissance Wing using the flying boom. (USAF)

aircraft were refueled three times by the then-new KC-97 in what was known as Operation LONG STRIDE.[51] The point of the operation was to demonstrate how quickly SAC bases in Europe and North Africa could be reinforced.

TAC's air refueling force grew dramatically in this period. After HIGH TIDE was completed, TAC first obtained a dozen ex-SAC KB-29Ms that had FRI hose reels. With retirement of SAC KB-50s, 136 B50Ds and TB-50Hs went to TAC as tankers. The modified -Ds became KB-50Js and the B-50Hs were redesignated as KB-50Ks. The modifications included a J-47-23 turbojet engine in a pod near each wing tip. The jet engines allowed a maximum takeoff gross weight of 173,000 pounds and boosted the refueling altitude to 25,000 feet at nearly 260 knots. Fuel available for offload was 37,019 pounds.[52] The KB-50s and even the KC-97s suffered by comparison to the projected capabilities of the tanker version of the C-132.

To facilitate the large overwater deployments, TAC placed tankers at forward locations. Pacific tanker locations included Hickam AFB, Hawaii, and Wake Island, for moves to Japan and Okinawa. In the Atlantic, these were Kindley AB, Bermuda, and Lajes AB, in the Azores. There were hazards in the aerial refueling operation, both in the process of passing fuel and at other points in the mission. An incident on February 9, 1962, points out the dangers.

Then A1C Jim Strobeck was a weather observer at Kindley, doing a routine launch of a weather rawinsonde balloon. When going out to the observation platform, he noticed a "sparkle" to the east, about 20 degrees above the horizon. Almost immediately after, the phone rang with the duty weather observer asking if he had seen a KB-50 explode. Strobeck replied that he had seen what looked like reflections off of Christmas tree tinsel. Shortly after, two officers from the Flying Safety Office arrived and got all the information he could provide. His data was correlated with other observations to pinpoint the center of the incident. What he had seen was the explosion of KB-50 48-082, in which Capt. Roman Pallow and his entire crew from the 622nd Air Refueling Squadron perished.[53] Very little wreckage and no bodies were found.

On these multi-aircraft deployments, the Douglas C-132 tanker would have done much to facilitate the move. It was projected to be able to transfer 110,000 pounds of fuel and could also have transported large amounts of the equipment and personnel involved on these huge deployments. For example, the F-100C, which began delivery in October 1953, carried a total of 11,342 pounds of fuel. If the fighter refueled whenever it had 5,300 pounds remaining, a single C-132 could have serviced 11 F-100s, two at a time. By comparison, the KC-97 had a maximum of 53,000 pounds offload fuel and could refuel only five such fighters, one airplane at a time and at a slower offload rate. Even the KB-50, with three hose reels, could only deliver fuel at 285 gpm per station, requiring nearly seven minutes to pass a 50 percent fuel load to an F-100C.

The U.S. Navy also got into aerial refueling during the Korean War, though it did not make large deployments like the Air Force. Instead, the focus was more upon extending the range of carrier-based strike aircraft. In 1950, there were potential Navy targets in the Black Sea, the Kola Peninsula, Vladivostok (in Siberia) and other locations in the Soviet Far East. The longest-range carrier aircraft of the time was the North American AJ-1 Savage, with a combat radius of 700 nm. With aerial refueling, there was greater chance that the aircraft could recover in friendly territory and the carrier could launch strikes farther out from the target. Along with the Savage, the Vought F7U Cutlass served in the tanker role. Both airplanes refueled probe-equipped McDonnell F2H-4 Banshees, Grumman F9F-8 Cougars and F9F-2 Panthers. The success with these systems encouraged the Navy to convert the Convair R3Y-2 Tradewinds turboprop flying boat with two Sargent-Fletcher hose reel units underneath each wing.[54] The Tradewind demonstrated that it could refuel four aircraft, concurrently, but it never went into squadron service.

After 1953, when the AJ-2 replaced the AJ-1, the earlier airplanes were outfitted as the first Navy tankers. Later, the Douglas A3D Skywarrior replaced the AJ-2. Its 900 nm combat radius could be stretched to 1,400 nm with refuelings from AJ-1 or AJ-2 tankers. Ultimately, the Navy developed the D-704 "buddy" refueling unit. This was an external 300-gal (1,980 lb) tank with a hose reel, built-in pump and power from a ram air generator. Finally, the D-704 was mounted on the Douglas A4D Skyhawk fighters. A pair of Skyhawk tankers could double the range of an A4D strike aircraft to 950 nm.[55] After 1963, when the C-132 could have been well into service, the Navy's best tanker was a modified A3D that could carry an offload of 21,775 pounds. These were used until 1969, including service in the Vietnam War. After they were retired, Navy aerial refueling capabilities diminished greatly. The Navy finally came to rely upon KC-135 USAF tankers, though the C-132 would have been an excellent tanker had USAF bought the plane.

What Might Have Been with the C-132

The C-132 project began in 1951 and progressed as far as a full-scale mockup, less the right wing and horizontal tail. Its first flight was projected for July 1959. Had the Air Force continued to fund the program rather than canceling it in March 1957, the first C-132s might have entered service in 1960 or 1961 and could very likely have served through the Vietnam War and into the 1970s and beyond.

Had there been sufficient funds, there might have been two tanker worlds, the KC-135 jet tankers serving SAC and turboprop-powered C-132s refueling TAC fighters and light bombers. There would also have been issues between TAC and Military Air Transport Service (MATS) about logistics transport. Technical issues were also present, with such a huge airplane and its powerful engines and very large propellers.

Political and Doctrinal Issues

By the early 1950s, the major arguments about airlift and its role had been largely resolved. Concurrent with the National Security Act of 1947, which created the Department of Defense and the United States Air Force, President Harry S. Truman issued an executive order prescribing the function of the services. The Air Force was made responsible for airlift and support of airborne operations and for air transport of the armed forces (with some exceptions for the Navy). The Military Air Transport Service (MATS) was established on June 1, 1948, incorporating Air Force non-tactical airlift and all but the non-scheduled portion of Navy airlift functions. Only three weeks later, what became the Berlin Airlift put the airlift world to a grueling and ultimately successful 14-month test.[56]

Within the Air Force, however, there were continued tensions about how to manage airlift, which were exacerbated by the demands of the Korean War. Though the Air Force was the executive agency for airlift, both SAC and TAC maintained squadrons of C-124s for their own organic airlift purposes. These included deployment support for both commands and troop and TAC equipment and troop drops. In addition, both commands added tanker aircraft as the procedure became more and more necessary. AMC had three logistics support squadrons of C-124s. Because of SAC's reliance upon the flying boom for its refueling, most likely only TAC would have bought C-132 tankers. Such a purchase would have represented somewhat of a technical regression over buying jet-powered tankers but would have given TAC organic logistic airlift much improved over the C-124 while greatly improving refueling capabilities.

Adding these huge airplanes to the TAC fleet would probably have presented challenges to airfield facilities of the time. Though the C-132 refuelers would probably have had only a few home bases, they would frequently have had to operate from other tactical fighter airfields with limited ramp space and relatively narrow runways and taxiways. Over time, these deficiencies would have been remedied to make the airfields more congenial to C-132 operations. Maintenance equipment, supplies and cargo handling capabilities would also have needed much reinforcement.

Purchase of C-132 tankers and logistic transports would have created some degree of airlift competition between MATS and TAC. Such competition already existed in the early 1950s. Both TAC and SAC had many squadrons of C-124 heavy transports, which were seen as essential to the missions of both commands. Ultimately, all were assigned to MATS in 1957, which command used them to carry out its assigned mission as the primary Department of Defense airlift agency.

In any case, purchase of the C-132 probably would not have eliminated the Air Force's desire for jet tankers and transports. General LeMay in 1948 began the push toward turbojet aerial refuelers to support SAC B-47s and B-52s. In 1954, the Air Force announced its requirement for a jet tanker and Boeing had flown what became the KC-135. They were equipped with the flying boom, so were not useful to all but a few tactical aircraft. For MATS, the airliner version of the C-135 soon fulfilled the command's requirement for a jet-powered personnel airlifter.

Tanker Inventory

The Air Force would eventually buy 732 KC-135 tankers, delivered between 1956 and 1965. Except for 17 B-models, all were KC-135A. In later years, various upgrades resulted in new designations for the airplane. Initially equipped with the flying boom, many KC-135s were later equipped with the capability to deliver fuel via either the boom or the probe and drogue method.

The only other jet tanker purchased by the USAF was the Douglas KC-10, a modification of the McDonnell-Douglas DC-10 airliner. The decision on the KC-10 was announced in December 1977 and 60 were built. The first airplane flew on July 12, 1980, and entered SAC service in March 1981. The KC-10 is equipped to take fuel via the flying boom and to deliver fuel by both its McDonnell-Douglas-designed boom and probe and drogue. It can takeoff with 365,000 pounds of fuel, all of which is theoretically available for offload.

Besides the big jet tankers, the U.S. military developed tanker capability with suitably modified C-130s, which is not covered here.

Technical Concerns

The C-132, along with the Douglas C-133 Cargomaster, represented the maximum development of turboprop propulsion, at the time. The airplane was even larger than the C-133, approaching the Convair B-36 in dimensions and far surpassing it in weight. Comparative figures are shown in Table 1. The C-132 statistics are for the aerial refueler version.

Projected fuel offload of the initial version of the C-132 tanker was 110,000 lbs at 20,000 feet refueling altitude and 410 knots. With 10 years of experience and further development, Douglas Aircraft Co. projected an increase in fuel offload to as much as 168,000 pounds at 20,000 feet and some 425 knots.[57] These speeds and offload capabilities would have made the C-132 very compatible with jet fighter and light bomber operations. With appropriate adjustments in the amount of offload fuel, substantial cargo could have been transported on the refueler facilitating overseas unit deployments.

As with the C-133, the C-132 presented challenges in cargo handling. With such large airplanes, it was necessary to incorporate total cargo management as part of the system. This

Type	Span	Length	Height	GWt
C-132	186'8"	183' 9.9"	57' 11"	469,225 lb
B-36J	230'0"	162'1"	46'8"	410,000 lb
C-133B	179'8"	157'6"	48'9'	300,000 lb

TABLE 1

process extended far beyond the airplane, prior to loading and after offload. Documentation of cargo, processing facilities, loading equipment and specialized procedures were necessary. Not only the Air Force but any customers had to have common instructions and procedures for cargo management.

Specialized maintenance equipment and procedures would have been needed for the very large C-132. Some precedents were in place with the B-36 and the C-124. Maintenance on the T-57 turboprop engines would have been somewhat less demanding than on the complicated R-4360 reciprocating engines powering both the latter aircraft. The 20 ft.-diameter propellers might have given somewhat the same problems as those on the C-133. At 900 rpm, the tip speed at sea level would have been Mach 0.92, significantly less than the C-133's Mach 0.97. If the airplane were constructed at an appropriate level of robustness, vibration due to tip vortices would have been less than the damaging levels experienced with the C-133. Lessons learned on the C-133 propellers could have been productively applied to the C-132, again reducing or eliminating the problems that the smaller airplane had.

The Wrap-up

Budgetary considerations and the desire for jet transports were the realities that led to the termination of the C-132 project. Yet, the prospect of its use as an aerial refueler showed important changes in the Air Force outlook. Had the airplane been bought and built, it would have been a very different air force and the KC-132 would have been a massive culmination of the development of aerial refueling since the very first attempts in 1916. By the year 2011, tankers had been long proven to be absolutely essential to military air operations. Without aerial refueling, the United States simply could not have provided an aerial presence in far-flung theaters of operation, where sometimes hundreds of sorties per day were flown by aircraft of the USAF, USN and foreign air forces.

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