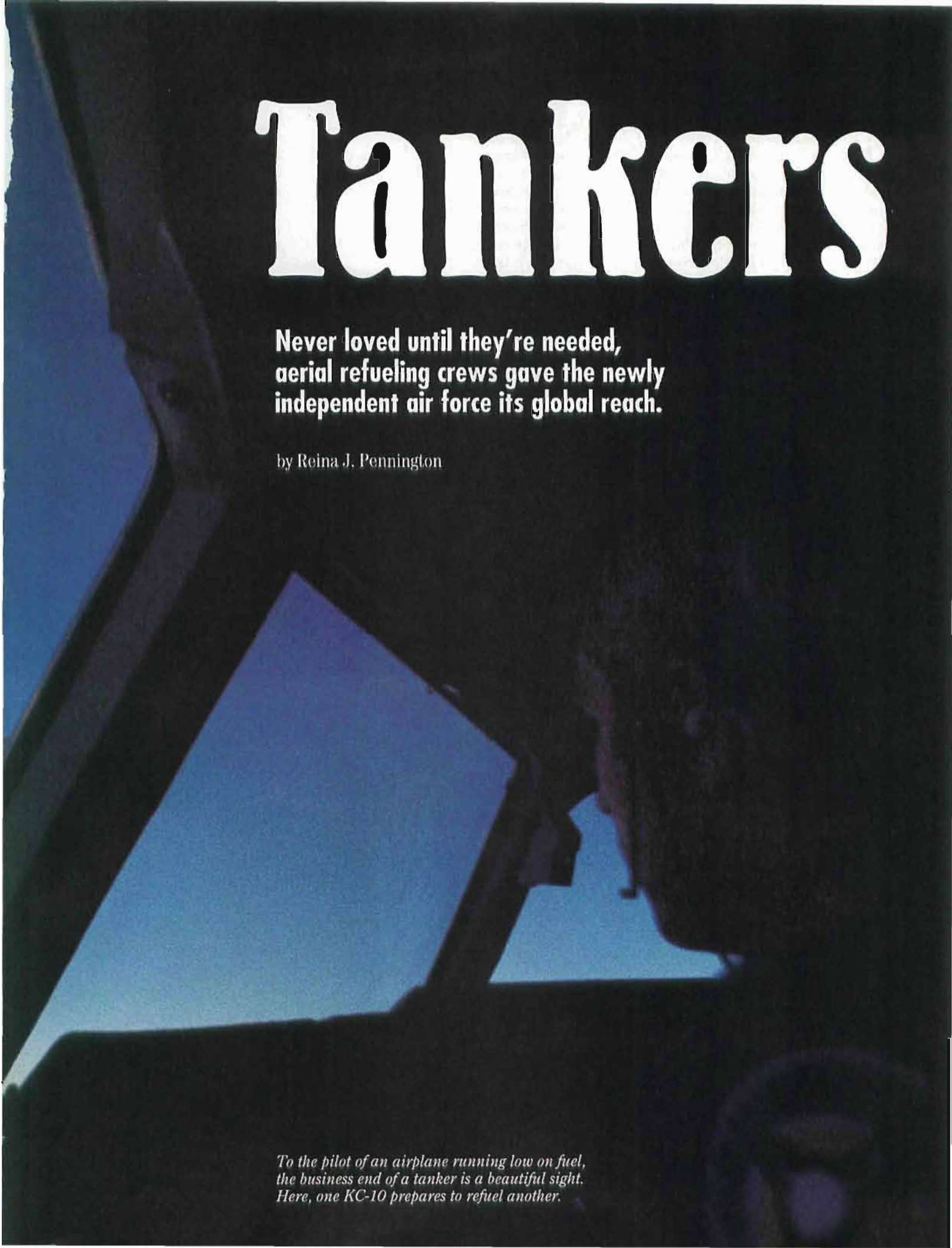
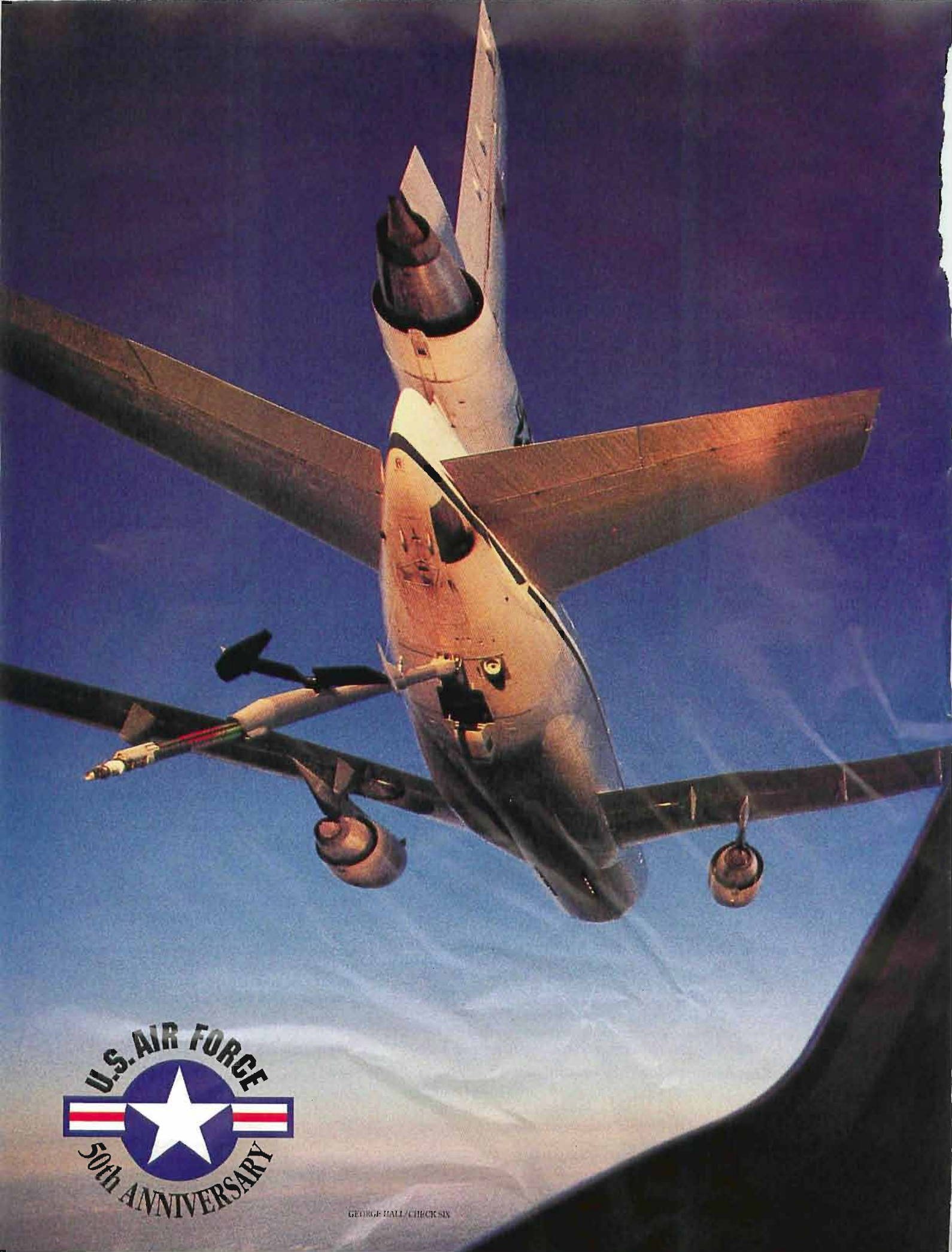
Tankers

Never loved until they're needed, aerial refueling crews gave the newly independent air force its global reach.

by Reina J. Pennington



To the pilot of an airplane running low on fuel, the business end of a tanker is a beautiful sight. Here, one KC-10 prepares to refuel another.



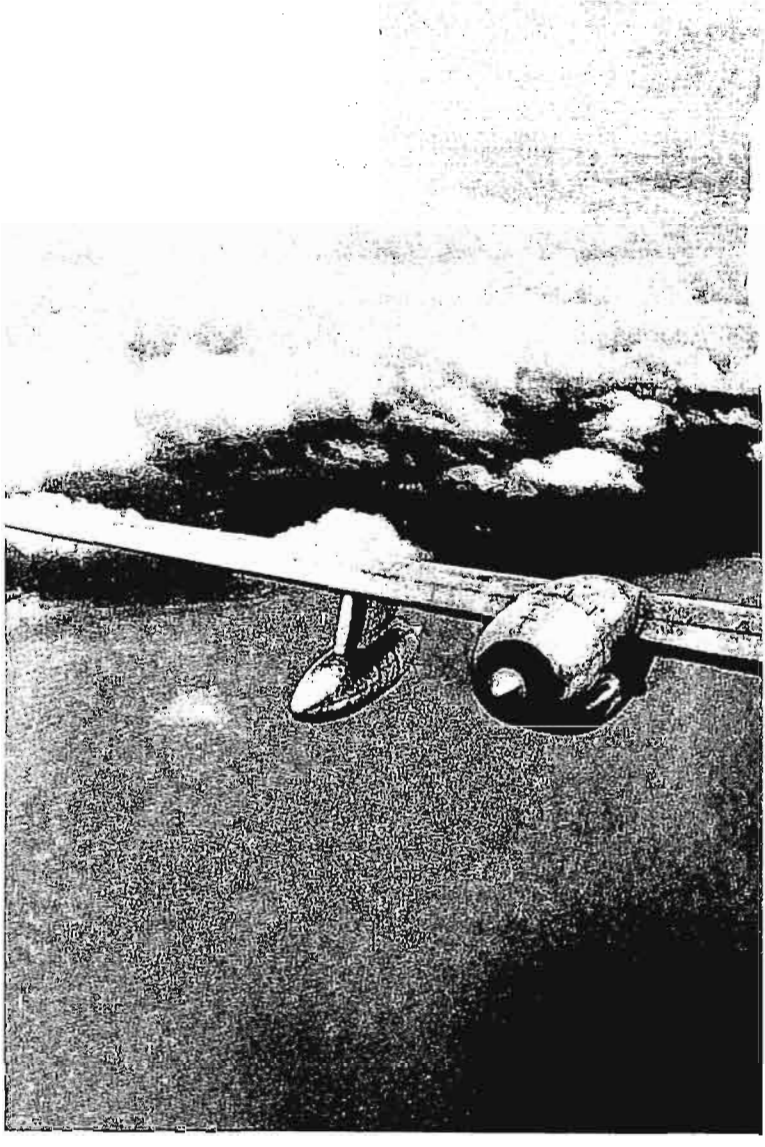
GEORGE HALL/CHECKSIX

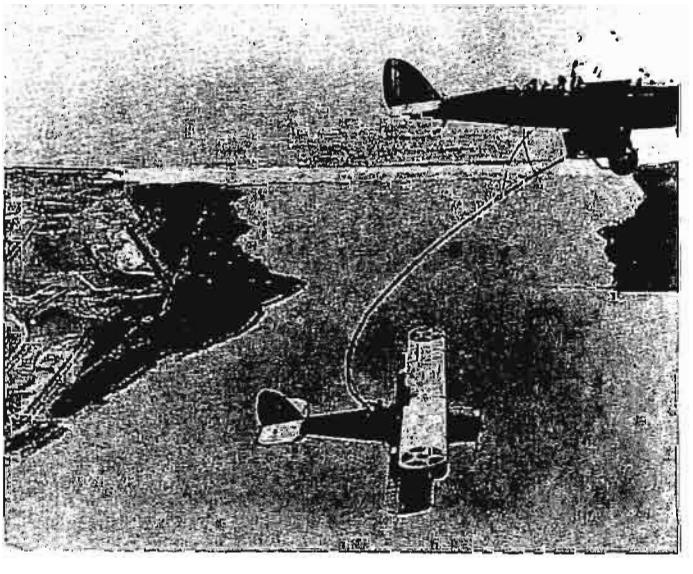
The first attempts to refuel while airborne occurred between 1918 and 1921, when U.S. Navy pilots used grappling hooks to snag five-gallon cans of gasoline from floats on the Potomac River. It was thought that snatching fuel from ships would enable aircraft to make ocean crossings. In 1921, the first transfer of gas between two airborne aircraft was accomplished when a wingwalker simply carried a container of fuel from one aircraft to the other. But techniques improved rapidly, and in 1923, Henry H. "Hap" Arnold—then a major in the U.S. Army Air Service—directed the first in-flight hose contact between aircraft.

The watershed for military aerial refueling was January 1929, when an airplane dubbed *Question Mark* stayed airborne for nearly a week. Using a crude hand-held hose to transfer gas, it made 43 contacts with two tankers and set an endurance record of 150 hours, 40 minutes.

The five-man crew of *Question Mark*, all members of the Army Air Corps, received the Distinguished Flying Cross. Several went on to renown: The commander, Major Carl A. Spaatz, became the first chief of staff of the independent Air Force in 1947, and Captain Ira C. Eaker, after commanding the Eighth and Mediterranean Allied Air Forces during World War II, became CEO of Hughes Aircraft. The crews of the tanker aircraft that refueled *Question Mark*, on the other hand, received letters of commendation rather than the DFC. This set an enduring precedent: Although tanker support was absolutely essential to the success of flights like those of *Question Mark*, it would usually be regarded as a less glamorous and somehow less deserving role. And yet the modern Air Force couldn't exist without it.

Hap Arnold articulated a "global mission" for the Air Force even before it was a separate service. He described a force "designed, equipped, and trained to operate beyond the sphere of influence of either armies or navies" in *This Flying Game*, a book he co-authored with Eaker in 1936, shortly before he was named Chief of the U.S. Army Air Corps. Although this vision pre-dated the use of aerial refueling in the Air Force, aerial fueling helped make it possible. "The thinking was always global," says Colonel Phillip S. Meilinger,



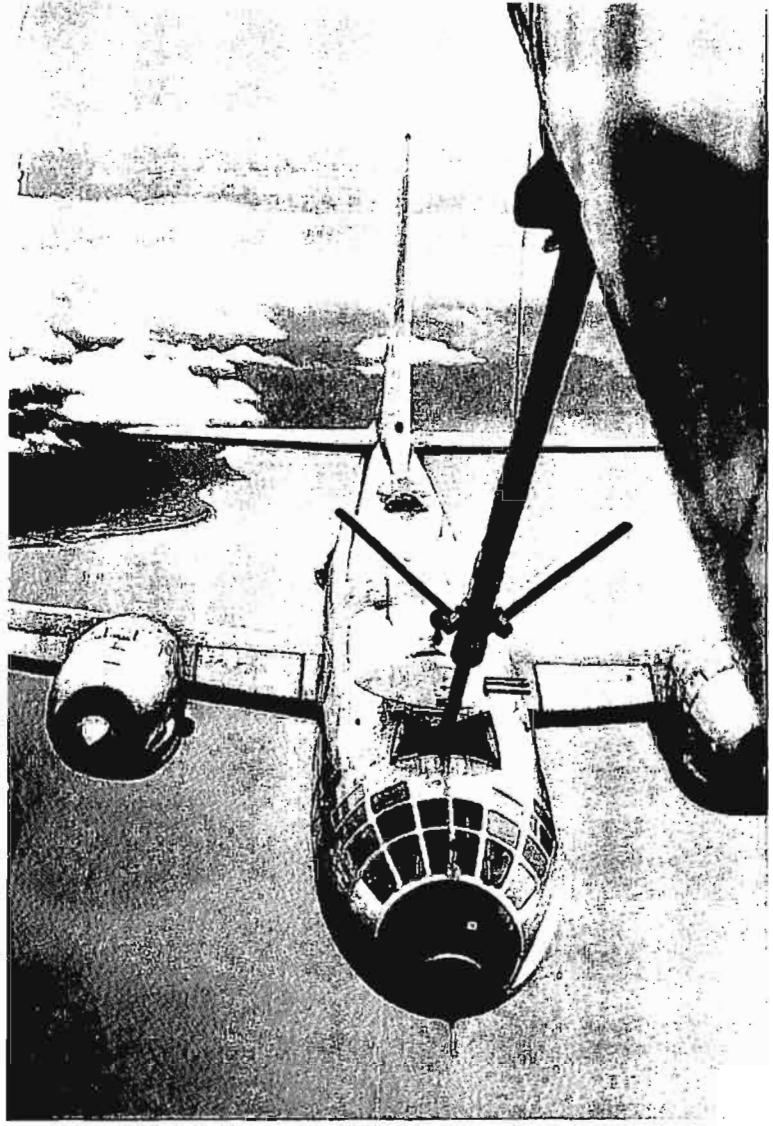


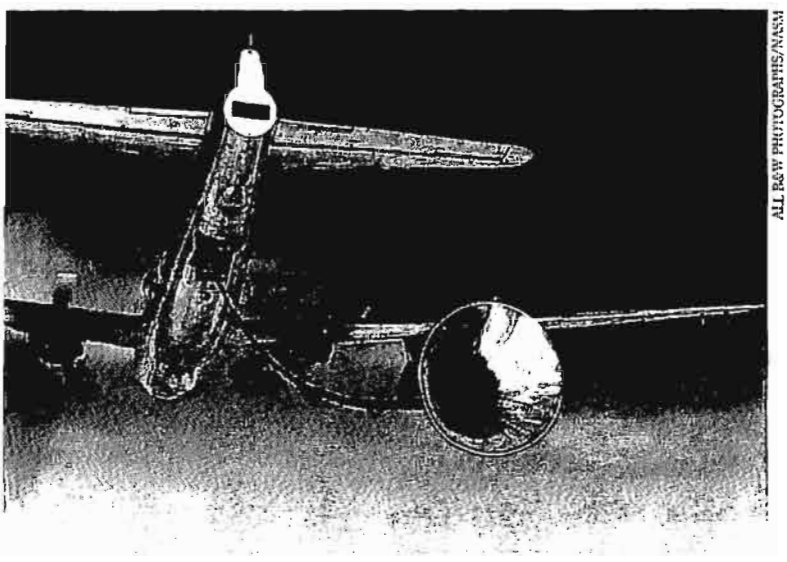
The U.S. military saw the potential of aerial refueling soon after it saw the potential of the airplane. The first in-flight experiment, which relied on one aircraft snagging a hose that dangled from another, was accomplished in 1923 by two U.S. Army Air Service de Havilland DH-4s (right). But the flying services didn't seriously pursue the idea until after World War II. In the early 1950s, the Strategic Air Command hosted a test of two refueling methods: the British-developed probe-and-drogue (far right) and the Boeing-developed flying boom (being used to refuel a B-50, top). SAC chose the latter.

REFUELING CHRONOLOGY

1923
Two U.S. Army Air Service DH-4s conduct first successful air refueling; first aerial refueling-related fatality.

1929
Flight of *Question Mark*.





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a historian and former commander of the School of Advanced Airpower Studies at Maxwell Air Force Base. "Refueling made it easier and cheaper." (An essay by Meilinger appears on p. 46.)

Following the end of the cold war, the roles of the Air Force have shifted from the strategic to the conventional, from apocalyptic nuclear war scenarios to a U.S.-based quick-response military, but aerial refueling continues to be the cornerstone of this new global engagement philosophy. "Even today, aerial refueling provides the capability to provide global effects, lethal and non-lethal, in a matter of hours," says Major Dik Daso, current Chief of the Air Force Doctrine Branch at the Pentagon. "Technology has not advanced to the point where limitless fuel supplies, something like cold fusion nuclear reactors, are available. Until this advance occurs, there will always be a need for in-flight refueling."

Air Force strategists consider the refueling tanker a "force multiplier" because it expands the power and reach of combat aircraft, just as if the service had more of those aircraft. The availability of a tanker allows combat aircraft to trade fuel for weapons: An aircraft can take off with minimum gas and maximum munitions, then top off its fuel in the air. Furthermore, the aircraft can stay in the air to the limits of pilot endurance.

Refueling is strictly a support function; tanker crews don't use weapons or risk death in combat. Yet they do make it possible for others to deliver weapons in greater quantities and at greater ranges, and they do on occasion save lives. Moreover, duty on a flying gas station is not without risk. Although tankers normally operate in protected airspace, they still must rendezvous with other aircraft at high speeds, sometimes at night or in bad weather and sometimes under conditions of radio silence. Tanker crews who venture into hostile airspace need courage: Their aircraft have no warning systems, no self-defense systems, and little ability to evade a threat. A tanker is essentially a 300,000-pound gas can—one flak hit could be lethal. A collision with a receiving aircraft could have incendiary consequences.

To be sure, not everyone takes tankers for granted. Certainly not the 13 airmen who were spared a dangerous and possibly fatal swim in the Atlantic in March 1986.

It started as a typical "fighter drag." Two brand-new KC-10 tankers from the 68th Air Refueling Group at Seymour Johnson Air Force Base in North Carolina were using their sophisticated navigational equipment to lead nine Marine A-4 Skyhawk attack aircraft in formation across the Atlantic, providing in-flight refueling as required. The pilot of one of the tankers, Lieutenant Colonel Marc C. Felman, had 2,500 hours in the KC-135, the tanker that for four decades has formed the backbone of Air Force refueling operations, but only six

1934
Flight Refueling, Ltd. founded in Great Britain.

1948
First KB-29M tankers developed; first two aerial refueling units in Air Force established (equipped with KB-29M hose-method tankers).

1949
Lucky Lady II completes the first nonstop around-the-world flight.

Fill 'er Up

Looped Hose

The first aerial refueling technique to be used regularly, the looped-hose method was developed in Great Britain by R.L.R. Atcherly in the 1930s. The tanker stationed itself below and to the side of the receiver aircraft, which trailed a 300-foot line with a pronged grapnel behind it. The tanker then fired a 100-foot weighted line—the contact line—with an attached hose so that it would arc in front of the receiver's line. The receiver reeled in the lines, removed the grapnel, and placed the hose into the receiving tank. The tanker then climbed until it was above the receiver and the fuel was transferred through gravity flow, flowing from the tanker down to the receiving aircraft. In use until the 1950s, this method required relatively low altitudes (below 10,000 feet) and slow airspeeds.

Probe-and-Drogue

In this system, the tanker reels out a hose which ends in a "drogue": a funnel-like basket. The receiving aircraft maneuvers into position to insert its fixed probe into the drogue. Advantages include the minimal equipment required: External pods with drogue reels can be mounted on many types of aircraft. Large tankers can carry several drogue refueling systems and thus refuel several aircraft simultaneously. One disadvantage is that the primary responsibility for making a hookup falls on the receiver pilots. A nervous receiver—such as one flying a damaged aircraft or in bad weather—can have trouble making a connection. The probe-and-drogue system was used on the KB-29M and TAC KB-50J and is used on some C-130s and on Navy, Marine, and all helicopter refueling platforms.

Flying Boom

Developed by Boeing Aircraft in 1948, the flying boom was put into military production the following year on the KB-29P tanker. The boom operator works from a station in the rear of the aircraft and controls the boom by manipulating its ruddervators—the little set of "wings" on the boom that act as both rudder and elevator. Receiver aircraft take an initial position about 10 feet behind and 25 below the tanker. The boom operator then maneuvers the boom into a socket in the receiver's refueling receptacle. When the tanks are full, the boom automatically breaks away. This method is the most reliable, has a higher fuel-transfer rate, and requires less skill on the part of receiver pilots. Flying booms were used on the KB-29P and KC-97 and are used on the KC-135 and KC-10 tankers.

missions in the KC-10. (The first wide-body tanker in military service, the McDonnell Douglas KC-10 is descended from the freighter version of the DC-10.)

Felman and three A-4s took off about 45 minutes ahead of the second KC-10 and the remaining six Skyhawks, headed for an island in the Azores, an archipelago near Portugal. The weather was supposed to be excellent all the way, but as Felman approached the island, fog and rain suddenly developed and visibility dropped to practically zero. The aircraft were instructed to divert to another island, 150 miles away, and finally landed there after three attempts in deteriorating weather. Three of the other six A-4s soon followed. But one of them sheared off part of its gear on lights at the end of the runway, strewing debris, closing the runway—and leaving the remaining KC-10 and three A-4s stuck in the air.

Felman and his crew immediately began loading their tanker with gas. For a while, radio contact was out and no one knew what was happening with the stranded aircraft. When Felman finally got the other KC-10 pilot on the radio, "He didn't want to talk to us, and that's understandable," he recalls. "Later I found out they were preparing to ditch. They had their life preservers on and they were running through the ditching checklist 'cause they were on fumes....It was getting kind of emotional for them."

Felman realized he had to get into the air immediately if there was to be any chance of saving the tanker and the remaining fighters. The fog was so bad that the tower could not see the runway, so the tanker's two crew chiefs stayed on the ground and marshalled the aircraft past the debris and out to a takeoff point. "We threw them their suitcases," Felman says; "I wish we'd remembered to throw them the gas credit card for the airplane so they could have paid for the gas. As it was, we technically stole $80,000 worth of gas from the country of Portugal. But there was no time to say 'How much do I owe you?' " (The bill was paid the following day.)

Within minutes, Felman flew up above the low cloud cover, met the other KC-10, hooked up, and began refueling at an altitude of only 4,000 feet—lower than *anyone had* refueled before—climbing all the way. He credits his boom operator, Master Sergeant Patrick S. Kennedy, for accomplishing the hookup under harrowing conditions. In 10 more minutes the words "below sea level" would have had a whole new meaning for a $76 million KC-10, three $2 million attack aircraft, and 13 people. After gas was transferred to the other tanker, the KC-10s cycled the A-4s through until everyone received enough fuel to land at an air station in Spain.

1950
First delivery of KB-29P flying boom tanker; first aerial refueling of a jet aircraft (KB-29P to RB-45C).

1951
First KC-97 flying boom tankers delivered; first use of aerial refueling in combat (July 6, 1951, Korean war).

1952
First nonstop transpacific flight (RB-45C refueled twice by KB-29Ps); first transoceanic deployment of fighters (F-84s refueled by KB-29s).

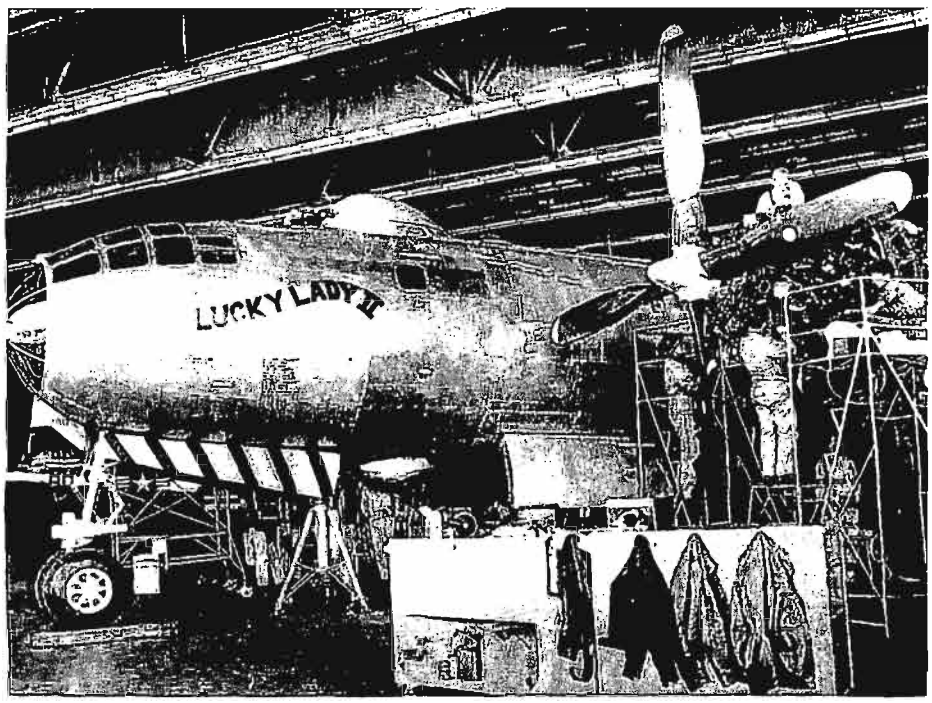
Few dreamed of such feats in the infancy of refueling. Although Spaatz and Eaker had demonstrated the military potential of aerial refueling, nearly two decades would pass before it became an operational reality. Commercial interest in aerial refueling increased during the 1930s, but military involvement waned. The demands of the second world war on both military and civil aviation left little room for continued experiments. Although the Army Air Forces studied several proposals for using aerial refueling in the Pacific, where air operations were severely constrained by the great distances between bases, none was implemented.

In the postwar United States, organizational changes and force drawdowns took center stage for a time. For most aviators, the first order of business was to get independent service status for the Air Force. Many key leaders, including Presidents Eisenhower and Truman, supported the concept. But the use of aircraft to deliver nuclear weapons had reinforced the preeminent role of air power, and the Strategic Air Command was created in 1946—a year before the U.S. Air Force gained its independence. In fact, SAC's long-range bomber capability was the bedrock on which Air Force independence was firmly established. Long range in the mid-1940s, however, meant only as far as a B-29 or B-50 could go, and they were unable to fly from the U.S. to the Soviet Union and back. Overseas bases would be required for any sort of sustained operations, and the United States had learned the hard way in World War II that negotiating the use of bases in foreign lands, even those of close allies, was risky. After strikes in Japan and Central Europe, bombers had been forced to land in China and Russia, and often U.S. officials had to fight to get them back—sometimes without success. Even in friendly situations, bases on foreign soil presented all sorts of potential problems with security and logistics.

Within weeks after the establishment of the independent Air Force, the Heavy Bombardment Committee, an Air Force advisory board, recommended that development of aerial refueling be the service's top priority. As the best candidates for tanker conversion, the committee chose the B-29 and B-36 strategic bombers.

The question of what refueling system to use took a little longer (see "Fill 'er Up," previous page). In 1948, the Air Force bought 35 hose-type refueling sets and reproduction rights from a British firm, Flight Refueling, Ltd., and contracted with Boeing to adapt the sets to the B-29. The use of B-29s as tankers and receivers meant that the U.S. now had the ability to operate against targets in the Soviet Union from bases in Iceland and Alaska—a potent strategic capability.

Early in 1949, the Air Force dramatically demonstrated its expanded capabilities to the world. In February, a B-50A, *Lucky Lady II*, made the first nonstop around-the-world flight. (The first *Lucky Lady*, a B-29, had flown around the world the previous year but had to land to refuel.) In 94 hours and



A stripdown inspection awaited Lucky Lady II *following the B-50's nonstop 23,452-mile flight in 1949, while Generals Hoyt Vandenberg and Curtis LeMay congratulated its pilot, Captain James Gallagher (above, far right).*

1953
First nonstop transatlantic deployment of fighters; first KC-97G delivered.

1956
Flight of first KC-135; last of 888 KC-97 tankers delivered.

1957
First KC-135 delivered; last KB-29 unit in the Strategic Air Command deactivated; *Lucky Lady III* completes the first B-52 nonstop around-the-world flight.

The Navy Experience

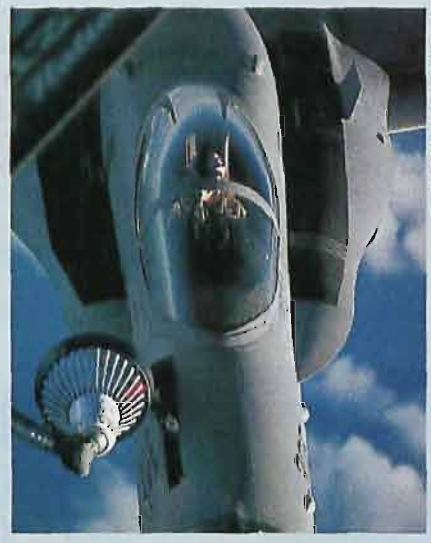
Shortly after joining the Navy's VX-3 air development squadron as a project pilot in 1954, I set out to start a program to evaluate the tactical effectiveness of in-flight refueling. The Navy had conducted some tests at its air station at Patuxent River, Maryland, a couple of years earlier but hadn't done much with it since then. I was convinced that in-flight refueling merited closer attention because jet airplanes were notoriously "short-legged" and we needed greater range and endurance at sea.

Only a month after I made my proposal to the Commander Operational Test and Evaluation Force, based in Norfolk, Virginia, the project was given the go-ahead. An AJ-1 tanker was assigned to us for the evaluation, and probes were installed on our fighters. The in-flight refueling packages we were given, however, were the ones left over from the original Patuxent tests. The hoses were brittle and the basket-like fuel drogues the tanker towed behind it were rickety and beat up. Using them was discouraging at times, but as our testing proceeded, it became clear to me that in-flight refueling was going to be not only tactically useful to the Navy, but absolutely necessary.

In late May, I and three others flew to the Vought plant in Dallas to pick up four of the early models of the F7U-3 Cutlass to be used in our tests. (We also used four F9F-7/8 Grumman Cougars.) We returned with those airplanes to VX-3's home in Atlantic City, New Jersey, and modified them for in-flight refueling.

Early in the program, our squadron commander, Hawley "Monk" Russell, took one of the Cutlasses on an air-refueling evaluation flight. Monk had earned a name for himself in carrier aviation during World War II flying early night fighters and had a wealth of aviation experience. He had not flown an air-refueling flight previously, however, so I gave him a procedures briefing.

At 20,000 feet, Monk rendezvoused with the tanker. As he slid his F7U-3 behind the tanker to receive fuel, the tanker pilot dutifully streamed the drogue. Monk was intent on positioning the 24-inch-long refueling probe extending from his aircraft's nose so as to plug into the drogue basket on his first attempt. We found the best method was simply to line up a few feet behind the drogue and just drive the probe into it. This took concentration and coordination. But Monk was concentrating so hard that he failed to see that the old, brittle fuel hose had parted just forward of the drogue and that the drogue was now hanging by only a thin hose-support wire. Focusing fiercely on the basket, Monk plugged in—and then looked in wonder at that small wire. He told me later that his first thought was *How in the hell am I going to get fuel through something as small as that?* In fact, if any fuel had been released, Monk would have had a full bath of it, and one or both engines probably would have caught fire.



TED CARLSON/FOTODYNAMICS

A Navy F/A-18 Hornet cozies up to a tanker's drogue.

He quickly realized that all was not right and backed away from the tanker. As he did, the wire broke and he flew off with the big basket of the drogue firmly planted on the Cutlass' probe. Near where the drogue was stuck, on the left side of the nose, the F7U-3 had an angle-of-attack sensing vane that provided attitude information to the flight control system. Unbeknownst to Monk, the drogue was disrupting airflow to the vane and causing it to feed erroneous information to the controls. In the process of evaluating the flying qualities of his "modified" F7U-3, Monk slowed up the airplane to test it, fortunately at altitude. As he did, the aircraft unexpectedly performed a quick snap roll and scared Monk nearly to death. A voluble man, he let go with a string of invectives that would have curled the hair of any sailor and greatly enlivened the VHF communications channel he was using. By the time he got back to Atlantic City to land, Monk had us all up in the tower to watch. It was a tribute to his flying ability that he got the airplane on the ground.

In flight testing at least half of what you learn is what *not* to do. With that flight, we learned not to fly without first checking the hoses. And we learned the importance of not disrupting the airflow to that vane. But the series of test flights also taught us, ultimately, that jet airplanes could be kept at sea, and that lesson led to the Navy's decision in 1956 that all future fighter aircraft have in-flight refueling capability.

—Donald D. Engen

(Adapted from *Wings and Warriors: My Life as a Naval Aviator*, Smithsonian Institution Press, 1997. Printed with permission.)

1 minute, *Lucky Lady II*, one of 57 B-50As converted to receive fuel through the looped-hose method, flew 23,452 miles and was refueled four times in flight by KB-29M tankers. Its crew (but not the tanker crews) was awarded the Mackay Trophy by the National Aeronautic Association for outstanding flight of the year.

While these flights demonstrated the potential of aerial refueling, substantial challenges in operations remained. Lim-

1961
SAC reaches highest number of assigned tankers in its history (1,095); first Air National Guard refueling wing established.

1964
First aerial refueling in Vietnam war.

1965
Last of 732 KC-135s delivered; last KC-97s retired from duty.

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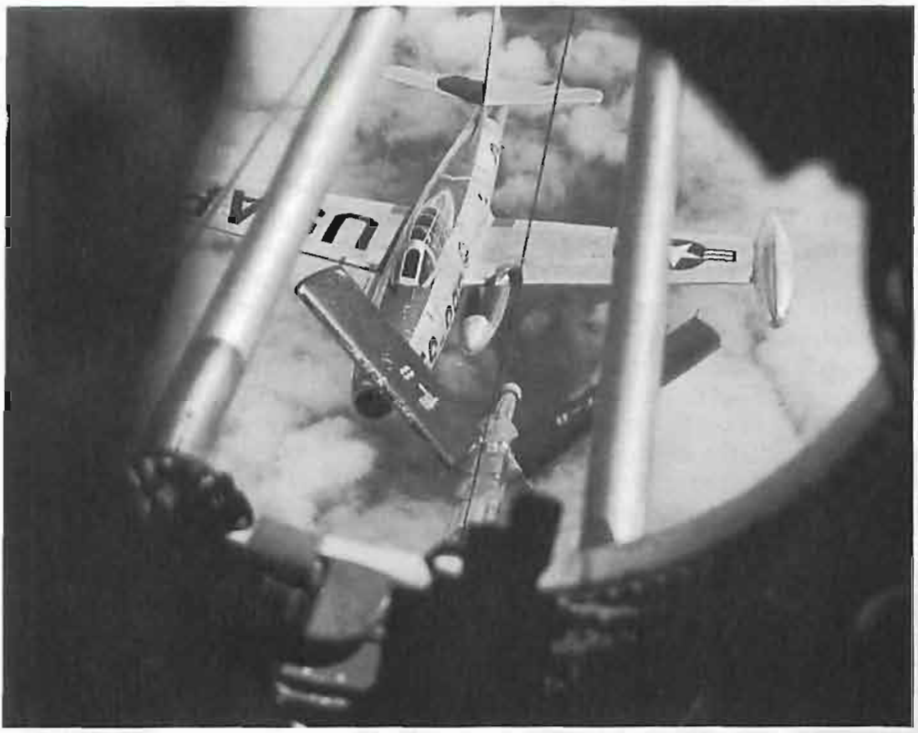

"Longer legs for the 600-mile-an-hour Boeing B-47 Stratojet bomber," proclaims the caption issued with a 1951 Air Force publicity photo of the bomber being refueled by a KC-97 (top left). The long legs increasingly benefitted conventional operations. In 1952, refueling permitted the first transoceanic deployment of fighters—58 F-84s, refueled by KB-29s, flying from Georgia to Japan (left). In Vietnam, SAC tankers performed more than 850,000 refuelings, mostly of fighters (such as the F-4 refueling from a KC-135 in the picture above).

itations in communications, radar, and navigation, for example, made it difficult to get the tanker and receiver to the same place at the same time. In the late 1940s, there were no satellites and few navigation aids or radar sites outside the United States. Aircraft had to rely on fairly primitive on-board communications and on electronics systems with limited range and poor reliability. Pilots could rendezvous by using predetermined times and coordinates, but for a receiver to find a tanker over the Arctic Ocean or the Canadian wilderness was almost like looking for a needle in a haystack.

In 1949, Flight Refueling, Ltd. successfully tested a new system of refueling known as probe-and-drogue. But a technique being developed by Boeing Aircraft, the "flying boom," had already caught the interest of the Air Force. That same year, it ordered that 40 B-29s be converted to flying-boom tankers and be redesignated as KB-29Ps.

About three years later, SAC tested the two methods face to face and chose the flying boom as the best all-around solution. It offered several advantages over the probe-and-drogue. In particular, it could transfer fuel under pressure and therefore at a higher rate, which SAC considered essential for refueling bombers. By 1958, Air Force headquarters had accepted the SAC standard; thereafter, with very few exceptions, all fixed-wing receiver aircraft would be built with boom receptacles rather than probes.

Aerial refueling was first tested in combat in 1951, during the Korean war, when KB-29Ms refueled reconnaissance aircraft and fighters. One year later, it enabled the first mass

1966
56 KC-135As converted to KC-135Qs to handle special fuel for SR-71s.

1968
First tanker casualty in Vietnam war (crash of KC-135 on emergency landing at Wake Island).

1973
Last tankers used in support of combat operations in Southeast Asia.

deployment of U.S. fighters across the Pacific, in combination with island hopping. Previously, deploying a fighter wing overseas meant dismantling the aircraft, loading them onto naval transports, sending them to their destinations, then reassembling them—a nearly three-week process. 1953 brought the first *nonstop* transatlantic deployment of fighters. Two groups of F-84s were deployed from the United States to French Morocco and the United Kingdom. Both groups completed the trip and were ready to fly in less than 12 hours.

Despite the increasing use of tankers in conventional operations, SAC regarded the possibility of a Soviet nuclear first strike as the most serious threat. The first priority for tankers, therefore, was to enable strategic bombers to deter such a strike. As SAC gradually increased the number of bombers on alert status, the number of tankers also increased. By the mid-1950s, the capability of Soviet intercontinental ballistic missiles spurred SAC to set the goal of keeping one-third of its bombers and tankers on ground alert at all times. To shorten response times, entire bomb wings and their supporting refueling squadrons were dispersed and deployed to forward bases, limiting the availability of tankers for nonstrategic missions. Those limits held until the war in Vietnam, when aerial refueling finally became commonplace in conventional operations.

In the meantime, SAC had sponsored another nonstop around-the-world flight. This time a B-52, *Lucky Lady III*, made the trip supported by KC-97 tankers. SAC commander General Curtis LeMay noted the military significance of this feat, saying it demonstrated "SAC's capabilities to strike any target on the face of the earth." But the jet-powered B-52s had actually been slowed down by the piston-engine tankers. Rapid improvements in jet *combat* aircraft required an improved tanker, and thus the venerable KC-135, predecessor of the Boeing 707 airliner, was born.

One of the great airplanes in Air Force history, the KC-135 has been the mainstay of the Air Force's refueling operations for 40 years. It proved itself time and again—and not just as a flying gas station. In 1957, LeMay flew a KC-135 from Massachusetts to Buenos Aires—a distance of 6,322 miles—in 13 hours, 2 minutes, and 51 seconds, setting a new world record for a nonstop unrefueled flight. In 1958, SAC KC-135s set a world weight-lifting record, a new speed record for New York to London and back, and several other world records for closed-circuit flights. The 135, under the right conditions, could strut its stuff.

By the time the United States entered the war in Vietnam, LeMay had gotten SAC designated the sole manager for KC-135 refueling operations. For the first time in its history, the command was involved in conventional operations on a large scale. Further, because SAC was able to use the weight it carried in the Air Force to claim priority—ahead of other commands, such as Tactical Air Command and Military Airlift Command—to those airmen who had served combat tours, more and more pilots with tactical experience filled its ranks. Quite a few pilots and navigators who'd started out flying light aircraft in Vietnam found themselves back in the theater on tanker crews.

One such pilot, John Wiley, recalls, "I was banished to SAC along with a bunch of F-100 drivers and assorted other miscreants, and no one was exactly happy to be in SAC." Flying a tanker was regarded as a great comedown from fighters; "tanker toad" was one of the more polite names Wiley was called. "Odd we never heard any wiseass remarks when some F-4 driver was sucking fumes and just praying for some tanker puke to disregard the SAC regs and come a little bit farther north!" he says.

In Vietnam refueling frequently became a matter of life and death. One extraordinary save occurred on May 31, 1967, when Major John H. Casteel and his KC-135 crew adroitly handled a complex emergency. While conducting a routine refueling of two F-104s, the tanker was alerted that two Navy A-3 "Whale" tankers, dangerously low on fuel, were en route. The 135 was topping off the second of the A-3s when two Navy F-8 fighters arrived, almost out of gas. The first A-3 refueled one of the F-8s, while the other fighter, unable to wait for the second A-3 to break away from the KC-135, hooked up to it in a "three-deep" refueling: The KC-135 continued to

A nighttime refueling etches the darkness with the movements of an F/A-18 beneath a KC-135's boom. Although carried out routinely, refuelings at night, in turbulence, in bad weather, and under the constant threat of collision require skillful flying and steady nerves.

TED CARLSON/FOTODYNAMICS

1975
First in-flight refueling of a B-1A bomber; first of 128 KC-135s transferred to Air Force Reserve/Air National Guard units.

1976
Air Force issues requirement for advanced tanker/cargo aircraft based on existing wide-body commercial freighter. Considers 747, then chooses DC-10 (becomes KC-10).

1980
Air Force begins to modify KC-135As to extend their service life until 2020: the KC-135R features modern F108-CF-100 high-bypass turbofans.

RANDY JOLLY

CHAD SLATTERY

GEORGE HALL/CHECK SIX

Small rooms, great view: Boom operators ply their trade in the relatively spacious surroundings of a KC-10's refueling station (above right) and the far cozier space in a KC-135 (above). Introduced into service in 1957, the venerable KC-135 (refueling an F-111 at right) is scheduled to serve well into the next century.

provide fuel to the A-3, which in turn provided gas to the F-8. Two Navy F-4s also showed up demanding gas; meanwhile, the F-104s provided air cover throughout, requiring additional refuelings themselves. Casteel's KC-135 ended up so short of fuel that it was forced to land at an alternate airfield in South Vietnam. He and his crew later received the Mackay Trophy.

F-4 pilot James D. High recalls a mission over Vietnam in 1970 when a tanker saved his hide. Lacking enough fuel to return to base, he was on his way to a KC-135. About three miles behind the tanker, he checked his fuel again. "I immediately noticed my fuel gauge counter decreasing 2100, 2000, 1900, 1800... going down about 100 pounds a second," he recalls; "not much time left before we became a very poor glider." The problem turned out to be a "reverse fuel transfer." A valve had failed to the "defuel" position and the airplane was actually pumping fuel overboard. "Normally, the tankers did not fly out of Thai airspace," High says. "But tonight, he was 65 miles in Laotian airspace. Decision made, it was tanker or nothing. When he asked how much fuel I wanted, I told him to pump until it quit."

In December 1972, tankers in the theater reached an all-time high of 195 SAC KC-135s, in support of the large-scale bombing of North Vietnam conducted during Linebacker II operations. Tanker navigator Rick Horne recalls one particular mission: "We were lead tanker during one of the night waves on the second day after the bombing resumed. We could see explosions from B-52s getting hit and burning pieces falling apparently slowly, twisting like burning leaves which have been carried aloft from a fire. I will never forget the way that looked, and the realization that there were some of our people in amongst those explosions.

"We were there, flying around like fools with all our lights on so the fighters could see us, well into North Vietnam," Horne recalls. "The North Vietnamese apparently never realized the role tankers played in the air war. They never, to my knowledge, made a serious effort to shoot down any of the tankers. If we'd had to have kept the tankers back, or if we'd had to divert a substantial portion of our force to pro-

1981
First KC-10A enters service.

1982
Southernmost in-flight refueling (performed by KC-10 750 miles north of South Pole).

1996
Longest combat mission in history. On Sept. 29, B-52s fly 36 hours and launch 27 cruise missiles at Iraqi targets during Operation Desert Strike; multiple refuelings by Air Mobility Command tankers make mission possible.

tect the tankers, the air war might have been much more difficult. We gassed some receivers two or three times on a normal mission. If they'd had to return to base each time, we'd have run out of airplanes on most of the big pushes."

From 1964 to 1973, SAC KC-135s transferred 1.4 billion gallons of gas during nearly 195,000 sorties in support of the air war in Vietnam. Even so, most of SAC's tankers remained stateside performing their strategic duties. The demands of routine tanker duty were considerable, as SAC continued to increase its alert posture and to experiment with "dispersal basing"—scattering aircraft at many locations so that they could not easily be destroyed by preemptive strikes against primary air bases.

Looking back on his tenure as SAC commander in the post-Vietnam period, General Russell E. Dougherty identifies two major accomplishments. "In Vietnam we had done 850,000-plus refuelings, mainly of fighters," he points out, "but there were no tankers operating in any of the war plans of any command other than SAC." There were two main reasons for this: the commitment of tankers to support the contingency plan for nuclear war—and the intricacies of determining who would pay for tanker time and gas. These problems were addressed under Dougherty's leadership, and today he feels that "the biggest thing we did in my command was to inject tankers into the operations of the entire Air Force." The second most important change, Dougherty says, was putting tankers in the Air National Guard. When the transfer program was completed in 1978, SAC retained 487 KC-135s. A total of 128 were transferred to the Air Force Reserve and Air National Guard units. This accelerated the shift of tanker usage and control from the strategic to a more flexible, force-wide employment.

Looking to expand and upgrade its fleet in the mid 1970s, SAC decided to adopt a multi-role tanker that could provide both refueling and cargo-carrying capability. Enter the McDonnell Douglas KC-10, which could carry 356,000 pounds of fuel (nearly twice the 135's load) and could accommodate 75 people and 170,000 pounds of cargo. It was also equipped with both flying boom and probe-and-drogue equipment and could itself be refueled in-flight by another tanker (KC-135s at the time could not). The first operational KC-10 was delivered in 1981 and set in motion an important change in the tanker business. "Tanker toads weren't trash haulers until we got the KC-10s," ex-tanker pilot Jon Mickley notes. Now they were required to perform double duty, filling in as airlift in addition to refueling duties.

Limited conventional conflicts increasingly occupied the United States military in the 1980s. The Air Force conducted long-range air strikes against Grenada in 1983 and Libya in 1986 and responded to several other crises, all with SAC tanker support. The demand for SAC tankers soared; more than half of SAC aerial refueling sorties were now flown in support of non-SAC operations.

By the end of the 1980s, even before the official demise of the Soviet Union, it was clear that the cold war was winding down. A nuclear war was no longer the first concern of American military forces. In order to prepare the Air Force for the transitional era to come, in 1990 the Air Force developed the concept of "Global Reach-Global Power," which outlined its changing role in national security. What exactly would be the role of the Air Force after the end of the cold war? Nuclear deterrence was still a priority, but the Air Force headquarters placed a new emphasis on versatility and rapid mobility, both of which would be required by small-scale, regional conflicts rather than nuclear war. The first test of this change in priorities occurred in Desert Storm—the most intensive aerial refueling operation in history.

In the Gulf war, the Air Force averaged 240 tanker missions a day, during which more than 1,000 aircraft were refueled: Navy, Marine, and allied coalition tankers provided another 120 sorties each day. Forty coalition refueling aircraft augmented 300 U.S. tankers—nearly half the U.S. fleet.

Even before the war began, aerial refueling enabled an astonishing *tour de force* of rapid deployment. One of the first steps the Air Force took was to stage tankers at various locations, including the Azores and Cairo, to form an Atlantic bridge from the United States to the Persian Gulf. Transports and combat aircraft were able to fly nonstop, refueling as often as necessary. Over a thousand aircraft were deployed this way, relying on nearly 100 tankers. Most aircraft took about 15 to 16 hours to make the flight, refueling anywhere from seven to 15 times. During the five-and-a-half-month buildup to war, SAC tankers flew nearly 5,000 sorties.

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Tankers were vital to the conduct of the war as well. High-priority targets in Baghdad required cruise missile strikes, which could only be delivered by strategic bombers, and stealth fighter-bombers. But logistics and security issues prevented basing B-52s in forward areas. No problem: the B-52s could simply fly from their home bases in the United States or from safe locations like the Diego Garcia U.S. air base in the Indian Ocean. For example, on January 17, 1991—

JIM BENSON/CHECK SIX

A B-52 (above) and an F-15 (left) gulp gas from KC-135s. Because of SAC's long-time emphasis on training for nuclear first-strike deterrence, tanker crews were as likely to train with SAC's bombers as with the 12-times-larger Air Force tactical fleet. Some have said this created a weakness in the performance of tanker crews in conventional operations, which became apparent during the Gulf war.

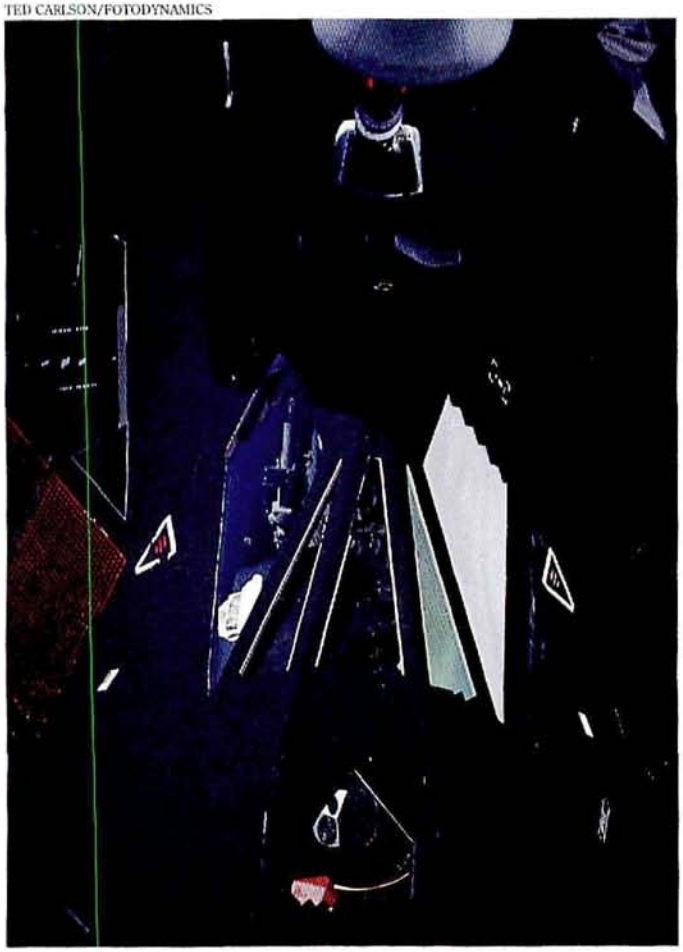
the first night of the war—cruise missiles were delivered against targets in Baghdad by B-52s flying directly from Barksdale Air Force Base in Louisiana to Iraq.

Aerial refueling made another, more unexpected, contribution during the conflict in the Gulf: The operation revealed that for all their successes, SAC tankers were not well prepared for an intensive conventional war. Despite the fact that the only combat SAC had ever experienced was conventional, the primary emphasis in its training had been for nuclear war scenarios. Tanker crews spent as much training time with 250 SAC bombers as with the more than 3,000 Air Force tactical aircraft. Passing fuel to bombers on intercontinental attack profiles involved predictable patterns: well-rehearsed rendezvous procedures, known quantities of gas, a measured pace, and a relatively low ratio of receivers to tankers. Refueling tactical aircraft in a dynamic combat environment was something else entirely. Although pre-strike refuelings were closely planned, all sorts of things could go wrong thereafter. Fighters burned varying quantities of gas during a mission, depending on weather and on time spent in afterburner, avoiding threats, reattacking targets, or chasing down the enemy. If a fighter was damaged in combat, it might leak fuel or be forced to jettison external tanks. It might not be able to reach the designated refueling areas. In addition, basic communications procedures used by tactical aircraft differed considerably from those used in SAC, and tanker crews were often unfamiliar with them.

Another complication was that airspace in the Gulf region was congested. Some 45 designated refueling areas were established and required close scheduling and monitoring. Scheduling was particularly complicated because of the need to match refueling equipment. If a non-Air Force or non-U.S. aircraft needed refueling, it had to be provided by a tanker equipped for probe-and-drogue. This was no problem for the dual-equipped KC-10, but KC-135s had to be fitted in advance with drogue adaptors and therefore were limited on any given sortie to refueling only one type of receiver.

Some fighter pilots who flew in Desert Storm criticized the tanker support they got. One F-15 pilot who prefers not to be named believes that the tankers were inadequately prepared for dealing with the crowded and chaotic conditions of wartime refueling. "During the first few days, we used the 'big sky theory' in the clouds," he says, meaning the idea that there's room enough for anybody. "With hundreds of us out there at the same time, amazing that nobody smacked into anyone else." Moreover, he says, "On the whole, I wasn't too impressed with the SA [situation awareness] of tanker crews—lots of inflexibility and questionable airmanship...tanker pilots were reluctant to cross the border into perfectly safe areas; others were flying at night well into Iraq *with their lights on!*"

TED CARLSON/FOTODYNAMICS



An intimate view of an F-117 being refueled shows the location of the stealth fighter's air refueling receptacle: above and behind the cockpit. Opposite, a KC-135 leads a trio of F-15s and an E-3 AWACS (Airborne Warning and Control System).

Brigadier General Richard C. Marr, who commanded a refueling wing during this period, acknowledges that there were shortcomings. "The tactical doctrine of air refuelers was not built for contingency operations like the desert war, because for generations we had been encumbered by a focus on nuclear mission support. And when you go out to refuel a strategic bomber, a B-52 or a B-1, the procedures are a lot different than when you go into a very rigidly managed airspace to refuel fighters. It's one heck of a big difference. I would say that our heritage of coming through the Strategic Air Command, and the emphasis on supporting bombers, did not enable us to have our crews as tactically honed as they should have been to support that war, although we did it, based upon the wonderful expertise of the individual crew members."

Major David Horton's experience flying a KC-135 on the second night of the war is one such example. There was a severe storm that night, the worst weather in the region in 14 years, and he picked up a distress call from an F-117. Returning late from an attack on Baghdad, the stealth fighter had missed its scheduled tanker and was critically low on fuel. Refueling the 117 required special procedures. For security reasons, most refuelings were accomplished with minimal communications, but for a tanker to achieve a visual rendezvous with a stealth fighter at night is tricky, to say the least. Further, the 117 pilot has a limited field of vision through the cramped windscreen. Luckily, Horton and his crew were qualified for F-117 refuelings and had a full load of gas. "We called AWACS and told them that we had the gas if he had enough time to get together with us," Horton says. They headed for the Iraqi border. "I found out afterwards that AWACS was contemplating turning us at that point to keep us from going into Iraq, but better judgment prevailed," he recalls. "By the time we hooked up, we were about 60 miles deep in Iraqi airspace, lit up like a Christmas tree because we had to [be] in order for him to see us in the weather we were in." Conditions were so severe that Horton's boom operator couldn't even see the 117 at the end of the boom.

By the time they finally hooked up, Horton says the F-117 had less than 100 pounds of gas left on board. The pilot "told my boom operator that he basically had one shot at this or he was going to have to [eject]," Horton recalls. "That would not have been the optimum place to lose a 117."

They achieved a second hookup as the aircraft turned south and started descending, finally emerging from Iraqi airspace. As the 117 took on fuel it had trouble maintaining altitude and retaining the hookup so Horton tobogganed his big tanker—descending with the fighter as both traded altitude for airspeed—enabling the fighter to stay with him long enough to take on a full load of fuel. "We found out afterwards that one reason he was having trouble holding altitude was he had a weapon on board, so he was a whole lot heavier without any gas," says Horton. "And flying at a high altitude, especially at the airspeed we were flying, was extremely difficult for him." As the stealth pilot disconnected from the tanker and headed to base, he told Horton and his crew, "You guys really saved my bacon."

During the 43 days of combat in Desert Storm, the coalition tanker fleet performed some 50,000 refuelings and transferred more than 700 million pounds of fuel. Phillip Meilinger, a member of the Air Force division responsible for the design of the air campaign during the war, points out, "There were thousands of aerial refueling sorties during Desert Shield and Desert Storm and not one mid-air [collision]. That's awesome. They must have been doing *something* right."

The Air Force is still studying the lessons learned. One thing is clear: Desert Storm would have been quite a different war without aerial refueling. It was refueling that allowed coalition forces to maintain the pace and intensity of operations. In many ways it was the tankers that determined the parameters of the air war; aerial refueling was both a limiting factor and an indispensable asset. Major General Hal Hornburg, who commanded a composite fighter wing in Desert Storm, says: "You never, in a combat operation, have enough tankers. [The] planning factor for tankers, which I've adopted, is to plan to the most minute detail the number of tankers required for any air operation, and then if possible, double it."

After the Gulf war, the Air Force underwent a massive reorganization. Both the Strategic Air Command and Tactical Air Command were merged into a new Air Combat Command. Their airlift and air refueling assets were assigned to a new Air Mobility Command. In 1992, AMC opened the Tanker Airlift Control Center, which now provides "one-stop shopping" for planning and directing tanker and transport aircraft operations around the world. It also created the Air Mobility Warfare Center at Fort Dix, New Jersey, under the command of Brigadier General Richard C. Marr. "The AMWC is like graduate school," says Marr. He says the experience of Desert Storm is very much taken to heart, and changes have already been made in tanker tactical procedures. For example, tanker formations—the vertical and horizontal distances between aircraft—were originally established for refueling bombers in friendly airspace, with sufficient space between tankers to allow the big bombers to get in and out easily. But those formations don't work well in situations like that found in Desert Storm, where tankers needed to be more closely spaced to allow more efficient management of the airspace and to allow groups of fighters to stay more closely in formation while refueling. So new "reduced interval" formations have been developed that are better suited to today's tactical environments.

There are plenty of disputes about the future of aerial refueling. Some argue that in the interest of efficiency, all tankers should be built on the KC-10 concept, offering both cargo and refueling capability and both boom and probe-and-drogue technology. Some argue that the Air Force needs more multi-point refueling capability—the ability to refuel several receivers from the same tanker simultaneously—to increase flexibility in conventional scenarios. Any new tanker will run in the neighborhood of $100 million per aircraft; with today's budget constraints, it likely will be years before the KC-135, an ancient aircraft by anyone's standards, can be replaced.

Despite the continuing limitations in the Air Force refueling fleet, it is still the world's best. During the dissolution of the Soviet Union, many tanker units ended up under the control of newly independent former republics, like Ukraine. The Air Force of the Commonwealth of Independent States tried hard to get them back. In 1992 the commander of the CIS Air Forces was quoted in the Russian press as saying, "Pardon my unparliamentary language, but bombers without tankers are like eunuchs." No air force has a credible global capability without tanker support.

RANDY JOLLY