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Tanker-Force Structure

Recapitalization of the KC-135

JUAN C. NARVID
Lieutenant Colonel, USAF

Air War College
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Foreword

Aerial refueling is key to the nation's global reach in response to operations in all parts of the world. As such, aerial refueling provides the bridge for air, joint, and coalition forces to deploy anywhere, any time around the world. It is important in this era of transformation that the tanker force and doctrine of aerial refueling also meet the challenges of the Air Force's task force concept of operations (CONOPS). The highly demanded tanker has the ability to affect global strike; homeland security; global mobility; space; and command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); global response; and nuclear response. The KC-135 aircraft has been an outstanding platform for aerial refueling, and through some enhancements, it has been able to leverage some of its capabilities in airlift and communication. However, the Air Force has the opportunity with its next class of tankers to field a new tanker with capabilities that can serve all services in more demanding joint and coalition warfare of the future.

In *Tanker-Force Structure: Recapitalization of the KC-135*, Lt Col Juan Narvid challenges air mobility warriors to develop a tanker-force structure that overcomes the thinking of old to launch new concepts and capabilities for the future tanker. He argues that the future of warfare will require a tanker that is able to operate as a force enabler across the full spectrum of operations. This research is very timely with the Boeing 767 being looked at as a replacement for some of the older KC-135s. In contrast to some of the 767's capabilities, he outlines a conceptual tanker that combines airlift and aerial-refueling capabilities and is able to survive in a combat environment, and he leverages its ability to act as a platform to enhance network-centric warfare. He points out that while the "Cadillac" of all tankers may only be conceived in the minds of Airmen, the tanker of the future cannot resemble the single-role tanker of the past.

In this paper, Colonel Narvid examines the chronology of the tanker and the role it has played throughout its history. He argues that the next tanker must break from old capabilities, tied to a Cold War strategy, and embark on new operations and more capabilities that are able to respond to future threats. Joint warfare already capitalizes on getting the right information to the decision makers and the warrior executing the combat mission. Innovative ideas within the mobility Air Force (MAF) are providing the link for information between the two through roll-on beyond line of sight (ROBE) systems. To employ these type capabilities into a combat area, tankers may come up against asymmetric threats from an enemy willing to blunt any advantages the MAF has to offer. Colonel Narvid believes the Boeing 767 improves on the capabilities of the KC-135 and that the Air Force currently needs to replace some of the older KC-135s. However, he argues, it will not fit the bill when it comes to meeting the challenges of the future—instead, a tanker designed from the ground up should recapitalize the KC-135 fleet.

As with all Maxwell Papers, this study is provided in the spirit of academic freedom, open debate, and serious consideration of the issues. We encourage your responses.

BENTLEY B. RAYBURN
Major General, USAF
Commandant, Air War College

About the Author

Lt Col Juan "Grande" Narvid is a graduate of the Air War College, Class of 2004. His assignments include operations officer of the 37th Flight Training Squadron, 14th Flying Training Wing, Columbus AFB, Mississippi; and tours at Laughlin AFB, Texas; McGuire AFB, New Jersey; and Scott AFB, Illinois. Colonel Narvid entered the Air Force from the University of Texas–San Antonio. He is a command pilot with more than 5,300 hours in the KC-10, C-141, C-9, T-37, and T-38. He qualified as an instructor pilot/flight examiner in four separate weapon systems. He served as major command regional operations director, Tanker Airlift Control Center, and was hand selected as director, Air Mobility Operations Inspections, Headquarters Air Mobility Command Inspector General. He is a distinguished graduate from Squadron Officer School; holds a master of arts in National Security and Strategic Studies from the Naval War College, Newport, Rhode Island; and one in Human Resource Development from Webster University, Missouri; and is a graduate of the Naval Command and Staff College, Newport, Rhode Island. Following graduation from Air War College, Maxwell AFB, Alabama, Colonel Narvid took command of the 735th Air Mobility Squadron, Hickam AFB, Hawaii.

Tanker-Force Structure

Recapitalization of the KC-135

"The Air Force recognizes the need to begin replacing its large, aging fleet of KC-135s as soon as possible."

—Lt Gen Stephen B. Plummer,
10 January 2003

The United States Air Force KC-135 fleet is nearly 50 years old; recent studies show that it is time for the recapitalization of this tanker fleet. The present inventory of aircraft went through many upgrades and modifications, but all are still the basic A-model aircraft initially purchased by the Air Force in the late 1950s. The Air Force needs to replace this aged aircraft by designing a new tanker from the ground up, capable of responding to the threat environment of today and the future.

Bomber and fighter aircraft dominate Air Force history. Despite the proven capabilities of aerial refueling during the birth of the Air Force, technology was directed at improving the reach of combat aircraft without regard to tankers. However, technology finally reached its limit and required aerial refueling to propel combat aircraft beyond the shores of the United States and the limits of forward bases.

Aerial refueling found its way into Air Force doctrine and became an integral part of the national military strategy (NMS). As the NMS reached into more regions of the world and encompassed more missions of vital national interest, tankers were required to expand the country's capability into a global strategy. Funding, importance, and old technology limited the emerging tanker-force structure. However, today's Air Force concept of operations (CONOPS) challenges Airmen to think differently about the threat of the future and the force structure required to respond to these threats.

The tanker-force structure was built from old bomber systems and off-the-shelf airline technology. It required little research and development to build or buy an aircraft that only needed to transfer gas to its receiver. While the mission of old only required this simple capability, time quickly outpaced the legacy systems. Future trends in war fighting require a capabilities-based tanker able to survive in today's combat environment while responding across the full spectrum of operations. The long-term reliance on old tanker weapon systems patched with rebuilds, refurbishments, or replacements will not meet today's Air Force mission.

The scope of research in this paper does not look into budget issues associated with the recapitalization or procurement of force-structure platforms. It serves as a think piece into the capabilities required for the future replacement of the KC-135 fleet. This research challenges the reader to look beyond the platform of the tanker and the upgrades that the Boeing 767 can deliver. The Air Force needs a tanker able to deliver the capabilities that the joint environment requires to operate across the full spectrum that the future holds. The tanker can no longer serve only the Air Force of the past but must meet the needs of the forces of the future. The capabilities built into a newly designed tanker will make it a valuable national asset across all services.

The Need for Aerial Refueling

US strategy has undergone massive changes since the end of the Cold War. No longer do we face a single foe in a given area of the world. Today, surgical strikes by combat aircraft may be required to defend the US homeland or destroy a terrorist camp in the desert.

National Security Strategy

The US National Security Strategy (NSS) requires the endurance and flexibility that aerial refueling gives to receiver aircraft in order to operate across the entire spectrum of the NSS operations. Aerial refueling gives the United States the ability to respond across the full range of operations, from combating global terrorism to humanitarian actions. Aerial refueling spans the gap between the robust nature of the regional commitment of the NSS and the limited bases that are available in the en route structure from which this strategy may be executed. Aerial refueling allows the US vision to become possible by using distant bases coupled with the global reach of tankers extending to all regions of the world.

Pres. George W. Bush outlined in the NSS a strategy that required the United States to respond to the higher end of the conflict spectrum, including conflicts stemming from terrorism and attacks against the United States and its allies.[1] Operation Enduring Freedom, Afghanistan, has proven to be a considerable challenge for US forces in the fight against terrorism. The mountainous terrain surrounding the area of operations is a haven for fleeing terrorists, and without tanker support to keep fighter aircraft loitering above the battle area, time-sensitive targets would easily escape. Likewise, intercept aircraft defending the shores of the United States from attacks by rogue nations or terrorist groups would also be unable to maintain their constant vigilance without the extension of fuel received from orbiting tankers.

Additionally, the NSS must respond to the lower end of the spectrum by addressing conflicts arising from infractions of human dignity.[2] Past US leaders have worried over the implications of committing US forces in response to humanitarian actions, particularly in Bosnia and Somalia. Torn between the atrocities being committed in these countries and the possibility of US soldiers being wounded or killed to preserve the peace, the administration looked to airpower to provide the United States the force needed to maintain credibility in the international arena while preventing public outrage due to American casualties.[3] Aerial refueling allowed the nation to reach out to these regions by providing fuel for the airlifting of supplies and fighter protection.

Finally, the NSS pledges to work with other nations to defuse regional conflicts.[4] Each region of the world offers a unique and volatile challenge requiring operations from airlift to strategic attack. In the poverty-stricken continent of Africa, aerial refueling will play a major role, linking the European en route structure to the vast areas comprising the southern countries in Africa. The two closest bases to the en route structure are Lajes, Azores, and Rota, Spain, which require an air bridge of tankers to respond to the region (fig. 1).[5] Additionally, the United States already has long-term commitments in Korea and Iraq requiring numerous aerial-refueling assets to support the operations. The NSS also lays out a willingness to respond to challenges in Israel, Palestine, India, Pakistan, Indonesia, the Western Hemisphere, and Latin America. Again, with the concentration of the en route structure established along the west coast of Europe and the east coast of Asia, aerial refueling will be a required resource to employ operations throughout the regions.

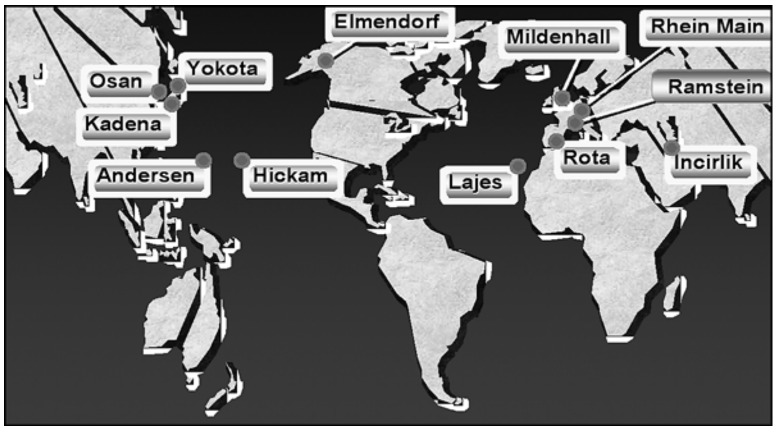

Figure 1. En route structures. (Adapted from Col Scott Phillips, "DIRMOBFOR," lecture, Air War College, Maxwell AFB, AL, 5 December 2002.)

Air Force Doctrine

The Air Force doctrine of aerial refueling is designed to support the service's power-projection capabilities, which in turn support our national security interests. Air Force Doctrine Document (AFDD) 2-6.2, *Aerial Refueling*, points out the numerous principles of airpower, such as time, distance, and payload, affected by aerial refueling. AFDD 2-6.2 outlines aerial refueling and its ability to increase mass, surprise, economy of force, flexibility, versatility, and maneuverability.[6] To execute this doctrine, tanker operations rely heavily on established airfields with a robust logistical system.

During the past decade, the United States reduced the number of overseas bases accessible by heavy aircraft such as tankers. During Operation Desert Storm, two of the six largest bases provided 58 percent of the airlift capability and access. This was due to their ramp space and runway length, which were capable of handling the heavyweight aircraft of Air Mobility Command (AMC).[7] The two bases, Torrejon, Spain, and Frankfurt, Germany, have not been used to their full capacity since Desert Storm. This reduction limits the compatible runways for AMC's large aircraft and causes aircraft to compete for a smaller pool of available forward operating bases. Reductions like these, as well as the denial of airfields by host nations, make aerial refueling vital to the Air Force mission. If reductions and denials continue, the United States will come to rely more on projecting power from its own shores or be forced to choose less-than-optimum locations further away from the fight than desired. While Central Europe and Central Asia may grant access to additional airfields, current tanker operations still require robust logistical support.

Logistical support impacts the ability of aerial refueling to increase the payload carried by receiver aircraft. Due to limitations in engine thrust, runway length, or aircraft weight, some aircraft are unable to take off with the maximum amount of payload and carry enough fuel to accomplish the mission. The sacrifice in payload on supply aircraft means less cargo (supply items) to deployed troops or kinetic weapons that are relied upon to "kill people and break things" to win wars. Fighter aircraft may have to sacrifice fuel or payload, thus reducing either time or lethal impact over the target. However, the use of a tanker aircraft can allow receiver aircraft to maintain high payloads and to extend airtime by in-flight refueling.

Tankers can deliver capabilities beyond AFDD 2-6.2. Recently, Gen John P. Jumper, Air Force chief of staff, outlined how the Air Force will tailor forces and employ them in response to a range of scenarios. In General Jumper's task force, CONOPS tankers must expand to become the tankers of the future. The next tanker-force structure must leverage its size and loiter time to enable all services a more robust C4ISR while combining capabilities and doctrine to help the airlift community to deliver global mobility and global response. Additionally, future tankers need to leverage the lethality of combat air forces by increasing global strike capabilities to linger over the battle area with larger payloads. The next tanker cannot just be a replacement for the KC-135. Airmen must think across doctrine, services, platforms, and organizations in fielding the next tanker.

History of Aerial Refueling

In 1921 the idea of aerial refueling was born in the minds of daring men willing to brave dangerous aerial demonstrations to please watching crowds gathered below. One of the first recorded aerial refuelings was such a stunt. A lone man named Dougherty crept across the wings of a Lincoln Standard biplane with a five-gallon gasoline can strapped to his back.[8] He stepped out onto the awaiting wing of a JN-4 Jenny aircraft and poured the contents of his can into the Jenny's tank; thus, the first historical recording of the first aerial refueling of an airborne aircraft. During the next couple of years, aerial refueling quickly evolved through trial and error. New methods of transfer were tested using hoses to transfer fuel instead of wing walkers, and endurance records were extended, fuel loads increased, and distance records were broken. However, it all came to a halt with the death of some Airmen in an aerial demonstration; the refueling hose from the tanker wrapped around the prop of the receiving aircraft.[9] The idea of aerial refueling seemed to subside in the chapters of airpower history. The fledgling airline industry did not share the initial interest shown by the military. Commercial flights simply did not require the endurance aerial refueling could provide to domestic flights. It was not until 1929 that the Army Air Corps brought back the revolution of aerial refueling, grabbing the world's attention. Two young officers, Carl Spaatz and Ira Eaker, piloted their monoplane named the *Question Mark*, smashing all air-endurance records—the aircraft remained airborne for 150.8 hours.[10] This famous demonstration of in-flight endurance made possible by aerial refueling caught the attention of proponents of airpower throughout the world.

The Early Years

The United States pioneered aerial refueling. However, as US involvement in World War II began in early 1940, aerial refueling would take a backseat to the strategic bomber. The strategic bomber had the endurance (fuel capacity) required to execute its mission when deployed to the region where bombing was required. However, fighter aircraft were still without the required range to escort bombers or fly long-range missions within the theater of operations. The United States failed to build tankers and equip fighters and bombers with transfer-receiver capability. Aerial refueling became important as World War II ended and the Soviet Union emerged as a foe of the United States. In 1946, to meet the new global mission to deter the Soviet Union, the Army Air Force converted B-29s into tankers. B-29 tankers off-loaded fuel to B-29 bombers via a hose winched from the bomber onto the tanker by a grappling line. By the time the first tanker was born, bombers with higher engine thrust were being built, and despite the invention of the more efficient flying boom, the KB-29 was unable to keep up with the faster bombers. The KC-97 tanker-transporter evolved from the KB-29, which had a more efficient boom system and, more importantly, gave the United States a swing capability to carry cargo. The propeller-driven KC-97 soon found itself outclassed by the more powerful bombers. The KC-97 had to descend while refueling or "toboggan," and the later version, the KC-97L, included an extra engine under each wing to provide the KC-97 enough thrust to stay ahead of the receiver aircraft. The older technology of the KC-97 was soon replaced by the "jet"-powered KC-135.

Tankers of Today

In 1957 the first KC-135 was delivered to the Air Force and became an important part of the Strategic Air Command's (SAC) strategy. When paired with the B-52 under the Joint Chief of Staff's *Single Integrated Operations Plan*, the team could deliver nuclear weapons to the Soviet Union.[11] The KC-135 was strictly tied to the strategic bomber force and not used to refuel Tactical Air Command's fighter force until the Vietnam War. The KC-135 could refuel at higher altitudes and easily keep up with the B-52, enabling them to maintain 24-hour coverage of the sky. The same boom-system design used on the KC-97 was still in place on the KC-135. In changing from a strictly SAC asset to refueling TAC aircraft, the KC-135's missions would undergo additional changes.

Although the Navy had its own small fleet of tactical tankers and the KC-135 inventory was quickly increasing, the Navy wanted access to the KC-135 as a viable refueler to increase the reach of their fighter force. To refuel Navy and North Atlantic Treaty Organization (NATO) aircraft, a drogue or "basket" was adapted to replace the boom tip for Navy or NATO refueling missions.

During the next 25 years, the KC-135 dominated the aerial-refueling arena while undergoing additional evolutions and transitions, such as new fuel-efficient and quieter engines, partial wing replacements due to metal fatigue, and engine-strut replacement. The KC-135 was already becoming outdated before the first KC-10 reached the Air Force inventory in 1981. The KC-10 was born under the advance tanker/cargo aircraft idea.[12] Not only would the KC-10 be able to carry nearly twice as much fuel as the KC-135, it could also alternate between boom and drogue refueling while airborne. Moreover, the KC-10 provided the Military Airlift Command (MAC) a tremendous boost in strategic-airlift capability due to its large cargo capacity. One of the biggest advantages the KC-10 has over the KC-135 is that the KC-10 eventually evolved to a dual-drogue system capable of refueling two Navy or NATO fighter aircraft at the same time from its wings. Eventually, the KC-135 was modified (in limited numbers), allowing it to trail two drogues from its wing pods. The KC-10 is often used in the "reliability tanker role" due to the massive amount of fuel it carries and its ability to refuel different types of aircraft, regardless of the refueling system installed.[13] Presently, the Air Force has not received a new tanker since the delivery of the KC-10 over 20 years ago and has a fleet of KC-135s nearly 50 years old.

Shortfalls

International tanker operations are required for modern US air campaigns. However, many international areas do not have infrastructure capable of supporting tanker ground operations.

En Route Structure

The international "en route structure" in which tankers are required to operate does not provide an endless number of options when it comes to selecting airfields to deploy assets. Every country varies in the infrastructure they can afford to build or maintain. In many cases, nations rely on antiquated airfields designed for World War II–era aircraft. The runway is unable to either handle the weight of large-tanker and cargo aircraft or the length of the runway is insufficient. Likewise, countries that do have the capability to support tankers may limit access due to disagreements over military use of airfields, or their top priority is commerce-producing commercial aircraft. These limitations in the en route structure highlight limitations in the US tanker force that must be addressed in the development of the future tanker-force structure.

The number of bases available within the en route structure is limited by runway requirements for tanker aircraft. The weight of tankers due to mission requirements for fuel often exceeds the weight capacities of many foreign runways. Additionally, many foreign runways are not long enough to allow a fully loaded tanker to take off. This limits access to bases/airports by all but a few overpowered aircraft. As in the case of the air operations in Kosovo, US forces had to rely on an old NATO and former Warsaw Pact en route structure designed for much lighter fighter aircraft and were unable to use the numerous bases available in the area.[14] Maj Gen Roger Brady, Air Force deputy chief of staff, noted that "the amount of bases close to combat operations and available to tankers were [*sic*] not readily available."[15] Moreover, the United States does not control the development or suitability of other nation's airfield infrastructure. The few bases the United States does maintain and contribute to the high cost of modernizing are not available in numbers large enough to accommodate the large expeditionary packages dictated by today's Air Force mission requirements. Without a change in foreign airbase operations or increased US funding for modernization of foreign bases in the future, the only runways readily available may be in austere locations.

Civilian- versus Military-Designed Aircraft

Civilian airlines rarely operate in austere locations or rely on airfields lacking support and required infrastructure. When they do service these areas, they do so with smaller aircraft capable of operating on limited-length runways. The larger civilian aircraft enjoy the luxury of modern international airports fully equipped with all the amenities afforded the high-commerce demands of airborne transportation and have no incentives to operate on less-than-normal runway lengths. However, US tankers designed on airline prototypes or slightly modified versions, such as the KC-135 and KC-10, must gain access to available airfields closest to the fight. The NATO standard 8,000-foot runway is not adequate for fully loaded KC-135s and KC-10s. The tankers in the Air Force inventory today are built to airline standards, not to military requirements, which limits the runways available. This is just one example where commercial off-the-shelf (COTS) aircraft design negates military requirements.

The development of the Boeing 767 seems to address the disparity between civilian and military specifications on runway-length capabilities and does allow the aircraft to take off fully loaded on an 8,000-foot runway, which gives access to 2,000 additional bases/airfields due to reduced runway requirements.[16] However, it has taken two generations of tankers to meet these requirements. While this new capability may fit a strategy linked to NATO allies, it may not suffice in the future for isolated areas away from the mobility en route structure. Tanker operations in the future may depend on less-developed runways with some missions requiring the building of refueling infrastructure (pipelines) to realize full capability.

Even with the new capability, the 767 will not match the capability to land on austere runways, such as the military-driven requirements of the C-17 or the heavier C-5.[17] If given these same capabilities, the 767 would have access to additional runways. However, to fully utilize a short-field capability, the tanker force will need to develop a new approach to tanker operations. Tanker forces may require pipelines to bring the fuel from large bases or offshore tankers to the smaller airfields. The flexibility to operate globally and in less-developed countries will be part of future tanker missions; critical planning is needed now.

Boom-Cycle Time

Boom-cycle time is the rate a tanker can off-load fuel to multiple receivers. Despite the amount of fuel that tankers carry, with only one boom, tankers can off-load only a set amount of fuel within a given time. This has been a problem with the tanker force from inception. Single-port refueling reduces the flexibility of the entire operational force. During multiple aircraft refueling, the single boom limits the entire aerial-refueling process. The single boom does not present the same problem when refueling large deploying aircraft or requiring extra fuel to make long flights across the oceans. However, it does affect small fighter aircraft flying long distances or loitering for long periods. The limited amount of fuel carried by smaller aircraft requires most to refuel hourly. With only one boom available, each aircraft must refuel in turn and burn onboard fuel while waiting its turn. When combat aircraft operate in packages, the waiting time is a limiting factor delaying the attack or restricting time over target. The following excerpt sheds light on the problem of refueling with a single boom.

> Three flights of four fighters each are airborne and burning fuel at an average rate of 8,000 pounds per hour (pph) or a total of 96,000 pph for the flights. One tanker can transfer fuel at a rate of 60,000 pph to these notional flights of fighters, allowing each aircraft to cycle on and off the boom. In this typical example, only 60 percent of the fighters can be refueled and will require an additional tanker to refuel the strike package.[18]

In the above example, adding an additional boom to KC aircraft allows a two-to-one reduction in tanker requirements and reduces required airspace. Currently, KC-10s already employ this concept when refueling naval aircraft by extending two hoses from the wings. Navy aircraft control their own refueling—closure to hose, connection to aircraft, positioned on the hose in relation to the tanker, and monitored by the boom operator on the tanker. Air Force use of a duel-boom system would not require an additional boom operator. Currently, only single-boom operations are allowed because the boom operator flies the boom into the receptacle of the awaiting aircraft. On the older KC-135, the boom operator monitors the refueling envelope and disconnects the refueling aircraft when or if limits are reached. However, on the KC-10, the boom system can operate in an autonomous mode with a computer monitoring the rate of closure and boom limits, even executing "disconnects." Current technology still requires a boom operator to make the contact with receiver aircraft; however, new technological advances in an automatic-boom-operating system can make dual-boom operations a possibility. Employment of the new technology will require new developments in breakaway procedures. The Navy already uses dual refueling, and the Air Force could easily adapt breakaway procedures from lessons learned by the Navy.

Refueling from a single boom reduces the flexibility of fighter aircraft. Current strike packages require the integration of many weapon systems spread among different fighter aircraft. One strike package may have two or three different types of aircraft providing defensive and offensive capabilities. If these packages are responding to a set time over target, the aircraft have a limited amount of time to refuel with the precoordinated tanker support. The problem becomes more pronounced when fighters are reacting to a time-sensitive target. Time-sensitive or pop-up targets require minimal response time and can be negatively affected by single-boom operations. If refueling is required, the time to cycle through refueling requirements is cut in half with an additional boom. Until additional booms are added, other tankers will need to deploy and will contribute to the already growing airspace issue.

The addition of a boom will most likely require extensive aircraft-design engineering, as the current aircraft design does not allow a simple bolt-on boom. One of the biggest unknowns in moving refueling operations from the tail of the aircraft to two booms on the wings is with heavy-receiver aircraft. What aerodynamic affect will a heavy aircraft have on the tanker by refueling from the wing? It is obvious that heavy aircraft will not have enough clearance from the tail of the tanker to refuel from the wing on commercial airline designs. It is most likely that the body of a dual-boom tanker will have to resemble a B-2 or have a blended wing where the boom can extend beyond the trailing edge of the aircraft. Designing a dual-boom system into an aircraft during the design phase will reduce drag, improve maintenance, and limit interference between aircraft systems. This will not be possible if the Air Force uses a COTS aircraft.

Getting Enough Gas to the Fight

Tankers are gas stations in the sky. As such, tankers must carry as much fuel as possible. Mission requirements dictate the amount of fuel needed, but having additional fuel increases mission flexibility and will cover contingencies, if needed. To deliver the maximum amount of gas to the fight, tankers leverage three capabilities. First, the more gas a tanker departs home station with, the more it will have when it reaches the planned aerial-refueling route. This is a simple concept—the bigger the tanker is, the more fuel it can carry. As mentioned earlier, the KC-135 can carry approximately half of what a KC-10 can carry. Second, the less fuel a tanker burns en route to the fight, the more it can deliver. The advantage of fuel-efficient engines is one the Air Force has continually pursued in the KC-135. Finally, the faster a tanker can off-load fuel to a receiver, the less time the additional receivers spend burning fuel in the refueling track.

The KC-10 can take the place of about two KC-135s on the ground and in the air. On the ground, a KC-10 has a smaller footprint than two KC-135s. Additionally, one KC-10 requires less maintenance and support while carrying more cargo than two KC-135s. The disadvantage is when a single KC-10 has a maintenance problem; twice the aerial-refueling capability is lost. Additionally, there are penalties involved with the KC-10 on the ground. Due to its weight and associated runway requirements, the en route structure may not have the required fields to accommodate heavy tankers. In the air, a single heavy tanker burns less fuel than two smaller tankers carrying the same amount of fuel as a heavy tanker. Additionally, a single tanker requires less airspace to perform aerial refueling and is more maneuverable. The standard spacing for a tanker-refueling cell requires one mile between each tanker. For every additional tanker added to a formation, the formation spreads out an additional mile. A formation of tankers avoiding thunderstorms or adjusting its turn must take into consideration all tankers in the formation. A single tanker or even a two-ship formation does not require all the airspace and precoordination that a large cell of tankers requires.

The less fuel a tanker burns, the more it delivers to the fighters. One of the most prevalent ways to reduce fuel consumption is to develop more fuel-efficient engines. Due to the limited en route structure, fighters are based closest to the fight, while tankers are expected to make the long haul to the aerial-refueling tracks. This positioning causes tankers to burn additional fuel to reach the refueling point. Technological advances in engine performance have driven numerous modifications to the KC-135 to increase the total fuel available for receiver aircraft. Commercial technological advances have shown numerous ways to improve aircraft efficiency. One of the most ignored is the design of the wing or aircraft. Preliminary analysis of blended-wing bodies, like the B-2, has shown the ability to exceed the capability of conventional aircraft of the same size.[19] A skin-friction reduction innovation, called micro-blowing technique, reduces the friction around the nacelle of an aircraft up to 70 percent.[20] The reduction in drag reduces the amount of engine thrust required and the total amount of fuel burned.

The rate fuel is transferred between the tanker and receiver using the boom or drogue must improve to reduce the time receiver aircraft spend awaiting and receiving fuel. Refueling using a boom enables tankers to transfer fuel at a maximum 1,100 gallons per minute.[21] This capability is reduced on the hose and drogue systems installed on the wings of some KC-10s and KC-135s. Though two hoses would seem to double the capability, a hose is only able to off-load fuel at a rate slightly more than half as fast as a boom. Despite having the added hose, two receiver aircraft are still only able to transfer fuel at about the same rate as one boom. The problem is even more prevalent when only one drogue is available (usual case) because there are not enough dual-hose kits to equip the entire force. For example, during a KC-10 deployment to Al Dhafra, United Arab Emirates, Operation Southern Watch, only one KC-10 was equipped with wing pods. If new advances are made in the transfer rates of fuel from a tanker, the receiver may become a limiting factor. The technology must be upgraded on the receiver aircraft to handle the higher transfer rates. With advances in technology to improve transfer rates on a drogue system, as well as the boom system, engineering studies must be accomplished to ensure center-of-gravity problems do not develop on the tanker during rapid-transfer fueling.

Trends

Future US air operations will place tankers in harm's way. For the tanker to continue to be a force multiplier, it must be able to evade or thwart enemy efforts to shoot it down.

Tankers Are Targets Too!

The United States, without disagreement, has the most formidable Air Force in the world and the best protection for its aircraft. Technological advances in stealth, early warning detection, and systems that defeat surface-to-air missiles (SAM) have been protecting the country's combat air forces with resounding success for the past decade. Additionally, fighter aircraft can employ tactics such as high-speed, high g-force turns, and steep approaches, which add to their self-defense. However, tankers are very susceptible due to their lack of aircraft defensive systems, slow speed, and vulnerability during takeoff and landings.

A threat definitely exists, and adversaries rely more and more on asymmetric weapons and tactics to bring down US airborne assets. First of all, shoulder-launched missiles are present in sizeable amounts and available to just about anyone with a reason to hate the United States. Stinger missiles were provided to the Mujahideen by the Central Intelligence Agency during Afghanistan's resistance to the occupation of their land by the Soviets.[22] Of these missiles, it is estimated that at least 30 of them are still available and in the hands of Osama bin Laden and his terrorist group, al-Qaeda.[23] If it is easy for terrorists to gain access to US missiles, how much more access do they have to Soviet-made missiles provided by nations such as Iran, Syria, or North Korea?

Secondly, the tactics to employ these missiles are simple to achieve and difficult to defeat. "You can't protect against somebody standing on a building or road and shooting off a missile," says Clair Brunavs, a spokeswoman for *Jane's Historic Military Aircraft Recognition Guide*.[24] Recent events have proven the ability of rogue groups to effectively employ shoulder-launched missiles, such as the Russian SA-7. Several strategic and tactical airlift aircraft were recently fired upon during the landing phase into Baghdad International Airport, Iraq. Moreover, an international carrier, comparable in size and weight to a KC-135, was struck by an SA-7 during takeoff.[25]

Finally, the future does not hold a better outlook for tankers. Smaller groups may not have the technology and infrastructure to research and develop weapons that can counter US systems. However, nation states that understand US capabilities and employment of air assets can develop the means to defeat US weaknesses while avoiding US strengths. Why should a foe be expected to face US strengths head-on? China is just one example of such a state that may be a peer competitor in the future and willing to invest funds to attack one of the Achilles' heels of the United States—a large, slow, less-maneuverable tanker aircraft. Additionally, it is no secret to the United States and the world that China is currently developing a new use for its over-the-horizon cruise missile to specifically attack air-to-air refueling capability.[26] China recognizes how reliant the United States is on its tanker force and aerial refueling to enable its bomber and fighter force to reach out and apply deadly force. It is also highly possible that other countries desiring protection against the United States will also be willing to either develop or purchase technology, allowing them to have an asymmetric advantage. Tanker aircraft are vulnerable in the low (takeoff) and high structure (in flight). Current technology limitations on the SAMs combined with US intelligence allows tankers to avoid known threat areas while in the high structure of flight. However, in the low structure during takeoff and landing, tankers need the capability to identify threats with warning equipment and to counter them with technology such as chaff and flares that are already installed on many airlift aircraft. Moreover, laser technology that deflects the course of hostile missiles would make tankers an even more difficult target to the enemy.

Network-Centric Warfare

With the advent of the Air Operations Center (AOC), the need for correct information from the battlefield to the decision maker and the war fighter has become a trend that is highly dependent on sensor and communication technology. The Committee on Appropriations submitted to the 106th Congress a report explaining a shortage of required assets needed in establishing a network-centric-warfare capability. They reported deficiencies in low-density, high-demand assets such as electronic warfare aircraft, tactical collection and dissemination of assets, secure communications, and command and control.[27]

Tankers can provide the link between decision makers and war fighters if they are afforded the technology and integrated in current doctrine. For years tanker aircraft have always been close to the fight. Tanker fighter-anchor patterns are assigned by AFDD and require the tanker on station as the gas station in the sky for as long as other aircraft are flying. The Air Force is currently taking advantage of the loitering tanker and integrating it into network-centric warfare. ROBE enhancement is the relay in the smart tanker concept receiving information from different locations and transmitting it beyond visual range to the right person, at the right time.[28] However, the tanker can go beyond ROBE and its capability of integrating the joint tactical radio system (JTRS). Recent shoot-downs of friendly helicopters and fratricide of friendly ground forces signal a need for identification of friendly forces. The JTRS has a function allowing a vehicle being targeted to transmit a specific signal.[29] With ROBE already onboard, the tanker can quickly transmit this information to the appropriate aircraft to prevent killing of friendly forces. Tankers are capable of combining capabilities of other battle-management aircraft.

Likewise, the decision loop, in the execution of combat forces, relies intensely on information from numerous sensors in, on, and around the battlefield. Optical sensors on unmanned aerial vehicles (UAV), air-to-air radar sensors on E-3 airborne warning and control systems, and air-to-ground radar sensors on E-8C joint surveillance target attack radar systems (JSTARS) provide battle-space awareness to decision makers and targeting information to war fighters in high fidelity. The capability of sensors and the advent of new ways to employ them have created a sensor race between services and major commands within the services. Although the many sensors can be linked by systems and share the information, the information sent or received is limited by the lack of equipment on ground units or airborne aircraft. Additionally, because some of these systems are service parochialisms, many services cannot receive the information simply because they were not planned as a customer of the information (i.e., the Air Force may not be able to receive Army information or the Army receive Air Force information). The outcome of the need for sensors and the lack of a centralized command for sensor production have created numerous platforms.

The tanker can provide the capability to act as the platform with the sensors needed to service the battle area. First, tankers have the capability to loiter while serving as refueling points for fighter aircraft. Anytime a fighter is patrolling the sky, the air tasking order contains an anchor point or a reliability tanker for emergency refueling. Second, tankers have ample space within the aircraft to house communication as well as sensor equipment. Finally, tankers have large surface areas outside the aircraft and the capability to mount aerodynamic components that can serve as sensor devices.

More Airlift

The National Military Strategy has moved away from fighting two major theater wars to a 1-4-2-1 defense strategy. The four parts of the strategy are (1) defend the United States (homeland defense), (2) deter aggression and coercion in four critical regions, (3) swiftly defeat aggression in two overlapping major conflicts, and (4) upon presidential direction, win decisively against one of the two major conflicts. A new force structure to support the airlift of this strategy would require 302 C-17s and 52 C-5s and the call-up of the Civil Reserve Air Fleet, Stage III.[30] AMC's 2004 planning factors uses a primary mission aircraft inventory (PMAI) of 94 C-17s, 96 C-5s, and 42 C-141s strategic-airlift aircraft in the active duty and reserve.[31] According to Air Force fact sheets, a C-17 can carry approximately 170,900 pounds of cargo,[32] a C-5 can carry approximately 270,000 pounds of cargo,[33] and a C-141 can carry 687,000 pounds of cargo.[34] Given the requirements of the new strategy and the current inventory, it is obvious that the nation is unable to meet the new requirements of a 1-4-2-1 defense strategy when one considers the total amount of cargo that is required by the strategy versus the total amount of cargo that is capable of being airlifted by military aircraft (fig. 2).

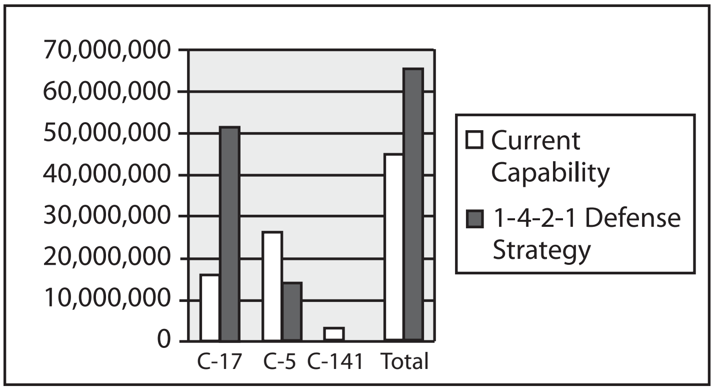

Figure 2. Current cargo capability versus required capabilities in 1-4-2-1 defense strategy.

Tankers, while limited in carrying outsized and oversized cargo, have the capability to carry more cargo than a C-141 and as much cargo as a C-17. According to Air Force fact sheet, *KC-10 Extender*, a KC-10 is capable of carrying 170,000 pounds of cargo, roughly equivalent to a C-17.[35] Likewise, according to Air Force fact sheets, the KC-135 is capable of carrying 83,000 pounds of cargo, which is more than a C-141 and almost half of what a C-17 can carry.[36] With 472 KC-135s and 54 KC-10s in AMC's PMAI, this gives the Air Force an additional 48-million pounds of cargo-lift capability. However, it is impossible to use the entire tanker-cargo airlift capability because of the tanker's requirements to fulfill aerial refueling for combat support and deployment missions. One of the lessons learned from Kosovo was not that the number of tankers was inappropriate but that planning and efficient use of tankers stretched aerial-refueling operations.[37] Tankers can be used more effectively to augment the strategic-airlift mission if planning is more efficient or planning models are used more effectively. Additionally, the total amount of cargo capability is somewhat different when operationally using the capability of a tanker as an airlifter. Air Force Pamphlet (AFPAM) 10-1403, *Air Mobility Planning Factors*, realistically states that a KC-135 can carry 36,000 pounds of cargo on a 3,200-nautical-mile leg because it is limited by the smaller number of pallets it can carry.[38] Tankers of the future must have better airlift capability to provide more options to the supported commanders. Airlift operations require access to shorter runways to deliver cargo closer to the end user. C-17s are designed to land on shorter runways, giving them access to thousands more runways than tankers. Given the number of tankers in the Air Force inventory and the need for airlift, a tanker capable of delivering cargo anywhere would enhance the airlift mission and the flexibility of combatant commanders. However, tankers would need the capability to survive the hostile threats facing airlift aircraft.

Tankers can also give the combatant commander the airlift capability normally received from AMC. Usually, the only airlift the joint forces commander has control of is through the joint forces air and space component commander (JFACC) and the AOC is tactical airlift using the C-130 force. On specific occasions, the tactical control of strategic-airlift aircraft changed to the theater. A temporary change of control over C-17s was done in the Kosovo crisis to move Task Force Hawk from Germany and was considered a "tremendous success story" according to Gen Charles T. "Tony" Robertson Jr., former commander of AMC.[39] It was such a success that General Robertson said, "It's something we're going to have to go back and write into the doctrine as to how that's done."[40] Tankers are assigned to an expeditionary air-refueling squadron and are under the control of JFACC, through the Air Mobility Division (AMD), within the AOC. Tankers are available in numbers to provide the theater airlift the joint force commander requires. However, the current tanker force is unable to act as a theater airlifter due to the risk of threats and the short runways. To use tanker assets to their fullest, JFACCs must develop the same understanding as that of the director of mobility forces (DIRMOBFOR), and the AMD must include in the planning of aerial-fueling capabilities the airlift capability of tanker aircraft. Moreover, a tanker with the airlift capability of a C-17 would give the JFACC the ability to control his or her tanker force in the role of an airlifter.

The recapitalization of the KC-135 is an issue of major importance for the Air Force, AMC, and the Air Force global-reach capability. One proposed solution has brought a lot of discussion and controversy—the leasing of the Boeing KC-767. Much of this controversy has been over the politics involved in the process of leasing the newly proposed tanker with little discussion over its capability. While leasing or purchasing the KC-767 will add many needed capabilities in the short term, a better solution is to design and build a new tanker: KC-XX, capable of multiple roles across the full spectrum of operations, able to survive in the demanding environment of the future, and based on capabilities, not platforms. A newly designed KC-XX is the better choice to fill the needs of the Air Force. Though the KC-XX may not be appealing because of the price, it may stand as an innovation to challenge the mind-set of Airmen.

An additional solution proposed by analysts and not considered a viable alternative in this paper was to again re-engine the aging KC-135. Whereas this would provide additional capability for takeoff payloads and fuel-burning efficiency, it would not address many problems with the age of the aircraft. Corrosion is one of the most pressing issues with the KC-135, and new engines will not fix it. The corrosion of the airframe remains one of the elusive problems with the tanker. It is difficult to predict when and where corrosion will appear and what impact it will have on the aircraft. A catastrophic failure due to corrosion would result in fleetwide grounding, crippling the nation's ability to project airpower due to the reliance on the KC-135 to provide the majority of the aerial-refueling capability. Despite a solution for the corrosion problem, the KC-135 is already over 40 years old and suffers from structural fatigue that cannot be overcome with modifications, short of a complete aircraft rebuild. The problem of age will simply get worse as time goes on, and to re-engine the aircraft will fail to address the sustainability of the aircraft as a future platform.

Full Spectrum of Operations

Future tankers must have the ability to operate across the full spectrum of operations. Tankers must have full access to airfields around the world and provide combat aircraft the fuel required in an expeditious manner. Future tankers cannot be tied to a Cold War strategy and an en route structure limited by runway weight or length restrictions. Future tankers must have the ability to respond to the mission dictates of fighter aircraft, such as quick response to targets or loitering over war zones.

An 8,000-foot NATO-standard runway may no longer suffice for conflicts in the future. The United States' decision to "go it alone" during Operation Iraqi Freedom (OIF) is evidence that the United States cannot expect access to another country's bases and runways. Even with former Soviet bloc countries joining NATO, allowing former inaccessible airfields to now be available, the lessons of OIF points to a world where tankers with the capability of short-field takeoff and landing like the C-17 will be mission critical. At the very least, the next tanker must be able to take off with full loads on smaller runways to open up isolated areas of the world to tanker operations. The KC-767 will allow access to more runways than the current inventory of KC-135s and KC-10s and with full fuel loads. However, will new capabilities built on old standards meet future mission requirements?

The global war on terrorism requires combat aircraft to be available at all times, defending the US homeland from terrorist attracts, such as those launched on 11 September 2001 (9/11) and meeting mission requirements such as the air war over Kosovo. Future tankers must deliver more fuel at a faster rate to ensure mission success.

Today's combat missions require information gathering, early warning, and communication-laden aircraft in and around the fight, limiting the availability of airspace. Large tanker formations add to the problems of confined airspace. Confined airspace requires fewer tankers delivering more fuel. A KC-10 currently delivers as much fuel as two KC-135 tankers. The proposed replacement, the KC-767, can carry roughly the same amount of fuel as a KC-135. While Boeing touts better fuel efficiency and maximum takeoff weight to deliver more fuel to the fight, it requires two KC-767s to do the work of one KC-10. The use of the KC-767 will increase the number of tankers in critical airspace. Additionally, there are no provisions to add a multiple-boom capability to the KC-767. The concept tanker would employ multiple booms providing fuel to multiple aircraft as the KC-10 currently does.

There are COTS aircraft available in the civilian community that are able to deliver large amounts of fuel. However, little has been done to increase the rate of transfer or boom-cycle time. If chosen, a civilian aircraft would immediately require modifications to add multiple booms. Engineering studies have not been accomplished on a COTS aircraft; therefore, it is unknown whether the aerodynamics of a COTS aircraft would allow advances in boom-cycle time. Design studies and engineering of a new tanker could build the use of multiple booms or other modifications into the design of the aircraft. A large tanker with two booms equals two KC-767s using current boom technology. The advantages gained from new engineering would result not only in capability but also would limit the number of tankers and their time exposed to enemy attacks.

Survivability

Tankers of the future must be able to survive in all environments. Of critical importance is the capability to identify and protect the asset during the takeoff and landing phases of flight. Of additional importance is the need to limit the exposure of tankers to attacks by limiting the amount of tankers in a formation. Large deployments to one base or large tanker formations are two examples of putting too many tankers together at one time. Extending the US global reach by using tankers could become an Achilles' heel, one the enemy would be willing to attack to defeat US forces.

Developments in OIF show the enemy has the ability and is willing to attack large susceptible AMC assets. A C-17 was unable to defend itself against SAMs and was hit during takeoff. Gen Richard Myers, chairman, Joint Chiefs of Staff, recounted the "harrowing experience" at the Reserve Officers Association, Mid-Winter Conference, Washington, D.C.[41] In a separate incident, a C-5 was forced to land after being struck by a missile on takeoff.[42] The current aircraft defensive systems (chaff/flares) used to protect airlift aircraft are designed to defeat older enemy technology and do not actively engage incoming missiles. Even though both aircraft were able to land without incident and the attack did not deter further operations, valuable ramp space was required by the battle-damaged jets, which limited ramp operations. Moreover, had the jets been shot down, operations may have ceased completely.

If COTS aircraft (KC-767) are used to replace the current tanker fleet, a bolt-on defensive system of flares or chaff should be added. This system would add weight, create drag, and decrease fuel efficiencies while arguably allowing the aircraft to be susceptible to enemy shoulder-launched missiles. A KC-XX would be able to capitalize on stealth technology and designs used in fighter and bomber aircraft proven successful in limiting heat signatures. Moreover, directed-energy technology that offensively takes action and redirects missiles could be built into the aerodynamic design of a KC-XX. Additionally, the KC-XX could incorporate fuel-cell technology used in AMC's airlift aircraft to increase survivability. Current COTS aircraft are not engineered to survive in combat and utilize wet-wing technology, making them a target for a lone rifleman on the outskirts of an airbase. However, the Federal Aviation Administration recently issued a requirement for "newly manufactured" aircraft to have a system to prevent fuel-tank explosions.[43] Without new technology, lone tankers are a prime target and become a more inviting target for enemy forces when bunched together.

The tanker's large footprint is further amplified when multiple aircraft cells are launched or when large packages are deployed to areas of hostility. The KC-767 is more fuel-efficient than a KC-135. However, the fuel savings are not enough to reduce the number of tankers required in the air or to reduce the ramp space required. The KC-767 promises a 20 percent increase in off-load fuel when compared to the KC-135E.[44] The KC-XX could be designed to carry twice the fuel of a KC-767. Even though a larger aircraft creates a larger footprint than a smaller tanker, a single KC-XX that is able to do the work of two KC-767s would make a smaller signature in the air and on the ground. A large cell requiring six KC-767s would only require three KC-XXs. The new KC-XX would result in savings by limiting the vulnerability to enemy attacks while reducing required airspace and ground requirements in and around the area of operations.

Capabilities Based

The tanker's primary mission is that of being a platform to provide fuel to aircraft. However, a KC-XX designed from the ground up to include joint war-fighting capabilities could provide more than fuel to the battlespace. The KC-767 is a better platform than its predecessor, the KC-135E, but it adds little to the current capabilities needed by the joint war fighter. Tankers can remain airborne on station for long periods. Normally, this capability is used to position a tanker in an orbit to await receivers. The KC-767 can depart with about the same amount of fuel as a KC-135, and through greater fuel efficiency, the KC-767 can arrive at the orbit with more fuel and thus remain on station longer. However, the KC-767 does little beyond providing power sources for add-on capability while in orbit. The KC-XX could leverage the increased orbit time to provide capabilities to the joint war fighter. Due to the long loiter times a tanker is able to sustain, there are capabilities in command and control, sensor, and communication that would make the KC-XX multimission capable. Instead of a modification to add these capabilities to an existing system, the new requirements could be designed into the KC-XX and avoid potential engineering problems. One example of a potential engineering problem was the KC-135's global air traffic management (GATM) upgrade. Newly modified aircraft experienced problems with interfering electrons from existing wiring and systems which caused a delay in fielding the upgraded aircraft. Adding planned zones to the design of the KC-XX would avoid compatibility problems. Additionally, planned zones can optimize the design of the aircraft for field maintenance and increase cargo handling and capacity.

The tanker's primary mission is to get gas to the receiver aircraft. In its new multimission role, the KC-XX would have increased cargo handling and capacity. The COTS aircraft currently used as tankers are limited in the oversize and outsize cargo carried and are not designed to speedily offload cargo in combat environments. They require specialized cargo-handling equipment to reach the high-deck heights of their load. This extra equipment creates a longer logistics tail and the possibility of increased maintenance problems. A KC-XX designed with low-loading heights like the C-17 and combat off-loading through the aft end of the aircraft would not require as much support equipment. This capability would give theater commanders the ability to operationally control the KC-XX strategic-lift-capable tankers without having to work through the prioritization process used to schedule airlift. Additionally, this new strategic-airlift capability would offset the large requirements of a 1-4-2-1 strategy.

Build or Buy?

The final decision for the procurement of a tanker will come down to whether the Air Force should build a tanker from the ground up or buy a COTS aircraft and modify it for military use. While it is natural to propose that the best solution to the tanker recapitalization is to build one, the tanker of the future must meet the current Air Force's fiscal constraints. Additionally, it will take decades to design and replace the current inventory of tankers.

Before considering any solution, Airmen should conceptually think through the capabilities required of a new tanker. The next phase would be to design the tanker including the capabilities and future requirements for a multimission, state-of-the-art aircraft. The design would serve as a baseline for a comparison between a COTS tanker and the KC-XX. Additionally, the design would convey to aircraft contractors the requirements and desires of the Air Force.

If operational needs and mission effectiveness is the criteria for building or buying the next tanker, it is more likely that an extra robust tanker meeting all requirements can be built rather than purchased. A COTS aircraft could be a good platform while still not meeting all performance requirements of the Air Force. However, if the capabilities outlined in this paper were to be included, a COTS aircraft would require major modifications and design changes to meet future tanker requirements. While COTS aircraft may be required as an immediate solution to the current tanker problem, the future of tanker operations will require a different solution. The airlift mission proposed in the KC-XX can serve as an example of how much more effective weapon systems can be when designed from the ground up. Nearly every strategic airlifter from the C-17 back into airlift history has been fielded in this manner.

Conclusion

It is hardly fair to compare the KC-767 to a notional KC-XX. The KC-XX is not constrained by a history and mindset of purchasing existing airline platforms to fulfill the role of aerial refueler. Since the advent of refueling, the role of the tanker has been to be present and off-load as much fuel as possible. The KC-767 only looks to continue this single role, whereas the KC-XX can be multimission while completing its primary mission. When one thinks of an aircraft combat package, only fighters or bombers come to mind. Yet, many times the tanker is called to fly into enemy territory to rescue its receiver when a crisis has developed, and the receiver has burned more fuel than was planned for the strike. This reliance on the tanker has made it an easy target of opportunity in asymmetric warfare. So, is it unfair to dream of a stealthy KC-XX equipped with offensive and defensive systems to combat a direct enemy attack? The KC-767 just cannot compete with such lofty ideas. While at it, why not invent a supertanker with short-field takeoff capability, able to deliver hundreds of thousands of pounds of cargo and carry a standoff-precision-attack capability used to target the enemy using its own sensor-array system. The idea of the supertanker encroaches on other platforms and is unattainable or is it?

While the next tanker may not be the KC-XX described in this paper, the future force structure must take advantage of a capabilities-designed tanker. The next tanker should be a national asset that can correct some longstanding shortfalls. Strike aircraft need gas, a lot of it, and they do not want to hover wasting time to get it. Strapping a boom or drogue to a COTS aircraft will not provide this capability. The next tanker must take advantage of future trends of warfare and bring to the war fighter multimission capabilities that use the orbit time and cargo hauling space of the tanker.

The Air Force must take the first step and design the tanker needed to provide the capabilities that the joint environment needs. While it may not seem feasible to build the "Cadillac" of all tankers, can the United States weather another 50 years of a single-role tanker, continually needing modifications to meet the requirements of the future? The Air Force cannot afford the risks of not having a tanker designed for the future.

The future holds a place for the tanker. The tanker of the future will not look like the tanker of the past. AMC pioneers need to take advantage of trends in warfare and look beyond the gas customer of yesteryear. Decision makers across all services can benefit from the capabilities a tanker can bring to command and control, communication, and sensors, thus linking the war fighter on the ground, in the air, and on the sea to the decision makers in the theater of operations. The next tanker will be a joint-force asset with a prominent role in the battlespace. The future tanker will fill the role of gas passer, but today's air warriors will need to decide if this much-unused enabler will take a multimission role in tomorrow's battle space.

Notes

1. *National Security Strategy of the United States of America*, sec. 3.
2. Ibid., sec. 2.
3. Western, "Sources of Humanitarian Intervention: Beliefs, Information, and Advocacy in the U.S. Decisions on Somalia and Bosnia," 112–42.
4. *National Security Strategy of the United States of America*, sec. 4.
5. Phillips, "DIRMOBFOR," 5 December 2002.
6. AFDD 2-6.2, 5.
7. Narvid, "Strategic Airlift: A Force Structure for the Challenging Future," 5.
8. Sunderman, *Early Air Pioneers*, 176–78.
9. Latner-Needham, *Refueling in Flight*, 3–4.
10. Smith, "Seventy-Five Years of Inflight Refueling: Highlights, 1923–1998," 52.
11. Monday, *The Official Pictorial History of the USAF*, 23.
12. Tankers, *Military Analysis Network*.
13. Burnett, "Control of Mobility Air Forces: Should the Director of Mobility Forces Command?" 65
14. Brady, "Building and Commanding Expeditionary Units: Lessons from Kosovo," 12–21.
15. Ibid.
16. "AMC Plans and Programs, KC-767A: The Aircraft to Begin Our Tanker Recapitalization," 3.
17. Polek, "Tanker Version of 767 Ready for Refit Program."
18. Callens, *Tankers—The Weak Link?*, 43.

19. "Affordable Air Travel," *SAT Annual Progress Report.*
20. Ibid.
21. Fact Sheet, *KC-10 Extender*, October 2003.
22. Isenson and Lindsey, "Kenya Rocket Attack: Is Europe Next?"
23. Ibid.
24. Ibid.
25. "DAHL Plane Hit by Missile in Iraq," *Airwise News*, 22 November 2003.
26. Wortzel, "China's Strategic Intentions and Goals."
27. House, *106-244 Department of Defense Appropriations Bill, 2000.*
28. KAL Gopaul, "Smart Tankers."
29. Miller, *Dominate Logistics: Extreme JTRS-A Combat Data Infrastructure,* 4 April 2003.
30. "AMC Plans and Programs, Air Mobility Requirements for the Future."
31. AFPAM10-1403, 15.
32. Fact Sheet, *C-17 Globemaster,* January 2004.
33. Fact Sheet, *C-5 Galaxy*, August 2003.
34. Fact Sheet, *C-141 Starlifter,* March 2004.
35. Fact Sheet, *KC-10.*
36. Fact Sheet, *KC-135 Stratotanker,* April 2004.
37. Garamone, "DoD Studies Kosovo Lessons Learned."
38. AFPAM10-1403, 12.
39. Schatz, "Theater Airlift Lessons from Kosovo."
40. Ibid.
41. Garamone, "Chairman Calls Reserves a National Treasure."
42. Mathews, "Robins Maintainers Team to Return C-5 to Airlift Rotation."
43. Koch and Lewandowski, "FAA Orders Fuel Tank Safety Systems on Jets."
44. Boeing Company, "Boeing's 767 Tanker Aircraft Delivers More of Everything," news release, 23 April 2004.

Bibliography

"Affordable Air Travel." *SAT Annual Progress Report*, 6 December 2003. http://www.aerospace.nasa.gov/library.

Air Force Doctrine Document 2-6.2. *Air Refueling,* 19 July 1999.

Air Force Fact Sheet. *C-5 Galaxy*. August 2003. www.af.mil/factsheets/factsheet.asp?fsID=84.11.

———. *C-17 Globemaster III*. January 2004. http://www.af.mil/factsheets/factsheet.asp?fsID=86.

———. *C-141 Starlifter*, March 2004. http://www.af.mil/factsheets/factsheet.asp?fsID=93.

———. *KC-10 Extender,* October 2003. http://www.af.mil/factsheets/factsheet.asp?fsID=109.

———. *KC-135 Stratotanker,* April 2004. http://www.af.mil/factsheets/factsheet.asp?fsID=110.

Air Force Pamphlet 10-1403. *Air Mobility Planning Factors*, 18 December 2003.

Air Mobility Command Plans and Programs. "Air Mobility Requirements for the Future." Point paper, 10 September 2003.

———. KC-767A: The Aircraft to Begin Our Tanker Recapitalization. Staff study, 10 January 2003.

Boeing Company. "Boeing's 767 Tanker Aircraft Delivers More of Everything." Boeing News Release, 17 July 2003. http://www.boeing.com/news/releases/2003/q3/nr_030717b.html.

Brady, Maj Gen Roger A. "Building and Commanding Expeditionary Units: Lessons from Kosovo." *Aerospace Power Journal* 14, no. 1 (Spring 2000): 12–21.

Callens, Maj Pierre A. "Tankers—The Weak Link?" Maxwell AFB, AL: Air Command and Staff College, March 1985.

"DAHL Plane Hit by Missile in Iraq." *Airwise News*, 22 November 2003. http//news.airwise.com/stories/2003/11/1069497490.html.

Garamone, Maj Jim. "Chairman Calls Reserves a National Treasure." *Defense Link,* January 2004. http://www.defenselink.mil/news/Jan2004/n01292004_200401291.html.

———. "DoD Studies Kosovo Lessons Learned." *Defense Link*, 14 October 1999. http://www.defenselink.mil/news/Oct1999/n10141999_9910144.html.

Gopaul, Kjall. "Smart Tankers." *Military Information Technology*, 30 March 2003. http://www.mit-kmi.com/archive_article.cfm?DocID=12.

Isenson, Nancy, and Daryl Lindsey. "Kenya Rocket Attack: Is Europe Next?" *Deutsche Welle*, 22 November 2003. http://www.dw-world.de/english/0,3367,1433_A_688486,00.html (accessed 4 December 2003).

Koch, Kathleen, and Beth Lewandowski. "FAA Orders Fuel Tank Safety Systems on Jets." *CNN.com,* 17 February 2004. http://www.cnn.com/2004/TRAVEL/02/17/faa.fuel.tank.system/.

Latner-Needham, C. H. *Refueling in Flight*. London: Sir Isaac Pitman and Son, Ltd., 1950.

Mathews, Lisa. "Robins Maintainers Team to Return C-5 to Airlift Rotation." *AFMC Public Affairs Link,* 1 March 2004. http://www.afmc-mil.wpafb.af.mil/HQ-AFMC/PA/news/archive/2004/March/0301-04.html.

Miller, Scott. *Dominate Logistics: Extreme JTRS-A Combat Data Infrastructure*, 4 April 2003. http://www.geocities.com/dominantlogistics/jtrs.html.

Monday, David. *The Official Pictorial History of the USAF*. New York: Arco, 1971.

Narvid, Maj Juan C. "Strategic Airlift: A Force Structure for the Challenging Future." Course requirement. Newport, RI: Naval War College, May 1998.

National Security Strategy of the United States of America, The. Falls Village, CN: Winterhouse Editions, 2002.

Phillips, Col Scott. "DIRMOBFOR." Lecture. Air War College, Maxwell AFB, AL, 5 December 2002.

Polek, Gregory. "Tanker Version of 767 Ready for Refit Program." *Aviation International News*, 2003. http://www.ainonline.com/Publications/paris/paris_03/pd2tankerspg73.thml.

Schatz, Lt Col Rowayne A. "Theater Airlift Lessons from Kosovo." *Air & Space Power Chronicles*, 10 July 2000. http://www.airpower.maxwell.af.mil/airchronicles/cc/schatz.htm.

Sunderman, Maj James F. *Early Air Pioneers*. New York: Franklin Watts, Inc., 1961.

"Tankers." *Military Analysis Network*, 2 May 1999. http://www.fas.org/man/dod-101/sys/ac/tanker. htm.

US House. *106-244 Department of Defense Appropriations Bill, 2000.* 106th Cong., 1st sess., 1999.

Western, Jon. "Sources of Humanitarian Intervention: Beliefs, Information, and Advocacy in the U.S. Decisions on Somalia and Bosnia." *International Society* 26, no. 4 (Spring 2002): 112–42.

Wortzel, Larry M. "China's Strategic Intentions and Goals." Testimony before the Armed Services Committee of Congress. http://armedservices.house.gov/testimony/106thcongress/00-06-21wortzel.html.