Tanker Acquisition

A Systems Engineering Perspective

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A short examination of air refueling, specifically its past, present, and future, offers valuable insight into the developmental needs of this critical capability. This article seeks not only to showcase an appreciation for the roots of air refueling but also to highlight the requirement for sound systems engineering in conjunction with the creativity and willingness to take risks, as exhibited by our forefathers in the field. These attributes are vital to furthering air-refueling technologies and capabilities as well as refining the somewhat flawed tanker-procurement process employed today.

The Birth of Air Refueling

Lt Col Stanley Dougherty asserts that no aircraft in the US Air Force inventory can conduct responsive global power projection without air refueling; quite simply, tankers are the cornerstone of global reach—global power.[1] Early conceptualizations of air refueling consisted of daring, brute feats of bravery and courage. According to the Office of the Historian at Headquarters Strategic Air Command, the history of air refueling began in 1918 when Lt Godfrey L. Cabot, a US Navy Reserve pilot, began snaring cans of gasoline positioned on floats.[2] This undertaking was designed to test the feasibility of putting fuel on ships in such a way that aircraft could access it and refuel during transatlantic flights. On 2 October 1921, rudimentary flight refueling took place in Washington, DC, when a Navy lieutenant in the rear cockpit of a Huff-Daland HD-4 aircraft used a grappling hook to snatch a five-gallon can of gasoline from a float in the Potomac River. A Long Beach “publicity stunt” marked the first true “air-to-air” refueling on record when Wesley May, a wing walker with a five-gallon can of gasoline strapped to his back, climbed from a Lincoln Standard onto a JN-4 and then poured the gasoline into the tank of the second aircraft. In April 1923, two US Army Air Service de Havilland DH-4Bs demonstrated the feasibility of transferring fuel between aircraft by performing the first in-flight hose contact, all under the direction of Maj Henry H. “Hap” Arnold. Later that year, the Army Air Service conducted its first successful air refueling: Capt Lowell H. Smith, along with Lt John P. Richter, set new records for duration and distance, culminating in one flight of more than 37 hours—made possible by 15 hose contacts. In January 1929, the flight of the *Question Mark* established the practical value of air refueling and tested the endurance of both crew and aircraft. Commanded by Maj Carl A. Spaatz, the modified Atlantic (Fokker) C-2A remained airborne for an astonishing six-plus days until engine problems forced it to land. Two modified Douglas C-1 biplanes played the role of tankers, passing 5,700 gallons of fuel as well as oil, food, and water to the receiver aircraft over the course of 37 hookups.[3] Spaatz, who later became the first Air Force chief of staff, proposed that all future aircraft acquisitions be equipped for air refueling during manufacture.[4]

Spaatz was not alone in his unwavering support for the development of air-refueling capability. Giulio Douhet, the Italian airpower theorist, considered range the defining characteristic that distinguished airpower from land or sea power; in his eyes, extended range equated to strategic effect. During his tenure as Air Force chief of staff (1948–53), Gen Hoyt S. Vandenberg directed that all future tactical aircraft be capable of air refueling.[5] Further, Maj Gen Perry B. Griffith asserted that “no single innovation of recent times has contributed more to air power flexibility than the aerial tanker.”[6] Gen Curtis E. LeMay was such a staunch proponent of air refueling that he declared, “If you gave us money for jet airplanes, I would buy tankers, not airplanes for MATS [Military Air transport Service, ancestor of Air Mobility Command]. . . . I think we would increase our combat capability more in that manner."[7] Dougherty affirms that air refueling still serves as a force multiplier by increasing the speed, range, lethality, flexibility, and versatility of today's airborne weapon systems through the extension of aircraft range to the limit of the aircrew.[8]

At this point, air refueling as we know it today began to develop. In 1948 Boeing proposed the flying-boom concept, and shortly thereafter Strategic Air Command procured the KC-97 (fig. 1). Next came the Dash 80 in 1954 and, finally, in 1957 the first of a generation of tankers still in use today—the KC-135A. Figure 2 depicts the legendary Dash-80 barrel roll, showing the wing inverted with the engines balanced precariously on top. Rumor has it that this particular demonstration was the impetus for proceeding with the purchase of the Dash-80 derivative of the Boeing 707—not the most objective or systems-engineering-oriented approach to procurement that the military tries to adhere to today!

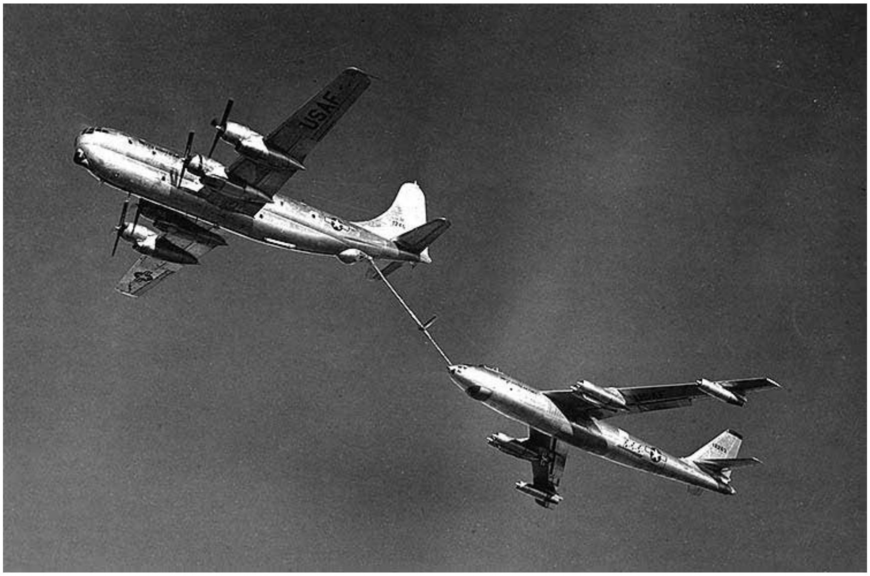

Figure 1. KC-97. (Reprinted from the National Museum of the Air Force, accessed 14 February 2013, http://www.nationalmuseum.af.mil/photos/media_search.asp?q=kc-97&btnG.x=30&btnG.y=8.)

Figure 2. The legendary Dash-80 barrel roll. (Reprinted with permission from Boeing Images, accessed 6 March 2013, http://boeingimages.com.)

Air Refueling Today

Air refueling alleviated strategic airlift's dependence on en route basing, dramatically increasing airlift's effectiveness and efficiency. Specifically, air refueling accelerates the operations of an air bridge—an airborne line of communications linking the continental United States and a combat theater—by reducing or even eliminating refueling stops. In 1991 during Operation Desert Storm, tankers enabled both additional speed and mass of attacks by concentrating combat power at a decisive place and time; they also afforded a vital margin of safety by providing airborne fuel reserves. Air Force officials at US Central Command emphasized the fact that the air campaign depended heavily upon these aircraft: "Tankers were the most critical limitation."[9] The tanker air bridge for Somalia in 1993, which extended nearly halfway around the world, proved that air refueling was a greater force multiplier than previously realized.

The North Atlantic Treaty Organization's (NATO) Joint Air Power Competence Centre (JAPCC) offers vital insight into the international perspective on the role of air refueling. According to the JAPCC, the primary air-refueling effect is "spatial or temporal extension of other air capabilities by providing additional fuel to airborne aircraft."[10] Second-order effects of this extension include enhanced flexibility, fewer operating locations, and increased payload capacity. Further, the JAPCC identifies the relevant measures of merit for the effect as reliably delivering the right amount at the right time in the right place. Consistent with Air Force doctrine, the JAPCC considers air refueling "an enabling or supporting effect instrumental to accomplishing ultimate air effects."[11]

Tanker Procurement and Systems Engineering

Despite the proven significance of air refueling in doctrine, more recent tanker procurement has proven controversial, and the acquisition process has not reflected its criticality. As Maj David Mazzara points out, "Despite its [significant contribution] to airpower, [air-refueling] technology has evolved little in the last 50 years. . . . The Air Force [still] uses the same basic refueling systems designed for Strategic Air Command (SAC) over a half-century ago."[12] Moreover, procurement of the current tanker fleet has occurred in a strikingly similar fashion for each platform: the Boeing 707 became the KC-135, the McDonnell Douglas DC-10 became the KC-10, and, most recently, the Boeing 767 finally became the KC-46. In essence, the procurement of tankers has followed a model of retrofitting an existing airframe for the purpose of the air-refueling mission. Maj Robert Basom emphasizes that

> an enormous advantage of . . . [proceeding in this fashion] is the cost savings, reaped from previous civilian research and development efforts. [An additional] advantage is time compression from design, flight testing, and operational delivery [since] the basic airframe has already received its air-

> worthiness certificate . . . [and only] requires . . . minor testing of the [added] air refueling . . . systems.[13]

On the other hand, the procurement process used thus far contradicts the very fundamentals of good systems engineering, which, according to the International Council on Systems Engineering, is

> an interdisciplinary approach . . . [that includes a] means to enable the realization of successful systems. [It reaches this goal by] defining customer needs and required functionality early in the development cycle, documenting requirements, [and] then proceeding with design synthesis and system validation while considering the complete problem. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. [Finally, it] considers both the business and the technical needs of all customers with the goal of providing a quality product that meets . . . user needs.[14]

Thus, with respect to the field of air refueling, a good systems-engineering approach would suggest that all stakeholders come together to identify capability gaps that the Air Force, as the service provider, then seeks to fill for all of its customers.

A final point on the evolutionary progression of air refueling deals with the United States' enjoyment of a virtual monopoly on air-refueling assets since the mission's very inception. According to the 2012 *Air Mobility Master Plan*, the Air Force's fleet of tankers consists of 59 KC-10s and 414 KC-135s—well over and above that of any other nation in the world.[15] Hence, the service is the primary provider worldwide to Air Force, Navy, and Marine receiver customers, as well as to our coalition and NATO partners who need tanker support. This particular point may contribute to the US military's complacency in the technological and conceptual advancement of this critical mission set.

Air Mobility Command maintains that its overall goal calls for meeting global air-refueling requirements; it acknowledges, however, that those requirements are not expected to diminish in the coming years. In fact, they will most certainly increase over the next 25 years and thereafter, resulting in the need to fill an ever-growing gap in force extension. The two main reasons for this upward trend are the growing challenges of regional antiaccess/area-denial strategies together with the development and fielding of remotely piloted combat air systems, both of which will drive the demand for air refueling above and beyond its current level.[16]

Summary

The Department of Defense must not rest in its pursuit of advancements in the field of force extension. Future war-fighter issues such as antiaccess/area denial are sure to take a greater toll on our aging fleet of tankers, as well as intensify the existing requirement to close the widening force-extension gap. Basing future procurement decisions on sound principles of systems engineering is critical. More importantly, we must be willing to exhibit the bravery and courage of our forefathers in air refueling; only then can we develop effective processes to correct inefficient tanker-procurement practices, particularly in today's fiscally constrained environment. ✪

Notes

1. Lt Col Stanley J. Dougherty, "Air Refueling: The Cornerstone of Global Reach—Global Power," research report (Maxwell AFB, AL: Air War College, 1 April 1996), http://dtlweb.au.af.mil///exlibris/dtl/d3_1/apache_media/L2V4bGlicmlzL2R0bC9kM18xL2FwYWNoZV9tZWRpYS8yNTQ5NQ==.pdf.
2. Office of the Historian, Headquarters Strategic Air Command, *Seventy Years of Strategic Air Refueling, 1918–1988: A Chronology* (Offutt AFB, NE: Office of the Historian, Strategic Air Command, 1990), 1–2.
3. Ibid., 12–13.
4. Dougherty, "Air Refueling," 13.
5. Ibid., 6, 21.
6. Maj Gen Perry B. Griffith, "Seven League Boots for TAC," *Airman* 4, no. 8 (August 1960): 44.
7. Maj David M. Cohen, *The Vital Link: The Tanker's Role in Winning America's Wars*, Fairchild Paper (Maxwell AFB, AL: Air University Press, March 2001), 3, http://aupress.au.af.mil/digital/pdf/paper/fp_0002_cohen_vital_link.pdf.
8. Dougherty, "Air Refueling," 44.

9. Ibid., 36.
10. Joint Air Power Competence Centre, *Future of Air-to-Air Refueling in NATO* (Kalkar, Germany: Joint Air Power Competence Centre, 2007), 2, http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA478072.
11. Ibid., 7.
12. Maj David J. Mazzara, *Autonomous Air Refueling for Unmanned Aircraft Systems: A Cost/Benefit Analysis* (Wright-Patterson AFB, OH: Air Force Institute of Technology, 2009), iii.
13. Maj Robert R. Basom, "Breakaway: A Look at the Integration of Aerial Refueling and Unmanned Aircraft Systems in Future Operations" (master's thesis, US Army Command and General Staff College, Fort Leavenworth, KS, 2007), 55–56, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA471147&Location=U2&doc=GetTRDoc.pdf.
14. "What Is Systems Engineering?," International Council on Systems Engineering, 14 June 2004, http://www.incose.org/practice/whatissystemseng.aspx.
15. Headquarters Air Mobility Command, *Air Mobility Master Plan* (Scott AFB, IL: Headquarters Air Mobility Command, 2012), 80, 84.
16. Ibid., 142.

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