In Search of a Good Host:
A Study of Airborne Aircraft-Carriers

BY

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Approval

The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

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Disclaimer

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

About the Author

Lieutenant Colonel Nate Padgett was born in Washington, D.C. He entered the United States Air Force in May 2005 after graduating from the Georgia Institute of Technology with a Bachelor of Science degree in Computer Science. He served at Joint Base Pearl Harbor-Hickam (HI) and Altus Air Force Base (OK) as a C-17A airdrop instructor and evaluator pilot before staff assignments at the 618 Air Operations Center (Scott Air Force Base, IL) and Special Operations Command (MacDill Air Force Base, FL). He is a distinguished graduate of the United States Air Force Weapons School, Squadron Officer School, and the Naval Postgraduate School, where he earned a Master of Science degree in Defense Analysis with a focus on Special Operations and Irregular Warfare. As a senior pilot with more than 2,700 flight-hours, he has commanded mobility missions in the Pacific, Northern, European, and Central Command regions.

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Abstract

As technological advances appear to indicate a possibility of the US Air Force returning to utilize airborne aircraft-carriers, I look to the past. In the last 100 years, the US military has attempted to create multiple flying aircraft-carriers, yet none of them operate today. This study examines what happened in some of those trials, where they succeeded and failed, and derives recurring themes from the attempts as potential guidelines for future carrier efforts.

To accomplish this, I first suggest a break from using the airborne aircraft-carrier term and instead to use Airborne Vehicular-Launch-Platform (AVLP). I then examine three cases in depth. They include the US Navy's rigid airship program and two from the US Air Force: the Fighter Conveyance program and the *Lightning Bugs* unmanned aircraft. From my analysis, I provide technological, logistical, operational, and administrative findings.

The study finds that AVLPs create logistic and tactical advantages in some operations. Moreover, it concludes that the airships failed as a viable platform, while the other two attempts succeeded. Key facets like iterative and modular designs, the enabling of longer sorties for launchable assets, multi-mission capability, and the existence of a military advocate appear to correlate with successful programs. I close with a brief analysis of current AVLP efforts and the particular challenges they may face.

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Chapter 1

Airborne Aircraft-Carriers

The concept of using one aircraft to carry and launch another dates back to at least 1916. The British tested launching a single-seat fighter, a Bristol Scout, from a Felixstowe flying boat as the embodiment of the theory that they could use such a system to target German Zeppelins.[1] The British never employed this tandem in operations, but military theorists continued to maintain interest in the ability to leverage the range of a larger mothership, and the tactical capability of the smaller in the objective area. As with many military innovations, the trials and existential threat from war spurred thinkers to design a novel use for existing assets.

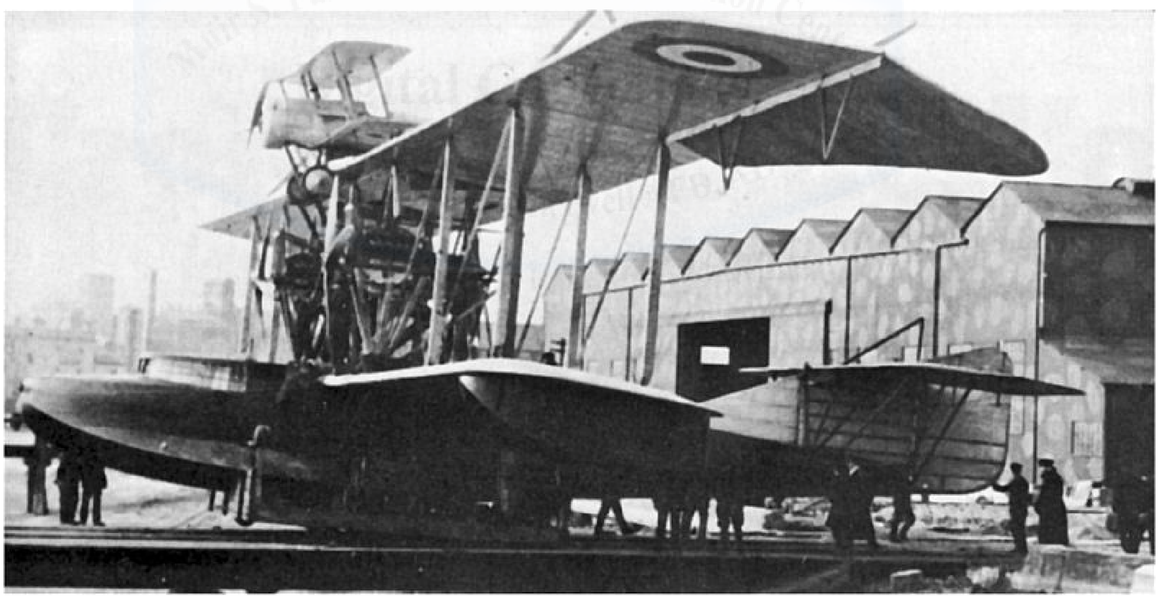

Figure 1 - A Bristol Scout Atop a Felixstowe Flying Boat
Source: Peter M. Bowers, *Unconventional Aircraft*, 1st ed (Blue Ridge Summit, Pa: TAB Books, 1984), 212.

[1] Peter M. Bowers, *Unconventional Aircraft*, 1st ed (Blue Ridge Summit, PA: TAB Books, 1984), 212.

The designers, names, and purposes have changed, but the allure of airborne aircraft-carriers (AACs) appears to be an enduring enticement to aviation innovators. Over the ensuing decades, multiple military services and nations have attempted to create AACs, but militaries still generally do not have or use them. This study seeks to more fully understand why that is by examining three AAC attempts by the US military in the 20th century: the US Navy's rigid airship program from the 1930s, the US Air Force's (USAF) Fighter Conveyance (FICON) program in the 1950s, and the Vietnam-War era *Lightning Bug* unmanned aircraft. Before turning to discussion and analysis, however, a review of terminology and concepts is in order.

Terminology and Concepts

Despite the diversity of systems, a few common terms permeate the AAC literature. While innovators have imagined a breadth of purposes and platforms for the air-launch mission over the years, the individual actors of the AAC construct are usually referred to as *host* and *parasite*. The carrier is the host, and its launchable asset is the parasite.

One logically understands the parasite moniker to imply a one-way positive relationship, but that is not completely accurate, and the reality of the actual relationship is important. As the case studies demonstrate, the interplay between the two assets is largely symbiotic. Generally, the host derives benefit from the parasite's ability to conduct a portion of the overall mission for which the larger aircraft cannot accomplish as effectively or at all. The parasite, in all of this study's cases, gains the benefit of the host's longer range and usually other advantages. While carrying another aircraft does cause operational penalties for the host, designers have paired the two under the belief that the synergistic effect of the tandem outweighed the cost to the individual.

The second term is *Airborne Aircraft-Carrier* itself. This term is not as universal, and some authors simply refer to program names instead of providing a broader categorization. However, using AAC as the category's title may actually be misleading. While it is generally the term authors use in the existing literature, it connotes more generally a flying version of the massive seaborne one. Thinking in that fashion drives one to think of an AAC needing to be a large vessel, as creators of science fiction works sometimes describe or depict it. This is a faulty construction and limits the conceptual space.

For this study, I use Airborne Vehicle-Launch-Platform (AVLP, "av-lip") to describe the host as an attempt to provide the necessary distinction from its seaborne cousin. If military theorists continue to refer to launch platforms as "aircraft carriers," their audiences are likely to understand them and consider their utility within the paradigm of naval carriers. This cognitive binning may then cause one to mistakenly compare the capabilities of a single aircraft to the combat power of a Carrier Strike Group. An AVLP is different in kind and the fundamental difference between the two is largely due to a fundamentally contrasting trait: temporality.

A naval aircraft-carrier provides persistent presence. It is a symbol of the might of the US Armed Forces and American military prowess. Between its organic airpower and the cumulative strength of the Carrier Strike Group, the Navy can maintain a position and conduct military operations in all but the most difficult conditions. But getting a large force to a strategic position may take days, or even weeks.

Most modern AVLPs would likely be able to reach such a position in hours. However, their ability to stay aloft while conducting launch and recovery operations and their operational capacity will remain significantly less than the naval variant for the foreseeable future. Thus, it is important to understand the fundamental differences between what the two systems offer.

Specifically, the carrier group provides persistent forward presence with generally unmatched offensive capability. A single, or even squadron of AVLPs would likely not be able to offer the longevity of operations, but may be able to provide asymmetric force-projection options on tighter timetables. Additionally, when combined with global-reach enablers like air-refuelers and multipliers like the USAF's en route logistic structure, an AVLP could offer a tailorable solution to a variety of strategic problems ranging from humanitarian crises to major war.

As with war itself, an aircraft carrier's nature is unchanging, but the character of the sea and air variants differ. The temporal trait of the two types of carriers is best understood as an amalgamation of effects across time and space. Each carrier's character is defined by its purpose, response time, persistence, and the time it takes to enable logistics for operations. The strengths of one are the potential weaknesses of the other. As a utility asset potentially capable of operating in diverse mission sets, AVLPs could offer the Department of Defense (DOD) another mechanism to address the logistic problem of forward basing and mission generation. Ultimately, aircraft carriers of the sea or sky serve as a means to mitigate the tyranny of distance.

Strategic Problem

Access matters. One need not be Clausewitz or Sun Tzu to grasp the fact that for a military to be successful in conducting its operations, it must be able to project power into a contested or geographically remote region. While military theorists have traditionally portrayed force projection through concepts such as interior and exterior lines of communication, offensive operations in neighboring countries, or naval power as an enabling force for ground operations, the 20th century showcased increasingly powerful militaries which found themselves suddenly with an unprecedented level of mobility and lethality.

The airplane obliterated traditional understandings of battlefronts and safe havens as the aviators soared above "impenetrable" lines of troops and began to assault the people on the surfaces beneath them. The effects of Douhet's offensive theories, albeit without all the promised results, forced theorists and strategists to address the critical defensive aspect of denying access in this new medium.[2] Defensive capabilities continued to improve toward the end of the century, with a focus on overlapping acquisition and targeting radars coupled with surface-to-air missiles (SAM) and fighter aircraft.

In modern conflicts, geographic factors will continue to define much of how the US military components operate. Theorists from A.T. Mahan and Julian Corbett to John Mearsheimer have noted how oceans serve as a "forbidding barrier"[3] to opposition forces. As the US military retools for 21st century Great Power competition, the ability to project power across oceans is of foremost importance.

Alliances and partnerships may allow for basing and overflight, but the expeditionary power of a carrier group enables forward presence, force projection, and a logistic foothold into geographically separated locations. Yet the days of aircraft carriers operating in high-threat environments is potentially drawing to a close. Military leaders,[4] academics,[5] and journalists[6] point to Chinese and Russian shore-based

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[2] Giulio Douhet, *The Command of the Air*, 1921st, Reprint ed. (Tuscaloosa, A.L.: The University of Alabama Press, 2009); Phillips Payson O'Brien, *How the War Was Won: Air-Sea Power and Allied Victory in World War II (Cambridge Military Histories)* (Cambridge University Press, 2015); Daniel T. Schwabe, *Burning Japan: Air Force Bombing Strategy Change in the Pacific* (Lincoln: Potomac Books, an imprint of the University of Nebraska Press, 2014).
[3] John J. Mearsheimer, *The Tragedy of Great Power Politics* (W. W. Norton & Company, 2003), 114; Julian Stafford Corbett, *Some Principles of Maritime Strategy* (Annapolis, M.D.: Naval Institute Press, 1988); A. T. Mahan, *The Influence of Sea Power Upon History, 1660-1783* (New York, N.Y.: Dover Publications, 1987).
[4] Patrick M. Shanahan, "Missile Defense Review: 2019," 2019, https://permanent.access.gpo.gov/gpo115034/2019-MISSILE-DEFENSE-REVIEW.PDF.
[5] Caitlin Talmadge, "Would China Go Nuclear? Assessing the Risk of Chinese Nuclear Escalation in a Conventional War with the United States," *International Security* 41, no. 4 (2017): 50–92, https://doi.org/10.1162/ISEC_a_00274; Andrew S. Erickson et al., "Correspondence: How Good Are China's Antiaccess/Area-Denial Capabilities?," *International Security* 41, no. 4 (2017): 202–13, https://doi.org/10.1162/ISEC_c_00278.
[6] "Aircraft-Carriers Are Big, Expensive, Vulnerable—and Popular," *The Economist*, November 14, 2019, https://www.economist.com/briefing/2019/11/14/aircraft-carriers-are-big-expensive-vulnerable-and-popular; "Aircraft-Carriers Are under Threat from Modern Missiles," *The Economist*, November 14, 2019,

threats to carriers, which more generally are applicable to any military with precision surface-to-surface munitions (especially hypersonic missiles).[7] As these capabilities and others preempt some of our expeditionary capabilities, we may be able to regain some capability through the use of AVLPs.

Research Question

Regardless of one's opinion on the future of carrier employment, should the US continue to maintain its current global security posture, the necessity of expeditionary power projection is likely to endure. In such a context, military strategists must consider elements of access, presence, and concentration. An AVLP may provide all or a portion of these elements to the joint force.

In nearly every decade of aviation history, there has been some attempt to create or utilize an AVLP. Although theorists and engineers have worked on AVLP designs for years, the USAF does not currently have a standing capability. This research looks to the past to find examples of AVLPs, examine their stories, and explicate the causes underlying leaders' decisions to terminate the programs.

Additionally, should the DOD desire to create another AVLP, whether it be a new aircraft or modification of an existing one, military proponents should be armed with a historical understanding of why previous programs fell out of use and what the common challenges of AVLP implementation may be. While an AVLP will almost certainly not answer all strategic logistic challenges, it could add another element to the nation's warfighting portfolio. Most notably, one that should be a practical utility for operators to use across the range-of-military operations. For these reasons, this study seeks to answer the following questions:

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https://www.economist.com/leaders/2019/11/14/aircraft-carriers-are-under-threat-from-modern-missiles.

[7] Shanahan, "Missile Defense Review: 2019," 18–19.

Why have airborne aircraft-carrier experiments ended and were there recurring themes which led to their success or failure?

Methodology

To address these questions, I conducted a qualitative historical analysis of three substantial efforts by the US armed services to create and employ AVLPs: the US Navy's rigid airships, USAF's FICON program, and the USAF's Vietnam-War era *Lightning Bugs*. This list is not inclusive of all the endeavors and does not cover the entirety of the conceptual space, but it does highlight each of the US military's primary efforts to realize the concept. In an effort to scope the topic, the study had to neglect some trials and designs.

The majority of those cut were designs which never went beyond prototype status or even made it to the flight line. The efforts I selected showcase major advances in technological design across multiple eras. Omissions from US efforts include test platforms like the B-52 carrying an X-15, transporters like Boeing's 747 Space Shuttle Carrier, and short-lived test programs like the Teledyne-Ryan YBQM-145A program.[8] Other programs have important aspects which furthered the technological and operational paradigms, but the characteristics of the programs are generally analogous to the three cases in the study.

[8] Yvonne Gibbs, "NASA Dryden Fact Sheets - X-15 Hypersonic Research Program," NASA, August 13, 2015, http://www.nasa.gov/centers/armstrong/news/FactSheets/FS-052-DFRC.html; William Wagner and William P. Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)* (Leicester, UK: Midland Publishing Limited, 1992), 189–91.

Figure 2 - NASA's X-15 Hypersonic Aircraft
Source: Gibbs, "NASA Dryden Fact Sheets - X-15 Hypersonic Research Program."

Figure 3 - Test F-4 Carrying a BQM-145A Reconnaissance Vehicle
Source: Joseph Trevithick and Tyler Rogoway, "The U.S. Sold This Unique Stealth Drone Called 'Scarab' To Egypt In The 1980s," The Drive, November 17, 2018, https://www.thedrive.com/the-war-zone/24966/the-united-states-sold-egypt-this-unique-stealth-recon-drone-called-scarab-in-the-1980s.

To analyze the AVLP subject, each chapter provides a similarly structured analysis of each case. Within the chapters, I outline the historical context surrounding the AVLP's development, the strategic problem it addressed, and its purpose. After establishing the history, I analyze the AVLP through the following lenses: Technology; Logistics and Operational Support; Employment and Doctrinal Integration; and Politics, Economics, and Military Leadership. Finally, I offer concluding comments regarding whether the asset succeeded or failed in its purpose and the conditions underpinning its removal from the active inventory. Ideally, the entirety of the analysis should reveal common traits which help us to understand positive and negative aspects of AVLP development and operations. These qualities, in turn, may serve to support our future efforts.

Without a full appreciation for the history, it is easy for one to presume that technological gaps were the culprit and that modern technology obviates these archaic challenges. While available and suitable technology is likely a highly-correlated, if not causal factor for failure, the contextual ecosystem which affected whether the services found AVLPs palatable is worth exploring. The losses and expenses in development were often no worse than any other major military technological advancement, yet the force behind the movement lacked the ability to overcome systemic institutional resistance to change or political factors blocking development.

An AVLP is not going to be a silver bullet; it will not win a war on its own. However, access matters. In some cases, this means the US will need superior firepower and next-generation capabilities which can punch holes in defenses. Yet, not every problem is a nail for our most-lethal assets to hammer. I inspect AVLP utility and underlying military facets to examine whether they can deliver tailorable effects to match the contextual needs of a military operation. Furthermore, I seek to understand if they can create those effects in the air; the domain in which the US can project power with considerably greater speed than with its ocean-bound brethren. The effects will not be the same and one AVLP will not be equivalent to a naval aircraft-carrier, but then, that is potentially its greatest strength.

Chapter 2

Cities in the Sky

History and Context

The concept of using air vehicles to first observe and then attack ground targets has been around for centuries.[1] The first balloon flew in 1783 and toward the latter portion of the 19th century, as the concept of a dirigible became more practical the theoretical concepts of air-based attack started to become reality.[2] The 1870s saw the French, and then British, become the first to create permanent elements of air forces inside of their militaries.[3] In the following decade, "ballooning units appeared in the armies of Russia, Germany, Italy, and Spain."[4] Rapid advances in technology and theory followed in-turn.

The stalemate and heavy loss of life which resulted from trench warfare led theorists like Giulio Douhet to argue for the aircraft's primacy and ability to win a war on its own.[5] However, not all military leaders and theorists believed in this future, and certainly not those army and navy officers entrenched in their pre-aviation paradigms. In the US, while the celebrated Brigadier General Billy Mitchell advanced his arguments for an independent and strategic air force, he also saw great promise in the use of airships to support both commercial and, ultimately, military aviation.[6]

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[1] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945*, Princeton Studies in International History and Politics (Princeton University Press, 2004), 12.
[2] Lee Kennett, *The First Air War: 1914-1918* (Free Press, 1999), 3–4.
[3] Kennett, 3.
[4] Kennett, 3.
[5] Douhet, *The Command of the Air*, 14, 98.
[6] William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power--Economic and Military* (Tuscaloosa, AL: University of Alabama Press, 2009), xix, 39, 90–92.

In much the same way that armies initially saw aviation's applicability to the reconnaissance mission, the US Navy (USN) made a similar judgment. The fundamental difference, however, was the scope of the tactical problem for the Navy: the ocean, as renowned naval theorist Julian Corbett notes, is vast and supports a "particular free and secrecy of movements at sea."[7] The need for flexibility in counter-sea operations and importance of early warning is essential to a navy's ability to counter an enemy's deceptive division and subsequent recombination.[8] The first airships then, were to be scouting vessels for the fleet.[9] This is a logical pretext, given both the Navy's operational role and the more general strategic environment for the US.

Strategic Problem

As American naval theorist A.T. Mahan posits in his six sea power principles, the US geographic position and its physical conformation forced the nation to look to the sea for external threats.[10] The USN was particularly concerned with the size of Japan's navy and the potential that an "enemy fleet could disappear for a few days or weeks and arrive either at Panama or Puget Sound without being intercepted"[11] similar to how the "the Spanish Fleet had in 1898."[12] As the US retrenched into isolationism, its military, and specifically its navy, looked to address the problem of defending two oceans. Some military theorists believed airships could assist with long-range reconnaissance and patrols.

At the time, rigid airships offered triple the speed of surface ships, substantially more cargo-carrying capacity than any of the era's

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[7] Corbett, *Some Principles of Maritime Strategy*, 133.
[8] Corbett, 133–34.
[9] William F. Althoff, *Sky Ships: A History of the Airship in the United States Navy*, 25th anniversary edition (Annapolis, Maryland: Naval Institute Press, 2016), 4.
[10] Mahan, *The Influence of Sea Power Upon History*, 28–35, 42–44.
[11] Herbert V. Wiley, "Value of Airships," *Proceedings* 60, no. 375 (May 1934): 670.
[12] Richard K. Smith, *The Airships Akron & Macon: Flying Aircraft Carriers of the United States Navy* (Annapolis, MD: United States Naval Institute, 1965), xx.

airplanes, and at least ten times the range of 1920s aircraft.[13] With the challenge from the vastness of the ocean along with a potential asset to exploit the air medium, the USN seemed ready to proceed to its next phase. It just needed an airship to test the ideas.

Beginnings: The USS *Shenandoah* (ZR-1) and USS *Los Angeles* (ZR-3)

One can broadly define airships as propellable and steerable lighter-than-air (LTA) aircraft. Rigid airships differ from blimps in they have a framed hull instead of a structure supported by just an LTA gas. The USN had experimented with nonrigid airships as early as 1915, and even hoped to use them against the German submarine fleet.[14]

The first US-built rigid airship, the *USS Shenandoah* (ZR-1), was to be the first in a succession of military and commercial airships.[15] However, the Navy lost its chance to benefit from training and operational learning on the ZR-2, a British craft, as it crashed before it could even come to the US. Therefore, as engineers and military leaders prepared ZR-1 for its unveiling, virtually every aspect of large-airship "operations [remained] almost entirely new to the Navy."[16] ZR-1 launched on August 20, 1923 to much public and military fanfare, but immediately faced difficulties at both its home base and in executing operations.[17]

Even without ZR-2, the Navy learned a great deal about airship operation from the *Shenandoah*. The ship ran into trouble multiple times with its mooring and weather at Naval Air Station (NAS) Lakehurst, New Jersey, and with storms while airborne.[18] The USN also tested mooring

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[13] Smith, xxi.
[14] Althoff, *Sky Ships*, 4–6.
[15] Althoff, 20.
[16] Althoff, 16–18, 29.
[17] J. Gordon Vaeth, *They Sailed the Skies: U.S. Navy Balloons and the Airship Program* (Annapolis, Md: Naval Institute Press, 2005), 26; Althoff, *Sky Ships,* 29.
[18] Althoff, *Sky Ships*, 34-35, 37.

operations at sea with a converted oiler ship, the *Patoka.*[19] Yet the newness of all of these operations and lack of logistic support led the Bureau of Aeronautics (BuAer) chief, Admiral Moffett, to prevent the *Shenandoah* from engaging in any substantial ocean exercises.[20] However, in October 1924, the ZR-1 did successfully conduct a transcontinental round-trip in which the crews learned flight dynamics, helium conservation, and temporary mooring techniques.[21]

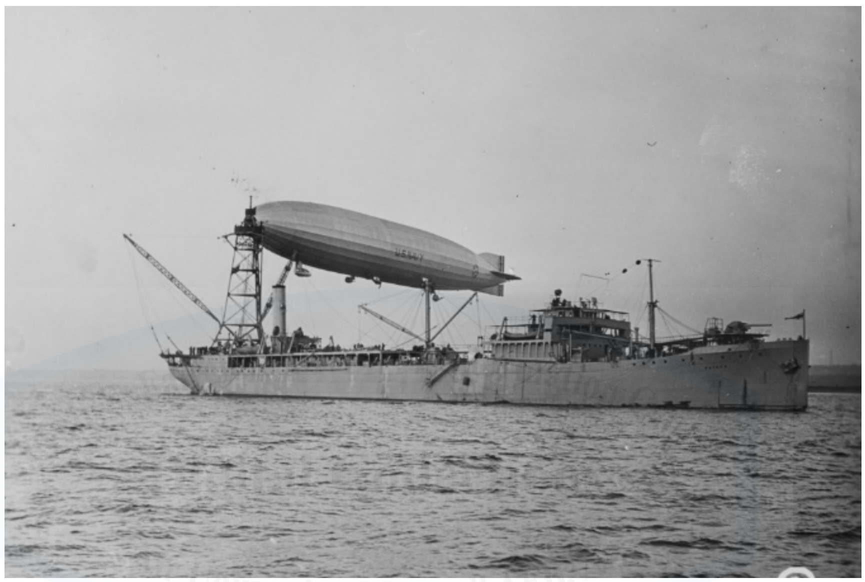

Figure 4 - The USS *Shenandoah* (ZR-1) and USS *Patoka* Conducting Mooring Operations
Source: Naval History and Heritage Command, "1920–1929," 1920-1929, September 13, 2019, https://www.history.navy.mil/browse-by-topic/communities/naval-aviation0/1920-1929.html.

Unfortunately, the *Shenandoah* needed repairs and had also used a substantial portion of the Navy's helium budget in its transcontinental mission.[22] Additionally, the Treaty of Versailles had virtually eliminated the German airship industry (restrictions later canceled in 1925) and

[19] Vaeth, *They Sailed the Skies*, 29-30.
[20] Althoff, 43.
[21] Althoff, 44–45.
[22] Althoff, 46.

paved the way for a "partnership arranged between the Goodyear Tire and Luftschiffbau Zeppelin which, in the fall of 1923, created the ancillary Goodyear-Zeppelin Corporation."[23] As part of war reparations, Zeppelin manufacturers built an airship for the USN. This airship, the USS *Los Angeles* (ZR-3), crossed the Atlantic Ocean and arrived in New Jersey on 15 October 1924.[24] It served as the test and training platform during the construction of the larger rigid airships, the USS *Akron* (ZR-4) and *Macon* (ZR-5).[25]

With two airships but only enough helium budget to support one, the *Shenandoah* sat largely unused for months until finally it was re-inflated in June 1925 when the *Los Angeles* needed repairs.[26] While this first integrated fleet-airship operation was an important milestone in airship and Airborne Vehicle-Launch-Platform (AVLP) history, it also tragically set the stage for the *Shenandoah's* crash on September 3, 1925 during a violent storm. ZR-1 met the same fate as its sister-ship, the ZR-2. BuAer maintained suspicion that modifications to the airship's air-venting valve system, an effort to limit helium loss, may have rendered the ship harder to control in the storm.[27] Regardless, the Navy learned that its airships needed to have substantially stronger frames to handle the forces of nature. The *Akron* and *Macon* would both have significantly strengthened hulls, and coincident weight penalty, as a result.

Practicing for the Future

One of the pivotal challenges engineers needed to solve in order to create an AVLP was how to launch and recover airplanes. The first airborne link-up between a blimp and an airplane took place on 15 December 1924. On that day, Army First Lieutenant Finter successfully

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[23] Smith, *The Airships Akron & Macon*, 7.
[24] Vaeth, *They Sailed the Skies*, 32.
[25] Althoff, *Sky Ships*, 58.
[26] Althoff, 48.
[27] Althoff, 47–49.

hooked his Sperry Messenger bi-plane onto fellow First Lieutenant McKee's TC-3 blimp.[28] Continued testing led Goodyear-Zeppelin innovators to forward the army's design by creating a trapeze-like system, which was a "landing bar or yoke at the lower end of a rectangular frame structure extending beneath the airship."[29] The Navy borrowed this idea for its platforms.

The Navy formalized its AVLP venture with the *Los Angeles* when they installed a trapeze apparatus in December of 1928.[30] The trials did not actually begin until the following summer, when 4 of the 15 hook-on attempts were successful, with issues stemming from aerodynamics to mechanical failure.[31] By August, improvements to the hook-on mechanisms and pilot proficiency allowed for public demonstration. Overall, the success of trapeze trials drove the Navy to believe that an AVLP employment model was the right way ahead with the larger rigid airships.[32] As the *Akron* prepared to emerge from its factory cocoon in Ohio, emotions in the US ranged from indifference, due to pressing concerns about the Great Depression, to excitement over what this new age of aviation may mean to the country.

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[28] Bowers, *Unconventional Aircraft*, 258; Smith, *The Airships Akron & Macon*, 21.
[29] Althoff, *Sky Ships*, 81.
[30] Smith, *The Airships Akron & Macon*, 21.
[31] Smith, 21–23.
[32] Althoff, *Sky Ships*, 81.

Figure 5 - USS *Los Angeles* with its Parasite
Source: San Diego Air and Space Museum, USS *Los Angeles* ZR-3, n.d., n.d., https://www.flickr.com/photos/sdasmarchives/15323626075/.

LTA Carriers: USS *Akron* (ZRS-4) and *Macon* (ZRS-4)

Mrs. Lou Hoover, the wife of President Herbert Hoover, christened the USS *Akron* in early August of 1931 in the midst of one of the worst years of the Great Depression. The federal government hoped the airship's name would serve as a beacon of hope to the people of the rubber-manufacturing city ravaged by the economic downturn.[33] A giant aircraft at 785 feet in length, 144 feet wide, and 155 feet tall (imagine 8 C-130s in a row stacked 4 high) the *USS Akron* was an engineering marvel.[34] As the first true American AVLP, its massive size provided it with room for five fighter planes in its 75' x 60' hangar located in the front third of the airship, although structural design errors limited it to only three fighters.[35] By the time Admiral Moffett's wife christened the

[33] Robert Cressman, "Akron (ZRS-4)," May 4, 2017, https://www.history.navy.mil/research/histories/ship-histories/danfs/a/akron.html; Douglas V. Smith, ed., *One Hundred Years of U.S. Navy Air Power* (Annapolis, Md: Naval Institute Press, 2010), 47.
[34] Smith, *The Airships Akron & Macon*, 194.
[35] Vaeth, *They Sailed the Skies*, 72; Smith, *The Airships Akron & Macon*, 67.

USS *Macon* in March of 1933, a full complement of five Curtiss F9C-2 *Sparrowhawks* could come aboard.[36]

Figure 6 - A Floating City: the USS *Akron*
Source: "NH 44099 USS Akron (ZRS-4)," accessed April 14, 2020, https://www.history.navy.mil/content/history/nhhc/our-collections/photography/places/washington-dc/main-navy---munitions-buildings/nh-44099-uss-akron--zrs-4-.html.

The F9C-2 *Sparrowhawk*, a derivative of two 1931 test platforms for traditional carrier-based aircraft (the XF9C-1 and XF9C-2), measured approximately 25 x 20 x 7 (length, width, height) feet.[37] Though not explicitly designed for the AVLP service, its smaller size was helpful not only for fitting within the internal storage, but also for weight considerations onboard the AVLP.[38] Additionally, the plane needed to fit

[36] Althoff, *Sky Ships*, 106; Smith, *The Airships Akron & Macon*, 67.
[37] Ray Wagner, *American Combat Planes*, 3d, enl. ed. (Garden City, NY: Doubleday, 1982), 141; Smith, *The Airships Akron & Macon*, 201.
[38] Althoff, *Sky Ships*, 92.

through a T-shaped door which the airship's trapeze utilized during launch and recovery operations.

Figure 7 - Curtiss F9C-2
Source: "NH 98098 Curtiss F9C-2," accessed April 14, 2020, https://www.history.navy.mil/content/history/nhhc/our-collections/photography/numerical-list-of-images/nhhc-series/nh-series/NH-98000/NH-98098.html.

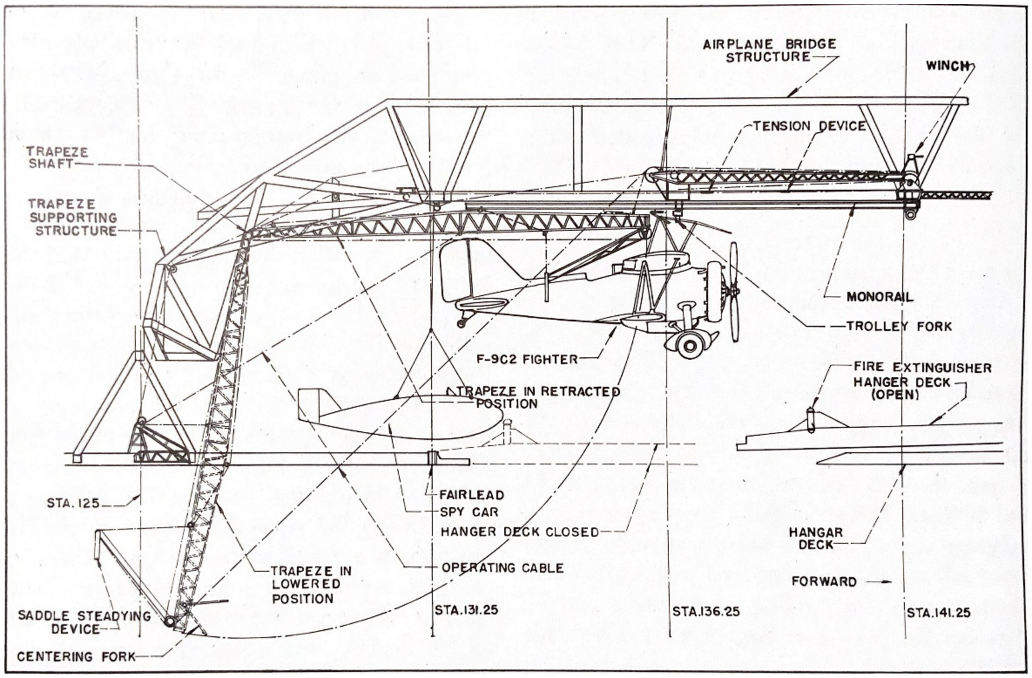

Figure 8 - Trapeze Mechanism with F9C-2 Fighter and Spy Car
Source: Smith, *The Airships Akron & Macon*, 202.

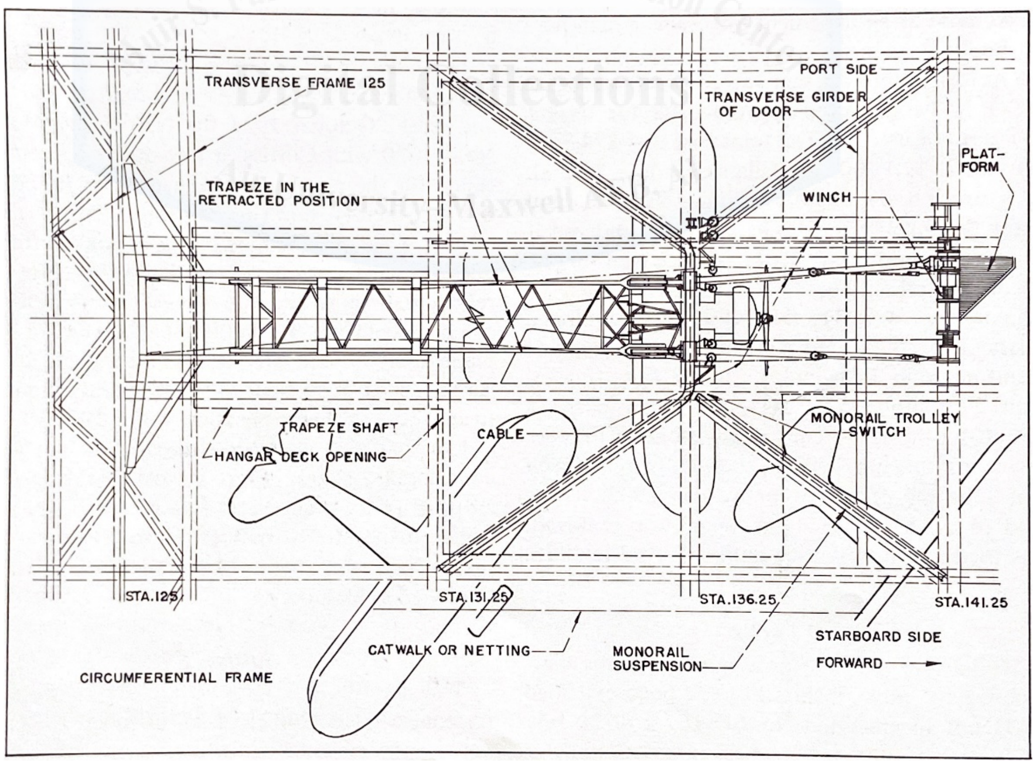

Figure 9 - Overhead View of Trapeze and Storage Configurations
Source: Smith, *The Airships Akron & Macon*, 202.

With its aircraft on-board, the *Akron* "had the potential to provide the fleet with [an] unprecedented intelligence-gathering capability."[39] At the outset, however, military theorists believed the aircraft would serve a defensive role, with the airship itself as the tactical scout.[40] The airship's vulnerability due to large size, slow speed, and permeable skin was also of constant concern to Navy officials (of note, helium does not burn like hydrogen, but if the airship received structural damage from an enemy aircraft attack it could still quickly become unflyable).[41]

The *Akron* began flight operations on September 25, 1931 and completed its first hook-ups with airplanes on May 3, 1932.[42] One Consolidated N2Y (an earlier parasite model) and a Curtiss XF9C-1 were able to test the trapeze system which engineers had only recently installed on the *Akron* in February 1932.[43] However, in the airship's first 9 months of operations, it often flew without its aircraft onboard.[44]

As the preferred F9C-2s were not available for airship operations until the fall, crews conducted initial parasite operations using the N2Ys.[45] However, a combination of N2Y hooking issues and, more importantly, the Navy's prevailing operational theory that the airship should conduct its own scouting missions, obscured the need for parasites.[46] Representative of that mindset was the *Akron's* "spy car" (or spy basket) concept which was essentially a tethered tiny airplane with a telephone cord.[47] The tactical idea was that an airship could remain

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39 Smith, *One Hundred Years of U.S. Navy Air Power*, 48.
40 Althoff, *Sky Ships*, 99.
41 Smith, *The Airships Akron & Macon*, 58.
42 Smith, 180; Cressman, "Akron (ZRS-4)."
43 Cressman, "Akron (ZRS-4)"; Smith, *The Airships Akron & Macon*, 47.
44 Smith, *The Airships Akron & Macon*, 51–62.
45 F9C-2s were ordered at the end of 1931 and not available for flight testing with the *Akron* until June of 1932. They became the operational aircraft for the LTA units in September when they moved to Lakehurst (Smith, 203).
46 Smith, *The Airships Akron & Macon*, 59.
47 Smith, 55.

masked by clouds from ground observation while the manned spy car dangled up to 1000-feet below the platform and communicated its findings.[48] Trials of this concept failed on both the *Akron* and *Macon* due to extreme aerodynamic control issues.

Figure 10 - Lt Howard Young's XF9C-1 hooks up to the Akron's trapeze 3 May 1932
Source: "80-CF-4184-14 Curtiss XF9C-1," accessed April 15, 2020, https://www.history.navy.mil/content/history/nhhc/our-collections/photography/numerical-list-of-images/nara-series/80-CF/80-CF-4184-14.html.

The *Akron* was only the "seventh rigid airship built in the world since 1919"[49] and as such, its crew learned much of the airship's operational capability and limitations from practice. Unfortunately, as such a large and expensive vessel, these growing pains generated ripple effects throughout the traditional deep-water Navy. Airship personnel

[48] Smith, 55.
[49] Smith, 45.

and advocates steadily competed for prestige and purpose while striving to meet tactical and strategic objectives.

The newness of the platform also led to issues during "routine" operations. Without advanced weather analysis capabilities from either the ground or the air, the *Akron* often found itself in the same undesirable weather conditions which had felled the *Shenandoah* years prior. Most aviators have a healthy fear of ice formations on lift-generating surfaces, and events such as the January 1932 one where "eight tons of ice formed on [the *Akron's*] hull"[50] due to inadvertent weather penetration simultaneously represented the airship's structural resilience and its vulnerability to the elements.

An airship's problems were not even limited to in-flight operations, as the USN consistently struggled throughout this period with maintaining control and safety of airships while moored to masts. Strong winds, heat effects on helium, poorly designed hangars, and general mishaps all plagued ground operations. Only a month after the icing incident, the *Akron's* tail section came loose after a wind gust broke it free from its 85-ton stern beam. The control car and tail collided with the ground repeatedly, causing structural damage to the tail fins and putting the *Akron* out of commission for two months.[51] When it returned to flight operations, an incident in California during mooring operations led to the *Akron* lifting three ground crewmen into the air, with two falling to their deaths when they could no longer hold onto their line.[52]

Throughout the remainder of 1932, the *Akron* participated in exercises and developed new techniques and principles for parasite employment. As the *Macon* was nearing completion, its crew began shadowing the *Akron's* in efforts to familiarize themselves with

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[50] Smith, 49.
[51] Smith, 53; Althoff, *Sky Ships*, 95.
[52] Cressman, "Akron (ZRS-4)."

operations before ZRS-5 arrived.[53] 1933 was intended to be a monumental year with the two giants interoperating with the fleet, but instead it was a disaster.

The *Akron* crashed in the Atlantic ocean in the early morning hours of April 4, 1933.[54] The *Akron* had unknowingly sailed into a severe cold front and the resultant turbulent air from a once-in-a-decade storm along with repeated exposure to severe down drafts and a faulty altimeter eventually drove the airship into the sea.[55] There were only three survivors, including most notably, the future *Macon* commander, Lieutenant Commander (LCDR) Herbert V. "Doc" Wiley. An indicator of how the Navy struggled with comprehending the airship's paradigm, its oceanic-patrol airship carried no life jackets that night.[56] This fact heavily contributed to this event being the greatest loss of life in a single accident in aviation in history up to that point.[57] The Navy also lost its BuAer chief and airship advocate, Admiral Moffett, who perished in the crash.

The *Macon* took to the skies just weeks later on April 21, 1933.[58] The USN moved the airship's main operating base from Lakehurst, NJ to its Sunnyvale station in California, and renamed it Moffett Field in October of 1933.[59] From there, the *Macon*, at the behest of the Chief of Naval Operations (CNO), took part in extensive military fleet exercises to "determine her military value."[60] With new commanders, technology, and

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[53] Althoff, *Sky Ships*, 105.
[54] Naval History and Heritage Command, "1930–1939," accessed April 14, 2020, https://www.history.navy.mil/browse-by-topic/communities/naval-aviation0/1930-1939.html.
[55] Althoff, *Sky Ships*, 105; Smith, *One Hundred Years of U.S. Navy Air Power*, 48.
[56] Vaeth, *They Sailed the Skies*, 95.
[57] Vaeth, 96.
[58] Smith, *The Airships Akron & Macon*, 108.
[59] Naval History and Heritage Command, "Macon," April 26, 2016, http://public1.nhhcaws.local/content/history/nhhc/research/histories/ship-histories/danfs/m/macon.html.
[60] Althoff, *Sky Ships*, 116.

a full-complement of *Sparrowhawks*, the *Macon* did better tactically, but the Navy needed more proof.[61] When Commander Wiley took over in July 1934, the pressure, from new BuAer Chief Admiral King, to perform was immense.[62]

Wiley pushed the *Macon* too hard, and its operational schedule took its toll on the *Macon's* condition.[63] The *Macon's* frame had issues stemming from an April 1934 flight and engineers suggested tail-section reinforcements to address it.[64] Parts of those repairs had happened, but the cost and BuAer's pressure to stay involved with exercises drove a piecemeal approach to the modifications.[65] On February 12, 1935, the non-reinforced upper fin failed due to a sudden gust, and the resultant damage forced the *Macon* into a steady descent into the water to meet the same fate as its sister-ship.[66] The *Macon's* commander, CDR H.V. "Doc" Wiley had served on the *Shenandoah*, commanded the *Los Angeles*, and survived the *Akron* crash, but could not rescue his charge. Fortunately, this time at least life jackets were available to the crewmembers. When the *Macon* crashed, it took 2 lives, its 4 *Sparrowhawks*, and the Navy's rigid airship program to the bottom of the Pacific Ocean.[67]

Yet there is much to learn from this initial effort. While the program had not ushered in an age of airship-launched parasites to solve strategic search problems, it marked the US military's entry into AVLP history. As will become evident in the course of this work, a number of recurring themes manifest themselves throughout each of the cases under examination. These themes suggest insights which might tip the scales in favor of success in future AVLP endeavors.

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[61] Smith, *The Airships Akron & Macon*, 111, 125–35.
[62] Vaeth, *They Sailed the Skies*, 98.
[63] Althoff, *Sky Ships*, 123.
[64] Althoff, 123.
[65] Vaeth, *They Sailed the Skies*, 101; Althoff, *Sky Ships*, 123–24.
[66] Smith, *One Hundred Years of U.S. Navy Air Power*, 48.
[67] Bowers, *Unconventional Aircraft*, 258; Vaeth, *They Sailed the Skies*, 101.

Analysis

Ultimately, the rigid-airship program failed. All aspects of the program invited scrutiny: the airships embodied an innovation in aircraft technology and employment, they were expensive and physically large vessels, and they were antithetical to the surface-focused existing naval operational employment concept. The historical context and brief operational summary provide the framework to examine what the airships set out to do and their ultimate failure. Further analysis of specific areas allows for discussion of important factors which may have broader applicability to the entire AVLP field.

Technology

The airship's structure was a modern marvel, but it was not without its faults. The structural reinforcements to the *Akron* and *Macon*, a response to the *Shenandoah* mishap, generated a subsequent weight penalty.[68] However, hull strengthening and atmospheric modeling "was a highly complex problem for designers [as] ample knowledge and understanding remained wholly incomplete in the 1920s and 1930s."[69] Suffice to say that the airship itself was a good idea for an AVLP, but the development of the vessel was not yet at the level where it needed to be.

There should have been five carrying positions for *Sparrowhawks* on the airships: four corrals and one on the trapeze itself hanging above the door. However, incorrect placement of girders in the *Akron* eliminated 40% of the storage space for aircraft. In practice, this would have been reduced from five to four anyway because operations officers elected to leave one spot open in the hangar in case the airplane on the trapeze failed to start.[70]

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[68] Althoff, *Sky Ships*, 89.
[69] Althoff, 99.
[70] Smith, *The Airships Akron & Macon*, 67.

The trapeze itself would lower an aircraft down below the T-door where the parasite could begin its sortie. Although not present initially on the *Akron*, engineers eventually installed another trapeze, the "perch," a few aircraft-lengths aft of the main trapeze.[71] From this position, the pilot could await formal recovery into the hangar or further scouting assignments. Once the work was done for the sortie, the *Sparrowhawk* pilot would hook-up to the main trapeze.

The hooking mechanism, developed using the *Los Angeles*, was initially quite dangerous for both the parasite pilot and the airship. With the hook top-mounted on the bi-planes (all variants), the pilot effectively had to stall the airplane to get it to settle on the apparatus.[72] This put the airship at risk because of the high angle-of-attack necessary to achieve the stalled condition, and errors in power management could lead to the airplane striking the airship. However, once engineers improved the mechanism and pilots became proficient at connecting, most reported the process to be "unusually simple"[73] and there was only one (reported) near-accident due to trapeze operations during the AVLP's tenure.[74]

An important lesson for pilots and military theorists was the seeming presence of an air barrier (turbulent air) emanating from larger aircraft.[75] This turbulence could stop the approaching aircraft from closing unless its pilot used a delicate application of power to push through the turbulent air. Although still new to aviators of the time, this fundamental aerodynamic feature remains one which designers must account for in most AVLP recovery or air refueling operations.

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[71] Smith, 67, 138.
[72] Smith, 23.
[73] Althoff, *Sky Ships*, 99.
[74] Smith, *The Airships Akron & Macon*, 139.
[75] Smith, 21.

As for the parasites themselves, the fundamental issue was that the “requirement was exotic; no one knew what characteristics were desirable in an airship-based airplane.”[76] As Goodyear-Zeppelin engineers had already designed the T-shaped door for the trapeze apparatus, the Navy’s search focused on existing airplanes which could fit through the door and in the notional hangar space.[77] The F9C-2 fit, but was not ideal for operations. “The concept of the ‘flying aircraft carrier’ was hampered by poor radio communications and direction-finding equipment on the airplane.”[78] Without radio-direction finding equipment (RDF; a radio homing capability) or better communications capability, the true implementation of AVLP tactics was severely limited.

The 1931 Harrigan Report, authored by one of the “Men on the Flying Trapeze”[79] pilots, suggested a Flight Control Officer capable of conducting command and control (C2) of the parasites along with a radio capable of communicating out to 250 miles;[80] these were mostly implemented by 1933 when F9C-2s began RDF training with the *Akron* (which met with mixed results).[81] The *Macon* continued this training with some improvement, and the *Sparrowhawks* were able to utilize the entirety of their operational range.[82]

What truly affected the F9C’s usability was the fact that it was a fighter, and not a scout. With limited range, poor visibility from the cockpit, and a weak communications capability, it was never a platform which offered the assistance to the AVLP that a deliberately-designed airplane could have. The crews of ZRS-4 and -5, along with the parasite fighters did the best they could, but with the losses of both AVLPs so

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[76] Smith, 25.
[77] Smith, 25.
[78] Smith, *One Hundred Years of U.S. Navy Air Power*, 48.
[79] Smith, *The Airships Akron & Macon*, 69.
[80] Smith, 70.
[81] Smith, 75.
[82] Althoff, *Sky Ships*, 121; Smith, *The Airships Akron & Macon*, 110–13.

early in operations, there was never a time to look for more suitable aircraft.

While any AVLP is likely to be a technologically complex undertaking, there are four key points about technology that the airships' era offers. First, the airship was a technological feat, yet its complexity significantly hampered maintenance and usability. The limitations of the day in design and construction modeling affected the final product and its survivability. Second, as the *Akron* and *Macon* were effectively prototypes and crashed soon after initial launch, there was little time for development of new technologies or improvements to initial operating capability. Most weapon systems are able to enjoy years of iteration; the airships had no such luxury. Third, communications and C2 capabilities on both host and parasite were severely deficient and limited operational strategies. Finally, while a dedicated parasite would likely be more costly initially, it also may reap substantial rewards in operational capability. In such a deliberate design, engineers could work with military theorists to tailor the parasite's abilities to match either inherent weaknesses of the AVLP, or increase its strengths. Regardless of the degree of complexity, an AVLP will likely need substantial logistical support to enable mission generation and ensure continuity of operations.

Logistics and Operational Support

Logistical complexity is not a desirable trait for military operations or assets. The airships were the embodiment of a logistical nightmare. Basic needs for flight operations, hangars and mooring requirements, and onboard capabilities were all complex. The airships' logistical requirements created difficulties in execution, increased the likelihood of vessels receiving damage, and caused fleet-integration problems. However, despite all the issues, there was one element, literally, where they had an advantage.

The US airships used helium as opposed to the hydrogen commonly found in European craft. In 1934, then LCDR Wiley argued for airships and noted the uniqueness of the US situation, "No other country has this non-inflammable gas and hydrogen-filled craft has no place where it is liable to be attacked."[83] Some of the advantages for US airships were they were inherently safer than hydrogen-filled craft and the US had helium as a natural resource.[84] One need not look much further for proof of Wiley's theory than the spectacular Hindenburg crash (at Lakehurst no less) in 1937, which effectively killed civilian airship programs.[85]

For the US, helium deposits in Texas and Colorado provided a great resource, but the extraction was expensive and some plants could not provide the Navy with enough helium due to the Great Depression.[86] For the purposes of AVLP operations, helium appears to have been the better choice militarily, but was a source of trouble during the testing phase, as there was not enough helium for all of the operations or to even keep all three airships inflated.[87] The helium problem, like most other airship servicing needs, created problems in sustainability.

The main logistical challenge was support during operations. "The problem of maintaining a rigid airship away from its home base for extended periods was a formidable one that was never completely solved. This was essentially an economic issue."[88] Creating a network of support bases and ships beyond the five mooring masts on land plus the *Patoka* was simply infeasible for the limited number of airships, especially given

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[83] Wiley, "Value of Airships," 670.
[84] Hugh Allen, *The Story of the Airship (Non-Rigid): A Study of One of America's Lesser Known Defense Weapons* (Chicago: The Lakeside Press, 1942), 34.
[85] Althoff, *Sky Ships*, 140–42.
[86] Smith, *The Airships Akron & Macon*, 15, 109.
[87] Althoff, *Sky Ships*, 105.
[88] Smith, *The Airships Akron & Macon*, 45.

the expense of doing so during the Depression.[89] Additionally there were only "four airfields which had gassing facilities adequate to the needs of a large airship."[90] For an asset whose primary role was defensive operations, this situation may not have been too precarious. However, had the fleet grown in size, been needed away from its main hubs, or desired for overseas operations, the Navy would have needed to address it. As it stood, while the crew could conduct limited maintenance onboard the airships, most mission generation away from home-station presented a challenge.

The lack of thorough maintenance capability away from the specially-built hangars at Sunnyvale and Lakehurst was an issue. Construction of these facilities around the continent could likely have only been feasible if the airships had become a staple in coastal defense strategies. Additionally, the manning requirements for both maintenance and handling personnel would have been substantial. The Navy, however, did not seem to deem training a priority. The sailors who died during the 1932 mooring accident at Camp Kearny, California, were part of a contingent of "raw recruits [brought up from] the San Diego Naval Training Station."[91] With no specific training or frame of reference as to what to expect, they became overwhelmed by the experience of handling the imposing *Akron* and struggled to maintain focus on the task. Furthermore, the novel nature of the airships did not just create problems on the road; the airships' home-station was also a place of continual challenge.[92]

Aside from the phenomenal cost of creating a hangar, a $3 million appropriation in 1919, the hangars were incredible constructions.

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[89] Smith, 45.
[90] Smith, 45.
[91] Smith, 56.
[92] Smith, 56.

Housing the airships "was a structure 943 feet long, 350 feet wide, and 200 feet high" (804 x 264' interior).[93] Unfortunately, the Lakehurst location was a poor choice due to the frequency of storm fronts rolling through, and the hangar itself was ill-aligned with the prevailing winds at the base, which further complicated ground-handling.[94] The Navy addressed this variable in the construction of the Sunnyvale (Moffett Field) hangar.[95]

Figure 11 - The *Akron* along with its Hangar and Mooring Circle at Lakehurst, NJ
Source: "UA 460.22 UA 460.22 George Carroll Collection," accessed April 15, 2020, https://www.history.navy.mil/content/history/nhhc/our-collections/photography/alphabetical---donations0/c/ua-460-22-george-carroll-collection-.html.

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93 Althoff, *Sky Ships*, 13.
94 Althoff, 11.
95 Smith, *The Airships Akron & Macon*, 101.

Winds were a huge impediment to mooring operations. To better address control issues, the *Los Angeles* conducted trials on a mobile mast which led to BuAer implementing an improved rail-mounted mobile mast at Lakehurst by the time the *Akron* arrived; this significantly reduced the number of personnel required for and increased stability during ground operations.[96] Yet, this was the system which experienced the beam failure in 1932, and the handlers' ensuing loss of control nearly led to a re-creation of an infamous moment in the *Los Angeles's* history (Figure 12). To obviate some concern about winds, the airships often took off at sunset or sunrise, which occasionally also provided the benefit of superheated helium ready to rise.[97]

Figure 12 - *Los Angeles* Near Vertical due to Winds

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[96] Althoff, *Sky Ships*, 80–81, 95.
[97] Smith, *The Airships Akron & Macon*, 66.

Source: "NH 84568 USS *Los Angeles* (ZR-3)," accessed April 15, 2020, https://www.history.navy.mil/content/history/nhhc/our-*collections/photography/numerical-list-of-images/nhhc-series/nh-series/NH-84000/NH-84568.html.*

The hangar within the *Akron*-class airship was as novel as the one at Lakehurst. Onboard the airship, the electrically-actuated trapeze system and monorail to slide the airplanes to and from their storage spots was well-executed and an innovative utilization of space.[98] Unfortunately, while the majority of the *Akron* had been designed for access, the hangar lacked catwalks which would have enabled faster servicing on the AVLP's parasites.[99] Additionally, the *Akron* did not have appropriate mechanisms to secure the airplanes in storage, nor did it have enough room for parasite supplies, ammunition, or fuel.[100] Future iterations in hangar design could have alleviated these problems along with the planned change to address the girder issue in the *Akron* in order to regain the two obstructed storage locations.

[98] Althoff, *Sky Ships*, 90.
[99] Smith, *The Airships Akron & Macon*, 67.
[100] Smith, 67.

Figure 13 - A Sparrowhawk on the Trapeze Inside the Akron
Source: "NH 80773 Curtiss F9C-2," accessed April 13, 2020, https://www.history.navy.mil/our-collections/photography/numerical-list-of-images/nhhc-series/nh-series/NH-80000/NH-80773.html.

In order to shave thousands of pounds on liftoff, the hangar was often empty at the outset of a mission.[101] While this was a good technique for airship considerations, it could have severely limited the effectiveness of its mission capability. The airship's scouting capability was exponentially increased by the number of parasite scouts available. During airship trials, there were no additional F9C-2s available as backup aircraft. A failed start on ground for one of them would have resulted in the AVLP propelling away from an aircraft that may never be able to link up with its mothership. If the airships had survived and gone on to conduct longer range scouting missions, the Navy would have

[101] Smith, 56.

needed to procure spare aircraft and potentially sought to use a shared aircraft fleet between its airships and aircraft carriers.

The logistical challenges with airship operations were substantial, and three key items from these trials should stand out. First, as with any program, resourcing, natural or otherwise, may drastically affect testing, usability, and operations. If the AVLP or its assets require specific components or handling, then wartime infrastructure and logistics must support the personnel and delivery requirements. Second, low-density assets are less likely to have a backup options; this is a detriment to normal operations. If the AVLP or its launchable-vehicles are such assets, the reliability rates among its components and parasites are all the more critical to operations. Given that AVLPs are inherently multiple-aircraft, the interaction of low-density with reliability factors could be exponentially more limiting. Third, cost comparisons amongst competing assets must include holistic outlooks on the platform (the AVLP or its alternate), basing requirements, procurement, roles, and expeditionary requirements. All of these factors affect not only the logistical backbone of the operation, but the methods whereby operators can employ them.

Employment and Doctrinal Integration

The airships' employment doctrine and integration with existing Navy operations was strained from the start. As the seaborne aircraft carrier had yet to become the dominant force on the water, there was likely not enough experience to derive analogous principles for its skyward cousin. Additionally, even theorists framing the airships as LTA aircraft carriers may have occluded theorists' vision of the potential best use for the parasite aircraft. The size and cost of the airships created an impression that it should be the panacea for search operations, not one that needed to rely on tiny *Sparrowhawks* to achieve strategic effect. Thus, it took multiple years for the superior employment constructs to take root, and dispel the notion of the airship itself conducting the tactical scouting mission. Further complicating this problem was the failure to base the airships near the fleet and the limited capabilities of the parasite fighters.

The airships took part in numerous fleet exercises (entitled Fleet Problems) and over the course of a few years the employment model evolved from tactical scout to AVLP.[102] Perhaps no clearer representation of the initial mindset exists than the fact that there were no planes, or even a trapeze installed, during the *Akron's* initial sea trials. The prevailing Navy opinion was that the "airplanes were regarded as auxiliaries on a par with the spy basket."[103] Even at this embryonic stage, the *Akron's* commander found the doctrine to be deficient, and asserted that the airship would almost certainly have discovered its targets with even a reduced complement of scouts.[104] However, even without airplanes the airship was still better suited for strategic missions (e.g. searching large expanses of ocean) than comparable surface assets.[105]

Since the *Akron* crashed little more than a year after its initial fleet exercise, the majority of doctrinal advances occurred during the, admittedly also short, tenure of the *Macon*. With the *Macon*, the airship initially remained the scout, but the plan was then to "retreat from the scene and launch her planes to maintain and develop the contact."[106] It was truly not until Doc Wiley took over in July of 1934 that the airship became the platform to enable the scouts, and not the reverse. Wiley saw the airship as a strategic search asset, but one that with parasites working in geometric precision generated a strategic capability far beyond wandering the seas. In his words,

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[102] Smith, 45.
[103] Smith, 51.
[104] Smith, 51.
[105] Wiley, "Value of Airships," 669–70; Vaeth, *They Sailed the Skies*, 98.
[106] Smith, *The Airships Akron & Macon*, 90.

> Tactical scouting can be carried out efficiently when the airship lies back and sends in its planes … Reconnaissance, bombing, photographic missions, submarine patrol, offshore patrol, convoy escort, decoy work, can all be carried out.[107]

It was through this lens that the Navy should have seen the airships. Many senior officials, however, remained tied to their perceptions of German dirigibles in WWI. They failed to see how novel their asset truly was. Although it looked like a large version of WWI blimps, it was an entirely new thing, an airborne aircraft-carrier.

Surface ship commanders disputed some of the parallels to their vessels, and a fundamental indictment was the inherent vulnerability of the airship when compared seaborne carriers. Wiley dismissed this charge as a fallacious comparison, suggesting that "While the surface carrier is generally well protected by combatant vessels of its own fleet, the airship ordinarily has to operate independently and depend upon its armament and planes for defense."[108] It was not that the AVLP itself was more vulnerable, it was the operational paradigm in which it operated that led to its unprotected exposure. Carrier-launched airplanes consistently found and "killed" the *Akron* and *Macon* during exercises, and Navy leadership's perception of airship vulnerability remained firmly entrenched.[109]

Airship opponents, however, failed to acknowledge that the higher airship death count was likely heavily correlated with the inappropriate tactical-scout role that the Navy assigned the *Macon*.[110] Additionally, Wiley adds that there appeared to be a double standard for the airship: "In nearly every scouting exercise, the scouting vessels suffer losses of a

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[107] Wiley, "Value of Airships," 669.
[108] Wiley, 669.
[109] Althoff, *Sky Ships*, 103, 112–13, 121.
[110] Althoff, 118.

few destroyers and/or cruisers in making or developing contact and gaining information. This is a matter of course and little comment ensues."[111] The AVLP needed to have the proper role and mission for its strengths and weaknesses, just like any military asset. Instead, Fleet exercises led the Navy to believe the floundering *Macon* was a failure as there was no historical reference for comparison, especially given the loss of the only other reasonable modern benchmark, the *Akron.*[112]

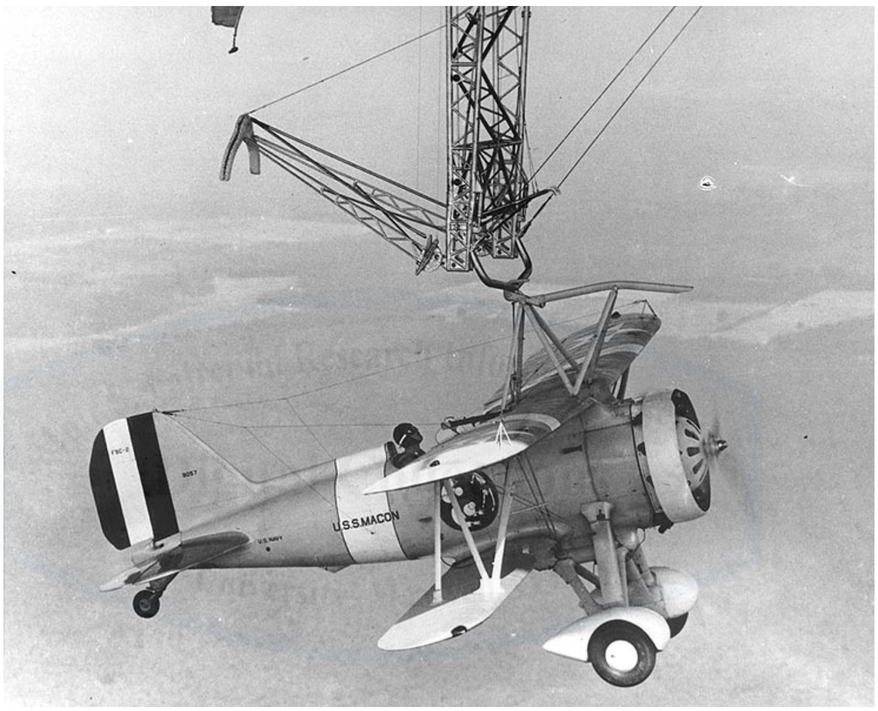

Figure 14 - A Parasite Finds its Host (flown by Lt Harrigan)
Source: "80-G-441979 Curtiss F9C-2," accessed April 17, 2020, https://www.history.navy.mil/content/history/nhhc/our-collections/photography/numerical-list-of-images/nara-series/80-g/80-G-440000/80-G-441979.html.

Wiley's push for the AVLP construct had a self-reinforcing function to it. As the conceptual purpose for the airship shifted from scout to launch platform, innovations in airplane usage abounded. Heavier-than-

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[111] Wiley, "Value of Airships," 667.
[112] Smith, *The Airships Akron & Macon*, 126.

air (HTA) *Sparrowhawk* pilots became more proficient with the trapeze, so they removed the landing gear to allow for longer range and higher speeds.[113] "The senior pilots of the HTA unit had always seen the airship for what she was—the means of extending the range of their airplanes."[114] Parasite purpose changed too; too valuable in small numbers to be lost in engaging enemy fighters, their role now was principally scouting. The parasites were able to cover large swaths of ocean using geometric timing triangles and their RDF gear, and the massive size of the *Macon*, to home back to the trapeze for recovery.[115] But the F9C-2 was still fundamentally a fighter and a specialized scout plane would eventually be necessary. Obtaining such an asset would require even more money, and that required political will.

The airships never achieved broader acceptance into the Navy's operational dogma. Admiral Moffett had tried to establish airship commanders as equivalents to their surface counterparts, but with such a short operational period and only limited interaction with the fleet, the concept never took root. Moreover, the tremendous expectations the country and Navy levied on the airships created a strong feeling of disappointment as their operations continued to find trouble. Of note, three particular lessons stand out with regard to doctrinal and operational integration of AVLPs during this time period.

First, for future AVLP endeavors and any paradigmatic shift in military application, a belief that a weapon system assures operational success is likely fallacious. While systems may fundamentally alter warfare's character (e.g. machine gun, aircraft, nuclear weapons), they usually only offer periods of temporary advantage, and are not guarantors of victory. Second, vulnerability is contingent on both internal

[113] Vaeth, *They Sailed the Skies*, 98; Althoff, *Sky Ships*, 122.
[114] Althoff, *Sky Ships*, 119.
[115] Smith, *The Airships Akron & Macon*, 110–13.

and external factors. Moreover, it is likely multi-faceted. The airships were "vulnerable" to enemy fighters in that they were a slow and large target. However, they could also likely sustain a heavy onslaught of machine gun fire. Some in the Navy rejected these claims despite evidence from WWI operations and pleas from advocates.[116] Third, a leader's vision often enables innovation. Improvements to operational methodology, tactics, and technology all followed from Wiley's updated construct of the *Macon's* true nature.

Politics, Economics, and Military Leadership

Throughout its short history, the rigid airship program faced heavy political and military leader scrutiny. Much of this had to do with the expenses related to airship production, sustainment, and operations. When combined with the fact that the airships failed to win over Navy traditionalists who doubted the platform's efficacy from the outset, there was always a strong contingent of political and military leaders looking to divest from airships.

Aside from the initial $4 million for the hangar at NAS Lakehurst, the US government incurred a nearly $8 million expense in 1928 for acquisition of the airships *Akron* and *Macon* ($5.375M and $2.45M respectively).[117] The Navy had spent $75,750 on the XF9C-1 test platform, and each *Sparrowhawk* was $22,965. When combined with spare parts and other parts of the contract, it was $267,000 of expenses.

It is important to note that the era of the Navy's rigid airship program overlaps almost entirely with the Great Depression; the federal government generally looked to avoid additional financial burdens and had increased scrutiny of the platform. At nearly all times during development and execution, those with counter-airship mindsets believed

[116] Wiley, "Value of Airships," 665–67.
[117] Vaeth, *They Sailed the Skies*, 62.

airship funds were better spent on "two or three hundred carrier planes or four dozen twin-engine flying boats."[118] This constant preoccupation with price remained at the forefront throughout development and trials.

For example, after only months of operation, a member of the Committee on Naval Affairs launched an investigation into "*Akron's* military worthlessness."[119] Much of this may have been political grandstanding, but it reflected the political aversion some had to the massive machines and their frustration that the airships did not do everything expertly and efficiently.[120] Regardless of any personal preferences for the platform, by 1932 Congress was hunting for any fiscal relief and informed the Navy that there would not be funding for three airships, prompting BuAer to retire the *Los Angeles* in June for both financial and helium budgetary reasons.[121]

News media joined in the close scrutiny of airships. Quick to highlight any shortcomings in development or failures in operation, many in the airship program found the coverage to be biased and lacking a logical comparison to struggles with aviation in general.[122] Wiley pointed to the front-page story of an $8000 repair for airships juxtaposed with "three Navy planes, one of which cost $60,000, [which] were demolished in the neighborhood of Washington and this news took only two inches of one column."[123] Because of their size, the recency of the *Shenandoah* crash (and later, *Akron's* too), and the near unlimited promises of early airpower advocates, each misstep for the airships was magnified and a constant black eye for the Navy.[124]

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118 Smith, *The Airships Akron & Macon*, 171.
119 Smith, 51.
120 Smith, 51–55.
121 Althoff, *Sky Ships*, 104–5.
122 Smith, *The Airships Akron & Macon*, 38.
123 Wiley, "Value of Airships," 665.
124 Smith, *The Airships Akron & Macon*, 82.

The *Akron* crash may have been the most significant event in the whole period. Admiral Schofield, the commander-in-chief of the US Fleet in 1932, had already presented his view "that the rigid airship was entirely unsuitable for naval service in terms of cost, of excessive dependence on kindly weather and hangar facilities, and its 'extreme vulnerability' to airplanes";[125] he also suggested canceling the *Macon's* construction.[126] Losing Admiral Moffett, a longtime proponent for the whole project, in the *Akron* crash was a near death-blow to the program by itself.

As the Chief of BuAer, his "view of the air weapon was an organic one, in which it was a vital part of the Fleet; the airship was only one part of the organization as he saw it."[127] He envisioned the US as a global leader in airship application for military, global freight, and personal transport uses.[128] But his clout and esteem were lost along with "one-half of the 1926 airship program and almost one-third of the Navy's experienced airship operating personnel."[129] With the loss of yet another airship, the *Akron's* airmen, and the Chief of BuAer, there was simply no persuading the Navy or Congress to fund a replacement ship, especially during the heart of the Depression.

As Naval leadership like Admiral Reeves, who had pushed for San Diego over Sunnyvale and also been upset by Wiley's stunt use of the *Macon* to deliver a letter to President Roosevelt at sea,[130] moved into the command echelons, the airship program was already in danger. Following the loss of the *Macon*, he canceled the program; there was simply no appetite for these large, cumbersome assets which appeared to

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[125] Althoff, *Sky Ships*, 103.
[126] Althoff, 103.
[127] Smith, *The Airships Akron & Macon*, 92.
[128] Smith, 40.
[129] Smith, 77.
[130] Smith, 37, 131; Vaeth, *They Sailed the Skies*, 98–99.

fail with uncomfortable regularity.[131] The Navy wanted to spend its money on ships, carrier-based aircraft, and the promising PBY flying-boats.[132]

Lessons garnered from the politics, economics, and military leadership aspects of the airship era are arguably among the most important. Specifically, the interaction of critical variables like high-cost, novelty, and not having a champion were too much for airship proponents to overcome. Large costs are easy targets for political and media sniping. Without a strong military advocate or existential challenge, programs running over budget or having substantial challenges in operation are likely to disappear. These traits, however, are not unique to airships and rather are more broadly applicable to most military programs. The airships demonstrate how difficult integrating a new capability into a military service can be: theorists' preconceived concepts inform a service's employment strategy and acquisitions.

If a significant deviation from the norm is to occur, there again must be a champion guiding it who has the political prowess to navigate not only the military command echelons, but Congress as well. This is especially important in its initial phases when one can expect the most problems with efficacy and overall safety in operations. Lastly, comparisons of non-equivalent technologies often stem from faulty logic, but will occur. One can consider this similar to Khong's treatment of historical analogies leaders sometimes use to inform decision-making.[133] As a proponent of the targeted asset, it is important to ensure military leaders are aware of the appropriate differentiation metrics and how best to frame the cost-comparison or relative advantages.

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[131] Smith, *The Airships Akron & Macon*, 125.
[132] Smith, 175.
[133] Yuen Khong, *Analogies at War: Korea, Munich, Dien Bien Phu, and the Vietnam Decisions of 1965*, Princeton Paperbacks (Princeton, NJ: Princeton University Press, 1992).

Figure 15 - Consolidated PBY-5 Catalina Patrol Plane
Source: Naval History and Heritage Command, "1930–1939."

Conclusion

The 1940 King-Fulton[134] Report expressed disappointment in the rather poor way the Navy used the AVLPs and how the "promising development of operating airplanes from airships was arrested before its full possibilities could be appraised."[135] The Navy, however, was unmoved and no further AVLP airships ever came to be. The promise of aircraft was too hard to ignore. The Navy had already had success with its P2Y-l flying boats and to fulfill strategic search and patrol capability, it purchased 200 Consolidated PBY-5 Catalina flying boats in 1939. The rigid airships, which had seemed such a promising solution to coastal defense problems a decade prior, were nowhere to be seen as the nation began to watch its shores, and ultimately missed the threat from beyond the horizon.

The Navy would continue to use non-rigids during WWII, spending a staggering $227,831,000 on the program (including $58M for

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[134] Admiral King and Captain Fulton of the US Navy.
[135] Smith, *The Airships Akron & Macon*, 169.

airships).[136] The Cities in the Sky may have just come around at a bad time. As historian John Jackson elaborates, “Decades later, literally thousands of aircraft would be lost to accidents as the Navy transitioned from propeller to jet-propelled planes, yet development continued because of the great potential seen in the new technology.”[137] Ultimately, context determines whether an asset succeeds or fails: how much support is behind a movement or idea, what the contextual definition of “failure” is, and whether the asset arrives in a world in which it can actually serve its purpose. Regardless, while the *Akron* and *Macon* had thoroughly impressive search capability and loiter capacity even without parasite scouts, their usefulness would have run its course in the ensuing decade.

For the remainder of the 1930s and into WWII, radar, surface aircraft-carriers, and airplane capabilities matured. The need for an eye in the sky remained, but technology had changed substantially. Airplanes could be larger and heavier with improved aerodynamics and engines. Fighters and anti-aircraft measures improved defense capabilities thereby requiring faster and more capable assets to counter. As for AVLPs, the possibilities of extending the range of a parasite and trapeze system were still viable solutions, the military just needed a faster host, and a more capable parasite.

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[136] Althoff, *Sky Ships*, 202.
[137] Smith, *One Hundred Years of U.S. Navy Air Power*, 49.

Chapter 3

Peacemakers and Parasites

Introduction

This chapter analyzes the United States Air Force's (USAF) attempt to turn the ironically-named B-36 *Peacemaker*, a nuclear bomber, into an Airborne Vehicle-Launch-Platform (AVLP) during the 1950s. I examine the purpose and development of the Fighter-Conveyance (FICON) program, along with the iterative evolution from XF-85 *Goblin* to the RF-84K *Thunderflash*, the *Peacemaker's* reconnaissance parasite. The program was a qualified success. It did not lead to a permanent role in the USAF, but it did see some operational use and the FICON program itself did not have any major accidents during development or trials. Overall, the USAF's willingness to iterate through designs and operational strategies led to a functional AVLP, but the program itself lost its relevance to Strategic Air Command (SAC) as other advances in technology, most notably aerial refueling and the eight-engine B-52 *Stratofortress*, began to operate.

Figure 16 - A B-36 *Peacemaker* with F-84E *Thunderjet*
Source: USAF, FICON Harnessed, n.d., https://www.nationalmuseum.af.mil/Upcoming/Photos/igphoto/2000544511/.

History and Context

The failure of the airship programs may have confined Naval Aviation to sea-based carriers and flying boats, but as the newly minted USAF sought to establish its identity, it too began a series of tests with AVLPs. While World War II (WWII) challenged many early airpower theorists' views of the bomber always getting through,[1] it did demonstrate the effectiveness of combined formations of bombers with fighter escort.[2] After the Allies vanquished their German adversaries and pivoted to the Pacific, overcoming the tyranny of distance during bombing missions became altogether more critical.

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[1] Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945*, 165.
[2] Biddle, 207–13, 224.

In WWII, General Tunner's notable airlift operation featured airmen flying cargo from India over the Himalayan Mountains ("The Hump") to provide critical supplies and enable civil engineers to develop vital logistic infrastructure in the Chinese theater.[3] While this operation set the stage for the Allies to bomb mainland Japan, it was General LeMay's B-29s out of the Mariana Islands which ended up conducting the majority of the long-range bombing.[4] The B-29 proved to be a stalwart workhorse for the US Army Air Forces' (USAAF) efforts to degrade Japanese industry. Even as it delivered two atomic weapons at the end of the war, plans were already in place for the next generation bomber, the B-36.

The B-36 *Peacemaker*, so named as "a hopeful reference to the deterrent effect of having so powerful a weapon in the arsenal,"[5] was the result of a 1941 requirements document stating the need for the US to have a bomber capable of striking Europe from North America.[6] Its specific charge was to be able to deliver 10,000 pounds of bombs to a target 5000 miles away or 72,000 pounds at a shorter distance at cruising speeds of 300-400 mph.[7] The first B-36 was not completed until September of 1945 and was delivered to a USAAF suddenly without a need for an intercontinental mission.

With production lines finally able to operate at full capacity, but without an enemy to necessitate such an effort, "the concept of a bomber of intercontinental capability was not generally popular in some circles."[8] Many questioned the need for such a large bomber following victory. Unfortunately, the final years of the 1940s saw the beginnings of what

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[3] John D. Plating, *The Hump: America's Strategy for Keeping China in World War II (Williams-Ford Texas A&M University Military History Series)* (Texas A&M University Press (2011), Edition: General, 320 pages, 2011); Schwabe, *Burning Japan*, 21.
[4] Schwabe, *Burning Japan*, 97.
[5] Meyers K. Jacobsen, *Convair B-36: A Comprehensive History of America's "Big Stick"* (Atglen, PA: Schiffer Pub, 1997), 64.
[6] Jacobsen, 21.
[7] Jacobsen, 21.
[8] Jacobsen, 37.

would become the Cold War and the US military, now notionally "unified" under the DOD, found an all too pressing need for intercontinental attack.

Strategic Problem

The Soviets always had a numbers advantage. The US military drew down significantly after WWII and the threat of the massive Red Army rolling across western Europe loomed large over defensive plans. The B-36 was a featured player in most of those counter-Soviet war plans.[9] In 1947, the USAF altered the B-36's purpose to focus on long-range nuclear bombing.[10] Rapid testing ensued and the aircraft proved its legs by logging a 43-hour sortie in 1949.[11] The aircraft could do the mission, but WWII had taught airpower theorists that protecting bombers to their targets was predicate to mission success. The challenge then, was how to protect the bomber through payload delivery when the target could be thousands of miles away. The USAAF, and later USAF, knew that long-range fighters lacked the legs for intercontinental operations and began searching for a possible way to combine a fighter and bomber on the same mission.

Parasitic *Goblins* and *Thunderjets*

During the Cold War era, engineers and airpower theorists created scores of designs and many of the production aircraft went through numerous iterations as technology and capabilities improved. The B-36 was no exception. While the B-36 had numerous variants, the one General Curtis LeMay ordered SAC to modify into a reconnaissance platform, the RB-36D, is relevant here. From the base RB-36D, the USAF created two AVLP models: the GRB-36D-III,[12] a Fighter Conveyance

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[9] Jacobsen, 77.
[10] Jacobsen, 49.
[11] Jacobsen, 76.
[12] The "III" connotes the "featherweight" modification. This removed most armament from the aircraft and enabled higher-altitude operations. Marcelle Size Knaack,

(FICON) model; and a JRB-36F, used for FICON and a wing-coupling experiment in Project Tom-Tom.[13] Of note, because B-36s had a substantial operational commitment for counter-Soviet operations, the USAAF and USAF accomplished some AVLP testing on B-29s and C-47s.[14]

General Curtis LeMay drove the charge for SAC to turn bomber platforms into reconnaissance ones, and the RB-36D program began in 1948.[15] The RB-36D's 22-crewmen worked flight operations and processes to ensure the aircraft's 14 cameras operated effectively over their target.[16] Although planners initially believed the RB-36D would be able to fly higher and turn better than its Soviet adversaries, its vulnerability became too pronounced during the early 1950s. This harkened back to detractors who lamented the bomber's potential vulnerability during the USAAF's initial operational testing.[17] After experimenting with various tactics, trying different engines to gain altitude, and adding a nose turret,[18] the USAAF decided it was time to try to add fighters to the bomber.

The operational construct they adopted was conceptually similar to that of the Navy's initial approach with the airship's parasites. As the service responsible for conducting long-range fighter escort missions in WWII, the USAF knew that establishing hand-offs between escorts was a highly complex operation. With the sheer size of the now 10-engine RB-36D and increased technological capabilities in small-form jet engines, the USAF believed it had a chance to add organic parasite fighters for

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Encyclopedia of US Air Force Aircraft and Missile Systems: Post-World War II Bombers, 1945-1973, vol. II (Washington D.C.: Office of Air Force History, 1988), 33.
[13] Don Pyeatt and Dennis R. Jenkins, *Cold War Peacemaker: The Story of Cowtown and the Convair B-36* (North Branch, MN: Specialty Press, 2010), 107.
[14] Pyeatt and Jenkins, 225.
[15] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:36.
[16] Knaack, II:36–38; Pyeatt and Jenkins, *Cold War Peacemaker*, 82–86.
[17] Jacobsen, *Convair B-36*, 49.
[18] Jacobsen, 51.

protection. The first candidate for the role was the XF-85 *Goblin* (Figure 17).

Figure 17 - XF-85 *Goblin*
Source: USAF, Goblin on Rollers, n.d., https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195800/mcdonnell-xf-85-goblin/.

Although termed a *parasite*, the operational construct was more symbiotic. A large bomber would carry its own ordnance and small fighters with it for support in high-threat operations. The diminutive *Goblin*, with its foldable 21-foot wingspan, weighed in at a mere 5,600 pounds.[19] The *Goblin*'s design was a result of a USAAF study from 1944-45 which determined that the "most viable solution [to long-range escort] was the parasite fighter concept."[20] A modified B-36 would either carry

[19] Wagner, *American Combat Planes*, 460.
[20] Dennis R. Jenkins and Tony Landis, *Experimental & Prototype U.S. Air Force Jet Fighters* (North Branch, MN: Specialty Press, 2008), 81.

three *Goblins* and no bombs, or one fighter along with a reduced bomb load.[21]

In June of 1946, the USAAF began testing prototypes of an XF-85 with a modified B-36 bomb-bay.[22] With a plethora of B-29s and no B-36s to spare, the USAF conducted its first operational test of the parasite fighter in August of 1948.[23] After failing to connect to the B-29's trapeze system multiple times, the pilot attempted one more hook-up in which an errant control input drove the canopy into the trapeze, "smashed the canopy and the pilot was forced to make an emergency landing."[24]

Figure 18 - *Goblin* on Approach
Source: Diseno Art, "McDonnell XF-85 Goblin," accessed May 6, 2020, http://www.diseno-art.com/encyclopedia/strange_vehicles/mcdonnell_xf-85_goblin.html.

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[21] Jenkins and Landis, 82.
[22] Wagner, *American Combat Planes*, 460.
[23] Jenkins and Landis, *Experimental & Prototype U.S. Air Force Jet Fighters*, 85.
[24] Wagner, *American Combat Planes*, 460.

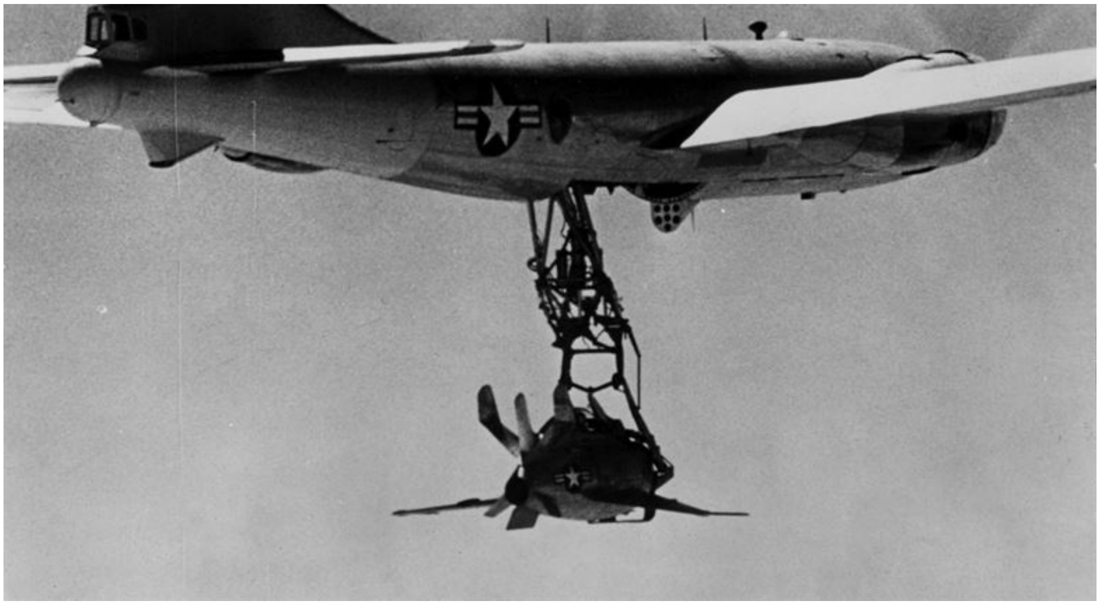

Figure 19 - *Goblin* on the Trapeze
Source: USAF, Goblin Hooked, n.d., n.d., https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195800/mcdonnell-xf-85-goblin/.

Figure 20 - The XF-85 *Goblin's* Folding Wings
Source: USAF, Goblin with Folded Wings, June 4, 2007, June 4, 2007, https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195800/mcdonnell-xf-85-goblin/.

The *Goblin*s would continue to fly more sorties, but the program was canceled after little more than a year, in October 1949.[25] Ultimately, the *Goblin*'s small size rendered it inferior to the most recent Soviet fighter aircraft, thus making it a suboptimal solution for the bomber-protection problem. Additionally, due to the difficulty in reconnecting with the trapeze system, the USAF "concluded that the recovery operation would probably be beyond the capabilities of the average squadron pilot."[26] The *Goblin* was finished, but the USAF still felt it had a viable solution. What the Air Force needed was a better recovery system and a more capable fighter. It would soon find both as the F-84 entered the program.

The GRB-36D-III FICON was, like its predecessors in the airship era, an engineering wonder. Aircraft manufacturer Convair won a contract in January of 1951 to modify a RB-36D to have redesigned paneling on its belly and an H-shaped catching system.[27] They designed the AVLP to be able to either fly with an F-84's canopy and a portion of the vertical stabilizer in its bomb bay (the wings and engines still beneath the B-36) or with specialized panels filling the void.[28] The USAF conducted its initial testing of the FICON construct with the F-84E, and had its first successful flight in the era on January 9, 1952.[29] However, even as this phase of testing completed, the USAF decided it no longer needed the fighter to protect the *Peacemaker*, but rather to meet a new requirement: high-speed reconnaissance.

With the change to operational requirements, the USAF decided its operational FICON squadrons would focus on this new mission. The

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[25] Pyeatt and Jenkins, *Cold War Peacemaker*, 222.
[26] Jenkins and Landis, *Experimental & Prototype U.S. Air Force Jet Fighters*, 85.
[27] Jacobsen, *Convair B-36*, 344.
[28] Pyeatt and Jenkins, *Cold War Peacemaker*, 225.
[29] Jacobsen, *Convair B-36*, 345.

reconnaissance-variant fighter of choice, the RF-84F *Thunderflash*,[30] had 15 cameras in its nose.[31] The eventual FICON aircrafts' operational record is still unknown, either lost or still classified, but historians presume the USAF used them in missions over the Soviet Union.[32] FICON aircraft fulfilling the penetrating-reconnaissance role was not to be enduring as a dedicated long-range reconnaissance platform, the U-2, began its operational life in 1955.[33] The B-36 AVLP experimentation pivoted one final time.

Figure 21 - Rendezvous

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[30] The USAF modified the RF-84F into a GRF-84F, then renamed the platform.
[31] Marcelle Size Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, vol. I (Washington, D.C.: US Government Printing Office, 1978), 46; David R. McLaren, *Republic F-84: Thunderjet, Thunderstreak & Thunderflash: A Photo Chronicle*, Schiffer Military/Aviation History (Atglen, PA: Schiffer Pub, 1998), 195; Wagner, *American Combat Planes*, 449. – Wagner states that there were only "six cameras in an elongated nose," however, Knaack's specific accounting of the 15 cameras is likely the correct reporting.
[32] Pyeatt and Jenkins, *Cold War Peacemaker*, 224.
[33] Wagner, *American Combat Planes*, 539.

Goleta Air and Space Museum, “Flying Aircraft Carriers of the USAF: Project FICON,” accessed May 6, 2020, http://www.air-and-space.com/ficon.htm.

Projects TIP TOW and Tom-Tom

In 1949, the USAF had tested a wingtip-hooking mechanism for fighters to essentially clip onto a larger aircraft. A Culver PQ-14, equipped with a lance on its wing, would pull slightly ahead of a Douglas C-47A mothership, with a corresponding ring-slot on its wing, and then the PQ-14 would drift back to slide “the lance into the ring.”[34] In 1953, Project TIP TOW utilized the same construct, but with F-84s trying to link with a B-29.[35] Unfortunately, aerodynamics did not support this ingenuity. Pilots found controlling the F-84 near the B-29’s wingtips to be particularly difficult due to wingtip vortices (swirling, turbulent air currents). On April 24, 1953, “one of the fighters rolled up and over onto the wing of the B-29,”[36] and both airplanes crashed.

Project Tom-Tom (derived from the USAF and Convair project leads, both named “Thomas”),[37] would attempt to accomplish the same feat, with a claw on an RF-84F *Thunderflash’s* wing and a B-36. Trials began in winter of 1955. The same oscillation problems affected this airborne courtship, and the USAF abandoned the project in the fall of 1956.[38] With advances in aerial refueling, simpler solutions appeared to be at hand.

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[34] Pyeatt and Jenkins, *Cold War Peacemaker*, 225.
[35] Wagner, *American Combat Planes*, 424.
[36] Pyeatt and Jenkins, *Cold War Peacemaker*, 226.
[37] Pyeatt and Jenkins, 226.
[38] Pyeatt and Jenkins, 226.

Figure 22 - Project Tom-Tom
(note the claw on the right wing of the RF-84F)

Source: Goleta Air and Space Museum, "Flying Aircraft Carriers of the USAF: Project Tom-Tom," Goleta Air and Space Museum, accessed May 2, 2020, http://www.air-and-space.com/tomtom.htm.

Peacemakers to Pieces

The B-36 was a massive player in early Cold War deterrence. The USAF conducted innovative research and experimentation in an attempt to obtain more life and usefulness from the *Peacemaker* through its FICON, TIP TOW, Tom-Tom, and other projects. However, FICON did not add enough capability for it to keep pace with emergent capabilities like aerial refueling and jet-engine technology. The TIP TOW and Tom-Tom wingtip projects were failures, but without extensive computer modeling capability, trials were the only effective way the USAF could test the concept.

The FICON program had begun where the airships left off: a small airplane hooking up to a flying trapeze. The Air Force's *Goblin* flight tests and tactical analysis of the airplane's likely ineffectiveness in an escort role drove a change in parasite selection. Once designers settled on the parasite's role to be reconnaissance, the program attained limited success. The FICON effort had not failed, but it was an inferior solution to the other organic improvements the USAF was implementing in operating constructs and capabilities. B-36 *Peacemakers* would not need their parasites as they began, in 1956, to reconnoiter the west coast of the USA en route to the boneyard at Davis-Monthan Air Force Base, Arizona. The *Thunderflashes* would finish their phaseout in 1972, and reunite with their hosts.[39]

Analysis

This study seeks to find factors which appear across multiple AVLP efforts. While the B-36 FICON squadrons only existed operationally for 18 months, their successful marrying of assets showcased how future technological and operational constructs could work. To further refine takeaways, we look to the same four focus areas as chapter one did: technology, logistics, employment methodology, and political-economic factors.

Technology

As the preeminent bomber of its time, the technology on the B-36 represented the best capabilities designers could implement. The *Peacemaker* benefited from wind-tunnel testing, new materials and metals which enabled a stronger structure at reduced weight, and improved thrust from its six propeller engines.[40] Mounting those engines on the rear of the wings allowed for improved laminar air-flow over the wings and helped to get the B-36 the needed endurance for 10,000-mile missions.[41] To increase speed over its target and aid with some thrust deficiencies during takeoff, the USAF added two jet engines on the B-36's outer portion of each wing, bringing the total engine count to ten on the B-36D (the model which became the AVLP).[42] This increased power

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[39] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1978, I:48.
[40] Jacobsen, *Convair B-36*, 39–56.
[41] Jacobsen, 24.
[42] Pyeatt and Jenkins, *Cold War Peacemaker*, 76–77.

supported heavier weight operations and the additional components needed for FICON within the GRB-36D-III.[43]

The technology allowing for the aircraft to launch and conduct such a long-range mission drove the concurrent need for forward defense of the *Peacemaker* at incredibly long ranges. Its range, loiter time, and payload capacity made the B-36 an attractable platform for AVLP operations. This was especially so given that the RB-36D was "becoming more and more vulnerable, and now new form of defense was readily available."[44] The reconnaissance-version of the *Peacemaker* still had a mission, but its ability to do it was dwindling without a technological improvement. Fortunately for the USAF, aviation technology had advanced significantly since the days of airship operations. Moreover, adapting the RB-36D from a strictly reconnaissance platform to an AVLP created a substantially more stable platform than the airships ever offered. The F-84 parasite was also quite a bit more capable than the *Sparrowhawks* could have ever hoped to be.

The F-84F *Thunderstreak* was hardly an F-84, except in name. Although Republic, the manufacturer, stated that it could use 55% of the F-84E model in its swept-wing variant, even its company drawings depicted the new jet as an F-96.[45] The USAF requested Republic, the manufacturer, utilize the F-84F nomenclature to solve a funding issue; there was money for modification, not for new aircraft.[46] By the third prototype, the YF-84F had almost completely new parts.[47]

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[43] The III was a weight reduction modification entitled "featherweight."
[44] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:38.
[45] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1978, I:39; Jenkins and Landis, *Experimental & Prototype U.S. Air Force Jet Fighters*, 71.
[46] Gordon Swanborough and Peter M. Bowers, *United States Military Aircraft since 1909* (Washington, D.C: Smithsonian Institution Press, 1989), 532; Jenkins and Landis, *Experimental & Prototype U.S. Air Force Jet Fighters*, 71.
[47] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1978, I:38.

A stock F-84E and this newer swept-wing YF-84F were the test platforms for the FICON program, with the F-model eventually receiving further modification and a new engine to become the RF-84F *Thunderflash*. Those modifications included the wing-root intakes so the nose could hold the 15 cameras, and a wire recorder for the pilot to speak his observations into.[48] Modifying the RF-84F into a FICON RF-84K bird required engineers to place the retractable hook on the nose for trapeze-cradle operations, and cant the tail's horizontal stabilizers downward.[49] These advanced capabilities for high-speed reconnaissance enabled the *Thunderflash* to conduct the RB-36D's mission in higher-threat environments, becoming essentially a smaller version of the 10-engine host. The RF-84K, however, was not completely alike and had one major deficiency: range. The RF-84K consumed gas quickly and needed a launch-and-recovery platform in order for it to meet its strategic purpose.

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[48] Knaack, I:46; Wagner, *American Combat Planes*, 450.
[49] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1978, I:48.

Figure 23 - RF-84K Thunderflash
Source: Ken LaRock, "Republic RF-84K Thunderflash," National Museum of the United States Air Force, May 29, 2015, http://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/198072/republic-rf-84k-thunderflash/

Launch and recovery operations on the B-36 AVLP went generally well. The hooking mechanism on the F-84 was ahead of the cockpit and allowed for the pilot to maintain normal sightlines during docking operations.[50] Conversely, the hook on the F9C-2 *Sparrowhawk* (the airships' parasite) was mounted on top of the bi-plane's upper wing, forcing the pilot to look up while attaching. In execution, even subtle requirements to changes in the pilot's eye-line can disorient the operator, and potentially lead to accidents. Additionally, *Sparrowhawk* pilots had to maintain a high angle-of-attack to essentially stall the aircraft while settling onto the trapeze.

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[50] Pyeatt and Jenkins, *Cold War Peacemaker*, 222.

On the F-84, the designers eliminated many of these problems by having the hook ahead of the pilot. While airship operators had used flashlights from the hull to illuminate the trapeze, FICON designers installed mission-specific lights on the GRB-36D-III's cradle to enable night-time hookups.[51] Additionally, the H-shaped cradle apparatus folded down onto the fuselage only after a positive hooking. This design left a clear flight path to the hook-on point, and allowed the fighter pilot to stabilize in a relative position to the B-36 without much concern of striking either the cradle or the B-36 itself.

Figure 24 - Republic YRF-84F Test Platform Linking up to B-36
Source: USAF, Republic YRF-84F, November 6, 2015, November 6, 2015, https://www.nationalmuseum.af.mil/Upcoming/Photos/igphoto/2001315693/.

[51] Pyeatt and Jenkins, 223.

Despite the positive aspects of the design, there are divergent reports regarding how easy coupling operations were. Some historians report troubled recovery operations,[52] while others found it to be "practical"[53] with even the initial tests being "remarkably trouble-free."[54] Boyd reports poor performance on the opening day of operational training, with three of the first six pilots causing damage to their *Thunderflashes* during rendezvous maneuvers.[55]

Perhaps the most salient points about the hooking apparatus come from two of the era's test pilots Bud Anderson and Beryl Erickson (a test pilot for the B-36 and F-84 on Tom-Tom and FICON). Anderson describes the air underneath the 10-engine B-36 as quite turbulent and that the latching operation was difficult even for an experienced jet pilot.[56] Erickson, conversely, found the system to be "tinkertoy [sic] easy to perform the engagement"[57] and thought that other pilots may have been intentionally flailing at the maneuver to sabotage the program.[58] Bravado aside, with no major accidents and at least one save of an RF-84K which could not make it to an alternate airfield, the functional aspect of the airborne link-up appeared to be sufficient. In fact, the entire FICON rendezvous operations worked smoothly because the USAF made it easier for parasite pilots to return to their host.

The previous era's Curtiss F9C-2 *Sparrowhawk* pilots suffered from navigation problems. They had to rely on known wind-drift angles,

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[52] Robert J. Boyd, *SAC's Fighter Planes and Their Operations* (Office of the Historian, Headquarters Strategic Air Command, 1988), 16; McLaren, *Republic F-84*, 195.
[53] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:38.
[54] Pyeatt and Jenkins, *Cold War Peacemaker*, 222.
[55] Boyd, *SAC's Fighter Planes and Their Operations*, 81.
[56] Clarence E. "Bud" Anderson, *To Fly and Fight: Memoirs of a Triple Ace* (Xlibris Corporation, 2017).
[57] Samantha Magill, "Compound Aircraft Transport Study: Wingtip-Docking Compared to Formation Flight" (Virginia Tech, 2002), 18, https://vtechworks.lib.vt.edu/bitstream/handle/10919/11122/disseration.pdf?sequence=1&isAllowed=y.
[58] Magill, 19.

trigonometry, and (fortunately) the sheer size of the *Akron* and *Macon* to find their way back to their mothership. With the *Peacemaker*, the parasite fighters were able to utilize an identification of friend or foe (IFF) signal to support link-up operations.[59] This reliable beacon also heavily simplified night rendezvous operations and reserve fuel planning.

The key technological takeaways from the FICON experiments are the apparent success of utilizing an iterative design with existing platforms and creating simple solutions to minimize human-factors risks. The RB-36D and RF-84F were both established major weapons systems with proven capabilities. While the modifications required to create the FICON capability were substantial, they did not require the USAF to seek an entirely new platform. The majority of the change had to come from removing equipment from the RB-36D's "bomb" bays, which generally carried camera equipment and extra fuel, to make room for the upper half of the parasite. For the RF-84K, the substantive modifications were the anhedral tail so it could clear the GRB-36D-III's bottom, and the retractable hook. Neither of these created significant challenges for aerospace engineers.

Designers' human-factor solutions like the forward-mounted hooking apparatus, lighted trapeze system, and IFF beacon all minimized the complexity and chance for human error during missions. Future designers should consider how technological factors affect host-parasite interaction, mission execution strategies, and their potential effect on the logistics underlying the entire operation.

Logistics and Operational Support

The 1948 decision to construct and initially base B-36s in Texas was largely political. As the sole US bomber capable of attacking the Soviet Union from the continental US without requiring a stopover at one

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[59] Pyeatt and Jenkins, *Cold War Peacemaker*, 223.

of SAC's European bases, basing it farther north would have been more operationally sound.[60] However, given the political situation around the B-36, the USAF wanted to simply get it flying.

Polar operations taught the USAF about the hazards of flying in extreme cold. To prepare, the Air Force used a special temperature-controlled hangar in Florida for the purposes of subjecting the B-36 to the likely temperatures.[61] Once actual training operations began, the USAF found anomalies in "metal shrinkages, unexpected behavior of fuel and lubrication, and difficulties of clothing and the crews' health" due to the high-altitude and cold temperatures.[62] All of these problems likely affected the design choice to have the FICON fighter semi-submerge into the B-36 as a pilot left stuck in a *Thunderflash* for 50-hour missions in extreme temperatures would fare much worse.

Figure 25 - YF-84F Hooked and Reeled into a GRB-36D-III
Source: USAF, Republic YRF-84F.

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[60] Jacobsen, *Convair B-36*, 77.
[61] Jacobsen, 77.
[62] Jacobsen, 79.

Although an awkward visual signature and setup, Convair's modeling and aerodynamic analysis enabled the semi-submerging of the RF-84K into the GRB-36D-III. This came at a fuel penalty of 5-10% for the GBR-36D itself, but with the ability to launch the fighter for the reconnaissance mission, the overall operational range increased by 20%.[63] Storing portions of the parasite in the GRB-36D-III's interior also paid great dividends to the *Thunderflash* pilot. Enabling the pilot to egress from the fighter and not waste fuel, electric power, or life-support supplies decreased both waste and lessened chances for mission failure due to systems malfunctioning during the long flights. Equal in import, it gave the parasite pilot a much-needed respite from the cramped quarters of the F-84 and a chance to rest inside the B-36.[64]

63 Raymond L. Puffer, "Two Warfighters in One Package," Edwards Air Force Base, October 27, 2006, https://web.archive.org/web/20061027180244/http://www.edwards.af.mil/moments/docs_html/56-04-27.html; Jacobsen, *Convair B-36*, 347.
64 Jacobsen, *Convair B-36*, 347.

Figure 26 - YRF-84F in its Stowed Position
Source: Goleta Air and Space Museum, "Flying Aircraft Carriers of the USAF: Project FICON."

On a mission which could last upwards of 50 hours, the fighter pilot needed to be fresh when he was needed. This was especially important, given the high-threat operation he was to conduct. But the AVLP supported not only the pilot's needs, but his jet's too. To enable aircraft servicing during a mission, the GRB-36D-III carried an 1140-gallon jet fuel container as the GRB-36D-III itself, even with 4 jet-engines, only used aviation gas.[65] This amount of fuel provided flexibility for mission execution, which fit the differing methods of possible employment.

Operationally, while it was possible for the two aircraft to launch with the F-84 already onboard, its usual employment methodology was

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[65] Pyeatt and Jenkins, *Cold War Peacemaker*, 223.

to conduct an airborne rendezvous.[66] As the FICON program matured, its main operating bases changed from Florida to Washington state, at Fairchild AFB for the GRB-36D-IIIs and Larson AFB (Moses Lake) for the 91 Strategic Reconnaissance Squadron's RF-84Ks.[67] Engineers installed a downward-sloping ramp to a pit where a B-36 could hoist the parasite into its undercarriage for concurrent takeoff. However, usually the two would launch from their respective bases.

This setup supported training operations as the two aircraft would launch from separate locations and link up in the sky, similar to the F-84's post-mission requirement to return to its mothership. The fuel onboard the *Peacemaker* supported this construct. The *Thunderflash* could launch from Larson, merge with its host, refuel while the pilot slept or prepared for his mission, and there would still be enough for more sorties, whether operational or just an administrative leg back to Larson after a long day(s).

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[66] Pyeatt and Jenkins, 223.
[67] Pyeatt and Jenkins, 223.

Figure 27 - The FICON ground-loading ramp at Fairchild AFB
Source: Jim O'Connell, "The Lost Mission: Fairchild's Bombers and the FICON Project," July 7, 2015, https://www.fairchild.af.mil/News/Features/Display/Article/763107/the-lost-mission-fairchilds-bombers-and-the-ficon-project/

Without an operational record to refer to, researchers are left with mostly questions about reliability and how well these logistic functions served operations. However, some principal tenets are still apparent. Just as technology can mitigate potential human-factors issues, if future iterations of AVLPs include manned parasites, then designers must certainly address the sustainment of the operators for both assets. Given a generally lengthy mission duration for the FICON tandem, and the high-threat operation the *Thunderflash* pilot had to conduct tens of hours into the sortie, the interior housing of the cockpit removed a need for the fighter jet itself to provide options for basic quality of life factors like food, water, bathrooms, temperature control, comfort, and sleep. While these may not be the primary elements leaders consider during fighter-jet acquisitions, they may be critical to effective operations. Using a host aircraft to reduce weight and alleviate other requirements from the parasite appears to offer a reasonable and manageable solution to this problem.

Figure 28 - Catwalk Around the Parasite
Source: Goleta Air and Space Museum, "Flying Aircraft Carriers of the USAF: Project FICON."

Employment and Doctrinal Integration

As opposed to the airship's constant need to prove any level of usefulness to the fleet, the FICON experiments were congruent with existing USAF doctrine and employment strategies. The B-36 FICON program was a USAF response to a strategic problem. Once designers recognized the fighter-defense role by either a *Goblin* or *Thunderjet* was inappropriate, the USAF decided to strengthen its RB-36D's strategic reconnaissance capability as their likely best way forward.

The need for the USAF to transition away from fighter-support to reconnaissance became clear as FICON operational capability drew nearer to reality. The USAF decided its employment philosophy was flawed after recognizing that, in the event of a major war, it would launch a sizable bomber force for nuclear operations. Recalling WWII doctrinal beliefs, strategists believed such a large force could self-protect its formation and get to the target.[68] This realization did not kill the FICON program, rather it drove a shift in focus and application. While the bomber may indeed get through, the question was: get through to where? The reconnaissance RB-36D could not survive solo incursions into hostile airspace to find targets or ensure their viability, but a fighter could. The USAF elected to retool the swept-wing RF-84F *Thunderflash* for FICON operations, and designated it the RF-84K.[69]

The *Thunderflash* was ideal for penetrating Soviet airspace, avoiding detection, and coming back to its host.[70] The USAF tested this theory by conducting FICON operations out of Eglin AFB in Florida against US bases, to see how well radar and fighter-sweeps could do

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68 Pyeatt and Jenkins, 223.
69 Wagner, *American Combat Planes*, 448–49; Swanborough and Bowers, *United States Military Aircraft since 1909*, 534.
70 Pyeatt and Jenkins, *Cold War Peacemaker*, 223.

against an ingressing solo fighter.[71] With effective incursions, USAF theorists even postulated arming the RF-84K with an atomic weapon should the need arise to engage a target immediately or in situations where the bomber formation may meet severe opposition.[72]

The doctrinal employment method was for the B-36 to bring the fighter within 800-1000 miles of its target and launch the recon jet at around 25,000 feet.[73] With both the parasites and hosts in SAC, the command was able to direct synchronized employment strategies for both assets. SAC procured the FICON assets and their overall mission directly supported SAC's strategic reconnaissance and strike purposes. There was little internal discord about the purpose or best employment methodology for the FICON assets.

Unlike the airships, SAC accepted FICON as a good asset for its purpose. With the ability to take readily available assets and combine them to serve the command's mission, FICON integration to the larger SAC enterprise was relatively seamless. The major change was to make the RB-36D a carrier instead of the photographer, but the fundamental mission remained unchanged.

Perhaps as a subconscious bias toward risk mitigation and protection of life resulting from recently finished World Wars, theorists in both the airship and FICON eras initially sought to use parasites as defensive assets. In both cases, those roles quickly morphed into reconnaissance ones. While anecdotal, this may suggest that the limitations due to the size of the parasite or overall structure of AVLP operations may be more suited to an information, surveillance, reconnaissance (ISR) role. Until further technological advancements may drive a change to this concept, designers and strategists may need to

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[71] Goleta Air and Space Museum, "Flying Aircraft Carriers of the USAF: Project FICON," accessed May 6, 2020, http://www.air-and-space.com/ficon.htm.
[72] Pyeatt and Jenkins, *Cold War Peacemaker*, 223.
[73] Pyeatt and Jenkins, 223.

accept that a diminished-capability parasite may be the only option, and design employment constructs around those limitations. Especially if they know the asset's lifespan is already going to be short.

Politics, Economics, and Military Leadership

FICON was designed as a stopgap measure to get from the WWII-era bombers to new reconnaissance jets like the RB-47, RB-52, and U-2.[74] As such, its overall demise had less to do with funding or support from military leadership, and more with the emergence of new, superior technologies. The overall B-36 program, however, had been continually marred by financial troubles during its developmental phase.

The "B-36 program suffered from constantly shifting notions of its priority in the halls of the USAAF."[75] With consistent changes in construction priority dating back to 1942 and deviations from programmed versus appropriated money, the USAAF was apprehensive at best during its acquisition process.[76] In 1946, the USAAF SAC Commander, General George Kenney, stated his preference for the B-50, essentially an upscaled B-29, to the B-36 and suggested that with the B-52 coming within a decade, that the USAAF should wait for the best product.[77]

General Spaatz, then chief of the USAAF, considered the dissenting vote, but ultimately sided with others who believed this was the best product available to counter potential Soviet aggression.[78] The B-36 was arriving right at as the aviation industry was pivoting to jet engines, and its long-term viability was always in question. Thus, as the *Peacemaker* was already on its last legs in the mid-1950s, FICON was an attempt to

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[74] McLaren, *Republic F-84*, 194; Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:218–20.
[75] Jacobsen, *Convair B-36*, 19.
[76] Jacobsen, 28–30.
[77] Jacobsen, 46–47.
[78] Jacobsen, 47.

get a few more years of use until SAC squadrons could receive replacement RB-52s and U-2s.

B-36 funding was controversial from the start. Congress had already forced the USAAF to use remaining appropriated money from 1942-1946,[79] when the "Revolt of the Admirals" happened in 1949.[80] The Navy's issues stemmed largely from the cancellation of the USS *United States*, but used the floundering B-36 program as an example of USAF waste.[81] The USAF had to counter the Navy's powerplay.

The USAF had only recently gained its independence from the Army and then been tasked as the lead service in strategic nuclear strike offensive mission. Had the Navy been able to usurp the role and appropriate the corresponding funding for itself, the fledging USAF may have lost its core purpose.[82] Instead, with the USAF able to assert the B-36's capabilities and the service's preeminent ability to conduct the global mission, it won a major political and public validation.[83] Congress solved funding issues with large DOD funding increases in the fiscal-year 1951 and 1952 appropriations (the Korean War), paving the way for both the procurement and the initiation of the FICON program.[84] The final FICON program costs were $4.1 million per GRB-36D-III,[85] and $667,608 for an RF-84F[86]. The specialized ramp at Fairchild AFB also accounted for a $55,000 expense.[87]

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[79] Jacobsen, 48.
[80] Edward Kaplan, *To Kill Nations: American Strategy in the Air-Atomic Age and the Rise of Mutually Assured Destruction* (Ithaca: Cornell University, 2015), 51–68; Jacobsen, *Convair B-36*, 82–85.
[81] Wagner, *American Combat Planes*, 422; Jacobsen, *Convair B-36*, 83–84.
[82] Kaplan, *To Kill Nations*, 68.
[83] Kaplan, 68.
[84] Jacobsen, *Convair B-36*, 90–91.
[85] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:38.
[86] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1978, I:47.
[87] Jim O'Connell, "The Lost Mission: Fairchild's Bombers and the FICON Project," July 7, 2015, https://www.fairchild.af.mil/News/Features/Display/Article/763107/the-lost-mission-fairchilds-bombers-and-the-ficon-project/.

While the airships lacked a senior-level advocate after Admiral Moffett's death, the conversion of strategic bombers to reconnaissance platforms was often directed by General LeMay himself.[88] With a proponent whose name is synonymous with the organization he led, the need for any further advocacy was eliminated. The problem for B-36 support had been during its development, not during FICON.

During its formative years, the B-36 program had nearly been canceled five times.[89] Therefore, it should have come as little surprise to SAC when it received only 10 RB-36Ds and 25 RF-84Fs compared to its ask of 30 and 75, respectively.[90] With so many other programs like the B-52, U-2, KC-135, ballistic missiles, and century-series fighters in the works, further modifications to a platform which was practically obsolete on arrival was simply not in the cards. As another recession hit the US in 1956, the *Peacemaker* became an obvious target for divestment.[91]

Conclusion

The FICON effort ended not because of a lack of mission requirement or viability, but instead as a casualty of the larger B-36 program and the impending arrival of sufficient numbers of Cold War SAC jets. By 1956, the "FICON project [had been] discontinued in favor of newer technological advances in reconnaissance aircraft, in-flight refueling, and the pending phase-out of the B-36 fleet." Projects TIP TOW and Tom-Tom had failed to achieve viability. The USAF began phasing out its B-36s in 1956 and 1959 was its final year of operations.

The FICON program achieved limited success. It showcased improvements in modern coupling technology, innovative approaches to aerial defense and reconnaissance, and did not suffer from the many logistic challenges that plagued the airship era. While it did not have a

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[88] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:36.
[89] Jacobsen, *Convair B-36*, 106.
[90] Knaack, *Encyclopedia of US Air Force Aircraft and Missile Systems*, 1988, II:38–39.
[91] Pyeatt and Jenkins, *Cold War Peacemaker*, 162.

long service life or esteemed operational record, it was a functional AVLP able to conduct its mission safely and effectively.

The Air Force-Navy political battles waging behind the scenes of B-36 development nearly ended the *Peacemaker* project. However, without the Navy's constant derogatory references to the "plane as a 'sitting duck' for enemy jet fighters,"[92] the USAF may never have looked to solve its defensive problem by morphing it into an AVLP. While the parasite fighter was never used in its originally-intended sweep role, the USAF's adjustment to a penetrating reconnaissance platform was innovative and addressed a critical gap in its airborne kill-chain. However, as the U-2 offered more loiter time and capabilities, it largely outclassed the FICON-recon platform.[93] Save for the possibility of nuclear delivery from the parasite, there was no longer a need for the FICON program.

The USAF had tried many variants with the B-36 to both increase its utility and prolong its service life. Aside from FICON, TIP TOW, and Tom-Tom, the USAF attempted Project TANBO which saw Convair convert the B-36 into a tanker platform.[94] But it was a short-lived dalliance known as Project RASCAL which served as another foundational shift in AVLP thinking. In RASCAL, Convair modified B-36s to carry the GAM-63 "Rascal" guided missile.[95] The aptly-named "Director" version of the B-36 would "serve as carriers and controllers for GAM missile development."[96] A new direction for AVLPs, launching semi- or fully- autonomous air vehicles, had arrived.

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[92] Jacobsen, *Convair B-36*, 84.
[93] Swanborough and Bowers, *United States Military Aircraft since 1909*, 390–95.
[94] Jacobsen, *Convair B-36*, 350.
[95] Pyeatt and Jenkins, *Cold War Peacemaker*, 215.
[96] Swanborough and Bowers, *United States Military Aircraft since 1909*, 189.

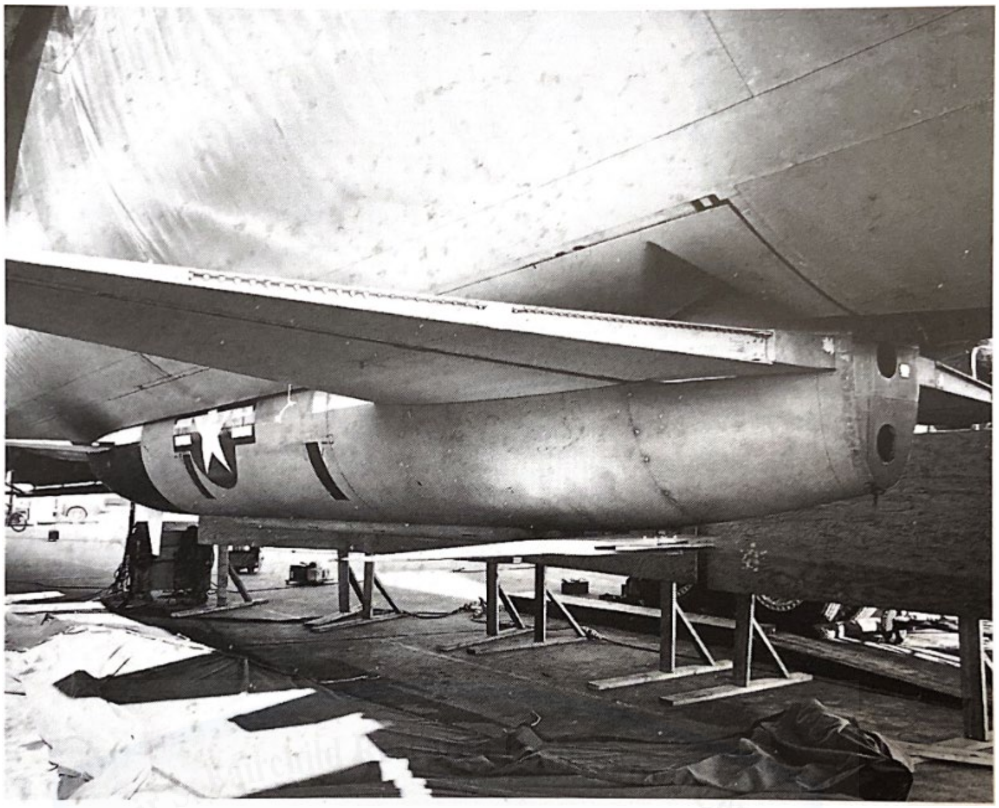

Figure 29 - A GAM-63 "Rascal" semi-submerged into the EDB-36H
Source: Jacobsen, Convair B-36, 350.

Chapter 4

Through the Eyes of Insects

History and Context

The "Director" B-36 could not keep time with the evolving orchestra of military weaponry and soon a new maestro took the stage. The "Director" variant of the famous C-130 cargo airlifter, the DC-130, was the mothership for the next wave of Airborne Vehicle-Launch-Platforms (AVLP), launching Ryan Aeronautical Company Model 147s to conduct information, surveillance, and reconnaissance (ISR) missions for the US military during Vietnam.[1] Ryan created its initial Model 147 *Fire Fly* by converting its *Firebee* target-drone (Ryan Q2-C) into an ISR-capable platform during a period marked by advances in strategic intelligence gathering, including those made in the U-2 and CORONA satellite programs.

[1] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 1.

Figure 30 - DC-130 with 2 Model 147s in Vietnam
Source: USAF, DC-130 with AQM-34s, n.d., n.d., https://media.defense.gov/2014/Jan/14/2000883976/-1/-1/0/140114-F-DW547-007.JPG.

To understand why the USAF turned to the *Fire Flies* as a solution to ISR, it is helpful to have a quick primer on the other major ISR capabilities of the day. The first U-2 *Dragon Lady* launched from Groom Lake, Nevada in 1955.[2] Central Intelligence Agency (CIA) pilots began Soviet-overflight operations in the summer of 1956,[3] and by 1957 had "penetrated the Soviet air defenses and successfully photographed the Tyura Tarn ICBM test launch area in Kazakhstan."[4] Eventually, the U-2's

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[2] Swanborough and Bowers, *United States Military Aircraft since 1909*, 390.
[3] Kevin Ruffner, ed., *CORONA: America's First Satellite Program*, CIA Cold War Records Series, 1995, 3, https://www.cia.gov/library/publications/intelligence-history/corona-between-the-sun-and-the-earth.
[4] Joan Bird and Bird, John, eds., "Penetrating the Iron Curtain: Resolving the Missile Gap with Technology" (CIA, 2013), 11, https://www.cia.gov/library/publications/cold-war/resolving-the-missile-gap-with-technology/.

operational footprint would extend into China, with both Taiwanese and USAF personnel conducting photo and signals intelligence missions, along with air sampling in the *Dragon Lady*.[5]

CORONA satellites would begin orbiting Earth in 1960.[6] "The CORONA program got under way initially as an interim, short-term, high-risk development to meet the intelligence community's requirements for area search photographic reconnaissance."[7] After numerous failures, the program managed a successful recovery of a capsule which had orbited the planet in early August of 1960.[8] Later in the month, DISCOVERER XIV sent 20 pounds of film from orbit and "yielded photo coverage of a greater area than the total produced by all of the U-2 missions over the Soviet Union."[9] The future of ISR had seemingly arrived.

Though these advances in high-altitude and low-earth orbit surveillance technologies provided the DOD and US intelligence agencies access to imagery at unprecedented levels, the ISR assets were not without their own shortcomings. CORONA's reliability was always uncertain as it relied on a complex system operating in space and its aircraft-film-retrieval method also invited failure. The U-2 offered better image quality of the target, but its "[b]latant violation of Soviet airspace was a risky, hit-and-miss means of espionage."[10] The Soviets agreed.

Strategic Problem

When a Russian surface-to-air missile (SAM; an SA-2) struck Francis Gary Powers's U-2 on May 1, 1960, it blew up not only the jet,

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[5] Anthony M. Thornborough, *Sky Spies: Three Decades of Airborne Reconnaissance* (London□: New York, NY: Arms and Armour Press□; Distributed in the USA by Sterling Pub. Co, 1993), 12.
[6] Ruffner, *CORONA: America's First Satellite Program*, 3.
[7] Ruffner, 9.
[8] Ruffner, 18–22.
[9] Ruffner, 22.
[10] Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (Baltimore: Basic Books, 1985), 117.

but the cover on the CIA's covert ISR program. The US, in efforts to stave off political fall-out and any ensuing escalation with the Soviets, attempted to downplay the operation as a National Air and Space Administration (NASA) weather study, but the Russians knew the truth.[11] Another U-2 loss during the Cuban Missile Crisis[12] coupled with the minimal space-collection capability in the early 1960s demonstrated a strategic need for high-fidelity reconnaissance that was neither limited by the satellite program's processing delays nor the threat of losing a pilot. Just as Earth's insects can survive in the worst conditions and gain access to areas with only the slightest openings, Ryan Aeronautical believed its *Firebees* could be the pests the USAF needed.

Firebees*, *Fire Flies*, and *Lightning Bugs

Figure 31 - BQM-34 *Firebee*
Source: USAF, BQM-34, March 5, 2009, https://media.defense.gov/2009/Mar/05/2000614758/-1/-1/0/090305-F-1234P-005.JPG.

[11] McDougall, 220.
[12] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 1.

The Ryan Aeronautical Company created its Q-2 *Firebee* in 1948 to serve as "a jet-propelled target drone for both surface-to-air and air-to-air gunnery training."[13] The Q-2 *Firebee* was a remote-piloted vehicle (RPV; "Q" designated an RPV in the DOD) and measured approximately 17-feet long, by 11-feet wide.[14] Both the company (acquired by Teledyne in 1969 and then by Northrop Grumman in 1999)[15] and the *Firebee* would undergo continual modifications over the years, but this chapter focuses primarily on the main Vietnam-era models in the Ryan Model 147 family of drones as many of the future iterations were test platforms or ground-launch only. The extensive Model 147 family of drones was arguably the most successful AVLP program of the twentieth century.

The Ryan Model 147A was a Q-2C *Firebee*, a slightly larger variant than the Q-2, but modified with "a new navigation system and increased fuel capacity."[16] Ryan Aeronautical's concept to convert the *Firebee* into an air-launchable ISR platform dated back to 1955. The program was even pitched to the USAF the month before the Powers incident.[17] Despite the *Firebee's* promise, however, Ryan received only a token $200,000 from the USAF in the summer of 1960.[18] Ryan used this seed money to modify the Q-2C *Firebee* and also attempted development of two newer models, but they soon became cost-prohibitive.[19] Fortunately, the USAF's quick acquisition and management program BIG SAFARI[20]

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[13] Bill Yenne, *Attack of the Drones: A History of Unmanned Aerial Combat* (St. Paul, MN: MBI Pub. Co, 2004), 20, 23.
[14] Yenne, 23.
[15] Yenne, 23.
[16] Norman Friedman, *Unmanned Combat Air Systems: A New Kind of Carrier Aviation* (Annapolis, MD: Naval Institute Press, 2010), 82.
[17] Friedman, 81; Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 1.
[18] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 1.
[19] Wagner, *American Combat Planes*, 1.
[20] BIG SAFARI was "a secretive Air Force acquisition program for specialized special mission aircraft." From: John Harrington, "Changing the Face of War; Saving Lives – the Legacy of Bill Grimes," Air Force Materiel Command, September 24, 2018,

was undeterred by the failure, and took on the modified *Firebees* (the Ryan 147A) in February of 1962.[21]

The USAF's acquisition of 147As was the beginning of the *Fire Fly* program.[22] Model 147A showed great promise and after Maj Rudolf Anderson was shot down over Cuba later in the year, the USAF supplied a formal contract which ultimately led to the new designator-family AQM-34 (air-launched, RPV, missile; some air- or ground-launchable variants were denoted BQM).[23] In the words of a program expert during the period, "The real purpose of starting the program, or the thing that kicked it off, was the Cuban crisis."[24] The USAF needed a tactical recon platform which could operate in high-risk areas without incurring substantial risk for the pilot or national prestige. As Model 147Bs and Cs were going through testing and trials, the *Fire Fly* name was compromised and the USAF renamed the program *Lightning Bug*.[25]

Both the CIA and USAF controlled *Lightning Bugs* in the Vietnam War. Drone historian Bill Yenne reports, "The Bugs were air launched from DC-130A and DC-130E 'mother ships,' or drone director aircraft, of which at least 15 were converted from Lockheed C-130 Hercules transports."[26] During the course of the Vietnam conflict, the RPVs conducted image, electronic, and communications intelligence (IMINT, ELINT, COMINT) operations.[27] Additionally, AVLP operations enabled the

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https://www.afmc.af.mil/News/Article-Display/Article/1643538/changing-the-face-of-war-saving-lives-the-legacy-of-bill-grimes/.

[21] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program" (Briefing Transcription, Pentagon, Washington D.C., 1973), 6; Friedman, *Unmanned Combat Air Systems*, 82.

[22] Friedman, *Unmanned Combat Air Systems*, 81.

[23] Also notated as BQM-34 due to the ability to ground- or air-launch the vehicle.

[24] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 6.

[25] Wagner, *American Combat Planes*, 2; Carl Schuster, "Lightning Bug War Over North Vietnam," *Vietnam* 25, no. 5 (February 2013): 51.

[26] Yenne, *Attack of the Drones*, 25.

[27] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 13.

RPVs to conduct decoy, chaff-corridor, and leaflet-drop missions in support of air and psychological operations.[28]

The most common mission was IMINT. While the Army, Navy, and USAF all launched variants of *Firebees* from the ground, the USAF's preferred method was using the AVLP construct. The DC-130 carried either two or four RPVs on its wings, depending on pylon configuration and the types of RPV it was to launch.[29] The RPVs' direction came from a Microwave Command Guidance System (MCGS), which was situated in the DC-130's nose or at a ground station.[30] The airborne-variant MCGS was particularly useful for combat operations, as the system relied on line of sight; any low-altitude operations or those beyond 200 nautical miles from a base would be impossible without the AVLP Director.[31] A single AVLP could direct multiple RPVs, but at diminished capacity, as the broadcast antenna would have to split time between the individual aircraft.[32]

[28] Wagner and Sloan, 13.
[29] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 32; Air Force Flight Test Center, "DC-130H Multiple Drone Control/Strike System (MDC/SS) Combined DT&E/IOT&E Flight Test," March 1978, 10–11.
[30] Thornborough, *Sky Spies*, 36; United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 34.
[31] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 34.
[32] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 34.

Figure 32 - The DC-130 with Pronounced 'Chin' and 'Nose' along with its Parasite
Source: San Diego Air and Space Museum, DC-130 Profile in Flight, n.d., https://www.flickr.com/photos/sdasmarchives/34270168272/.

After launch, the *Lightning Bug* would follow either a pre-programmed route or the Director's MCGS commands to the desired point, and then return to friendly territory once its mission was complete. Once at the designated return position, the *Firebee* would deploy a parachute and float down to the ground or, after 1969, to an awaiting "CH-3 or CH-53 helicopter equipped with MARS (Mid-Air Retrieval System). MARS hooks were designed to snag the drones' 100ft-diameter main 'chute."[33] From there, the helicopter would drag the drone back to its home-station to refit and refuel for future sorties.

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[33] Thornborough, *Sky Spies*, 35; Yenne, *Attack of the Drones*, 25.

Figure 33 - Helicopter Retrieval
Source: USAF, Helicopter Recovery, n.d., https://www.nationalmuseum.af.mil/Upcoming/Photos/igphoto/2000883975/.

With so many different variants, Model 147s were quite a ubiquitous asset. The variation within the RPV population also enabled it to excel in those different mission sets. A particular mission that garnered the most praise and prestige, though, was Strategic Air Command's (SAC) BUFFALO HUNTER.[34] BUFFALO HUNTER was the code name for the low-altitude operations which allowed the USAF to conduct reconnaissance missions below the cloud cover which frequently hampered IMINT operations. Along with countering weather issues, the low-altitude profile simultaneously kept the RPVs out of enemy radar coverage for longer periods of time. Finally, it kept human pilots from having to operate so low to the ground in poor visibility conditions, where they were also more vulnerable to enemy anti-aircraft systems. The

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[34] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program."

program was efficient and effective. So much so, that it became the standard bearer for all USAF drone operations.

As the number of drones operating in Southeast Asia increased, the USAF realigned all drone ISR missions under the BUFFALO HUNTER moniker to maintain unity of command and purpose.[35] While the various Model 147s had distinct purposes, their thematic purposes were generally aligned: conduct operations into higher-threat regions and during times in which human operators could not risk such exposure. The RPVs excelled in this role, especially so when the DC-130 AVLP could get them closer to their targets and help mitigate navigation problems. Overall, the RPVs were a successful ISR component in support of US military objectives during the Vietnam War.

From the Past, the Future

The modified *Firebees* were the first widely employed drones in combat operations.[36] During the 1960s and 1970s, 1,016 *Lightning Bugs* flew more than 3,400 sorties over China, North Vietnam, and North Korea.[37] While the RPVs were generally successful, 544 missions ended with the asset failing to return; the USAF attributed at least one-third of those losses to mechanical failure.[38] The success of the program, however, did not lead to permanent adoption. While the USAF continued testing on DC-130s into the late 1970s,[39] including external targeting for an RPV armed with Maverick missiles,[40] operational ISR RPVs were all but gone by the end of the decade. The USAF, facing budget constraints

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[35] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 22.
[36] Friedman, *Unmanned Combat Air Systems*, 85.
[37] Steve Zaloga and Ian Palmer, *Unmanned Aerial Vehicles: Robotic Air Warfare, 1917-2007*, New Vanguard 144 (Oxford; New York: Osprey, 2008), 14.
[38] Zaloga and Palmer, 14.
[39] Air Force Flight Test Center, "DC-130H Multiple Drone Control/Strike System (MDC/SS) Combined DT&E/IOT&E Flight Test."
[40] Thornborough, *Sky Spies*, 36.

in the drawdown after Vietnam, cut the program in favor of its preferred manned-ISR paradigm and platform, the U-2.[41]

Though *Firebee* RPVs continued to have a role in the target-drone arena, they did not participate in US wartime operations until nearly 30 years later. After decades in storage, Northrop Grumman used AQM-34L wings to modify and upgrade five *Firebees* so the RPVs could create chaff corridors during the first few nights of the US-led invasion of Iraq in 2003.[42] Once again, the RPVs raised no concern over flying into a high-threat scenario. Most RPVs, however, remained in warehouses save for the ones the USAF sold to the Israeli Air Force.[43] While the RPVs slept in storage, a technological revolution happened.

With computer power increasing inversely to the size required for the machine, unmanned and autonomous platforms were bound to displace the RPV paradigm. Unmanned Aerial Vehicle (UAV) research became increasingly important to the DOD in the 1980s and especially for high-altitude ISR. The services even tried to work together to create a common system, the Joint Services Common Airframe Multiple Purpose System (JSCAMPS or BQM-145A), but funding issues derailed the program.[44] Regardless, the services showed interest in continuing research and development in UAVs. With continued improvements in small-form technology, powerplant efficiency (loiter time), and communication and data networks, UAVs becoming a staple in operational missions was a near certainty.

The story of UAVs, though, is for another researcher. Our focus here is on the DC-130 AVLP and its parasite RPVs in the Vietnam War. As the first truly successful example in this study, there are salient

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[41] Friedman, *Unmanned Combat Air Systems*, 86.
[42] Zaloga and Palmer, *Unmanned Aerial Vehicles*, 26; Yenne, *Attack of the Drones*, 29; Schuster, “Lightning Bug War Over North Vietnam,” 55.
[43] Friedman, *Unmanned Combat Air Systems*, 88.
[44] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 176; Friedman, *Unmanned Combat Air Systems*, 87.

points in each of the focal areas of technology, logistics, employment methodology, and administrative factors (leadership, politics, economics).

Analysis

The *Firefly-Lightning Bugs* project was successful for a myriad of reasons, but performed better than the two previous AVLP cases due to the USAF's adaption of existing technology, the ISR assets' ability to fill an existing tactical gap, and the relatively low cost of the RPVs themselves. The airships were novel, tremendously expensive, and counter to the larger Navy's identity. The B-36 FICON program revolved around a bomber consistently shrouded in controversy and overwhelmed by advances in technology. The BUFFALO HUNTER RPVs, however, had a long and successful tenure. This AVLP program provided the USAF and DOD with reliable host airframe, and low-cost, attritable assets. When married together, the union provided a launch platform for a sorely needed ISR aircraft capable of operating in degraded conditions and high-threat regions, and reliably and rapidly returning images to analysts .

Technology

Teledyne-Ryan and the USAF's reworking of existing technology, rather than waiting for a full-developmental cycle of a new capability, fed the quick success of the *Lightning Bugs*. Both the C-130 and Q-2 *Firebee* were already successful platforms, and the requirement to change portions of them instead of creating a new carrier or parasite enabled the rapid acquisition and implementation of the concept. BIG SAFARI's "streamlined management [process focused on] quick reaction, use off the shelf components and minimum data."[45] By turning to existing technology, BIG SAFARI enabled rapid modifications and delivered a serviceable asset to the force quickly.

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[45] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 6.

The base C-130 has been a modifiable platform seemingly by design. A rugged and reliable machine, multiple military services have used it for everything from Arctic airlift using skis to severe-weather penetrating reconnaissance missions.[46] The DC-130 utilized the pylons, initially installed on the C-130A model to hold external fuel tanks,[47] to serve as hardpoints for the *Firebees*. Internal modifications added the hardware, antennas, wiring, and stations for its dedicated RPV mission personnel.

Although Ryan Aeronautical's initial and more expensive attempts to create a new ISR drone were unsuccessful, the return to modifying the Q-2C was a technologically (and fiscally) efficient maneuver.[48] The change from the Q-2C to 147 required three modifications: a 35-inch fuselage extension to allow for more fuel, installing the U-2's Hycon A-1 camera, and a programmable navigation system.[49] The crux of the program's success, however, was not in that initial modification, but in Ryan's ability to further modify the platform to fit niche needs.

During the Vietnam period, Ryan produced 28 distinct variations of the original *Firebee* concept to create its "family of unmanned aerial vehicles" (Figure 34).[50] The tailorable technology granted RPVs abilities such as protecting fighters by providing chaff corridors, conducting high-altitude ELINT/IMINT missions, and of course to execute the BUFFALO HUNTER low-altitude profiles (the majority of RPV missions; list available in Table 1).[51] All of the possible RPV alterations, like the ability to change the reconnaissance payload, enabled the USAF to adjust onboard

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[46] Swanborough and Bowers, *United States Military Aircraft since 1909*, 383–89.
[47] Swanborough and Bowers, 383.
[48] Friedman, *Unmanned Combat Air Systems*, 81.
[49] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 8; Schuster, "Lightning Bug War Over North Vietnam," 51.
[50] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 12.
[51] Wagner and Sloan, 13.

technology to meet emergent needs. One such example was the addition of a television camera onto the 147SC (AQM-34L) to get near "'real-time' video imagery to the mothership for taping"[52] and even allow remote-flying by the controller.[53] Additionally, successes in modifying these aircraft also fostered an environment for further experimentation with new designs, like the advanced high-altitude platform COMPASS ARROW (Ryan Model 154; USAF AQM-91A).[54]

The initial *Firefly-Lightning Bug* (147A) could conduct a 1200-mile sortie, but depending on the model and mission, some variants like the AQM-34N could travel upwards of 2,415 miles while the AQM-34G/H/M/Q/R even had extended-range tanks.[55] The most-common model, the 147SC had a range of 750 miles, a service ceiling of 50,000 feet, and a maximum speed of 645 miles-per-hour.[56] This range was suitable for its mission set in Southeast Asia where its range was less important than its ISR capabilities. However, its range and high-accuracy imagery meant very little if the RPV could not navigate to the right spot.

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[52] Thornborough, *Sky Spies*, 35.
[53] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 47.
[54] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 38–43.
[55] Friedman, *Unmanned Combat Air Systems*, 82; Wagner, *American Combat Planes*, 12.
[56] National Museum of the United States Air Force, "Teledyne-Ryan AQM-34L Firebee," Teledyne-Ryan AQM-34L Firebee, May 18, 2015, http://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195747/teledyne-ryan-aqm-34l-firebee/.

Figure 34 – Teledyne-Ryan's Family of UAVs
Source: San Diego Air and Space Museum, Teledyne Ryan Aeronautical Family of Unmanned Aerial Vehicles, n.d., https://www.flickr.com/photos/sdasmarchives/7204141008

Table 1 - Ryan Reconnaissance Model Directory

Ryan 147 Model	Military Model	Length '	Span '	Area □ '	Thrust (lbs.)	Mission	Month/Year Operated	Number Launched	% Return	Most Flights by a Bird
A		27	13	36	1700	Fire Fly — first recce demo drone	4/62-8/62			
B		27	27	80	1700	Lightning Bug — first big-wing high-altitude day photo bird	8/64-12/65	78	61.5%	8
C		27	15	40	1700	Training, and low-altitude tests	10/65			
D		27	15	40	1700	From C for electronic intelligence	8/65	2		
E		27	27	80	1700	From B for high-altitude electronic intelligence	10/65-2/66	4		
F		27	27	80	1700	From B — electronic countermeasures	7/66			
G		29	27	80	1920	Longer B with larger engine	10/65-8/67	83	54.2%	11
H	AQM-34N	30	32	114	1920	High-altitude photo; more range	3/67-7/71	138	63.8%	13
J		29	27	80	1920	First low-altitude day photo (BLACS)	3/66-11/67	94	64.9%	9
N		23	13	36	1700	Expendable decoy (from BQM-34A)	3/66-6/66	9	0	
NX		23	13	36	1700	Decoy and medium-alt. day photo	11/66-6/67	13	46.2%	6
NP		28	15	40	1700	Interim low-altitude day photo	6/67-9/67	19	63.2%	5
NRE		28	13	40	1700	First night photo (from NP)	5/67-9/67	7	42.9%	4
NQ		23	13	36	1700	Low-altitude NX; hand controlled	5/68-12/68	66	86.4%	20
*NA/NC	AQM-34G	26	15	40	1700	By TAC for chaff and ECM	8/68-9/71			
NC	AQM-34H	26	15	40	1700	Leaflet dropping (Bullshit Bombers)	7/72-12/72	29	89.7%	8
NC(M1)	AQM-34J	26	15	40	1700	Interim low-altitude, day photo and for training				
S/SA		29	13	36	1920	Low-altitude day photo	12/67-5/68	90	63.3%	11
SB		29	13	36	1920	Improved SA low-altitude bird	3/68-1/69	159	76.1%	14
SRE	AQM-34K	29	13	36	1920	Night photo version of SB	11/68-10/69	44	72.7%	9
SC	AQM-34L	29	13	36	1920	The low-altitude workhorse	1/69-6/73	1651	87.2%	68**
SC/TV	-34L/TV	29	13	36	1920	SC model with real-time TV	6/72-	121	93.4%	42
SD	AQM-34M	29	13	36	1920	Low-altitude photo; real-time data	6/74-4/75	183	97.3%	39
SDL	-34M(L)	29	13	36	1920	SD bird with Loran navigation	8/72	121	90.9%	36
SK		29	15	40		Navy operation from aircraft carrier	11/69-6/70			
T	AQM-34P	30	32	114	2800	Larger engine; high-alt. day photo	4/69-9/70	28	78.6%	
TE	AQM-34Q	30	32	114	2800	High-altitude; real time Comint	2/70-6/73	268	91.4%	34
TF	AQM-34R	30	32	114	2800	Improved long-range TE	2/73-6/75	216	96.8%	37
								3435 operational sorties by 100th SRW		

NOTE: * *NA/NC Combat Angel birds were operated on standby in U.S. by Tactical Air Command for possible pre-strike ECM chaff-dispensing missions.*

** *68 missions by Tom Cat*
63 missions by Budweiser
52 missions by Ryan's Daughter
46 missions by Baby Buck

Source: Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 13.

At this early stage of computer development and without the aid of Global Positioning Satellites (GPS), the 147SCs (and 154) utilized Doppler radar (signal processing to determine ground speed) and onboard inertial systems to maintain track.[57] This system was not always sufficiently accurate at low altitudes as the "Doppler radar on the DC-130 was itself only accurate to within a few miles and the drone's system was only accurate to within 3 percent of the distance traveled from the launch point."[58] Navigational precession errors had an interactive effect and could cause mission failure even before RPV launch. In execution, loss of LOS or the decreased reliability of plotting and datalinks at ranges beyond 100-150 miles drove substantial navigation problems.[59] Later variants like the 147SDL added long-range navigation (LORAN) backup to further refine the RPV's positional awareness.[60] While the SC model relied on updates from the DC-130's controllers to ensure navigation veracity, the later models moved closer to the autonomous capability of modern UAVs.

The requirement for interaction between the operator on the DC-130 and the RPV also created limitations. The DC-130 RPV-crew consisted of two launch control officers, an airborne control officer, and an airborne technician.[61] Even at the time, experts considered the invisible tether between AVLP and its parasite RPV to be the "biggest limiting factor, not because it is deficient but because it will constrain us in future missions." Future applications needed either increased bandwidth and antennas to control more RPVs at the same time, or for

[57] Friedman, *Unmanned Combat Air Systems*, 83; Wagner, *American Combat Planes*, 38.
[58] Schuster, "Lightning Bug War Over North Vietnam," 53.
[59] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 17.
[60] Friedman, *Unmanned Combat Air Systems*, 83; Wagner, *American Combat Planes*, 13, 38.
[61] Schuster, "Lightning Bug War Over North Vietnam," 50.

the drones to become more autonomous and thereby reduce communication requirements.

Overall, the technology for the *Lightning Bugs* was sufficient for its purposes even with its navigation and communication limitations. The DC-130 was a reliable platform and the most telling fact about the AVLP in the literature is its near absence from the texts. The dearth of discussion about the DC-130 itself in the literature concerning *Lightning Bug* employment suggests that the AVLP itself did not hamper operations, and allowed for the parasites to operate and thrive in the best way available. In the few experiments with airlift assets launching UAVs after Vietnam, from further experiments with *Firebee*-derivative RPVs to DARPA's *Gremlins* program, the C-130 has remained the preferred delivery vehicle.[62]

Navigational accuracy was addressed by the introduction of LORAN, refined operator inputs, and internal component updates which caused the margin to dwindle down by a "figure of three to roughly 1% of the distance traveled."[63] The navigation and communication problems for many modern UAVs generally benefit from space constellations providing those services. Also, lost-link procedures are standard for military UAVs and provide a layer of redundancy if the operator loses his interactive capacity.

In summary, there are three key elements from the technology section. First, the USAF demonstrated the viability of adapting existing aircraft for its AVLP program. The necessary modifications for the C-130 and *Firebee* were not overly complex and allowed for a quick implementation of a concept without resorting to a long acquisition cycle.

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[62] Air Force Flight Test Center, "DC-130H Multiple Drone Control/Strike System (MDC/SS) Combined DT&E/IOT&E Flight Test"; DARPA, "Gremlins Program Completes First Flight Test for X-61A Vehicle," January 17, 2020, https://www.darpa.mil/news-events/2020-01-17.
[63] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 24–25.

Secondly, once they had an initial concept vehicle, the USAF and Teledyne-Ryan applied an iterative design methodology to attain further capability as operational needs emerged. Lastly, the limits of bandwidth and communication limited navigational accuracy and employment, and although small form technology has improved, there will likely be performance tradeoffs between size, form, and power (whether it be engine performance or computer processing).

While the use of semi-autonomous agents represented a significant technological leap, it is equally interesting to note the change in "social technology,"[64] specifically the organizational shift away from creating both a distinct AVLP and corresponding launchable aircraft. What distinguishes this attempt from the previous ones, and provides a potential direction for future AVLP designs, is that the AVLP itself, the DC-130, was of secondary concern to the deployed asset. The AVLP's capabilities mattered, but in this case the strategic gain came from the parasites' effects and the host DC-130 AVLP was merely a means of conveyance.[65] The AVLP's strategic purpose was always logistical in nature, and not tactical like its predecessors' initial designs.

Logistics and Operational Support

The BUFFALO HUNTER mission was a complex affair. A DC-130 would launch with its preprogrammed parasites, although in-flight reprogramming was also possible, and proceed to the launch location.[66] Launching usually occurred overwater due to the conflict's geography, but that was not a requirement nor the only launch location. The DC-130 would attempt to remain clear of enemy missile systems and fighters

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[64] Eric D. Beinhocker, *The Origin of Wealth: The Radical Remaking of Economics and What It Means for Business and Society* (Boston, MA: Harvard Business School Press, 2008), 243.
[65] One wonders how Immanuel Kant may have reacted to a robotic "sentient being" using a human-controlled platform as a *mere means to an end*.
[66] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 8.

while simultaneously getting the RPV closer to its ingress point to facilitate both fuel savings and navigational accuracy. Logistically, this created challenges for the ground-launched variants of the RPVs, as they were too far from the objective areas to maintain a valid navigation solution and also would have lacked the fuel. Thus, the air-launched variants from DC-130s were, in this case, the better option.

Figure 35 - The Famous 'Tom Cat' 147SC (AQM-34L): Conducted a Record 68 Missions[67]
Source: San Diego Air and Space Museum, Tom Cat on DC-130, n.d., https://www.flickr.com/photos/sdasmarchives/6871023835/in/album-72157626514780879.

[67] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 6.

Figure 36 - Tom Cat Airborne

Source: USAF, Tom Cat in Flight, n.d., https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/579666/planes-without-pilots-sac-remotely-piloted-aircraft-rpa/

Figure 37 - DC-130 with 4 Extended-Range RPVs
Source: San Diego Air and Space Museum, DC-130 with 4 RPVs, n.d., https://www.flickr.com/photos/sdasmarchives/8519615090/.

The logistics of ISR processing was a principal reason leading to the use of 147s. With the Corona project, "From the time an image was taken, it might be several days before the recovery capsule (the 'bucket') could be de-orbited and recovered, and, beyond that, several more days for the imagery to be processed and analyzed."[68] Those delays combined with the "timeliness of centralized film processing was unresponsive to bringing weapons to bear on recently discovered targets."[69] The DC-130-launched RPVs eliminated much of this by having a responsive platform which could infiltrate hostile zones or politically unacceptable regions for

[68] L. Parker Temple, "The Second Great Divide," *National Reconnaissance: Journal of the Discipline and Practice*, January 2015, 7.
[69] Temple, 6.

manned flight and return with its reconnaissance data in hours instead of days.[70] However, operating in high-risk areas does have its downsides.

Hostile action and malfunction were the two largest causes for RPV losses.[71] The USAF's planning assumption was that *Lightning Bugs* would survive "2.5 sorties, but in practice the average was 7.3 missions."[72] Survival, however, did not mean success. USAF Reconnaissance Experts found that *Bugs* effectively imaged their assigned targets around 40% of the time, with nearly half of the failures coming from navigation errors.[73] Also, there were at least 200 aircraft losses to enemy fire, weather, and malfunctions.[74] This failure rate also generated the need for extra sorties to collect the necessary intel, eliminating some of the gain from the RPVs' high return-percentages (see Table 1). For the *Bugs* though, getting to the target was only half the battle as an often-complicated recovery awaited them on the return home.

By developing the helicopter MARS, the USAF gained performance and reliability advantages, but at a cost. To obtain more robust mission capability, the 147's structure became brittle and in "both land and water surface recoveries [the] damage was prohibitive."[75] By catching the drones, the USAF was able to keep the aircraft from getting damaged or destroyed on impact, and also prevent water damage to circuitry and components from sea exposure.[76] But even the savings from this type of

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[70] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 3.
[71] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 23.
[72] Friedman, *Unmanned Combat Air Systems*, 85.
[73] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 45.
[74] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 23; Thornborough, *Sky Spies*, 36.
[75] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 37.
[76] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 38.

recovery were still largely considered wasteful due to the need of a helicopter for recovery.[77]

Recovery missions were complex operations which put the helicopter aircrew at risk, created cost for maintenance and fuel from the helicopter, and diverted the helicopter from conducting another mission.[78] Launch and recovery from an airfield is preferable, but may not always be possible given the strategic situation or capabilities of a particular UAV. Additionally, even with greater loiter or fuel capacity, the navigation precession problem would have potentially negated gains from a land-based hub; longer missions would have less chance of success of flying over the target although likely would still have returned to the base given the range of the ground-based MCGS stations which usually vectored RPVs to their recovery locations.[79]

The DC-130 and its RPVs provided a superior platform for timely ISR and the logistic requirements were manageable for the USAF. The drones had adequate loiter time, especially considering the variants for different missions, to conduct their operations and did not create needless challenges for the host AVLP. DC-130 operations still required fighter escorts to ensure their safety from enemy fighters, but the general goal was to launch-and-leave to stay away from enemy SAM systems, while still maintaining a close-enough position to provide course corrections to the RPVs.

While the AVLPs allowed for one aircraft to unleash the power of many, they did create additional cogs in the system. DC-130s needed defensive-counterair fighters to support ingress, which also potentially risked those aircrew entering SAM engagement rings during operations. Although the North Vietnamese Army did not ever shoot down a DC-130,

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[77] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 75.
[78] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 35–37.
[79] Schuster, "Lightning Bug War Over North Vietnam," 54; Friedman, *Unmanned Combat Air Systems*, 82.

they did target them and generally forced them to stay over water rather than support the RPVs from a closer position.

Logistically, this created more requirements for combat operations, even though the actual ISR mission only needed the RPV(s). Regardless of the tactical reality, simply having more aircraft airborne increases the likelihood for broken parts and a need for spares; all of those problems create logistic requirements and demand on personnel. With better communication and navigation capability, avoiding the entirety of the AVLP construct may have been more desirable. However, risking manned crews and expensive fighters in a high-threat operation would have created even further demands on manpower, force packaging, and maintenance requirements. Additionally, putting humans at risk would have driven a need to have an alert-rescue capability, and escort forces for it to operate too.

Recovery operations were intricate ones, but not to the point where mission-effectiveness degraded. The overwater launch location also allowed for DC-130s to return to Da Nang and await the RPV's return before heading back to Bien Hoa, though this does not always seem to be how the USAF managed missions. After the introduction of MARS, the airborne-helicopter retrievals generally went well and allowed the USAF to reuse its RPVs well beyond the expected 2.5 sorties. Further modifications to counter-fighter and -missile algorithms also assisted with UAV survival.

While there were some inefficiencies in the logistic enterprise, namely the multiple base and aircraft launch and recover setup, the *Lightning Bugs* program was generally a sound model for future endeavors. The DC-130 AVLP diminished the effects of distance on the RPVs and the parasites themselves provided quicker access to raw intelligence data than could otherwise be obtained. After working through some initial launch problems, the DC-130 and its RPVs were reliable platforms which did not require substantial ground work after each flight. Ultimately, this construct allowed for the RPV to employ effectively without incurring large risk to either its host's or another aircrew. Yet, the RPV itself was expected to operate in those high-threat environments. Interestingly enough, sometimes the USAF did not even want the drone to come back.

Employment and Doctrinal Integration

The SA-2 SAM system was a significant threat to aviators in Vietnam. Little was known about how exactly the SA-2's target-tracking radar or fuzing functioned until the USAF sacrificed an RPV to get the data. The USAF equipped a 147B (high-altitude IMINT platform) with "very sensitive receivers and added a real-time telemetry system" to create the 147E variant.[80] This RPV was sent to bait an SA-2 site to fire at it, and the RPV's on-board sensor suite monitored every aspect of the radars' signals and sent them to another nearby aircraft. "In an instant, U.S. intelligence had captured the deadly missile's tracking, acquisition and guidance signals, and the sequence in which those signals appeared during an engagement."[81] This information enabled the creation of counter-measure algorithms and honed-equipment for manned aircraft.[82] A *Lightning Bug* (147F) even tested the electronic-countermeasures pod against the SA-2 before pilots began flying with it.[83] The *Bugs'* missions, whether it be flying the most dangerous reconnaissance sorties or helping uncover enemy capabilities ultimately saved aircraft and lives of American pilots in Vietnam.

As an additive element to USAF ISR operations, the DC-130s and *Lightning Bugs* fit well within existing military structures and procedures in Vietnam. Rather than create new specialized bases (as with Airships),

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[80] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 10.
[81] Schuster, "Lightning Bug War Over North Vietnam," 48.
[82] Schuster, 48.
[83] Friedman, *Unmanned Combat Air Systems*, 82.

or house the AVLP and parasite at separate locations (the FICON program), the USAF created a squadron containing both DC-130s and RPVs and designated it to become part of “the 4080th Strategic Reconnaissance Wing at Davis-Monthan Air Force Base in July 1963.”[84] The squadron was commanded by reconnaissance officers who were already familiar with the mission and could implement the platform within existing paradigms on ISR.[85] When deployed to the Pacific, the unit initially flew out of Kadena Air Base, Japan in its counter-China missions, but moved to Vietnam as part of a larger ISR mission-consolidations into the 100th Strategic Reconnaissance Wing at Bien Hoa in South Vietnam.[86]

This Wing’s grouping of RF-101s, U-2s, and AVLPs supported the needed efficiency in film development and intelligence-creation processes as the photo analysts were at the same location.[87] From a command and control standpoint, this construct also allowed for rapid analysis of mission priority and risk, combined with matching the most appropriate ISR asset to the tactical task. Asset utilization was even more relevant once there was an increased presence of enemy fighters and SAM systems countering manned-aircraft operations.[88]

The only major inefficiency in operations was that the recovery zone for RPV operations was in the northern portion of South Vietnam at Da Nang. While this supported fuel considerations for both the RPVs and the helicopters recovering them,[89] it did require an AVLP or other airlifter to bring the RPV back to the intelligence hub at Bien Hoa, just north of Saigon.[90] With such a low density of DC-130s, this could have created

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84 Schuster, “Lightning Bug War Over North Vietnam,” 51.
85 Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 4.
86 Wagner and Sloan, 4.
87 Schuster, “Lightning Bug War Over North Vietnam,” 51.
88 Schuster, 51.
89 Mid-air helicopter recoveries did not begin until March 1966. Prior to that, the RPVs, under canopy, would drift down to the earth or out to sea for recovery.
90 Schuster, “Lightning Bug War Over North Vietnam,” 52.

challenges if there had been greater operational requirements or more threats to aircraft in the vicinity of Da Nang.

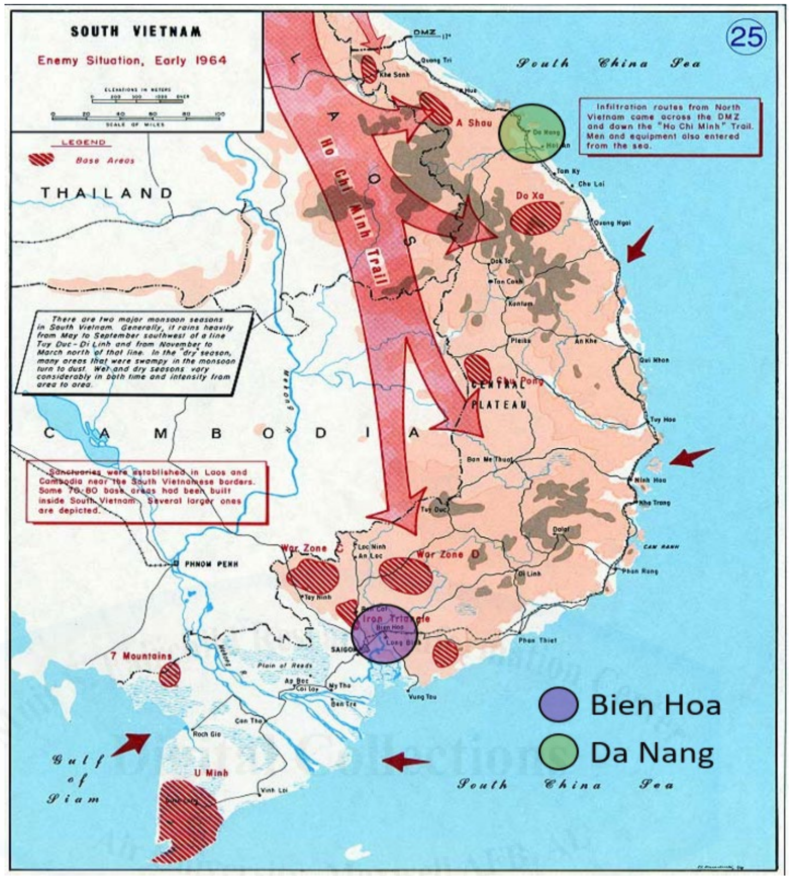

Figure 38 - Vietnam 1964 with RPV Callouts
Source: RPV Bases by Author. Original map from US Military Academy, "The Vietnam War | United States Military Academy West Point," accessed April 6, 2020.

The BUFFALO HUNTER low-altitude reconnaissance program was particularly helpful to military ISR requirements during Vietnam's monsoon season (November-March).[91] With both the cloud cover from the rainy season, and the SA-2's ever increasing engagement altitude compressing viable airspace,[92] the drive to low-level reconnaissance was a near military necessity. But the low-level weather formations,

[91] Friedman, *Unmanned Combat Air Systems*, 83.
[92] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 12.

potentially irregular or unknown terrain and meteorological conditions (e.g. barometric pressure), and necessary speed for fighter-reconnaissance missions drove a high-risk environment. The unmanned assets were a perfect fit for a military requirement when space assets and high-altitude ISR planes like the U-2 could not see through the weather, and low-altitude manned flight was overly dangerous.

In short, the *Lightning Bugs* construct meshed easily into the operational requirements and strategy for the region. Along with going to places manned ISR could not, the RPVs also supported military operations through their tailorable variants and payloads. Teledyne-Ryan and the USAF could alter the *Lightning Bugs'* equipment and missions as required to meet emergent military needs, and could do so without fear of loss of life. A USAF Reconnaissance Office expert, referring to tinkering with RPVs, reported simply, "These are the things you can do with an unmanned vehicle where you don't need quite the same safety margin as you do in a manned system."[93] If a drone was lost due to technical failure, updates to the whole fleet were possible with no need for retraining or instruction. A loss of a pilot and airframe in combat was a substantially more serious event politically, fiscally, and most importantly to the morale of the unit and the family back stateside.

However, despite the cohesion with the military it supported, this AVLP effort suffered from the same political shortcomings as its predecessors. The Navy's leadership were all too ready to disband the expensive and disaster-prone airship program when budgetary pressures arose. The FICON project ran out of steam as better military options became available which were cheaper and had more universal application to military problem-sets. Conversely, the protean *Lightning Bugs* could adapt to most any ISR challenge effectively and were quite

[93] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 11–12.

cheap at $200,000 apiece in 1966 dollars.[94] What drove TAC to put them in hangars was their lack of a key ingredient: a pilot.

Politics, Economics, and Military Leadership

While agencies like DARPA and even the US Army still pushed for UAV development into the 1970s, the USAF "was substantially less interested; cynics would say that it had no interest in reducing pilots' roles."[95] In 1975, TAC began the process of extricating itself from the UAV business and in July 1976 consolidated its remaining RPV units into one Group at Davis-Monthan, Arizona.[96] Although some testing and innovation attempts occurred, when budget shortfalls in 1979 pressed TAC to choose between funding manned operations or the "manpower, maintenance and operation of DC-130s, helicopters and RPVs themselves,"[97] the Fighter Generals chose fighters. The RPV Group at Davis-Monthan had already seen the writing on the wall; they believed the parent command saw the current AQM-34Ms and Vs "'as a burden, competing with the B52/Cruise Missile penetration force for the limited dollars available to them.'"[98] Despite dissenting opinions from the RPV Group, US Senators, and Teledyne-Ryan, the RPVs were done.[99]

The end of operations, though, did not mean the end of UAV development, and Vietnam-era AQM-34s even reemerged to conduct chaff-corridor operations during the second Gulf War in 2003.[100] The problem was never their functionality, but rather the distinct nature of drones. While they meshed operationally with the USAF, they did not fit in well to the bookkeeping or cultural side of the business.

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[94] Bishane Whitmore, "Lightning in a Bottle: How Air Force Culture Contained the Rise and Fall of the AQM-34 Lightning Bug" (Maxwell Air Force Base, Alabama, Air University, 2017), 92, https://apps.dtic.mil/dtic/tr/fulltext/u2/1047375.pdf.
[95] Friedman, *Unmanned Combat Air Systems*, 86.
[96] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 104.
[97] Wagner and Sloan, 108.
[98] Wagner and Sloan, 108.
[99] Wagner and Sloan, 108.
[100] Yenne, *Attack of the Drones*, 29.

The BIG SAFARI acquisition cycle described in this chapter's introduction was a precursor to the troubles the RPVs would have in the political-economic sphere. Quite simply, the newness and unique character of the vehicles did not fit neatly into programming or acquisition cycles:

> In the Air Force today we think in terms of manned aircraft weapon systems on one end of the spectrum and expendable ordnance on the other end. RPVs must fall somewhere in between. But we find that our logistic support, our design criteria, and even our thinking falls to one end or the other with no niche in the middle. It is hard to imagine the turmoil we have gone through trying to make drones fit one category or the other.[101]

There had never been a mass-produced aircraft like the RPVs, and the Cold War SAC and TAC acquisition and funding constructs did not lend themselves to systems that traversed both realms. Additionally, RPVs, unlike pilots, generally did a very poor job extolling their successes at the bar. USAF culture at the time did not offer prestige to the operators onboard the DC-130, and there was limited chance for career progression for the operators.[102]

From the very start, Ryan Aeronautical had struggled to find the right place in the USAF to get consistent funding and development.[103] But, as discussed, the BIG SAFARI program managed to keep the program alive until there was enough USAF funding to keep the *Firebee* family supporting warfighters from training to combat during Vietnam (and beyond). BIG SAFARI and USAF managers additionally made good decisions about keeping the procurement costs down throughout the period. Specifically, the *Lightning Bugs* were meant to be lost. Vietnam-

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[101] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 79–80.
[102] Whitmore, "Lightning in a Bottle: How Air Force Culture Contained the Rise and Fall of the AQM-34 Lightning Bug," 98.
[103] Wagner, *American Combat Planes*, 36.

era USAF analysts posited, "You can spend so much in improving reliability that you are no longer willing to employ the system because now it costs too much and you aren't willing to expend it"[104] and further, "Drones, to be worthwhile, must be small, inexpensive and quasi-expendable."[105] The USAF utilized this concept of the expendable drone in the conflict by having them conduct high-risk ISR runs, operate as decoy drones, and fly the ELINT SAM-tracking role discussed previously.[106]

The *Lightning Bugs* lacked a true champion within the DOD. While there were pockets of support and also outside agency interest from DARPA and the CIA, the USAF never truly adopted the platform as part of its identity. This is similar to the airships' situation where there was a lack of top-level push for the program once Admiral Moffett, the top-military proponent for the AVLP, perished in the *Akron* crash. Without support from the top echelons of the service, the organizational resistance to change may be too much to overcome.[107] This is especially true when the new paradigm challenges the very nature of what the organization does.

Yet during the conflict, the USAF and its RPV units appear to have had a mostly utilitarian relationship. A low-cost, low-risk asset with potential high-strategic payoff is likely to be an attractive option for military commanders. When the budgets and risks were high, the *Lightning Bugs* were able to support the USAF's objectives and collect critical intelligence for air planners. As the RPVs fit neither the manned-aircraft paradigm nor the expendable-projectile categories, the pilot-led

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[104] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 53.
[105] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 77.
[106] Friedman, *Unmanned Combat Air Systems*, 83.
[107] Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars (Cornell Studies in Security Affairs)* (Cornell University Press (1986), Edition: N/A, 288 pages, 1986).

USAF struggled to define a programming space for them. Once the USAF had settled back into its traditional Cold War stance, the service looked to man its airplanes, not have robots take over the jobs. The oddity of the niche asset became all the more apparent, and maybe even abhorrent.

Conclusion

After nearly two decades of UAV operations in support of US-led operations in the Middle East, there is little doubt that the *Firebee*-forefathers played a critical role in developing the intellectual and operational space for the DOD's modern use of UAVs. Large, high-altitude platforms like the RQ-4 Global Hawk and its more tactical brethren the MQ-1 Predator and MQ-9 Reaper logged thousands of hours across the globe in support of military and CIA operations. Today, even smaller UAVs provide limited ISR support to small tactical units and even have applicability to securing an airbase's perimeter.[108] For the foreseeable future, it appears that UAVs will be a part of military conflict.

What then of airborne aircraft-carriers? Because of the geography of the conflict, the DC-130 provided an absolutely necessary transport service to get the RPVs closer to the intended target, and also served as the airborne controller attempting to mitigate the shortcomings of the 147s' navigation capability. The AVLP construct in Vietnam worked and was effective. The key attribute of both the DC-130 and its parasites was modularity. The DC-130 could operate in a two or four pylon configuration and the pylons could even be set outward to support the larger AQM-91 (Ryan 154).[109] The RPVs' parts, sensors, and later weapons were generally interchangeable and with 28 variants flown

[108] Nathan E. Padgett, "Defensive Swarm: An Agent-Based Modeling Analysis" (Naval Postgraduate School Monterey United States, December 1, 2017), https://apps.dtic.mil/docs/citations/AD1053392.
[109] United States Air Force Directorate of Reconnaissance and Electronic Warfare, "History of Buffalo Hunter Drone Program," 32.

during the conflict, provided comprehensive coverage of military ISR needs.[110]

As early as 1973, USAF RPV proponents foresaw multiple-drones per controller as the way ahead and even drones as a part of a beyond-line-of-sight datalink operator.[111] The 4-pylon DC-130 AVLP allowed more RPVs to get airborne, but the control dynamics were not sufficient to truly allow control from the one platform.[112] As we look back on what they were able to do with pylon-mounted, non-GPS RPVs communicating over a minimal bandwidth communication network, one must wonder what we could do today with small, GPS-guided, autonomous UAVs launched from within a substantially larger AVLP?

[110] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 12–13, 98–99.
[111] United States Air Force Directorate of Reconnaissance and Electronic Warfare, “History of Buffalo Hunter Drone Program,” 77.
[112] United States Air Force Directorate of Reconnaissance and Electronic Warfare, 34.

Chapter 5

Parasitic Power Potential

Introduction

The US military's various attempts at Airborne Vehicle-Launch-Platforms (AVLP) are qualified success stories. While none of these platforms exists as a current mainstay in the US military, they all added to a framework from which military strategists can analyze theories of warfare in relation to technological evolutions. In summary, I grade the airships as a near total failure,[1] the B-36 FICON program a moderate success, and the *Lightning Bugs* as a success. Yet, a particular program's failure or success is not an indictment of the innovators of that generation nor an indicator of how any future platforms may work. When future air advocates look to these examples, it is necessary to understand how they are alike and where they differ. Through mapping of failure and success spaces, we can better understand what lessons might be gleaned for future attempts.

When military theorists and strategists look back on our AVLP attempts for insight, it must be with an understanding of the contextual problem of what the actors were attempting to solve. Revisiting an idea from Chapter 2, Khong's Analogical Explanation framework,[2] may be helpful to differentiate the strategic problems theorists envisioned historical attempts at AVLPs would address and whether those problems are still relevant.

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[1] Noting that this was essentially a completely novel paradigm at the time. Additionally, the airships lacked some basic technological features which would be readily available by the time the FICON program began.
[2] Khong, *Analogies at War*, 10.

Other than the AVLPs in this study, there have been successes and failures, along with variations of the idea. The 747 carried the Space Shuttle, but almost strictly as a means of transport.[3] The 747 also nearly became an AVLP, but Boeing's 747 Micro-Fighter concept, where a 747 would house up to ten small fighters,[4] never became a reality. As precision-guided munitions and stand-off weapons came to dominate the weapons market, some look at airborne aircraft-carrier relatives like arsenal planes and standoff-missile-launching platforms as the realization of an AVLP. This study looked only at the intersection of those intellectual spaces and chose representative models fitting the definition of an AVLP as an airborne carrier which launches a re-usable platform.

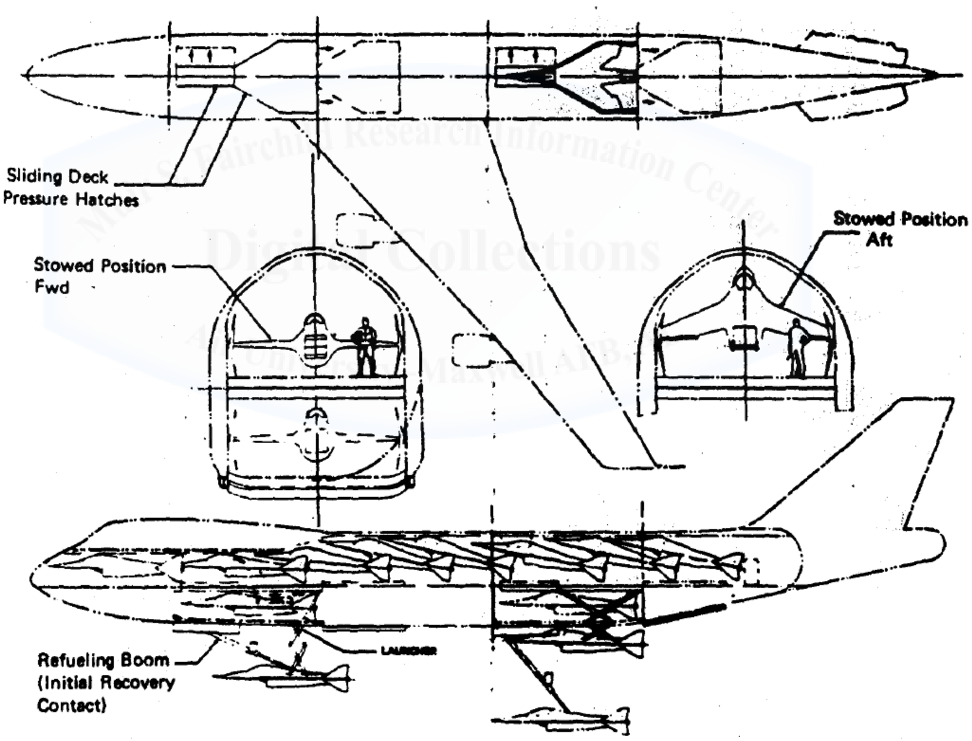

Figure 39 - Boeing 747 Micro-Fighter Concept
Source: Nelson et al., 4.

[3] There were some flight tests where the Shuttle was released to glide during flight. Bowers, *Unconventional Aircraft*, 213.
[4] B.D. Nelson et al., "Investigation of a Micro-Fighter / Airborne Aircraft Carrier Concept" (Wright-Patterson Air Force Base, Ohio: Air Force Flight Dynamics Laboratory, September 1973), Nov 2, 2019, https://apps.dtic.mil/dtic/tr/fulltext/u2/529372.pdf.

Throughout the years, the attempts at AVLPs provided a resource for us to discover recurring themes and trends. While none of the aircraft from this study still fly today, the designs which we see today in those smart-missile carriers and increasingly with UAVs feature similar constructs. This study's structure was arranged around the following analytical areas: technology; logistics and operational support constructs; employment and operational cohesion; and the contextual economic-political landscape. The following sections offer a recap of the substantive elements from each case study and identify key points from which to derive some implications for future development efforts.

Technology

Technology is critical to aviation. As a fundamentally inaccessible medium to humans, we rely on technology to enter and exploit the air domain. In AVLP history, the technological means were often a prerequisite to any employment strategies or theories and the study therefore addresses them first. In summary, the study found the airships lacked the necessary technological means to be successful and their deficiencies were likely causal to their demise, both literally and programmatically; the FICON program's technology was sufficient for operations, but overcome by competing advances in aircraft design; and the *Lightning Bugs* to represent a strong marriage of available technology to implementation. We begin the technological summary with the airships.

The airships were simply too much for the times. While technological issues like the parasite fighters' communication and navigation capabilities hampered operations, a lack of access to high-fidelity weather monitoring both on the ground and in flight was arguably the most serious flaw. That capability simply did not exist at the time. With compounding factors like limited de-icing capability and the airships' inherent susceptibility to severe weather problems, they were unfit to serve as a host AVLP. The vision and idea, especially once the

Macon began to employ its fighters as scouts, were sound, but the carrier was unable to fulfill the role safely due to its technological limitations. Indeed, the massive airships themselves may not have been a sound idea for military use.

The FICON program worked. The B-36 was capable, as was its ultimate parasite, the RF-84K. The USAF took what worked well from the airship era, namely the trapeze system, and attempted to recreate the airship concept using the diminutive *Goblin* fighter. However, just as the *Sparrowhawks* were unsuited to long-range scouting, the *Goblin* would have been overmatched against contemporary enemy fighters. By altering the program and the B-36 to use a modern and more capable jet parasite, the USAF avoided wasting resources and time developing a program that would have been ineffective at the outset. Furthermore, the USAF leveraged the F-84's strengths to create versatility in mission capabilities: the *Thunderflash* served as a scout with potential to deliver ordnance. This multi-mission capable parasite was a critical element in the *Lightning Bugs* effort.

In the final case study, the USAF's utilization of technology demonstrated a cognitive leap from previous generations. Due to wing-mounting the remote-piloted vehicles (RPVs) and without needing a recovery system on the AVLP, the DC-130's modifications were far less substantial than what was required for the B-36. As for the *Firebee* conversion, BIG SAFARI acquired not just a tailorable asset, but the first unmanned parasite. Without fear of losing a pilot and by having the ability to alter RPV ISR payloads, Ryan-Teledyne offered a platform with a ubiquitous nature; it served the USAF in a wide variety of missions largely due to interchangeable parts and sensors. The modified *Firebees* were pivotal steps along the path toward the modern autonomous UAVs in service today.

These cases offer insight into two specific traits which appear to be critical to the technological success of an AVLP and its parasite. Specifically, an AVLP's design and communication-navigation capabilities fundamentally alter its operational capabilities and strategic effect. Looking at these variables helps to illuminate what may matter in a future effort.

Design

AVLP design hinges on whether advocates elect to create new or use existing models. In the case of both the airships and the FICON, the new design methods failed. The airships themselves were new and untested. Their limited survivability inhibited the program's ability to gain long-term support from Naval leaders and Congress. The technological flaws inherent in the design led to inefficiencies at the outset and abrogated any chance of sustained AVLP operations. The airships' parasites, the F9C-2 *Sparrowhawks*, were not ideal assets, but did perform the role without any losses during flight operations.[5] The FICON attempt featured the specially designed XF-85 *Goblin,* which much like Boeing's micro-fighters,[6] would have been outclassed by evolutions in adversaries' airborne and ground-based defenses.

The B-36 and its RF-84K reconnaissance jet, on the other hand, along with the DC-130 *Director* and its *Lightning Bug* players, were all derivatives of existing assets in the USAF's inventory. These programs benefitted from proven technologies which already had operational track records and communities of knowledge on how best to operate them. Though these AVLPs and parasites were distinct from their conventional counterparts, there was institutional knowledge about feasibility in operations and technical employment.

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[5] Discounting the four lost in the *Macon* crash.
[6] Nelson et al., "Investigation of a Micro-Fighter / Airborne Aircraft Carrier Concept," 20–27.

This derivative acquisition model is similar in concept to many of current USAF C-130 Special Operations Forces (SOF) platforms. The SOF Acquisitions, Technology and Logistics Center, often looks to leverage successful conventional assets and adapt them for specialized missions and purposes.[7] In this study's small sample, the modification method led to more success than new designs. While not a truism, it may indicate that the complexity of the mission leads to a need to remove "growing-pain" obstacles which traditionally plague newer aircraft. However, regardless of how the asset came to be, the necessity for both the AVLP and parasite to navigate and communicate is essential.

Navigation and Communication

In USAF Undergraduate Pilot Training, instructors hammer home the concept of "Aviate, Navigate, Communicate." Students are to understand that maintaining aircraft control at all times is paramount, and only while under control can they worry about getting to the next point or talking on the radio. The same trinity is at play for parasite aircraft, whether it be manned or a robot.

Both the *Sparrowhawks* and *Lightning Bugs* struggled with navigational accuracy and communication limitations. Early aircraft lacked capabilities like directional homing, reliable compasses, and beyond line-of-sight (BLOS) communication mechanisms, all of which are now relatively standard tools. The Model 147s had BLOS communication issues too. They, however, began to demonstrate some autonomous navigational capabilities with radar mapping and inertial guidance, but the fidelity was not quite good enough yet. The F-84s benefitted from having a pre-designated mission, but the pilot could utilize charts and navigational resources to conduct dynamic missions (as required). Additionally, he had the B-36's IFF beacon to support link-up operations

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[7] SOCOM, "SOF Acquisitions, Technology, and Logistics (SOF AT&L)," 2016, https://www.socom.mil/SOF-ATL/.

once he was in range. In modern times, communication and navigation issues remain, but they have a different character to them.

While the specific issues of communication and navigation in previous AVLP models are now largely irrelevant, their importance in principle remains. Most modern military aircraft utilize a form of GPS and usually multi-frequency or -modal BLOS communication. While the limited communications-navigation equipment initially hindered *Sparrowhawk* pilots from operating too far away from the airships, today's aircraft may experience similar problems due to signal interference (natural or from adversary action), and the limited power and shielding available for small-form transmitter-receiver units (like on smaller UAVs).

Key Technology Facets

- Derivative design
- Modular components to support multiple mission sets
- Robust communication and navigation equipment

Figure 40 – Technology
Source: Author

If one assumes that the future of AVLPs involves autonomous UAVs, regardless of their form factor, the ability to communicate will remain critical. Broadly, communication can enable UAVs to operate with a hive mind or perform swarm-like dynamics, allow for controllers to distribute tasks or provide redundant coverage to others, or link back to command and control (C2) authorities to send or receive updates. The key element is that, given the tactical problem, the desirability of what to communicate, and with whom, can shift.

In humanitarian operations, the operators may desire to maximize information output to facilitate information sharing. In a wartime environment, on the other hand, the AVLPs should be able to operate with minimal electromagnetic emissions as contested communication domains may prevent normal information flow. In the latter scenario, the ability for an autonomous parasite to solve its own navigation solution without reliance on off-board cues, whether it be satellite or C2 links, may be essential to its efficacy.

Overall, the history of aviation innovation has largely depended on technological advancement. The history of AVLPs follows the same pattern, with reduced difficulty and increased operational success as the technological development timeline progressed. If the USAF desires to create another AVLP, it should consider utilizing its existing arsenal of technologically advanced aircraft to create the platform, demonstrate a baseline capability, and iterate from there.[8] While new technologies usually enable increased capability and reliability, the underlying logistic enterprise must support any new operational approach.

Logistics and Operational Support

Baron De Jomini presents his principles of logistics, in his favored enumerated-list format, as a reminder to military practitioners that a failure to keep all aspects of planning, supply, and execution "intimately connected"[9] may spell disaster for the force. While the Baron may not have had the foresight to apply his concepts to AVLPs, the importance of logistics remains paramount to militaries. Modern warfare features long-range and stand-off munitions with increased lethality, speed, range, and accuracy capable of threatening bases and formations on different continents. Resultantly, militaries must consider dispersing forces and trying to harden their interior-line logistics; those lines which are behind the main battle front.

These challenges can affect future AVLP operations too, yet history demonstrates that it was already a challenge to begin with. For AVLPs, a variety of factors affected operational utilization and functionality. The

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[8] As seen with airships' radios and parasite evolution: F9C-2 as simply the aircraft that fit in the hangar, the *Goblin's* flight test and theorists' recognition that it would be inferior in air-to-air combat, the procession of F-84 variants, and all of the *Lightning Bugs*.

[9] Antoine Henri Jomini, *The Art of War* (Radford, V.A.: Wilder Publications, 2008), 197.

two major recurring themes were challenges regarding in-flight servicing capabilities and basing.

In-Flight Servicing: Internal versus External Storage

While surface aircraft-carriers have set the standard for the number of aircraft, servicing, and employment doctrine, AVLP designers looked to accomplish some of those same logistical feats in their efforts. While the "movable-island" airbases must produce relative mission-generation capabilities relative to their terrestrial counterparts, AVLPs are a slightly different construct. The airship and FICON attempts both had parasites capable of conducting multiple sorties during the same mission, but the AVLPs lacked the major maintenance capabilities of a seaborne carrier. Fundamentally, the AVLPs in this study benefited from their ability to routinely return to traditional depot facilities and not rely on continual sortie generation from the AVLP itself. All of them did, however, maintain some ability to service the parasites during a mission.

The airship was the first US attempt at creating an AVLP and a critical element to that experiment was its internal hangar. While one can forgive the construction flaws on the *Akron,* due to its novelty and prototype character, it is necessary to understand how errors in construction can lead to tactical failure and strategic irrelevance. Without two of its holding mounts, the *Akron* could not utilize its already limited parasitic power for scouting. While other factors prevented Naval aviators from rapidly developing tactical theory, an increased allotment of aircraft may have streamlined testing and proof-of-concept operations. However, regardless of the outcome, the airship era demonstrated how an airborne hangar, complete with maintenance and arming faculties, was an inventive way to further enable strategic airplane operations.

The B-36's semi-enclosed "hangar" emerged from an alternate path: designers developed the hangar to fit the F-84 rather than how the Navy selected an airplane which could fit its cargo hold. This is an interesting development in AVLP history, as it set a precedent for future tests and variants like the DC-130. Using the conceptual framework of an airship as a downsized surface carrier (capacity and capability), and the two different methods of storage on the last two cases, it is worthwhile to discuss the relative properties of internal and externally stored parasites.

Internal versus external storage is largely a matter of purpose and tradeoffs. Both the Navy's airships and the FICON-variant *Peacemakers* were long-range platforms and operational planners could not expect the parasite pilots to stay in their aircraft for the duration of those sorties. Additionally, the parasites needed onboard support to conduct operations. Thus, having at least a portion of the parasites in internal storage was a logistic requirement. This requirement drove technological requirements like trapeze apparatuses and the airships' monorails.

Alternatively, the externally-mounted RPVs did not need in-flight servicing as they were one-way assets; there was no return to the mothership. Furthermore, wing mounting reduced loading and launch complexities (compared to using the DC-130's ramp), and the wider-wing variants simply would not have fit inside the *Director*. Yet while the RPVs did not need pre-launch assistance, the entire logic behind *Lightning Bug* sorties depended on the AVLP for range augmentation and navigational assistance. Therefore, absent these sorts of requirements, it may be advantageous to carry the parasites internally for a number of reasons.

Clean aircraft configurations, those with little extra drag along the surface of an aircraft, are inherently more efficient flyers. Unless the internal storage capacity reduces parasite capability to unacceptable levels, internal housing may be the preferable option. Aside from the aerodynamic advantages, internally-storing parasites, at least in larger AVLPs, will generally also afford access to maintainers and operators who could potentially mount different components or change mission profiles without having to rely on wired or wireless connections to the asset. Also, if it is a manned platform, this setup allows for the pilot to find some respite from what will likely be cramped quarters. The predominant negative factor is that internal storage likely requires a larger AVLP, which generally creates adverse operational parameters: increased weight and fuel expenditure, a need for longer runways, a larger radar cross-section, and generally a larger frame implies more aircraft components which generates corresponding concerns for reliability and a need for system redundancy.

For future AVLPs, choosing a design which features an ability to recover parasites in flight could factor heavily in the designers' internal versus external storage decision. While having a catch-and-release mechanism on a wing pylon is technically feasible, if in-flight servicing for future sorties during the same mission is a military service's requirement, internal storage may provide an easier solution. Much of this has to do with the size of the AVLP and the parasite, coupled with whether it is an autonomous or manned platform. Manned parasites will almost certainly need internal access to the host, while autonomous platforms may be fine re-attaching to a wing (which also may entail additional modifications to the AVLP to refuel and retool the asset for further missions). Considerations for size, weight, inflight logistics, and this potential need for aerial recovery are all elements that designers must consider.

Ultimately, whether the parasite is onboard or external prior to launch, Jomini's conceptual theory holds true: "Strategy decides where to act; logistics brings the troops to this point; grand tactics decides the manner of execution and the employment of the troops."[10] The AVLP is that logistic link. The complementary forces of the host and parasite are in fact symbiotic. An AVLP provides the forward launch point to the smaller, but tactically more capable parasite. The pair work in concert

[10] Jomini, 52.

with the strength of one giving way to the other where logistics morphs into tactics.

Basing

Home stations for AVLPs serve the same purposes as they do for any other military aircraft. They provide a location for training and recurring maintenance and also usually serve a larger strategic purpose. For example, the USAF's operational fleet of strategic airlifters (C-5, C-17) all reside in coastal states to enable faster transfers from sea vessels to the cargo jets, and a quicker continental exit as the primary mission from these bases is global delivery. AVLPs need all of the same basics as conventional inventory, but logisticians must also account for where the parasites or common operational partners are, and if a unit can accomplish training anywhere or if specific requirements are necessary.

For the entirety of the airship period and the initial phases of the FICON project, the Navy and USAF failed to place the AVLPs' bases in optimal locations. Although Congress plays an important role in base allocation processes, military services must continue to fight for the primacy of operational factors in bed-down locations. From their distant positions in New Jersey and northern California, the airships struggled to integrate with the fleet they supported. For an asset which already suffered from logistic challenges and a lack of mooring stations both on land and at sea, creating an administrative travel leg for every integration exercise wasted precious resources and created more chances for maintenance and weather issues to arise. The B-36s initially had a polar bombing mission and a home in Texas. The USAF, however, did address this by moving the AVLP and its parasite F-84s to Washington at bases which supported quick aerial link-ups for their northern mission.

The *Lightning Bugs* project demonstrated the best basing setup. Their integration with similar ISR assets in Vietnam allowed for intelligence analysts to exploit their operational findings quickly. However, there was a tradeoff there, too. By having a base farther from its strategic purpose, the AVLP's average mission was longer and the RPVs were also unable to fly all the way back to the launch base in the south. This problem created additional logistic needs for helicopter retrieval platforms to exist closer to the front-line and also for an airlifter to deliver the RPVs back to the mission-generation base. All of these penalties introduce maintenance, fuel, and personnel requirements which could be used to support other operations. The benefit may be worth the cost, but analysts must account for duality of basing effects: increases in operational capability may drive detracting logistic ones.

As with strategy, the answer likely lies with understanding the desired ends. One can think of basing as a tactical problem requiring the weighing of effectiveness, efficiency, and risk. Co-location with other like assets may be beneficial for operators to develop new tactics and procedures, while also further integrating the AVLP into the service's operational paradigm. This option presumes that a location contains the specific infrastructure that the AVLP needs. One recalls the giant hangars and mooring masts of the airships and the "pit" where loaders could lift an F-84 into a B-36 on the ground. Multi-use hangars and logistic facilities are desirable, but planners must develop solutions for when those are not available (e.g. using separate launch and recover bases, conducting airborne linkups instead of launching together). These considerations, however, fall more into the space of the operational theory underwriting an AVLP's purpose.

Figure 41 - RF-84K Loading Operation at Fairchild AFB
Source: Pyeatt and Jenkins, Cold War Peacemaker, 224.

Asset Density and Attrition

Finally, all of the AVLPs in this study shared the trait of being low-density assets; there were only two airships, 10 GRB-36Ds,[11] and 16 DC-130s.[12] Other than the airships' limited eight-ship supply of *Sparrowhawks*, parasites tended to be more available, as the F-84 and RPVs had larger production pipelines. The takeaway is that a relatively scarce asset generates particular logistic challenges.

Having a small quantity of a military asset likely means they will all be concentrated in a single location to achieve some efficiencies in logistics (e.g. the B-2s at Whiteman AFB, MO). This is not a categorical fact, as the USAF does disperse high-value, low-density assets like the Airborne Warning and Control System (AWACS) to multiple locations in fewer number. What is relevant are some generalizable factors that come along with a small footprint: less personnel available for deployment or surge periods (maintenance and operations), minimal reserve-parts reservoir (and likely comparatively higher cost per item), a smaller or closed production pipeline, and most importantly, less redundancy in the

<u>Key Logistic Facets</u>

- AVLPs offer extended range to its parasites. Above any other fact, this appears to be a crucial conceptual piece to their function and purpose.
- In-flight servicing capability and basing contingent on tactical employment concept.
- Internal storage provides more flexibility with smaller parasites.
- Low-density potentially adds significant reliability and operational considerations.

Figure 42 – Logistical Facets
Source: Author

[11] Jacobsen, *Convair B-36*, 347.
[12] 15 operational and 1 DC-130H used for testing. Thornborough, *Sky Spies*, 36–37.

physical AVLP itself. Operationally, if the primary AVLP is unable to execute, there may not be many spare aircraft available. If ground handlers can move the parasite and its control systems to another aircraft quickly, that could help offset limitations from a smaller force size.

Just as modular sensors and interchangeable parts were factors in technological success, a modular carrying-capability (e.g. roll-on, roll-off system) for larger aircraft may help in asset management. If maintainers can trans-load conventional airlifters, fighters, or bombers with the parasite launchers within relatively short periods of time, it may allow for some increased operational availability. Regardless, unless this method becomes a major element of conducting operations, either the AVLP, the parasites, or the modular mechanisms are likely to be in short supply. If so, the most important decision may be in how operational planners and military theorists suggest to use the assets.

Employment and Doctrinal Cohesion

Militaries, like most large bureaucracies, are generally averse to large changes.[13] It is an unexpected finding then, that two of the three novel platforms generally fit into the operational paradigms of the time. While the larger Navy balked at the airships' potential, the Air Force generally accepted the GRB-36D-III and DC-130 aircraft into the inventory with little objection. This may simply have been a case of introducing a large flying vessel into a battleship dominated Navy, whereas the two USAF cases involve flying assets which did not represent radical departures from existing norms. Additionally, aside from Admiral Moffett, there were few flag officers in the Navy who saw great potential for the flying scouts. In all cases, what appeared to matter most was

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[13] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military (Cornell Studies in Security Affairs)* (Cornell University Press (1994), Edition: 63799th, 288 pages, 1994), 2.

whether military leaders and planners saw the asset as something which appropriately addressed an operational gap.

Purpose

Theorists initially misunderstood the appropriate use of the airships' loiter time and scouting planes. The *Sparrowhawks* were insufficient as a defensive platform, especially given contemporary designers' rapid improvement of aircraft. Relying on a handful of aircraft and AVLP machine guns to defend something so large was not terribly promising. Additionally, with the planes operating as scouts, the airships' strategic potential was much greater.

The same conceptual mistake occurred with the *Goblin* and *Thunderjet* during the FICON program. Although the USAF was quick to pivot away from the *Goblin*, it nevertheless believed initially that the F-84E could defend the B-36 during ingress operations. They soon moved on from this flawed construct too. The *Goblin* was too small in size, and the *Thunderjet* was likely to be outnumbered by enemy aggressors. The USAF's resultant integration of the *Thunderflash* reconnaissance jet to the AVLP showcased the effectiveness of iterative development on both technological and operational fronts. That dual-front approach is the simplest description of the entire *Lightning Bug* era, where 28 different Ryan models executed nearly 3,500 sorties.[14]

The major insight these cases offer is that military services must be willing to move beyond their initial concept of an asset's purpose. Even adding minor technological improvements, like the homing capability on the *Sparrowhawks*, can create large changes in operational principles. Conversely, those same technological improvements may eliminate any need for what the AVLP and its parasite can accomplish. The B-36 FICON project created an innovative pairing of capabilities and

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[14] Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 13.

may have had some operational success,[15] but advances in jet engines, aerial refueling, intercontinental ballistic missiles, and strategic ISR assets like the U-2 and satellite programs largely eliminated any need for what the AVLP could offer. AVLP development does not happen in a vacuum; advances in competing programs may lead to a service re-designating the AVLP's role (if possible), stripping its funding, or even outright cancelation. Those competing programs exist not within, but also between services, and finding the right mix of capabilities and assets is vital to creating integrated effects.

Integration

A service attempting to integrate an AVLP into its arsenal does not necessarily drive a need for it to conduct a major overhaul of its operational art. The airships called for a new approach to operations, not an outright rewriting of the strategic search mission. FICON aircraft supported SAC's long-range reconnaissance mission rather seamlessly, and the *Lightning Bugs* also performed well in the high-threat ISR role. In each case, there was a pre-existing asset which performed the mission, but needed an updated method of operations. Each AVLP offered an innovative way to address a challenge and aimed to offer an improvement to its service's effectiveness. Therefore, a key piece to integration is not just the AVLP's role, but how it interacts with existing capabilities.

As for the airships, while they struggled to prove their utility to the Navy, this could have changed over time. Had they remained in service, updates to technology and doctrine may have led to safe and refined operational efficacy. Ultimately, the 1930's era airship was unfit for military operations, as there were just too many technical weaknesses in both design and capability. These limitations hobbled any reasonable

[15] The operational record of the FICON period appears to have been lost over time, potentially due to classification and handling. Pyeatt and Jenkins, *Cold War Peacemaker*, 224.

attempt at fleet integration, as the vessel could not safely perform the mission it set out to do.

FICON *Thunderflashes* and *Lightning Bugs* were quite the opposite. In both cases, the parasite served as a high-speed ingressing ISR asset which could perform a role that other aircraft either could not or should not do. Both AVLPs also integrated well into existing operational structures and employment constructs, as they conducted the same mission as current aircraft, but had particular capabilities which made them superior for niche mission subsets. The fact that RPVs were pseudo-expendable increased their integrative likelihood, as they could conduct missions which were too dangerous for human operators. They enabled flexibility in operations while decreasing risk to manned counterparts. As the case studies show, the parasite's ability to perform a specific mission and address an operational gap or mission better than existing assets increases its utility to military operations.

An AVLP's operational tenure, however, may be fleeting. Just as technological development may eliminate an AVLP's purpose or drive a desire for leaders to acquire a new platform with the new capabilities, an AVLP's mission may also disappear. This was, to some degree, the case for the *Lightning Bugs*. With the end of the Vietnam War, the daily high-threat mission generally disappeared. While the US military still needed reconnaissance capabilities and imagery, the immediacy of the need was not as pronounced. The USAF was able to rely increasingly on satellites and, by the end of the 1970s, an upgraded U-2R.[16] The interaction of the USAF's preferred space or manned-ISR assets, the technological improvements to the U-2's sensors, and the lack of wartime requirements diminished the need for the DC-130 and its parasites.

As with other military assets, time can reduce an AVLP's role or mission sets. A platform with multi-mission capability may enjoy a longer

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[16] Swanborough and Bowers, *United States Military Aircraft since 1909*, 393.

service life and be more able to flexibly address emergent operational needs of the DOD's overarching mission. Here again, the modular components within the *Lightning Bugs'* frames allowed Ryan-Teledyne the ability to offer the USAF a suite of effects, and often from the same airframe.

In future designs, a service should not just look at its own requirements, but how the joint force may address an issue. Even if an AVLP was the best solution to a tactical problem, if another service's capability provides a similar solution then that may largely negate the need for an AVLP. Service-common platforms are possible, but troubled procurement with high-performance assets like the F-111 and the Joint Strike Fighter (F-35) may render them less valuable as service-specific wants and needs begin to trump commonality.

The tradeoff then exists between a service defining a mission for the asset they want versus creating an asset to do the mission the DOD needs. The Navy may desire a new fleet of airships for strategic search, but emerging US Space Force capabilities may obviate any major operational utility for such an asset. Thus, the challenge may not be how an asset fits into operational paradigms, but the larger political and military leadership support behind its creation and use.

Key Operational Facets

- Smaller form-factor and numbers appear to limit counter-threat role.
- Although ISR roles have been the most effective, assets which have multi-mission capability may be more suitable for parasite roles as they increase potential operational uses.

Figure 43 – Operational Facets
Source: Author

Politics, Economic, and Military Leadership

Of all the categories, this is the most crucial to an AVLP's longevity. Like most any military program, as long as military and political leaders are willing to put money into a program, it will continue. That willingness is usually based on a proven track record of success, but having a strong source of potential energy in the form of leadership or economic capital generally reaps large returns once a project is in motion. With more funding and greater levels of backing from leadership, programs may have greater leeway for innovative approaches and less concern for intermediate failures. While a litany of factors affected the services' AVLP development and utilization, two broad categories comprise the main ones: the budget and service acquisition strategies.

Budget Changes

While the modern US military enjoys a budget that is orders of magnitude greater than its international competitors, there have always been checks against needless or extraneous spending. The DOD or a particular service's budget drives what it is able to do in procurement, sustainment, training, operations, and overall personnel numbers. However, while congressional budget allocations affected each AVLP, one cannot simply assert a causal relationship between budget reductions and program elimination. The more nuanced argument involves the interaction of a service's budget with the contextual factors surrounding it (e.g. the geopolitical landscape, competing programs, service identity, strategic vision). Due to the length of time major acquisition projects tend to take, variations in budgeting can drastically affect procurement timelines and programmatic growth.

The airships were technologically complex, a novel approach to the Navy's strategic search paradigm, and disaster prone. All of these traits cast them in shadow of potential waste during the Great Depression. Though the military would go on to spend billions of dollars in the second World War, the American people's desire to spend money on a preventative asset during such a turbulent political and economic era was waning by the time the *Akron* and *Macon* were lost to the sea. Having already sunk nearly 20 million dollars for facilities in New Jersey and

California along with the airships and parasites, the thought of continuing to add more money into the program after so many failures was anathema to many in the Navy and Congress. Competing, seemingly more stable Naval programs won funding as Congress continued to cut its military spending in the early 1930s (Figure 44). After the New Deal's and other effects began to drive the economy toward pre-market-crash levels (Figure 45), the military budget increased concomitantly. By 1935 though, both airships had crashed and the Navy had no others under construction, nor any particular interest to address that shortfall.

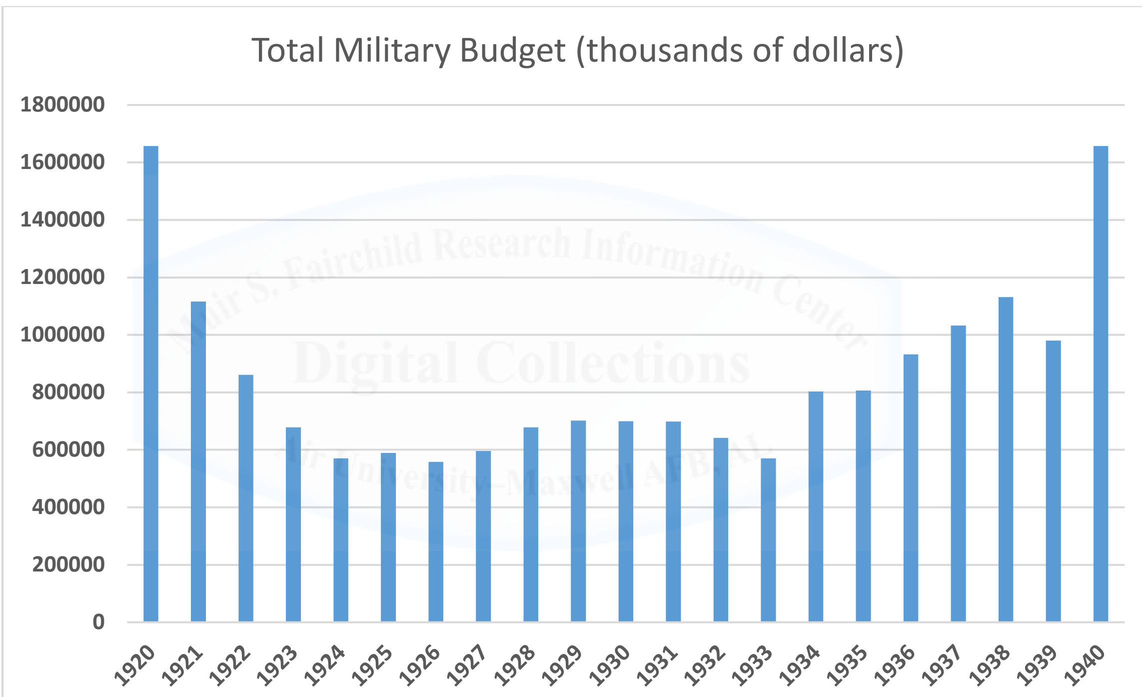

Figure 44 - US Military Budget (1920-1940)
Source: Author. Data from: David Singer, Stuart Bremer, and John Stuckey, "National Material Capabilities (v5.0) — Correlates of War," Correlates of War, February 1, 2017, https://correlatesofwar.org/data-sets/national-material-capabilities.US Military Budget (1920-1940).

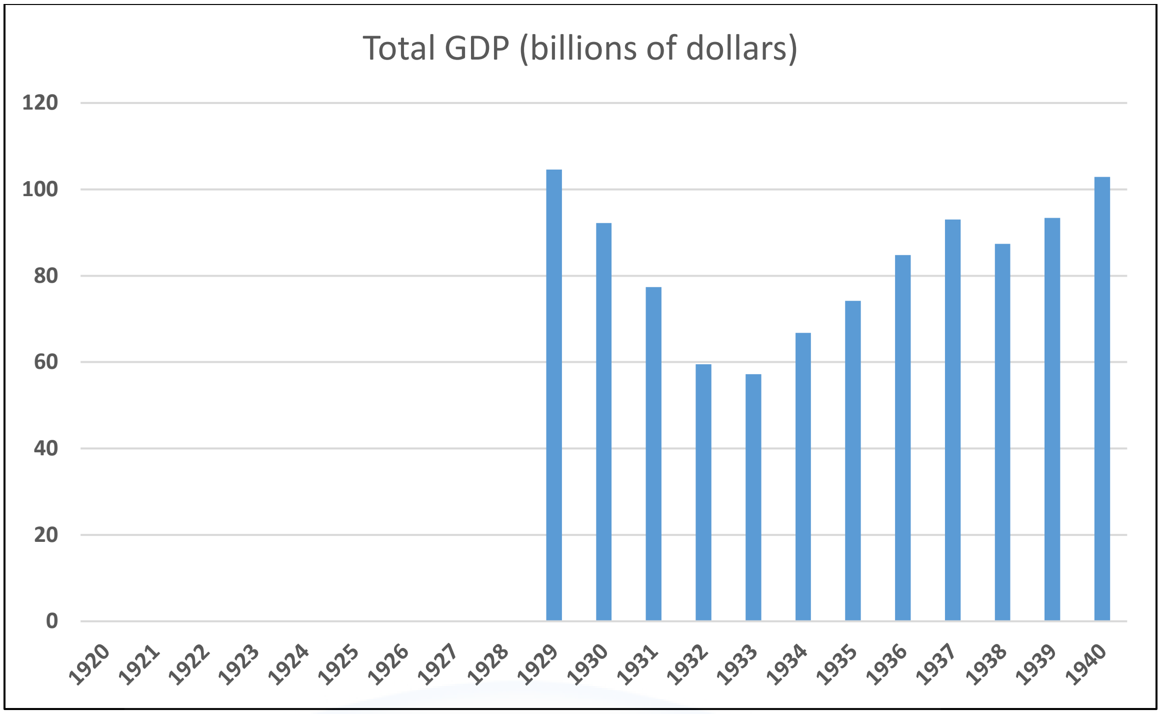

Figure 45 - Total US GDP (data unavailable prior to 1929)
Source: Author. Data from: U.S. Bureau of Economic Analysis, "Table 1.1.5. Gross Domestic Product," National Data, March 26, 2020, https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2; Singer, Bremer, and Stuckey, "National Material Capabilities (v5.0) — Correlates of War."

The overall DOD budget was slightly less of a factor in the FICON era. As the Korean War went into armistice status, Congress also reduced the military's budget. This reduction, however, came well after the B-36's development and acquisition, as well as the initiation of the FICON program in fiscal-year 1951. While the USAF had nearly canceled the B-36 program itself multiple times, it was never over a reduction in budget, but rather in favor of other assets. As the budget dropped from its Korean War highs, the FICON program was ripe for the USAF to begin termination. By then, the Air Force was looking to capitalize on newer jet-engine-based Cold War assets, and the niche bomber-recon platform became less necessary operationally. History has shown those thinkers to be correct, as three of the assets which received B-36 funds (B-52, KC-135, U-2) are still flying today.

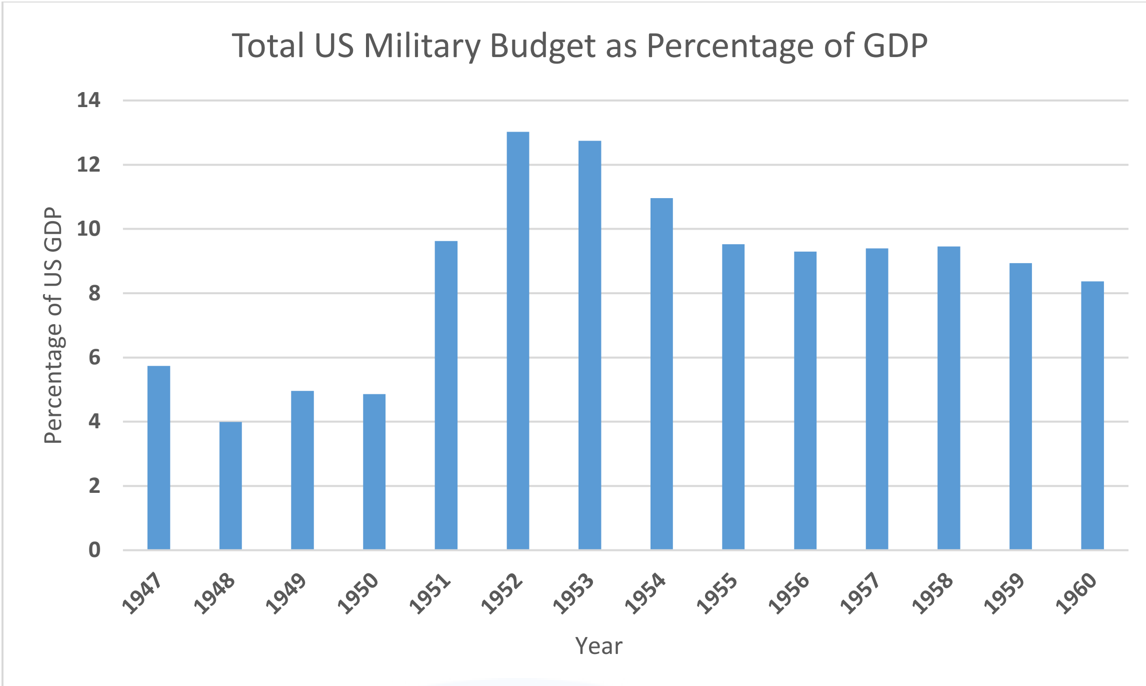

Figure 46 - US Military Budget (1947-1960)
Source: Author. Data combined from: Singer, Bremer, and Stuckey, "National Material Capabilities (v5.0) — Correlates of War"; U.S. Bureau of Economic Analysis, "Table 1.1.5. Gross Domestic Product."

The Ryan-Teledyne *Lightning Bugs* lost out to budgetary cutbacks, but not due to any congressional push. Tactical Air Command (TAC) had absorbed the RPVs in 1976 and was eager to get the them into storage so they could divest from the DC-130s, helicopters, and RPVs and move on to new age jet fighters like the A-7D, A-10A, F-15A, F-5E, F-4E, and F-111E.[17] As the military's budget decreased (relative to GDP, Figure 47) toward the end of the decade, the USAF's priorities did not stay with the RPVs as they did not match what TAC wanted: more fighters. Culture and identity are critical elements in whether an asset becomes an accepted part of a service. Without a champion in the military, the money, whether due to Congress or the service itself, will dry up.

[17] Schuster, "Lightning Bug War Over North Vietnam," 93–94; Wagner and Sloan, *Fireflies and Other UAVs (Unmanned Aerial Vehicles)*, 108.

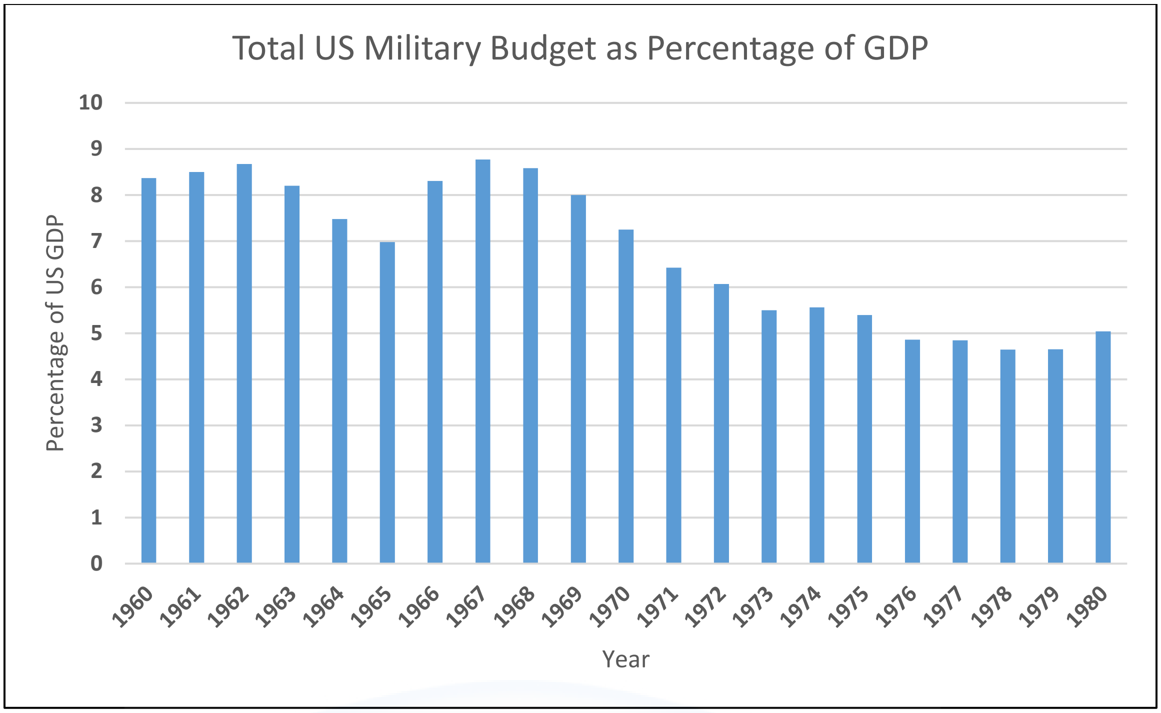

Figure 47 - US Military Budget (1960-1980)
Source: Author. Data combined from: Singer, Bremer, and Stuckey, "National Material Capabilities (v5.0) — Correlates of War"; U.S. Bureau of Economic Analysis, "Table 1.1.5. Gross Domestic Product."

Service Acquisitions and Development

Ultimately, each service determines its requirements and how it intends to acquire platforms, train people, and operate with respect to threats it perceives and the assets it has. While designers and proponents saw each of the AVLPs as helpful tactical asset for the respective service, the Navy did not wholly accept the airships and the USAF was all-too ready to move on from the B-36 and RPVs as financial restrictions began to constrain budgetary allocations. However, with the possible exception of the B-36 FICON program, the AVLPs still had potential strategic utility if the services had elected to continue the programs.

One may recall the issues airships had fitting into the broader Navy, but a telling quote from the chief of BuAer (in 1938) to congressional appropriators concerning funding new airship designs drives home the point: "I can frankly say that from the standpoint of the usefulness of rigid airships for scouting duty, I would not give you two cents for such a ship."[18] This statement represents the flawed perception that detractors may have about acquiring an asset which runs against traditional service functions. While the airships failed overall, proponents and visionaries certainly found them to offer exponentially greater value than a surface scout. Historian Richard Smith's quantitative analysis indicates a significantly larger search capacity than surface ships. When accounting for Goodyear-Zeppelin's delivery of the full complement of 10 rigid airships, he asserts that they would have been able to cover an expanse of ocean which would have required about 40 surface cruisers.[19] A 1-to-4 advantage in scouting capability surely indicates some usefulness and would seem desirable to the Navy, but the airships just could not stay aloft.

The airships' issues with durability, survivability, and logistic challenges created a strong distaste for the platform in the broader Navy. Dissenting opinions from top leaders were never far from the airships.[20] While Admiral Moffett himself had his reservations about the platform during the *Akron's* testing phase, his death removed him from Naval leadership ranks. When his successors pushed Commander Wiley to prove to the Navy that the *Macon* offered great potential, its lack of durability betrayed the asset. Smith argues that throughout the period, the rush to achieve stunning results was inappropriate. He laments, "too much was expected of [the airships], and too soon."[21] Without a proponent at the top level of the Navy, there was no one to counter views like the one from Admiral Cook above. With only negative press and animosity from the elite levels of leadership in the Navy, the airships may

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[18] Smith, *The Airships Akron & Macon*, 173.
[19] Smith, xxii.
[20] Smith, 55.
[21] Smith, 45.

have had good capability, but they lacked a mouthpiece to sing their praises or advocate acquiring more of them.

The B-36 program itself suffered from a lack of internal USAF cohesion about its value, but the FICON program was mostly tangential to that argument. With the rising budgets during the Korean War, coupled with the new strategic requirement for intercontinental bombing, the B-36 FICON program had enough advocacy for the experiment. However, the B-52's abilities were superior to the B-36's in nearly every category. The B-52G, the model in service as the B-36s began their boneyard procession, embodied the prototypical USAF metrics: higher and faster.[22] Had there been any major voices for B-36's FICON capability at the end, the program would have only survived if the parasites found a new host.

The *Lightning Bugs* represent another example of how the lack of a champion can seriously undermine survivability. This particular program, however, is more instructive as it is the clearest case of a success in the AVLP attempts. With DC-130s launching thousands of successful RPV missions in Vietnam and a company in Teledyne-Ryan willing to continue to modify its technology to adapt to emergent military needs, the RPVs just needed a champion in either SAC or TAC.

[22] Wagner, *American Combat Planes*, 422–35.

Whitmore's study on *Lightning Bugs* provides focus on the relative climates within SAC and TAC, "The RPV did not fit in either camp's business model for intellectual and financial investment, and thus did not garner any funds. In fact, RPVs became a capability to disband in order to garner more funds for other airframes."[23] The particular inter- and intra-service identities greatly matter to programming and acceptance of assets which threaten to change organizational models.

Key Administrative Facets

- World events impact budgets; a program may benefit heavily from this or be lost to history.
- Novel military applications must have a senior leader to champion it.
- New programs may struggle to gain a foothold in a service's pre-established. acquisition strategies and programming if they deviate from existing operational paradigms.

Figure 48 – Administrative Facets
Source: Author

One person's innovation may threaten another's livelihood. New assets may outmode an existing one, just as the oceanic aircraft-carrier did to the battleship. Therefore, when future endeavors look to these historical case studies, their designers should take time to discern what the new AVLP may replace or threaten. Aside from technical and operational feasibility, proponents must understand that services have an established architecture for both its hierarchy and employment strategy. It may have "sacred cows" which it is unwilling to part with, fears of political pressure if the service takes any path toward retiring an aging asset, or normal disagreement within the ranks on what the best strategies and assets are.

[23] Whitmore, "Lightning in a Bottle: How Air Force Culture Contained the Rise and Fall of the AQM-34 Lightning Bug," 94.

Recent AVLP Endeavors

These case studies offer no clear recommendation regarding the feasibility or efficacy of future AVLP development efforts. Certainly, the lack of a sustained AVLP platform provides a base level of skepticism that it may simply just not be a good idea to do this. The airships were expensive aircraft whose failure in trials fomented aversion to the assets and their price across the Navy and government. The *Peacemakers* were overmatched by technological advances and drove previously innovative ideas to dusty graves. The *Lightning Bugs* highlighted how finding a home for innovation efforts may run counter to a bureaucratic establishment. Yet, to military theorists there seems be an apparent attraction to AVLPs and the potential asymmetric advantage of parasitic power. Aviators began trials with AVLPs after only a decade of powered flight and innovation efforts continue to this day. Although none of these constructs exist as standard military weapon systems, the variations of the concept emerge nearly every decade. It may be that the critical concept is not the AVLP itself, but rather the concept of *unum de multis*, or "out of one, many."

Whether we recall the radio-controlled bombers of WWII,[24] modern bombers launching missiles which break off to target individual designated points of impact, or even an AWACS "directing" the airborne fight of coalition air assets, the idea that a singular aircraft can direct the effects of many recurs throughout aviation history. In Air Force mission planning, we often ask our "customers" for desired effects, not means. It may be that this is the appropriate lens for the AVLP paradigm as well.

Concepts such as the *Skyborg* program, in development by Kratos Defense, allow an F-35 or F-15EX pilot to control a robot wingman,[25]

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[24] Bowers, *Unconventional Aircraft*, 247.
[25] Bryan Ripple, "Skyborg Program Seeks Industry Input for Artificial Intelligence Initiative," U.S. Air Force, March 27, 2019, https://www.af.mil/News/Article-

thereby creating a potential modern variant of the AVLP. This construct allows for a human to remain in the loop, but also gain added support from a pseudo-attritable asset. In any potential major conflicts of the future, advanced defensive capabilities will likely present a need for this type of high-density, lower-cost asset. Pilots may stay in the loop for the next generation or two, but the speed of conflict may eventually drive them out of fighters.

Figure 49 - *Skyborg* Concept
Source: Ripple, "Skyborg Program Seeks Industry Input for Artificial Intelligence Initiative."

Dr. Timothy Schultz, of the Naval War College, suggests that the historical relationship of an aircraft's computer-aided automation and the pilot is one where they "[compensate] for the other's weaknesses to

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Display/Article/1796930/skyborg-program-seeks-industry-input-for-artificial-intelligence-initiative/; Valerie Insinna, "Under Skyborg Program, F-35 and F-15EX Jets Could Control Drone Sidekicks," Defense News, May 22, 2019, https://www.defensenews.com/air/2019/05/22/under-skyborg-program-f-35-and-f-15ex-jets-could-control-drone-sidekicks/.

optimize the function of the cybernetic system as a whole."[26] As advances in autonomous systems move us closer toward the Human-System operating teams,[27] like the F-35 with its *Skyborgs*, it is only natural for one to make the cognitive leap toward thinking of fully-autonomous strike packages and neural-net UAVs capable of swarming. DARPA's *Gremlins* program aims to be such a capability.

Figure 50 - DARPA's X-61A *Gremlin* Prototype
Source: DARPA, "Gremlins Program Completes First Flight Test for X-61A Vehicle," January 17, 2020, https://www.darpa.mil/news-events/2020-01-17

The *Gremlins* program is perhaps the closest modern parallel to the original airships. Launching from the ever-modifiable C-130, the program uses a trapeze concept similar to the ones used in the airships and FICON program. On the newest iteration, a robotic arm extends from the ramp of the mobility platform. The C-130 stores its *Gremlin* vehicles internally inside roll-on, roll-off containers. The *Gremlins* project presents an opportunity for the USAF to utilize modern mobility assets in a two-

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[26] Timothy Paul Schultz, *The Problem with Pilots: How Physicians, Engineers, and Airpower Enthusiasts Redefined Flight* (Baltimore, Maryland: Johns Hopkins University Press, 2018), 176.
[27] Greg Zacharias, *Autonomous Horizons: The Way Forward* (Maxwell Air Force Base, Alabama: Air University Press; Curtis E. LeMay Center for Doctrine Development and Education, 2019), 107.

fold approach: as AVLPs and in a kinetic role. Proponents should note though that an innovative path such as this, however, will likely feature the same obstacles and barriers that previous AVLP attempts faced.

Dissenting voices may argue that this blurring of combat and logistic capability creates potential pitfalls. Yet such dissent is likely to occur with any paradigm shift.[28] Depending on how an AVLP program develops, the USAF may, for instance, need to fundamentally shift its definition of what mobility aircraft are. If mobility is about logistics and opening access to military planners for further options, then operating as an AVLP may be aligned with doctrine. Mobility AVLPs have a multitude of possible uses: launching robotic airplanes as the first-wave in a major assault, having parasites function as an off-board threat and warning indicator during ingress to an objective area, or delivering site-specific materials in humanitarian or combat operations. These and more are possible, but organizational pushback may manifest even in the face of what could otherwise be an operationally beneficial innovation.

Innovators looking to leverage this type of capability will have to address technological factors, military structures, and funding to instantiate such a program. They may even suggest skipping this iteration and go straight to autonomous AVLPs carrying *Gremlins* or another parasite. A day for an asset like that will almost assuredly come, but proponents should take great care to decipher whether that day is upon us. They should wonder if they are advocating for a promising joint-warfighting platform, or another *Akron*.

Future Research

Should modern AVLP ideas like *Skyborg* and *Gremlins* become permanent military programs, military theorists and strategists ought to consider a few potential areas of research: ethics of autonomous strike

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[28] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 4. ed., 50th anniversary ed (Chicago, I.L.: The University of Chicago Press, 2012), 12, 18, 59, 64, 93.

and arming Mobility Air Force (MAF) assets. In both areas, if the DOD and USAF fail to address them before the physical realization of the technology, they will be left trying to address force structures and strategies in an era when the available time for wartime decision-making continues to decrease.

Although there is already a significant body of literature concerning the ethics of drone warfare,[29] the DOD needs to formalize its position regarding the implications of AI decisions to employ weapons. While an exploration of these concerns has begun in some corners, most notably in the DOD's policy on lethal autonomous weapon systems (LAWS) which requires human oversight for a notional robotic-actor,[30] there are systemic risks if technology outpaces the underlying social frameworks and norms. Given the pace of technological progress, it is likely that scientists will develop the weapons before those international norms exist. One can look to the current state of weaponization of space as an analogous construct.

Furthermore, ideas such as keeping a human operator in the loop for machine decisions will likely result in poor operating constructs.[31] With every advance in neural-network data processing, general artificial intelligence, machine communication and coordination, and hardware capabilities (e.g. exoskeletons, processors, sensors), the human operator is going to be at an exponential disadvantage compared to a machine in his or her ability to make timely inputs. A human directing generalized algorithms and protocols is possible, but this type of setup opens a pathway to the machine interpreting a situation in unforeseen ways, and largely leaves the problem unsolved. The bottom line is that robotic

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[29] For example, Cohn's *Drones and Targeted Killing*, Kaag and Kreps's *Drone Warfare*, and (former USAF officer) Strawser's *Killing by Remote Control.*
[30] Kelley M. Sayler, "Defense Primer: U.S. Policy on Lethal Autonomous Weapon Systems (Version 2)" (Washington D.C.: Congressional Research Service, December 19, 2019), https://crsreports.congress.gov/product/pdf/IF/IF11150.
[31] Sayler.

warfare is likely coming, and the DOD needs to have both physical and social technologies in place when it does.

Arming the MAF generates a variety of effects on funding, ownership, and operational employment. There are significant implications to how the USAF would fund such a program. Fundamental to such a question is whether the modification requires a permanent installation or if it is a roll-on, roll-off capability like *Gremlins*. Specific technological designs mandate different administrative structures. In turn, that interaction dictates whom the appropriate or necessary military advocate may be.

Ownership of the asset will likely follow from who pays for it. If it is a permanent modification, then similar to the SOCOM acquisitions model, the receiving command could acquire a modified cargo airlifter from Air Mobility Command. Non-permanent modifications may necessitate combatant commands vying for assets or major commands within the USAF working out new operating arrangements. In either case, there are potential second-order effects on manning, basing, training, ranges, logistic structures, and even other nations denying diplomatic overflight for mobility aircraft if they now can carry weaponized drones. As with any decision which incurs risk, commanders must understand the potential costs versus the reward of having such an asset.

Conclusion

The history of AVLPs in the US military is filled with engineering masterpieces, failed experiments, disaster, and triumphs. In these respects, it differs very little from the history of military aviation itself. Yet, whether known as a lighter-than-air carrier, host and parasite, an airborne aircraft-carrier, airborne vehicle-launch-platform, or another, these concepts embody the innovative spirit of aviation in its entirety.

Future designers will have to address challenges like the ones above and likely many more. If they can do so, and are able to choose the right designs for appropriate missions, then AVLPs can be an excellent asset for the DOD. Similar to their sea-based counterparts, AVLPs can offer military planners a dynamic force-projection option with capabilities like global reach, tactical surprise, and asymmetric concentration against enemy defenses.

Like the airplane before it, AVLP application will likely move beyond the military and into our civilian lives as well. We may see direct package and food delivery from a central platform, police helicopters dispersing drones to setup a search perimeter, or even our own "flying cars" connecting to a larger sky ship for long trips. It is easy to get lost in the science fiction and futurist ideas, but not fanciful. I began this project with my own "novel" idea: the USAF should have airborne aircraft-carriers. I was astonished to find out just how unoriginal and dated my idea was as I watched black-and-white footage of *Sparrowhawks* connecting to the *Akron*.

The allure of launching aircraft from the sky is enduring. From small propeller planes hooking onto a balloon to fighters joining midair with bombers, from Neil Armstrong in his X-15 to the Space Shuttle sitting atop a 747, and now even the ability to deploy micro-UAVs from carrier-based F-18s,[32] aviation innovators seem to feel a near magnetic pull toward the capability. It remains to be seen what our next attempt will be, but just as evolution marches on in nature, so too will come the next version of an AVLP host, and its parasite.

[32] Department of Defense, "Department of Defense Announces Successful Micro-Drone Demonstration," Release, January 9, 2017, https://www.defense.gov/Newsroom/Releases/Release/Article/1044811/department-of-defense-announces-successful-micro-drone-demonstration/.

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