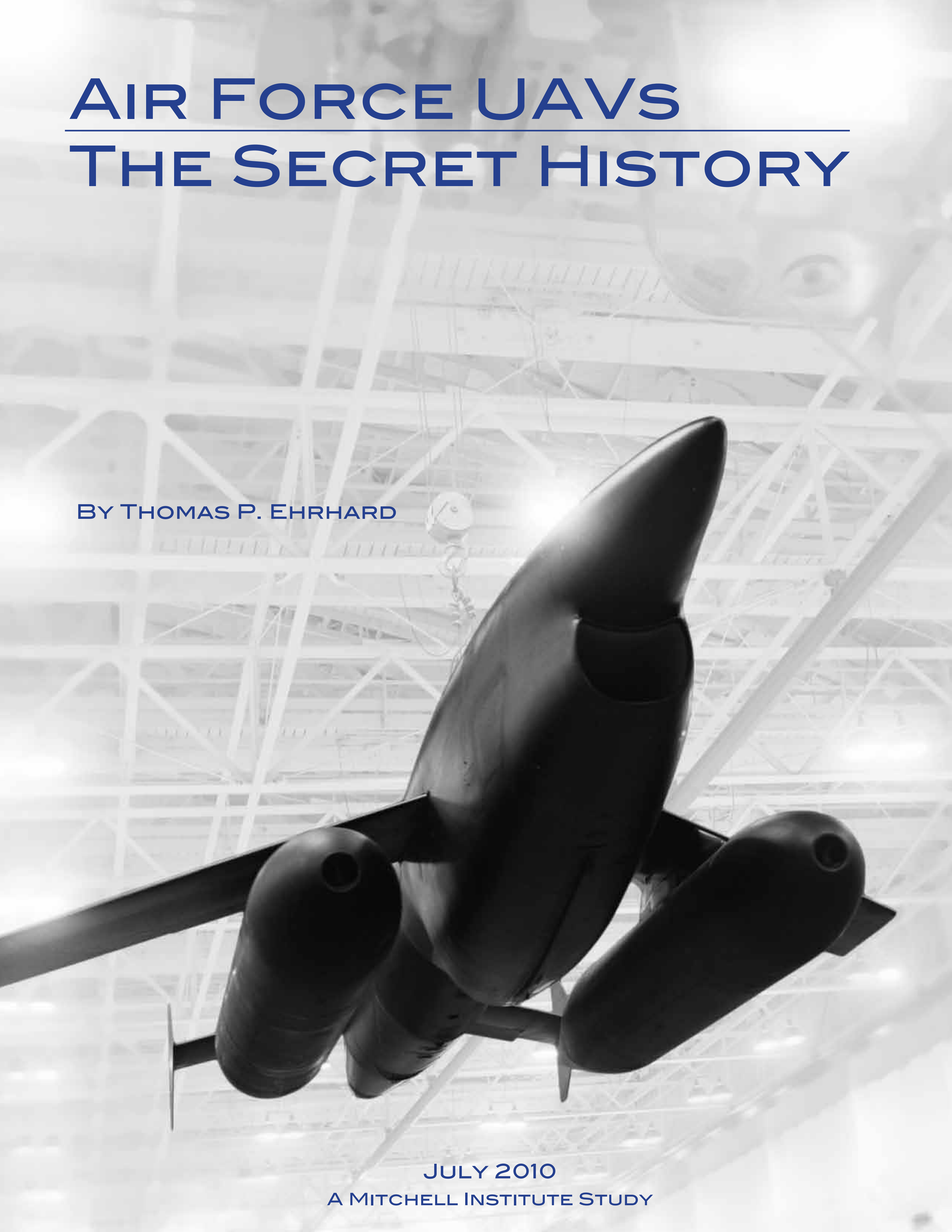
Air Force UAVs
The Secret History

By Thomas P. Ehrhard



July 2010

A Mitchell Institute Study

Brig. Gen. Billy Mitchell

On September 12, 1918 at St. Mihiel in France, Col. William Mitchell became the first person ever to command a major force of allied aircraft in a combined-arms operation. This battle was the debut of the US Army fighting under a single American commander on European soil. Under Mitchell's control, more than 1,100 allied aircraft worked in unison with ground forces in a broad offensive—one encompassing not only the advance of ground troops but also direct air attacks on enemy strategic targets, aircraft, communications, logistics, and forces beyond the front lines.

Mitchell was promoted to Brigadier General by order of Gen. John J. Pershing, commander of the American Expeditionary Force, in recognition of his command accomplishments during the St. Mihiel offensive and the subsequent Meuse-Argonne offensive.

After World War I, General Mitchell served in Washington and then became Commander, First Provisional Air Brigade, in 1921. That summer, he led joint Army and Navy demonstration attacks as bombs delivered from aircraft sank several captured German vessels, including the SS *Ostfriesland*.

His determination to speak the truth about airpower and its importance to America led to a court-martial trial in 1925. Mitchell was convicted, and resigned from the service in February 1926.

Mitchell, through personal example and through his writing, inspired and encouraged a cadre of younger airmen. These included future General of the Air Force Henry H. Arnold, who led the two million-man Army Air Forces in World War II; Gen. Ira Eaker, who commanded the first bomber forces in Europe in 1942; and Gen. Carl Spaatz, who became the first Chief of Staff of the United States Air Force upon its charter of independence in 1947.

Mitchell died in 1936. One of the pallbearers at his funeral in Wisconsin was George Catlett Marshall, who was the chief ground-force planner for the St. Mihiel offensive.

ABOUT THE MITCHELL INSTITUTE FOR AIRPOWER STUDIES: The Mitchell Institute for Airpower Studies, founded by the Air Force Association, seeks to honor the leadership of Brig. Gen. William Mitchell through timely and high-quality research and writing on airpower and its role in the security of this nation.

ABOUT THE AUTHOR: Dr. Thomas P. Ehrhard is Special Assistant to the Chief of Staff of the US Air Force. As the senior civilian assistant to Chief of Staff, he advises Air Staff leaders on strategy and policy and serves as the principal advisor to the Chief of Staff's Strategic Studies Group. Before his appointment in 2009, Ehrhard was a Senior Fellow at the Center for Strategic and Budgetary Assessments in Washington, D.C. Ehrhard, a 1980 graduate of the US Air Force Academy, served 26 years on active duty, retiring in 2006 as a colonel. During that time, he acquired a master's degree from California State University, a master of airpower art and science degree from Air University, and a PhD in international relations from The Johns Hopkins University. Ehrhard was military assistant to Andrew W. Marshall, the Pentagon's Director of Net Assessment. He also worked in various Air Staff and OSD strategy positions in the Pentagon, and was Chief of the US Central Command Air Forces Strategy Division during the opening phases of Operation Enduring Freedom in Afghanistan.

Published by Mitchell Institute Press

Design by Darcy Harris

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JULY 2010
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Preface

Has any airplane in the past decade captured the public imagination more than the unmanned aerial vehicle named Predator? Americans have been fascinated by the very idea of pilots, back in the United States, tracking targets for hours, watching the doorways of insurgent safe-houses, all the while poised to launch a Hellfire missile. This image will always be associated with the complex operations of Afghanistan and Iraq.

Predator did not come out of nowhere. Most know that the idea for unmanned flying craft is almost as old as Wilbur and Orville Wright's pre-1903 kites.

There's also solid archival evidence that airmen have long pursued the development of unmanned air vehicles. In World War II, the US Army Air Forces under Gen. H. H. Arnold converted battle-worn B-17s and B-24s into "Weary Willies," airplanes that were automatically piloted and laden with explosives. The USAAF Chief wanted the air forces to bring the "greatest pressure possible against the enemy." In a 1944 staff memo, Arnold remarked, "If you can get mechanical machines to do this, you are saving lives at the outset."

Still, 50 years passed between Arnold's comment and the 1994 deployment of Predator to support military operations in Bosnia-Herzegovina in the Balkans. Some think of the intervening half century as a kind of Dark Ages for unmanned aircraft, with the Air Force fighting to keep jobs for its pilots and turning up its nose at unmanned air vehicle technology.

Dr. Thomas Ehrhard blows the lid off that urban legend with Air Force UAVs: The Secret History, which the Mitchell Institute is pleased to publish. Ehrhard's unparalleled study—a rare blend of strategic, system, and intellectual history—covers the years of UAV development up to 2000. In it, Ehrhard brings to light the comprehensive story of highly secret Air Force involvement in numerous UAV programs.

The real story is hardly what you might think it would be. Starting in the early 1960s, the Air Force was operating unmanned aerial vehicles for the National Reconnaissance Office. NRO was an outfit so secret that even its name was classified until 1992. According to Ehrhard, the NRO was like a "rich uncle" pouring billions into unmanned programs known internally as Program D. The "CIA-Air Force combine proved to be fertile ground for UAV innovation, with the secret foreign intelligence budget allowing a relatively high-risk development environment and the Air Force contributing its substantial aviation expertise," said Ehrhard.

Staggering experiments resulted. In the mid-1960s, a modified CIA A-12 (same as the SR-71) flight tested the D-21B unmanned vehicle at Mach 4 with the hope of overflying China's nuclear development facilities.

Operational UAVs were vital to the Vietnam air war. "At the zenith of drone operations in December 1972," writes Ehrhard, "the Air Force depended almost entirely on them for bomb damage assessment due to bad weather."

Ehrhard populates his study with the real people who invested their talent in UAVs. There was Clarence "Kelly" Johnson, legendary Lockheed Skunk Works pioneer, who made the D-21B craft fly but then closed it down himself after a fatal accident and gave the money back to the NRO. "Kier's Bird" was the ill-starred program nicknamed for program manager and master salesman David Kier. Amber, a true ancestor of the Predator dynasty, was in Ehrhard's words "a product of Abe Karem's fertile but eccentric mind."

These names, both famous and little-known, join the dramatis personae of defense secretaries, chiefs of staff, officials, and leading members of Congress who grappled with the promise and problems of UAVs for some 40 years.

Then there were the operators. Strategic Air Command used the popular Lightning Bug for years to probe Chinese air defenses and to gather reconnaissance. The drones flew thousands of missions over Southeast Asia. "It is tempting to speculate about the number of pilot's lives saved by flying drones, and there arguably were some," writes Ehrhard. However, the reality was that "manned reconnaissance aircraft simply would not have been sent into the areas (like Hanoi during Linebacker II) covered by the drones and certainly would not have conducted decoy or missile electronics intelligence missions described earlier," he concludes.

Of course, unmanned vehicles had technical and operational challenges, as Ehrhard documents. They also had to compete with other breakthrough technologies. Fast, high-altitude aircraft such as the SR-71 excelled at global photoreconnaissance. Satellites were improving, too. Fleets of signals intelligence aircraft sniffed for the take along the borders of Communist nations. The early unmanned vehicles had to compete against systems with considerable capability, and they often came up short.

Much of Ehrhard's research is based on declassified documents. These, for the most part, came to light as a result of his own deep and meticulous research, originally performed in support of his doctoral dissertation at The Johns Hopkins University. The complete study, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," is a much broader, 210,000-word epic, encompassing all services and US agencies. It has only been seen by a select, professional audience, and is itself worthy of publication in full. With this paper, we present those portions dealing with the United States Air Force, directly or indirectly.

All along, there have been some tantalizing public hints about the extent of America's unmanned reconnaissance and surveillance work. What is striking, though, is how thoroughly the Air Force's secret role in UAV development remained "in the black world," unseen by any except those closest to the projects. The veil allowed speedy development of systems but gave the Air Force an undeserved reputation of indifference.

The clandestine nature of USAF's development efforts offers a potential back story to a recent defense puzzle. In 2008, Defense Secretary Robert Gates—a former CIA director—made what seemed like an offhand remark about a UAV program. He said that, as CIA chief, he had tried, but failed, to get the Air Force to fund this unnamed system. "In 1992," Gates complained 16 years later, "the Air Force would not co-fund with CIA a vehicle without a pilot." Gates didn't name the program, but as Ehrhard reveals, the NRO and the Air Force in 1992 were winding down a massive, stealthy reconnaissance UAV program called AARS—for Advanced Airborne Reconnaissance System. Ehrhard tells the fascinating story of its origins as a persistent system to track mobile targets and how the glut of "black world" money in the late Cold War years encouraged cost and requirements growth until all variants were slashed by Congress.

This Mitchell paper draws to a close at the turn of the 21st century. It is an appropriate stopping point, because the decades of clandestine operations were giving way to full integration of UAVs into joint operations. Light broke the horizon in the mid-1990s, when the Air Force began operating Predators over Bosnia and Kosovo. By 1999, Predators were handing real-time targeting information to the air operations center to be passed on to strike aircraft during NATO's Operation Allied Force. The terror attacks of Sept. 11, 2001, were just around the corner, and it was in the resulting wars—Afghanistan, Iraq—that the unmanned systems burst into full view and became matters of wide public discussion.

Within a decade, UAVs had revolutionized the conduct of ISR and certain types of attack, and all in the full glare of media coverage. "Today, we now have more than 5,000 UAVs, a 25-fold increase since 2001," said Gates in his 2008 speech at the Air War College at Maxwell AFB, Ala. A full share of credit for that astounding success must be attributed to the massive and long-term technical innovation of the Air Force and its intelligence agency partners over the decades. For more of this fascinating untold story, read on.

Rebecca Grant, Director
Mitchell Institute for Airpower Studies
July 2010

Air Force UAVs: The Secret History

Introduction

In 1956, Air Force Maj. Gen. David Baker addressed a meeting of industrial leaders by stating, "We can readily see that except for certain types of missions, the manned combat aircraft will become technically obsolete in the future."[1] He was referring not to UAVs, but to the possible replacement of manned penetrating bombers by intercontinental ballistic missiles and pilotless cruise missiles. The nuclear delivery mission was the keystone of Air Force organizational identity and budget share, however, so his statement speaks to the technological optimism of Air Force leaders concerning unproven, immature, and truly innovative aerospace technologies.

His comments do not wholly concern missile developments, however, for at the same time the Air Force was also investing in fairly sophisticated, jet-powered target drones. Camera-carrying derivatives of those jet drones, operated by Air Force pilots, would soon evolve into the first significant combat UAV in history.[2]

This paper explores Air Force UAV systems using a comparative analytical framework. Systems are presented chronologically and the analysis focuses on external and internal variables contributing to weapon system innovation. As with the other services, independent externalities such as aviation technology, the military threat, and politics provide the context for Air Force UAV decision-making.

The UAV programs described in this paper reveal how the Air Force's functional requirements, decision-making structure, and undiluted aviation culture affected UAV development. It chronicles the evolution and development of combat-support UAVs from the early 1960s (when the Air Force operated drones developed by the National Reconnaissance Office, or NRO), to 1994 (when all of the services lost UAV acquisition autonomy with the formation of the Defense Airborne Reconnaissance Office, or DARO) up to the year 2000.

As will be seen, the Air Force not only pursued its own systems relating to conventional combat operations but also had intimate involvement with the intelligence community UAVs, also profiled here. In these early decades, the Air Force record of adoption paralleled that of the other services—only one UAV system achieved operational status. The similarities end there, however. The fast, long-range, high-flying UAVs pursued by the Air Force resulted in different reactions to contextual elements.

Technologically, the lack of a cheap, reliable method for achieving location accuracy exerted a powerful brake on adoption despite the ground-breaking invention of the microprocessor. Perhaps even more compelling was the fact that satellites, manned aviation, and standoff missiles presented much more formidable competition to Air Force UAVs than they did to the UAVs of other services.[3]

Furthermore, international air traffic control and arms control regimes stood in the way of novel UAV models developed in a surge of Air Force development in the 1970s. Congressional influence played a larger role than in the other services, both in the constriction of Air Force UAV developmental efforts in the 1970s and through an accelerated drive for efficiency in the 1980s that neglected the services' unique operating environments.

In sum, UAVs presented a nascent challenge to the mature aviation meta-system, but failed to break through despite 30 years of fairly consistent Air Force investment.

Also in contrast to the other services, internal organizational dynamics generally spurred UAV development. The competition between the dominant Strategic Air Command and the rising Tactical Air Command stimulated aggressive prototype development. Powerful chiefs of staff played pivotal roles in the UAV surge of the early 1970s, and the presence of a strong aeronautical research and development base provided a source of low-level internal advocacy.

In the final analysis, however, UAV systems failed to demonstrate operational utility and never developed a tiered operational constituency—that is, one that spanned the operational structure from the flight line to the chief of staff.

One quasi-internal influence looms large in the history of Air Force UAV development and provides support for the importance of the services in weapon system innovation. The presence of a "rich uncle" in the form of the NRO contributed to an organizational schizophrenia within the Air Force, which on one hand allowed them to outsource high-risk development but, on the other hand, stimulated a desire for greater control of UAV development, adoption, and operational use.

As a result, the Air Force served initially as an operator of intelligence community-derived, "black" UAVs, but the leap to the white world proved difficult. The NRO's access to a deep well of intelligence money played a major role in jump-starting UAV interest in the Air Force. Yet, this easy access to money from external sources ultimately hindered the development of an Air Force UAV constituency necessary to realize full UAV integration. The boom and bust story of Air Force UAVs provides additional support to the argument that the services, as end-users of a weapon system, have a central, immutable role in the process of weapon system innovation.

The Air Force and the NRO

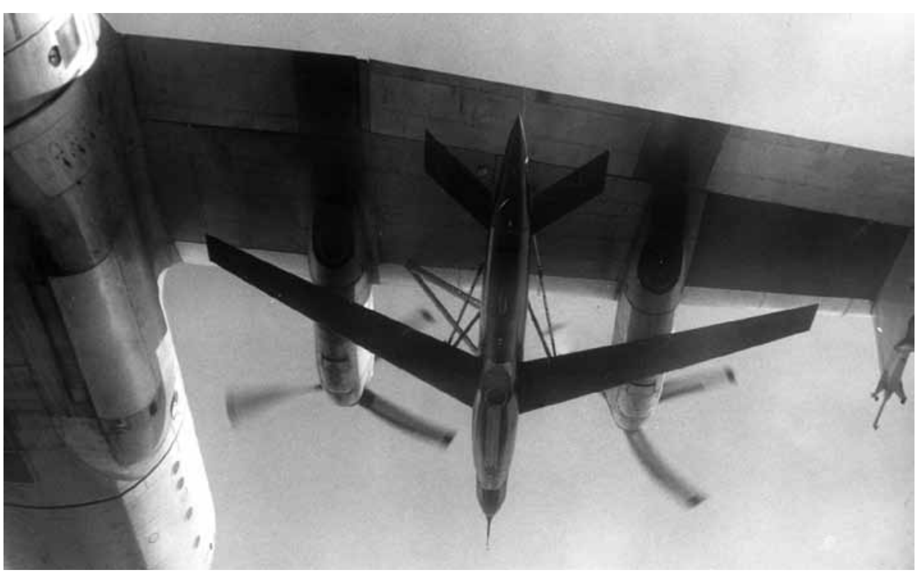
The US intelligence community is the single greatest contributor to US operational UAV development. Over the span of this study—roughly, 1960 through 2000—the intelligence community budget funded more than 40 percent of the total US UAV investment, double that of the next greatest contributor.

Yet, while this statistic reveals the pivotal nature of intelligence agency involvement in the UAV story, it obscures the fact that the "community" includes substantial portions of the US armed services.[4] In the case of national reconnaissance UAVs, the Air Force shared in development of every major system and operated all of them, arguably raising its contribution to more than 60 percent of the UAV programs in this period. This section focuses on how non-military intelligence agencies combined with the Air Force to produce the most exotic and important UAVs in history.

Three agencies in the intelligence community dominate the national intelligence UAV effort over these 40 years.[5] The Central Intelligence Agency (CIA), created in the National Security Act of 1947 to conduct foreign intelligence collection, and the US Air Force, designated as a separate service by that same act, worked together on all the major UAV programs herein discussed.[6] The vehicle for their interaction was the National Reconnaissance Office (NRO), an agency so secret even its name was classified until just after the end of the Cold War. The Kennedy Administration formed the NRO in 1961 to manage the proliferation of US satellite and airborne intelligence collection systems.[7] Over most of its history the structure of the NRO reflected its role as an integrator, with its "Program A" division stewarding Air Force projects, "Program B" handling CIA satellites, the small "Program C" dealing with Navy satellites, and the even smaller "Program D" section developing airborne intelligence collection platforms.[8] The NRO (through Program D) was the structure through which the CIA and the Air Force worked together to develop UAV systems.

Due to the sensitivity of the subject matter, the following paragraphs provide what is, to date, the only comprehensive compilation and analysis of US national intelligence-collecting UAVs. The information is taken from declassified documents and pieced together from open-source information and interviews. Several themes will emerge over the course of this discussion. First, the intelligence community had the most compelling need for unmanned aircraft due to the political fallout that might result if an adversary captured a pilot. Second, the CIA-Air Force combine proved to be fertile ground for UAV innovation, with the secret foreign intelligence budget allowing a relatively high-risk development environment and the Air Force contributing its substantial aviation expertise, resulting in efficient UAV flight operations.[9] The immaturity of UAV technology and the requirement to overfly vast expanses of territory led to very large, expensive UAV programs. The imperatives of the Cold War allowed for UAV technology development that might not have survived intense public scrutiny.

The intelligence community had the latitude to pursue the seductive promise of the UAV and represented its only solid constituency throughout most of the 1960s. Various NRO directors remained enthusiastic about UAVs, insuring a constant flow of ideas and money that led to the first major operational UAV in history, the Strategic Air Command-operated Lightning Bug. However, just like the services, the intelligence community's interest in UAVs ebbed due to events independent of UAV development. Chief among them was an upsurge in satellite capability that gradually eclipsed airborne systems as the premier strategic reconnaissance platform. The UAV found itself to be a misfit in



A Teledyne Ryan Model 147 (USAF AQM-34) remotely piloted aircraft is ready to air launch from its host DC-130.

the increasingly satellite-centered intelligence community, unable to muster consistent support and doomed to a world where the realization of its promise always seemed just out of reach.

■ Early "National" UAV Systems

In the years following World War II, an urgent requirement existed to penetrate the veil of secrecy that shrouded communist states. One way to do that was to exploit the dominance of US airpower. In the early 1950s, Air Force Logistics Command (AFLC) formed a highly classified, quick-reaction aircraft modification program office at Wright-Patterson AFB, Ohio, known as "Big Safari." It began to manage special airborne reconnaissance platforms that spied on communist states.[10] The CIA, on the other hand, managed the U-2 program throughout the mid-1950s, and began to look for its replacement by 1960. On Sept. 6, 1961 the National Reconnaissance Office was formed to coordinate the various overlapping strategic reconnaissance programs of various military and intelligence agencies. The NRO managed the Peacetime Aerial Reconnaissance (PAR) program, the predecessor to today's National Foreign Intelligence Program (NFIP), funneling money into promising reconnaissance systems.[11] The NRO's "Program D," an office established in July 1962 that was always headed by a senior Air Force pilot, used conduits like Big Safari to bring the programs to fruition.[12] Thus, although the Air Force operated special intelligence aircraft due to its expertise in conducting flight operations, those programs were "off-budget" and only affected the service through the salaries of the flight crews and support personnel. This "off-budget," or slack money funded the massive combat drone program run by the Air Force throughout the 1960s into the 1970s.

■ Red Wagon Rolls In

In 1954, fear of a Soviet nuclear breakthrough spurred the US to develop the U-2.[13] This very high altitude aircraft built by the legendary aircraft designer Clarence "Kelly" Johnson flew at altitudes over 70,000 feet, higher than the reach of any Soviet air defense system. Even in development the U-2 had political impact. President Eisenhower had the U-2 in mind when he proposed his "open skies" agreement for mutual overflight rights at the July 1955 Geneva summit. U-2s flew with impunity over Soviet airspace starting on July 4, 1956, collecting vital intelligence on Soviet aircraft and missile development. Soviet Premier Nikita Khrushchev seethed over an intrusion he could not oppose.[14] Work on the radar-guided SA-2 surface-to-air missile would change that.

The increasing risk of U-2 operations over the Soviet Union was not lost on members of the Air Force reconnaissance community.[15] In September 1959, Air Staff reconnaissance chief Col. Hal Wood and his assistant mulled over the risks of a U-2 pilot falling into Soviet hands. A contractor asked about using Q-2C Firebee target drones as a reconnaissance platform. Neither officer even knew anything about the drones, but they made informal contacts with the drone's maker, Ryan Aeronautical. By mid-April 1960 the contractor presented the Air Staff with a proposal for a strategic reconnaissance drone project. Its timing could not have been better.

Two weeks later, on May Day, a Soviet SA-2 barrage shot down a U-2 deep within Soviet air space. The shootdown and trial of the pilot, Francis Gary Powers, dominated the news for months and torpedoed the Paris summit between Eisenhower and Khrushchev.

The shootdown also led to the letting of a contract for an unmanned reconnaissance craft named Red Wagon.[16] Red Wagon was an apt name for the drone project, for it looked puny compared to its two competitors. First, the CIA was working on a manned reconnaissance aircraft with the codename Oxcart.[17] This extremely high speed, high altitude reconnaissance aircraft that the CIA called the A-12—later to become the Air Force SR-71 Blackbird—aimed to re-establish the dominance of aircraft over the burgeoning technology in surface-to-air missiles.[18] Second, the Powers shootdown also accelerated US efforts to conduct satellite photo reconnaissance. The seminal 1946 RAND Corporation report titled "Preliminary Design of an Experimental World Circling Spaceship" long before had spurred interest in possible satellites, and each of the armed services (save the Marine Corps) pursued satellite technology throughout the 1950s. The Soviet Sputnik, the first earth-orbiting satellite, shocked the US on Oct. 4, 1957, causing the first significant increase in the pace of satellite development. Eisenhower's promise to never again overfly the Soviet Union led to an acceleration of satellite work. The first working Corona surveillance satellite, Discoverer 14, flew just more than three months after the U-2 incident.[19]

Competition between the three modes of strategic reconnaissance—drones, satellites, and manned aircraft—continues to this day.

Drones lost all the early battles. Red Wagon enjoyed Air Force support. However, the aircraft, while small, was not cheap. The members of the Air Staff, led by the Chief of Staff, Gen. Curtis LeMay, approved a $70 million ($417 million in FY10 dollars) contract for Red Wagon and sent it with their full support to Deputy Secretary of Defense Roswell Gilpatrick. He approved the project, as did the CIA.[20] Despite this lineup of support, Harold Brown, Director of Defense Research and Engineering, used his veto power to hold up funds for Red Wagon. Brown wanted to keep all airborne reconnaissance money focused on the Oxcart project, which had received a $96 million contract in early 1960.[21] Over the Air Force's objection, Brown prevailed. Red Wagon was soon cancelled, winning the dubious honor of being the first of many UAV projects that could not compete with a manned aircraft or satellites.[22]

■ Fire Fly

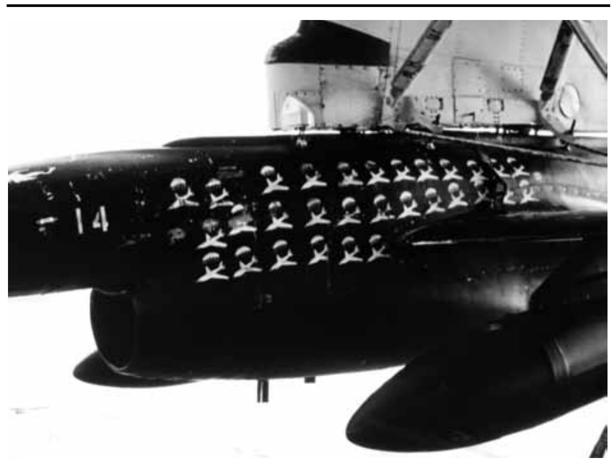
Like many innovations, the drone had formidable, seasoned competitors. There was a way to skirt com-

Above: AQM-34M remotely piloted aircraft in flight. Below: Closeup of a veteran AQM-34 RPA showing symbols of past missions.

petition with powerful competitors and keep the project alive, however. The Big Safari office carried out certain low-rate modification programs such as the RB-50E/G Haystack or C-130 Rivet Victor "ferret" aircraft (antecedents of today's RC-135 Rivet Joint aircraft) that sniffed for radar and communications emissions. Big Safari projects were managed in ways similar to today's "black" programs—with minimal oversight and paperwork. The NRO funded Big Safari to run a speculative program to do minimal modifications to the Ryan Q-2C Firebee target drone in lieu of designing a purpose-built reconnaissance drone. Ryan Aeronautical received more than $1 million in February 1962 to modify four Q-2C special purpose aircraft (SPA), which they called the Model 147A Fire Fly.[23]

The Fire Fly drone reconnaissance system was not only ready on time, but declared operational 91 days after Ryan received the contract. It successfully flew round-trip missions from Holloman AFB, N.M. to just west of the Great Salt Lake in Utah after air-launch from under the wings of a specially modified C-130 transport aircraft.[24] Test realism included a live weapons intercept by Air Force fighters in May 1962. F-106 Delta Darts failed to get a head-on radar lock on the small, stealth-enhanced Fire Fly, and numerous air-to-air missiles failed to down the drone from the tail-chase position.[25] The system looked promising, so an NRO briefing team consisting of Air Force officers shopped around the Fire Fly to find an operational home. The commander of Tactical Air Command (TAC) stated that he "wanted no part of unmanned aircraft," according to the lead briefer.[26] The team was turned down by several SAC agencies before they tried an 11th-hour pitch to the SAC director of operations, Maj. Gen. William H. "Butch" Blanchard. He accepted the system on the spot.[27] SAC had just bought into the most significant operational UAV system in history, one that would soon be elevated from obscurity by world events.

Arguably the hottest moment of the Cold War, the Cuban Missile Crisis provided yet another catalyst for UAVs. U-2s detected Soviet nuclear missile installations in Cuba on Oct. 14, 1962. Just prior to that date, U-2s discovered Soviet SAM installations in Cuba as



well; one of which eventually shot down the U-2 of Air Force Maj. Rudolph Anderson Jr. The SA-2 threat over Cuba was serious, and the tiny, two-air vehicle Fire Fly force at Holloman AFB, N.M., now on 72-hour operational alert, got the call to deploy to Tyndall AFB, Fla. for a short-notice mission. Lloyd Ryan, then an Air Force colonel and drone proponent, recalls that NRO chief Dr. Joseph V. Charyk (also an undersecretary of the Air Force) pushed hard to use Fire Fly for photo reconnaissance over Cuba.[28] On Charyk's orders, the drones were loaded, programmed, and the GC-130 mothership was taxiing to the end of the Tyndall runway when the mission was aborted.

The mission was stopped because, ironically, the Air Force did not want to tip the Soviet Union to the presence of this super-secret capability. Ryan remembers that he went looking for Air Force Chief of Staff

Dr. Joseph V. Charyk, National Reconnaissance Office director (September 1961-March 1963).

Gen. Curtis E. LeMay to kill the flight. "The Air Force side did not want to use drones in Cuba," Ryan said and added, "We only had two, and we had great visions of greater potential elsewhere [over the Soviet Union]."[29] This was a highly classified project and the exposure of the drone program over Cuba could have given the Soviets advanced warning of its capability. When Ryan found LeMay, they marched over to Charyk's office. LeMay unceremoniously threw out the Commander-in-Chief, Strategic Air Command (CINCSAC), Gen. Thomas S. Power, who was conducting a briefing at the time, and the three of them had an "impromptu" meeting. Ryan remembers, "LeMay flat out told the undersecretary, not only, 'No,' but 'Hell, no."[30] The flight was scrubbed, and the first real chance for reconnaissance drones to prove themselves went by the boards.

Although drone proponents killed the flight over Cuba with help from the cigar-champing LeMay, Anderson's U-2 shootdown led directly to another expansion of the drone reconnaissance program.[31] The NRO inked a contract for seven new high altitude reconnaissance vehicles, designated model 147B. The B model was still a derivation from the hardy Firebee target drone, but had a 62,500-foot operating altitude, 10,000 feet higher than the A model due to a larger wing. The old gyrocompass-based navigation system gave way to a more accurate and expensive Doppler radar emitter. A new contrail-suppression system promised to diminish the visual signature of the high-flying drone. The program was not cheap. The seven production drones cost the government $13 million, or $86 million in FY10 dollars, which comes to about $12.3 million per air vehicle at today's prices.[32]

This contract marked an important point in the drone program. The concept was emerging from the prototype stage and was about to enter the world of regular flight operations, a very different and more challenging world by any measure. The question remained whether world events would present a chance to prove the concept. As the new drones rolled off the production line, the intelligence community came up with a novel idea that took advantage of the drone's unique characteristics.

The CIA wanted a drone to collect electronic intelligence (ELINT) on the dangerous SA-2 missile system. This not only included picking up the radar tracking frequencies, but also characterizing the terminal tracking and warhead arming and fuzing signals. Here was a mission manned aviation simply could not do—the drone offered up its "life" to get the electronic information, which was beamed in real time radio waves to a ship or plane out of harm's way. By December 1962, the model 147D was declared operational for picking up SA-2 guidance and fuzing information from missiles stationed in Cuba.[33]

The contractor and the Air Force's Big Safari proved that they could react quickly to these special requests, but once again diplomatic events overcame their engineering and management dexterity. The Soviets stopped firing SA-2s from Cuba just as the system became operational, and the 147D models ended up reconfigured as reconnaissance drones.[34]

■ Lightning Bug

In March 1963, the still top secret program name, Fire Fly, was compromised and renamed Lightning Bug. Lightning Bug drones were still a secret Cold War capability, however, and went on 72-hour deployment alert out of Davis-Monthan AFB, Ariz. in July 1963 as part of the 4080th Strategic Reconnaissance Wing (SAC).[35]

This innocuous though highly-secret program seemed to have just missed its chance in the Cuban Missile Crisis. Several independent variables still worked in the drones' favor, however. The technological immaturity and cost of US reconnaissance satellites, the political sensitivity to manned reconnaissance due to the lingering effects of the Powers shootdown, and the rise of China as a nuclear power stimulated another resurgence of interest in unmanned reconnaissance aircraft. Fire Fly was an immature but pioneering system that led to four interesting Air Force-operated UAVs from the "black world" of the Cold War intelligence community.

Although Lightning Bug missed out in Cuba, the Tonkin Gulf incident of 1964 sparked a major operational deployment for the NRO drone program. On Aug. 4, 1964, the special SAC Lightning Bug unit (using the high altitude B models) got the order to deploy to Kadena AB, Japan. They would fly missions over China to learn details about Chinese air defense and nuclear weapons program. With hostilities escalating in Vietnam, attention also focused on China's massive army, whose intervention into Korea in 1950 transformed that war from a near-US victory into a bloody standoff. The mission was codenamed Blue Springs and, as had been the case with sensitive aerial reconnaissance since the 1950s, it operated under Presidential control.[36]

Nationalist China had already been operating U-2s as a CIA surrogate in order to gain information about the Chinese nuclear program and maintain plausible deniability of US involvement. Blue Springs also took upon itself a Nationalist Chinese cover, as each drone left the base with Nationalist Chinese markings. The first operational Lightning Bug sortie over China flew on Aug. 20, 1964, but, as Big Safari and the contractor quickly found out, turning prototypes into an effective operational capability proved much more difficult and time-consuming than pushing workable prototypes off the production floor.

The unit's initial performance was dismal. Recall that the drone used a special DC-130 launch and control aircraft, and upon return it parachuted to the ground.[37] Numerous single-point failures haunted drone operations. The first seven missions resulted in only two reels of film and a number of lost air vehicles, with most flights demonstrating poor navigational accuracy. Drone damage on recovery was a persistent problem.[38] Very quickly the unit was down to a few operating air vehicles and the program was in trouble.

With the drone inventory depleted, SAC stepped in, sending its senior aircraft maintainer, Maj. Gen. A. J. Beck, and a team of investigators to fix or shut down the inept Lightning Bug operation.[39] One of the problems the investigators solved was the acrimonious relationship between SAC and contractor personnel, much of which stemmed from the immaturity of the operation and finger-pointing due to losses—classic command problems. Beck kept the operation alive with an infusion of new air vehicles, and brought in the 4080th SRW commander, Col. John A. Des Portes, to personally oversee the program. Urgency was injected into the mission when China detonated its first nuclear device in the middle of October.[40] After some well-needed oversight, Blue Springs moved to Vietnam in October 1964 to concentrate on the emerging problems in that country and to get a better operational vector to sites in China.

SAC's attention and the natural learning curve helped resurrect Blue Springs as a viable reconnaissance capability, despite the growing air defense threat.[41] China had minor success shooting down this robot intruder but, unlike the Powers incident, it did not seem to matter politically. The first US drone shot down over China on Nov. 15, 1964 made the front page of the *New York Times,* but created little controversy. The slim article did little more than parrot Chinese pronouncements, while US officials said they were "baffled" by the charge of aerial intrusion.[42] This particular sortie was later revealed as a deliberate attempt to exercise Chinese air defenses to collect intelligence on intercept methods, demonstrating the confidence US officials had in the benign political impact of drones compared to their manned counterparts.[43] When the top secret US drone operation was unmasked two days later by an intrepid journalist, the response was again muted, lacking even the usual Soviet objections.[44]

Within a year, with its operations now becoming old news, the drone unit flew 160 Lightning Bug sorties in 1965-66.[45] The Blue Springs operation proved to be an invaluable shakedown for drone operations that benefited from SAC's stiff operational standards, expert contractor maintenance, and the strong mandate to monitor Chinese military operations without creating an international incident.

■ Tagboard and Senior Bowl

Lightning Bug drones could not reach some of the most important targets in China, however. The most difficult objective was the Chinese nuclear facility at Lop Nor, a 4,000 mile round trip from Taiwan. Only the U-2 had the range but, with the introduction of the SA-2 into China, five of these "Nationalist Chinese" U-2s were shot down.[46] This led Kelly Johnson and his Lockheed Skunk Works team to propose an unmanned offshoot of the SR-71 Blackbird for the Lop Nor reconnaissance mission.[47]

This idea evolved into one of the most exotic aircraft of the Cold War: the D-21 drone.

In 1962, Kelly Johnson took the idea to Washington and was rejected by the CIA, but he found a receptive audience from the Air Force's director of special projects (a euphemism for the NRO), Brig. Gen. Leo Paul Geary.[48] Geary scraped up $500,000 of developmental money to set Lockheed on its way, and Johnson conceptualized a design unique in UAV history. The exotic "D-21" drone looked like a mini-SR-71 with a single ramjet dominating its central axis. Forty feet long and more stealthy than the SR-71, the D-21 was designed to cruise at Mach 4 and 100,000 feet, guided by a stellar-inertial navigation system and fully autonomous flight controls.[49] Upon return from a mission, the D-21 would slow from its Mach 4 operating speed to Mach

1.6, drop its guidance package, avionics, camera, and film in a capsule and the airframe would self-destruct on command from a special JC-130 Hercules in the recovery area.[50]

The then-Secretary of the Air Force was Harold Brown, the person who blocked Red Wagon as a DOD executive in 1961. However, Brown enthusiastically supported the D-21.[51] The CIA jumped onboard in 1963 despite Congressional pressure questioning its expanding air and space forces and agreed to share funding and operational tasking with the Air Force through the NRO. Thus the top-secret project—dubbed Tagboard—began with a $31 million cost ($189 million in FY10 dollars) for 50 airframes. Industry insiders pegged the program as escalating to almost 10 times that figure over the intervening years even though production dipped to only 33 air vehicles, bringing the program to nearly $1.7 billion in constant FY10 dollars.[52] Like the other national reconnaissance drones, Tagboard was not just classified, it was a compartmentalized NRO program so secret that even Skunk Works engineers working in the Fort Knox-like SR-71 assembly building were restricted from viewing the D-21 by a hangar bulkhead dubbed "Berlin Wall West."[53]

Launch and recovery loomed as daunting engineering obstacles. The D-21's ramjet required speeds over Mach 2 just to gain enough air compression to achieve engine start, so the plan called for launch from a specially configured A-12 (the CIA version of the Air Force's SR-71) mothership called the M-12.[54] Johnson called supersonic launch of the D-21 "the most dangerous maneuver in any airplane that I've ever worked on."[55] Autonomous navigation over its phenomenal 3,000 nautical mile range only added to the engineering challenge. The first D-21 test launch was scheduled for Kelly Johnson's birthday, Feb. 27, 1965, but developmental problems delayed the launch more than one year. The first three tests went well, but the fourth, held on July 30, 1966, ended in a catastrophe. At launch the drone rolled into the M-12, causing a collision at 80,000 feet and Mach 3 that took out most of the M-12's right wing, rudder, and engine nacelle. It plunged earthward, the fuselage broke apart, and the crew ejected. Both pilot and drone operator survived ejection and landed in the ocean off California, but the backseater drowned before rescue helicopters arrived. A distraught Kelly Johnson unilaterally canceled the program and returned all developmental money to the NRO.[56]

High government officials wanted the drone, however, and persuaded Lockheed to try a new approach. China had already conducted its first nuclear test, a 22-kiloton explosion at Lop Nor on Oct. 16, 1964. The first weaponized nuclear test came quickly with a 40-kiloton bomb dropped from an H-6 (Chinese version of the Soviet Tu-16) bomber on May 14, 1965.[57] In December 1966, Deputy Secretary of Defense Cyrus Vance authorized a redesign of the drone (now called the D-21B), which would be launched from a specially configured B-52H. The D-21B achieved launch speed using an expendable rocket booster. The rocket took the D-21B up to Mach 3.2 while the B-52 stayed in international airspace after a flight from Beale AFB, Calif.[58] The modified project was renamed Senior Bowl. Vance emphasized that this project had to work because they would "never again allow a Francis Gary Powers situation to develop. ... All our flights over denied territory will either be with satellites or drones."[59] While Lockheed tarried, the Chinese conducted their first successful thermonuclear test on June 17, 1967 with a weaponized 3-megaton bomb.[60]

Test flights in late 1968 fully exercised Senior Bowl at operational distances to successful recoveries off Hawaii.[61] The D-21 successfully completed its operational test flights on five of seven tries, to include collection and processing of film. The first operational flight commenced on Nov. 9, 1969 under orders from President Nixon.[62] The target was an ICBM facility under construction near Lop Nor.[63] Lockheed's Rich remembers launching a D-21 cost "a bloody fortune to stage."[64] The B-52 launch vehicle, the expendable rocket booster, the Navy picket ships in the recovery area, two aerial refuelings, and the JC-130 recovery aircraft all cost untold thousands each time the D-21 flew. Drone operators aboard the B-52 successfully jettisoned the first operational drone after 14 hours of flight to the launch point, but the mission was unsuccessful. The drone was lost due to a guidance failure, which kept it flying across the Chinese mainland until it ran out of fuel, somewhere over Siberia.[65] Subsequent missions in October 1970 and March 1971 ran perfectly, but the recovery parachute failed to deploy on the first, causing the package to be lost at sea, and a frigate ran over the second package, resulting in another total loss. The fourth and final flight on March 30, 1971 also ended in failure as the drone vanished over "a heavily-defended area" in China.[66]

Senior Bowl closed its operational career with a record of 0-4. Diplomatic preparations for President Nixon's trip to China ended Chinese drone overflights altogether.[67] Although the failure to complete even one successful mission contributed to the D-21's demise, the intervention of international politics meant its only reason for being had vanished. Exacerbating that fact was an even more ominous, unmanned competitor—the satellite.

During this period, the NRO was rapidly improving its satellite reconnaissance capabilities. Like the drone, reconnaissance satellites lacked the political sensitivities associated with manned reconnaissance overflights. Furthermore, unlike the drone, satellites violated no international norm or law. With the new US promise to desist from all aircraft overflight of China, the low-profile nature of US drone operations turned into a political disadvantage.

■ Compass Arrow

Another outlandish UAV system designed for reconnaissance operations over China was the project called Lone Eagle, later renamed Compass Arrow.

Perhaps the key point about Compass Arrow is that it represents the only true follow-on UAV ever produced by the US. SAC wanted the completely new Compass Arrow to take over for the high altitude modified Lightning Bug drone that had proved vulnerable to enemy missiles.[68] The new design incorporated such highly sophisticated technologies that a SAC reconnaissance historian said it represented "a revolutionary development in the evolution of the special purpose aircraft."[69]

Officials at Air Force Systems Command, which represented the "normal" or "white world" of the Air Force acquisition system, had become so enthusiastic about the growth potential for drone reconnaissance that they attempted to wrest drone development from the NRO and the special acquisition arrangement with Air Force Logistics Command's Big Safari office. Systems Command believed that NRO drone management encouraged cozy "sole-source" (non-competitive) contracts that led to unnecessary cost escalation. Moreover, they felt normal acquisition practices would incorporate normal Air Force standardization and maintainability features that would minimize contractor involvement in operations and result in lower operations and maintenance costs.

NRO Director Al Flax, thought by many to be one of the most important advocates of drones in that era, fought hard for NRO and Big Safari cognizance over Compass Arrow. Still, AFSC's Reconnaissance/Strike office gained control and awarded the contract in June 1966.[70] The Air Force invited two companies; North American and Ryan Aeronautical to compete for the lucrative contract that included 100 production vehicles, which Ryan (maker of the Lightning Bug series drones) won.[71] Like the D-21, Compass Arrow was an "ultimate" design that soon ran into the cost-capability conundrum that afflicts so many UAV programs. It was built to do the job right, but the price was too high even for the NRO.

Although the "silver bullet" nature of the Lightning Bug drone program had resulted in high unit costs, standard acquisition practices proved even less efficient. Like the D-21, Compass Arrow was built for the trip to Lop Nor, and its capability goals were high. The challenges of autonomous flight at the required altitudes (80,000 feet) and distances pushed the state-of-the-art and the program quickly exceeded its budget and projected operational date. The original development program was bid at $35 million, but contractors later admitted they knew actual costs would be much higher. A company publication explained the huge cost escalation experienced by the program by saying, "The 154 [the company designation for Compass Arrow] was a victim of too much optimism in the heat of a very tough competition to get the business."[72] Only one year after the contract was awarded, the NRO cut the production number from 100 to a lean 20 airframes.[73] Ryan deliberately under-bid to get the job, counting on the support of the highly secretive NRO community to bail them out when the inevitable escalation occurred.

The contractor under-bid not only in terms of cost but also in time requirements. The planned times needed to reach an operational configuration were extremely short, based as they were on the rapidity of modifications in the Lightning Bug program. Although the NRO had achieved some success with the technologically challenging, Mach 3+ SR-71 program, the task of making this drone actually work exceeded the bounds of the technology of that era.[74] Originally planned to be an 18-month program, Compass Arrow took five years to yield 20 production airframes, at a final cost of $250 million, which equates to almost $1.7 billion in FY10 dollars.[75] The unit cost of $65 million makes Compass Arrow one of the most expensive drone aircraft ever.

Competitive bidding contributed to the illusion that drones constituted a cheap alternative to manned and satellite reconnaissance. Compass Arrow, the product of the United States' most knowledgeable drone contractor and a conventional program office bent on efficiency, proved that the most advanced aerospace nation in the world was not up to the engineering challenge of long distance, high altitude, unmanned operation within feasible limits of time and money.

Although Compass Arrow went well over budget, it was the time delay that proved even more deadly to the concept of drone reconnaissance. NRO director James W. Plummer told an audience of drone advocates in 1975 that advances in Soviet air defenses "resulted in the system becoming obsolete before an operational mission was ever flown."[76] Even that point was moot, for the Nixon Administration stopped Chinese overflights in July 1971, and the Compass Arrow's reason for being vanished before it had a chance to prove itself.[77] As with the D-21, accelerating improvement in US satellite reconnaissance rendered the "perfect" reconnaissance drone, Compass Arrow, an expensive anachronism.

The paradoxically exotic and obsolete Compass Arrow system stood on alert at Davis-Monthan AFB, Ariz. starting in December 1971. The futility of that face-saving move was apparent, and it was not long before the project suffered an ignominious end. The NRO di-

D-21 drone carried aloft by its mothership, a specially configured A-12, redesignated M-12 (also referred to as M-21).

vested itself of the project in 1974 under NRO director John L. McLucas, part of a post-Vietnam cost-cutting effort, and the Air Force put the expensive drones in a storage hangar.[78] Compass Arrow project manager Schwanhausser remembers that the Israeli military attaché, Maj. Gen. Elihu Zeira, had visited the Ryan plant and later, as the chief of Israeli intelligence, made "desperate attempts" to get the shelved vehicles just prior to the 1973 Yom Kippur War.[79] According to Compass Arrow engineer John Dale, President Nixon did not want the drones transferred to Israel and personally ordered that they be destroyed to end the issue.[80]

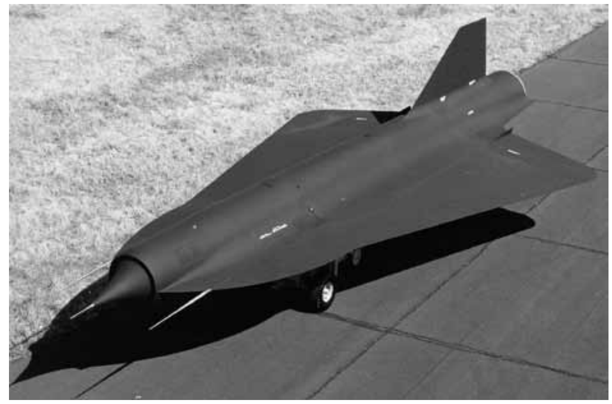
Whatever the reason for Compass Arrow's demise, it was born as, and died as, a political weapon system. Politically, technologically, and from a threat point of view, Compass Arrow was doomed, rendering any internal or bureaucratic analyses moot. It would not be the last UAV crushed by externalities that even the most enthusiastic developer could not overcome.

■ Combat Dawn

On April 18, 1968, North Korea shot down an EC-121 Super Constellation signals intelligence (SIGINT) aircraft in international airspace over the Sea of Japan, killing 31 American crewmen. President Nixon was roundly criticized for sending up an unprotected spy plane into that volatile region. As a result, the NRO asked Ryan Aeronautical to build a Firebee variant to accomplish the EC-121's suspended SIGINT mission.[81] The high altitude 147T photo reconnaissance version, with two and one-half times the wingspan of the Lightning Bug series, was modified for the SIGINT role with a National Security Agency (NSA) package, a real-time data link, and a more powerful engine. Four of these 147TE Combat Dawn SIGINT versions deployed to Osan AB, Korea under Air Force control in 1970.[82] Flying over international but prohibitively lethal airspace, these high altitude UAVs collected radar data from targets in North Korea, China, and the Soviet Union.

As with Compass Arrow and D-21, Combat Dawn flights were curtailed for a short period in July 1971 when President Nixon announced his trip to China.[83] On July 28, William Beecher of the *New York Times* reported, "Administration officials said the United States had suspended flights over Communist China by manned SR-71 spy planes and unmanned reconnaissance drones."[84] This was the first government acknowledgment of drone intelligence activity.[85] Soon thereafter, Combat Dawn drones continued flying over this region until 1975 with very high reliability rates.

Politics actually had little to do with the demise of this particular UAV mission; a much bigger factor was the emergence of satellites. Combat Dawn flights came to an end when satellites picked up the ELINT and COMINT missions.[86] Satellites had developed a strong constituency and had come to dominate NRO operations. Unlike UAVs, satellites incorporated technologies that responded to investment because their operational scheme was essentially mature.[87] Additionally, their invulnerability to direct action and politically benign nature contrasted with that of the UAVs. To make matters worse for UAV advocates, satellites achieved near real-time capabilities through digital image processing (so-called "electro-optical" imagers) and data links that made further drone operations superfluous.[88] The SAC commander-in-chief during those years, Gen. Russell E. Dougherty, remembered: "We got a downlink for real-time national intelligence at Omaha [SAC headquarters]. The drones did not fit that mode [did not have real time data links]. Drones had a great future, but they were an old capability at the time."[89] Although the drones seemed like an exotic, futuristic system whose time had come after the Powers shootdown, the technology of space reconnaissance left them a poor second place by the early 1970s.



Lockheed Skunk Works D-21B drone on display at the National Museum of the US Air Force.

In a watershed decision, the NRO divested itself of all airborne reconnaissance assets and budgets in 1974, transferring its entire SR-71, U-2, and drone inventory to the Air Force.[90] According to former NRO Director McLucas, the decision made sense for several reasons: "It was obvious to me that we didn't need to clutter up our minds with platforms the Air Force could operate, and it helped reduce resentment toward the NRO."[91] The "clutter up our minds" comment further reinforces that the NRO had become a satellite organization by this time and had essentially outsourced (in all but budgetary terms) its airborne reconnaissance to the Air Force. In the Administration of President Jimmy Carter (1997-81), lean, post-Vietnam budgets hit at the NRO and could not help but drive out peripheral programs. With the rise of the satellite, the NRO, which had played the "rich uncle" for drones throughout the Vietnam War, now handed to the Air Force the responsibility for development of future long range reconnaissance drones.

The Soviet threat still loomed large, however. New and more deadly Soviet weapons posed major dangers that episodic satellite coverage could not adequately address. Furthermore, the rise of stealth technology and the increasing sophistication of communications and sensor electronics (all based on the meteoric rise in microprocessor-based computing power) combined to give the national reconnaissance UAV new life in the 1980s. Ultimately, it took a change in presidential administrations to turn these trends into an actual UAV program—a program that lasted for more than 15 years and remained secret for a long time afterward.

■ Advanced Airborne Reconnaissance System

The stealthy, very high-altitude, intercontinental range UAV, known as the Advanced Airborne Reconnaissance System (AARS), was one of the grandest UAV conceptions ever. It had its roots in the re-heated Cold War and the associated US defense buildup of the 1980s. Knowledge about stealth aircraft construction, satellite data links, digital fly-by-wire autopilots, composite structures, and autonomous navigation using the Global Positioning System (GPS) satellites pointed toward the possibility of a UAV that could loiter so long, so high, and with such impunity that it would serve as an endo-atmospheric, geo-stationary satellite.[92]

Although each of the applicable technology fragments appeared feasible, the question remained whether the interested agencies could advocate and manage the broad-based technology push this program required. Furthermore, it remained to be seen whether they could piece together all the critical technologies, integrate those technologies into a workable system, and then, to navigate the organizational minefields that all innovative systems must traverse. AARS and its descendants offer lessons at both the high and low cost extremes of the UAV development continuum, highlighting the difficulty of finding appropriate levels of UAV capability and affordability in a rapidly changing political environment. Most importantly, the AARS story demonstrates how difficult, if not impossible, it is to innovate by relying on the support of multiple agencies, none of which has its core interests at stake.

The path to AARS development was impeded by choices made in the early days of strategic reconnaissance that emphasized episodic reconnaissance over extended surveillance.[93] For instance, the famous U-2 conducted reconnaissance over the Soviet Union starting in 1956, flying long tracks across the vast Soviet landmass to get snapshots of important military sites. The extreme ranges and the limitations of human pilots precluded the U-2 from loitering over important areas, and the possibility of being shot down increased with time over the target area. In any case, snapshots of many targets were far more valuable than in-depth surveillance due to the dearth of usable intelligence from other sources and the immobility of the targets.

As Soviet air defenses improved, spy plane designers were forced by the immature state of low observable (radar evading, or stealth) technology to use speed and altitude as defenses, accentuating reconnaissance at the expense of surveillance. Soon after the U-2 started flying, it became clear that new Soviet air defense missiles would eventually hold U-2 flights at risk.[94] Designers thought one possible answer lay

Two D-21 drones carried aloft by a B-52, which succeeded the A-12 aircraft as mothership.

in achieving increased altitude. For instance, Northrop proposed a large, subsonic aircraft with a high-lift wing that would allow it to reach more than 80,000 feet.[95] Lockheed's Johnson proposed two very different means of upgrading this vital national capability. One was a very fast (more than Mach 3), moderately stealthy, high altitude aircraft that became the SR-71 Blackbird. The other was a subsonic, 120-foot wingspan, stealthy aircraft called Gusto 2.[96] Both operated at high altitude, but the former used speed as a defense, while the latter used a low observable shape to avoid detection. The CIA chose the supersonic variant for sound technological reasons, but its choice locked the US into a restricted operational mode—fast reconnaissance.[97]

As spy satellite systems came on line in the 1960s, they shared the same fundamental operational scheme as the SR-71. Both conducted reconnaissance with relative impunity but were so fast that they only provided episodic coverage. The Soviet system of fixed air bases, missile silos, and command centers of the Cold War's first 30 years favored "fast pass" reconnaissance, however, so its weaknesses were not evident until the strategic equation shifted in the late 1970s. Soviet mobile missiles (both nuclear and air-to-air) and the advance of aviation technology opened the door for a true loitering surveillance UAV called AARS.

With the emergence of mobile nuclear ballistic missile systems, the weaknesses inherent in fast reconnaissance rapidly became a national security liability. The Soviet Union destabilized the European theater in 1977 by introducing hundreds of accurate, mobile, multiple-warhead SS-20 intermediate-range nuclear missiles that threatened key North Atlantic Treaty Organization (NATO) military sites.[98] Mobile air defense radars and launchers made getting to those missile sites a lethal proposition. Soviet nuclear missile submarines could flush out of their ports in between satellite overflights and be missed. Because the new, road-mobile missiles presented a vast array of moving targets that available reconnaissance assets could not track, NATO planners had no way of addressing the threat except by using fighter aircraft on suicidal hunter-killer missions deep behind enemy lines. The manned TR-1 (U-2 variant) high altitude reconnaissance plane had great payload and loiter capability, but it was unlikely that it would be employed deep in enemy territory.[99] The only militarily useful way to deal with the proliferation of critical mobile systems was to find and track them in real-time. Satellites provided only episodic coverage, so only a stealthy, data linked overhead system—an airborne system—could accomplish the "find and track" mission by filling the gaps between satellite overflights.

The catalyst for a persistent, survivable airborne surveillance capability came from a new presidential administration.[100] Ronald Reagan was swept into office in the 1980 election by promising to restore US military strength. Reagan's intelligence transition team perceived a number of shortfalls in US technical intelligence collection, airborne surveillance being one of them.[101] Author John Ranelagh got access to the team's top secret report for his book *The Agency,* and noted that the extra $1.5 billion per year they recommended be added to the NRO budget included development of a "long-endurance (up to two days), high altitude reconnaissance aircraft." The report added, "remotely piloted vehicles (RPVs), possibly using stealth technology, should be reviewed for ... strategic intelligence collection."[102]

The extra cash infusion into "black" portions of the Air Force budget provided developmental "elbow room," or slack funds—virtually the same environment in which the Lightning Bug drones flourished during the Vietnam War. Just as Al Flax, the NRO director who built the Lightning Bug program, had done in the late 1960s, Reagan's choice for NRO director and Undersecretary of the Air Force, Edward C. "Pete" Aldridge Jr., began preliminary design explorations on such a UAV soon after taking office in August 1981.[103] That UAV program became AARS. As McLucas said, "Pete Aldridge brought aircraft back [into the NRO]. He obviously didn't think, as I did, that we should divest NRO of airborne assets."[104] With the Reagan Administration's emphasis on national intelligence, the NRO ended its airborne reconnaissance hiatus, returning to an area they had ceded to the Air Force in 1974. The troika of the Air Force, the NRO, and the CIA was back in the UAV business again.

The expansion of Soviet mobile missile threat from one impacting the European theater to one that threatened the US homeland undoubtedly accelerated the project. Aware of Soviet work on an intercontinental version of the SS-20 and after several studies investigating the concept, the Air Force accepted design proposals from seven US aerospace companies for the big, covert surveillance UAV.[105] The year was 1984, not long after Reagan made his famous Strategic Defense Initiative ("Star Wars") speech. By 1985, the Soviets deployed an intercontinental-range, road-mobile ballistic missile called the SS-25.[106] The SS-25 and its railborne cousin, the SS-24, presented an ominous new threat because, as mobile missiles, they were designed explicitly to survive a nuclear strike and hold the US and its allies hostage in a protracted nuclear war environment.[107]

Dr. Alexander H. Flax, who served as USAF Chief Scientist (1959-61) and then NRO director (October 1965-March 1969).

The technological problem of holding these mobile missiles at risk, one that NATO had never solved with the SS-20, now became vastly more complex. US forces had to constantly monitor their movement and electronic emissions, something neither fast-pass satellites, U-2s, nor the SR-71 could accomplish. The mission also entailed breaking the over two decade-long declaratory policy of not overflying the Soviet Union, a prospect the Reagan Administration apparently felt was worth the gain. To complicate matters further, they needed a platform that could track those missiles in a nuclear detonation environment while flying from remote bases in the continental US.[108] Operating and receiving imagery from such a craft beyond line-of-sight using space relays would prove daunting. The political and design challenges loomed large, but in the end the Air Force/NRO/CIA consortium opted for a leap-ahead system and awarded competitive UAV contracts to aerospace giants Lockheed and Boeing, probably in late 1984 or early 1985.

To accomplish the loitering surveillance mission, this UAV needed autonomous (i.e., not remote controlled), highly reliable flight controls, and a design capable of intercontinental ranges from bases in the US zone of the interior with extreme high altitude capability (long wingspan with sailplane-type lift and multi-engine propulsion to reach altitudes more than 70,000 feet). Moreover, it had to carry an array of high-resolution sensors, high-capacity satellite communications capabilities, and various antennas—all in a package that was stealthy to the point of being covert.[109] The cost of developing each technology piece alone would be staggering, but integrating them presented an even greater challenge—thus the project became a magnet for the best and most starry-eyed technologists in the black world. As one CIA engineer said in an anonymous interview, this project was "the cat's pajamas," and "the single most fun project I ever worked on" because it stretched every conceivable technology area.

The Soviet mobile missile threat loomed large and the Reagan Administration kept the black money flowing. The big UAV had different codenames, but the characteristically bland cover name for it was AARS.[110]

The first official acknowledgment of AARS occurred in Congressional testimony delivered by Keith R. Hall, the deputy assistant secretary of Defense for intelligence and security, in front of the Senate Armed Services Committee on June 15, 1993.[111] Representing the defense intelligence community, Hall responded to a question from the committee chairman, Sen. James Exon, who asked why the SR-71 had been dropped (it was retired in 1990).[112] Hall said the prime shortcoming of the SR-71 system was the timeliness of imagery to the field commander because it lacked a real-time data link. "There was," Hall said to Exon, "a system conceived to do that job called the Advanced Airborne Reconnaissance System, which was going to be an unmanned (sic) UAV."[113] The program revealed by Hall must have been substantial, for in deliberations on the 1994 defense budget one month later, the Senate Armed Services Committee struck a preliminary budget request for $207 million slated for AARS development.[114] Other clues pointed to a large program as well. A 1998 Defense Advanced Research Projects Agency (DARPA) briefing on the history of high altitude endurance (HAE) UAVs mentioned a "Special Program" costing more than $1 billion for the purpose of "covert intelligence gathering in denied or heavily defended airspace," and in 1994, the head of the Defense Airborne Reconnaissance Office, Air Force Maj. Gen. Kenneth R. Israel, acknowledged that more than $850 million had been spent on a very big stealthy UAV program.[115] These shreds of evidence revealed the program's existence but more recent information reveals that AARS was, indeed, planned to be the ultimate surveillance UAV, one of the most ambitious Cold War aircraft programs ever.

I interviewed the last AARS program manager, who revealed some interesting aspects of this phenomenal UAV. David A. Kier, who was NRO deputy director from May 1997 to August 2001, disclosed that the large, stealthy high altitude, subsonic reconnaissance bird resembled a substantially scaled-up version of DARPA's DarkStar (a "white world" spin-off discussed below) and was a program funded by the intelligence community.[116] Kier acknowledged that AARS had a long history, dating to the early 1980s, "maybe even into the 1970s," and said the program assumed many different forms and functions over that period. Two particular designs stood out, however. "There was one do-all platform that was very, very expensive, then another scaled-down version that only did a few things," he said. In fact, a Lockheed engineer disclosed in 1995 that more than 50 shapes were analyzed for AARS, with the eventual shape, the very odd "flying clam," always showing better stealth characteristics for the high altitude loiter mission.[117] Kier said the AARS program management used the U-2 and SR-71 acquisition and operations model—it had composite intelligence agency roots and was to be operated by the Air Force.[118]

AARS pushed the technology envelope in many—perhaps too many—areas, and that translated into high developmental costs. Due to high costs, "black" UAV programs came under Congressionally mandated centralized UAV management in 1989 and "Kier's Bird," as some still call it, also transitioned from service management to a "joint" program office. When Congress directed unified management of Department of Defense UAV projects in 1988, they also ordered centralized control of secret, "national" airborne reconnaissance projects through a new agency called the Airborne Reconnaissance Support Program (ARSP) in the National Reconnaissance Office.[119] ARSP was essentially a resurrection of the NRO's "Program D," which had been disbanded in 1974. Despite its innocuous name and the fact that it also developed systems and technologies for manned spy platforms like the U-2, ARSP's dominant development program was the unmanned AARS.[120] Although the design had evolved by this point (along two lines—it was still a competitive development project between Boeing and Lockheed), the traditional UAV problem remained. To gain the required multilateral support for the "perfect" high altitude surveillance UAV, Kier had to please multiple clients.

Just as ARSP was conceived by Congress in late 1987, the Air Force got heavily involved in AARS under the leadership of its Chief of Staff, Gen. Larry D. Welch, himself a former CINCSAC. This was as AARS backers hoped, since the Air Force was the most likely to take over its operation.[121] The Air Force wanted an SR-71 replacement, or at least a developmental program pointing in that direction, because SR-71 operations and support costs (transferred from NRO control in 1974) were biting deeply into the Air Force budget as the platform aged. Furthermore, the SR-71 did not help with the mobile intercontinental missile threat. If

Teledyne Ryan Model 154 (USAF AQM-91) RPVs, known as Compass Arrow, carried aloft by a DC-130.

the Air Force pushed AARS, the program could provide the rationale for the SR-71's cancellation. They could then reprogram the SR-71's substantial budget into other programs while funneling only small amounts into a cooperative AARS development project shared by other agencies.

In 1988, in response to a reporter asking whether a B-2 derivative might take over the SR-71's role, Air Force Undersecretary James F. McGovern responded cryptically, "There is no plan at the moment in the Air Force to replace the SR-71 with a manned reconnaissance aircraft."[122] According to reports filed not long thereafter, the Air Force considered three UAVs for the SR-71 replacement role, two DARPA UAVs called Amber and Condor, and "a Lockheed candidate."[123] In January 1990, based on an Air Force initiative, the generals on the Joint Requirements Oversight Council (JROC) approved a formal military requirement called a "mission need statement" for a "long endurance reconnaissance, surveillance, and target acquisition (RSTA) capability" with the added requirement to conduct those missions in defended or "denied" areas for extended periods.[124] The requirement was probably timed to pave the way for the transition of AARS to production.

The underlying reason for the Air Force's interest in the AARS program was the mobile missile threat and how expensive systems like the B-2 stealth bomber might fit into a scheme for holding those missiles at risk. In 1989, for instance, Welch testified in front of the House Armed Services Committee, saying, "finding and striking highly mobile targets is neither the reason for the B-2, nor are we likely to accomplish that in the near-to midterm with great efficiency unless we make a further big commitment to some other systems."[125] In 1989, Strategic Air Command listed the strategic relocatable target threat as its top research and development priority.[126] Although "black" money abounded during the mid to late 1980s and AARS fit the Air Force's need for a mobile missile tracker, Kier still had to garner broad-based support for the concept, which undoubtedly had both competitors and skeptics.[127]

To keep the project going, Kier had to keep a number of plates spinning. To garner sufficient funding for the technological advances AARS required, his UAV had to serve multiple sponsors in the military and intelligence communities. This resulted in two problems. First, funding for the project had been spotty over its development history as one agency or the other took over responsibility for the project. In a highly classified report to the Secretary of Defense and the Director of Central Intelligence in January 1990, NRO Director Martin C. Faga said that Congress was concerned that "ARSP advocacy for an advanced airborne reconnaissance program has not resulted in funding for a full scale development program." He went on to say that ARSP had a structural problem. "The large number of diverse interests represented on the ARSP Steering Group," Faga said, "and the lack of an effective method in place to implement group consensus have contributed to the problem."[128]

That structural problem led to the second dysfunctional element of the AARS program. Proliferated, diffused support for AARS led to gold plating, or the addition of multiple capabilities important to each constituent but unmanageable in terms of total system integration and cost. The stipulations laid on AARS by each sponsor induced what Kier called "unconstrained requirements growth" that drove the program cost so high that it became a target for the budget ax. Kier said the large version of AARS, which according to some reports had a wingspan of 250 feet, cost less than a B-2 but more than $1 billion a copy.[129] Reportedly, the production plan called for only eight vehicles at a cost of $10 billion, each of the vehicles capable of an amazing 40 hours on station after flying to the area of interest. Air Force officials were so leery of the UAV's autonomous flight concept (no pilot had moment-to-moment control) that they reportedly insisted the flying prototype carry a pilot to handle in-flight anomalies and that the final design include a modular, two-place cockpit insert to make it optionally piloted.[130] "By the time everyone got their wishes included," Kier said, "it [AARS] had to do everything but milk the cow and communicate with the world while doing it."[131] With all of AARS's leading-edge sensors and communications links, each of which posed substantial technical challenges in its own right, flight reliability quickly became the biggest design hurdle according to Kier. The technologies were so secret, and the value of the payload and the air vehicle was so great that its loss over unfriendly territory was unthinkable. One defense official remarked, "If one had crashed, it would have been so classified we would have had to bomb it to ensure it was destroyed."[132] Sailing along on the glut of black money in the late 1980s, AARS kept moving forward despite its continually expanding, problematic requirements list. As happened with D-21 and Compass Arrow in the early 1970s, however, AARS was about to have its most vital mission curtailed.

The end of the Cold War brought the expensive program to a halt. An Air Force general familiar with the project said: "When AARS was invented, there was more money than they [the NRO] could spend. After the Cold War, the money went away and projects like that could not possibly survive."[133] Like predators stalking a wounded animal, manned alternatives to AARS emerged. One proposal would put a sophisticated target acquisition system on the B-2 stealth bomber—the so-called RB-2 configuration.[134] The proposal had value as a terminal tracking system, but the RB-2 lacked a method of off-board cueing to direct it to a search area. Kier mentioned that several other concepts for manned alternatives to AARS popped up in the early 1990s, including a minimalist design called the TR-3 that he derisively called "a Cessna 172 compared to a 747 [AARS]."[135] It is entirely possible that by this time the Air Force, which had retired the SR-71 in 1990, had grown tired of the expensive Cold War program and was submitting alternatives to stall AARS.

As it turned out, none of the alternative programs made the cut, for not only was the Cold War officially over with the dissolution of the Soviet Union, but the venerable Strategic Air Command was disbanded in June 1992. With that move, AARS lost its primary military constituent and the AARS alliance began to crumble. Unlike what the Air Force general stated above, the end of the Cold War did not have to be fatal for AARS, for it still had substantial utility in a conventional, post-Cold War world. The shift in the international situation rocked, but did not kill many other far more expensive Cold War programs. For instance, the Air Force space community retrenched to save its controversial satellite program called Milstar, as did the still powerful but fading bomber community to save the B-2 stealth bomber.[136] AARS, Milstar, and the B-2 were originally planned to work as a team to find, relay tracking information, and kill Soviet mobile missile systems. Yet, unlike for its more traditional, well-supported teammates, the Air Force pulled funding on AARS, and it was terminated in December 1992 by the intelligence community hierarchy just as it was to enter full scale development.[137]

AARS was, in the final analysis, a misfit. It was a major aircraft program backed by a satellite organization (the NRO), and a risky unmanned surveillance platform slated for a combat pilot-led Air Force—hardly an edifice solid enough to survive the removal of its strategic underpinnings. No one organization provided focus or advocacy for the program. As a result, the "perfect" surveillance UAV faded away even as the ultimate Cold War satellite system, Milstar, and the equally exotic B-2 stealth bomber managed to survive, backed as they were by one service, and powerful sub-groups within that service, who were culturally and operationally attuned to those configurations.

Programs that grow as large as AARS have a certain inertia, however, and the very odd-looking, unmanned "flying clam" showed remarkable resiliency despite its profound lack of fit within the national defense structure. The reason can be traced to the political constituency it gained by virtue of its price tag. Because it was an expensive program employing hundreds of voters, the program would not die. The first reincarnation of AARS would be as part of the Clinton Administration's plan to cut back and revise the previous administration's military aircraft modernization program.

■ Tier III

The new Administration conducted a "Bottom-Up Review" of military programs in 1993, paying special attention to UAVs because so little had been accomplished in that area. Staffers under new defense acquisition chief John W. Deutch came up with yet another nomenclature, the "Tier" system, for rationalizing UAV development.

A conflict in the former Yugoslavia had heated up by this time, and two rapid-reaction UAV systems went into development to provide overhead imagery and other intelligence functions for that conflict. Deutch's staff called these medium altitude (they flew at about 25,000 feet) programs Tiers I and II. Both were offshoots of DARPA's secret Amber program from the mid-1980s.[138] Although AARS had been canceled in late 1992, Deutch considered a smaller, less capable AARS as Tier III, for it was the only platform that fully satisfied the JROC mission need statement of 1990.[139]

David Kier, who stayed with the program even after its cancellation, revised his pitch for the big bird and framed the issue in the rhetoric of post-Gulf War "support to the warfighter." He argued that Tier III could be a survivable theater asset serving regional military commanders in chief. Unlike satellites, Tier III would not have "national" intelligence tasking interfering with battlefield surveillance as had happened to the Lightning Bug program in Vietnam. Because of its unique design, Tier III provided a "staring eye" that could more effectively track mobile enemy missiles like the one that caused so many problems in the Gulf War. "You don't need another SR-71, because the SR-71 was like a satellite, it did not have any loiter time," Kier said and added, "You need a dwell collector that's responsive to the theater commander."[140] Kier believed he could breathe new life into the program with this logic.

In an attempt to calm the critics of the formerly bloated program, Kier developed several scaled-down versions he hoped could make the transition to exclusively military operations. Even these reportedly varied from $150 to $400 million per copy at which price the military reportedly might buy only four or five "silver bullet" models.[141] Not even Kier, who by all accounts is a master salesman, could peddle a multi-billion dollar unmanned program to a skeptical Congress and defense establishment in the midst of drastic budget reductions. Since his bird had not yet entered flight testing, Kier fought an uphill battle.

Although a 1993 Defense Science Board summer study commissioned by Deutch was directed to consider the big UAV, insiders say it was a foregone conclusion that it would not be funded in its Tier III format.[142] The concept, despite almost two billion dollars in development costs and years of work, was still technologically risky and the principal decision-makers thought the potential for further cost expansion was more than the scaled-down budget could bear. With the intelligence community out of the picture after AARS's cancellation in late 1992, and OSD lining up against the project, only the Air Force remained as a possible advocate. Under Chief of Staff Gen. Merrill A. McPeak, a fighter pilot who alienated many of the service's subordinate communities, the Air Force saw no place in its force structure for this speculative reconnaissance project. The program looked like it would be rebuffed yet again, but the military and OSD were not the only affected parties.

One does not simply close down a major defense project without political ramifications, and Tier III did not go away gently. Rep. Norm Dicks (D-Wash.) and other concerned lawmakers put serious pressure on DOD officials to keep the program alive.[143] To understand Dicks' role, one must, as they say, follow the money—and the jobs (and votes) that come with it. Even before Kier transformed the program into Tier III, ARSP officials teamed Boeing with Lockheed on the AARS program just as Boeing's grandiose Condor UAV program was terminated after development by DARPA (see below).[144] The AARS program had already benefited from the political clout of Dicks, who in addition to having Boeing as a constituent served as the powerful chairman of the House Permanent Select Committee on Intelligence. Dicks and other interested lawmakers pushed hard for the revival of AARS as Tier III after the December 1992 cancellation by the intelligence community. One involved official recalled, "We felt all along that Tier III was a non-starter, but there was lots of scrambling to accommodate Congressional pressure."[145] That scrambling resulted in yet another shrunken incarnation of AARS as a means to placate Dicks.

Rather than reject Tier III outright and invite political retribution, Deutch and his advanced technology chief, Verne L. "Larry" Lynn (who would later lead DARPA), instead opted to split the Tier III requirement in two, using the remaining AARS development money. They proposed a competition for a non-stealthy, high altitude, long-loiter aircraft that they called "Tier II plus" (later renamed Global Hawk, see below) and a severely chopped-down version of Tier III called "Tier III minus," which later picked up the mysterious name DarkStar.[146] The sole source contract for "Tier III minus" went to the Lockheed Skunk Works and Boeing team, who were not to compete for Tier II plus. Both programs would be relatively open (i.e., not black world), streamlined Advanced Concept Technology Demonstrations (ACTDs) under DARPA, with a stringent cost goal of $10 million per air vehicle.[147] As RAND analyst Geoffrey Sommer noted, this cost goal forced the design teams to make "all other performance objectives subject to tradeoffs to meet the price objective."[148] There was just one problem—the cost cap, which was selected to drive innovation, could not possibly be met by either program, given the speculative nature of UAV technology for this class of air vehicle.

With the announcement of the cost cap, AARS backers immediately attempted to drive the program back to the preferred Tier III format. A campaign waged by Congressional and industry advocates focused on eliminating the non-stealthy Tier II plus program and folding it into one aircraft unofficially called "Tier IV."[149] They wanted an open competition for Tier IV, one that the Lockheed-Boeing team felt confident of winning due to the years of work and hundreds of millions of dollars already sunk into AARS. OSD officials balked at the proposal, fearing further program growth. A DARPA official supporting the split program and obviously referring to AARS, said, "It has been shown over the last decade that a highly stealthy long-endurance UAV with multi-mission requirements is not affordable."[150] Despite the pressure, Deutch and Lynn prevailed in keeping Tier II plus and Tier III minus as separate, highly constrained DARPA programs, dealing a serious blow to the once mighty but flightless bird called AARS (both are discussed more below). The $100 million sole-source contract for Tier III minus served as a consolation prize to mollify the powerful Dicks coalition.[151]

Unlike most UAV programs, AARS grew so large in the flush 1980s that it breached the threshold of serious Congressional interest, as one sees regularly with other major defense acquisition programs. Serious Cold War money and jobs brought UAVs out of the novelty category, but the end of the Cold War left AARS in a stunted format with little hope for success. Dicks provided the stewardship for the big UAV that the intelligence (satellite) community and the Air Force would not, but he was conducting a retrograde campaign because, ultimately, service support is required. The transfer of Tier III minus management from the NRO to DARPA meant the days of the black, open-ended UAV development that characterized the Cold War were over.

The intelligence community, primarily through the NRO, accounts for more than 40 percent (by cost) of the major historical UAV programs. All of them were operated by the Air Force, and all of them were managed by Air Force officers working for the intelligence community. While the NRO provided an optimal environment for UAV development by providing high-level advocacy (through NRO directors like Dr. Alexander H. Flax), easy access to funds, and streamlined acquisition processes, the overall effect on UAV development was negative. NRO UAVs cost billions, yet the NRO produced designs ill-suited to the highest priority conventional military challenge of the Cold War. Even though the NRO assumed developmental risk on behalf of the Air Force, the service still had to spend millions to develop its own conventional derivatives in the 1970s.

Intelligence community UAV programs also soured Congress on UAV affordability. Tagboard, Compass Arrow, and AARS all strained the case for UAVs by going well over time and budget, while none appreciably advanced the state of the UAV art or provided a dual-use platform the Air Force could adapt to its conventional war needs. Finally, the NRO was always a satellite-centered organization, but became increasingly so starting in the late 1960s. Satellites possessed superior technical and political characteristics that UAVs could not match. Every single NRO UAV eventually succumbed to the satellite onslaught, leading to the NRO's decision to drop them entirely in 1974. In the final analysis, NRO UAVs comprised a large portion of the UAVs in this study, but were anomalies—Cold War machines that either did not work, could not compete, or failed to add sufficient value to the Air Force's conventional war concepts of operations.

Dr. John S. Foster, Pentagon director of research and engineering (1965-73).

The Air Force and DARPA

The Defense Advanced Research Projects Agency is a non-service defense organization formed in 1958 by the Eisenhower Administration in the wake of the Sputnik surprise.[152] Its charter was then and remains the preclusion of technological surprise by pursuing high-risk, high leverage military technologies. In the words of one historian, it was also established to "develop new weapons for the unified and specified commands" should the services fail to support them adequately.[153]

To do this, DARPA required a different approach than that of the service acquisition agencies. In the words of Secretary of Defense William J. Perry, they developed an ethos "unfettered by tradition or conventional thinking."[154] In other words, DARPA is an extra-service organization set up to assume a high degree of risk on behalf of the services or the Joint Staff. It has done so at an increasing rate since the end of the Vietnam War.

DARPA's success is measured by its ability to transition risky technologies into military hands. In the case of UAVs, DARPA's record is poor. In the latter half of the 1960s and throughout the 1970s, DARPA pursued various UAVs designed for battlefield surveillance and attack, none of which reached the field. In the 1980s DARPA worked on much larger, more capable UAVs under black programs focused on countering various Soviet sea control capabilities and again, none reached the fleet. Despite its inability to transition UAV systems to the services, DARPA engineers did mature some UAV technologies that found their way to operational status.

■ The ELTAS Systems

The climate for drone development improved substantially in the late 1960s, mainly due to intelligence community initiatives. A 1970 RAND-Air Force RPV Symposium stimulated interest in the open literature that translated into a kind of UAV euphoria that led the Air Force to invest heavily in UAV system development.[155] DARPA conducted a thorough assessment of the RAND report, finding that it "strangely" emphasized roles such as defense suppression, weapons delivery, and air-to-air combat (pitched to the intended audience—the Air Force). The authors of the DARPA report came to the more sensible conclusion that battlefield support drones were more important and more technologically feasible than those touted by RAND.[156] Army and Marine Corps indifference ensured that land combat support UAVs remained neglected, so DARPA swung into action.

DARPA began to explore tactical RPVs for ground forces under the influence of Dr. John S. "Johnny" Foster, the Pentagon's director of Defense research and engineering.[157] Foster was an avid radio-controlled aircraft hobbyist, and his awareness of technological advances in that world shaped his vision for ground combat UAVs.[158] The advent of transistorized electronics and high-volume radio data links pointed to the possibility of "off-loading" the pilot to the ground control station while retaining the pilot's adaptive capabilities—thus the new label "remotely piloted vehicles."[159]

The DARPA study echoed the RAND report by keying on the data link as the leap-ahead technology. "When the remote pilot or operator is able to observe or to orient sensors and designators, limited very little by the fact that he is not actually in the cockpit," the study authors said, "then a sufficiently unique capability will exist for viable, general-purpose, unmanned, tactical, surveillance-and-target-detection vehicles."[160] Additionally, they concluded, "the current technology in propulsion systems, structures, airframes, and even in navigational/control systems and mission sensors is adequate for the development of superior tactical surveillance RPVs."[161]

Foster's advocacy for battlefield support UAVs provides a good example of how DARPA assumes risk for the services. The Army was of two minds about RPVs as the Vietnam War ground to a close. On the one hand, they were frustrated about what they saw as weak aerial reconnaissance support during the Vietnam War. DARPA found strong sentiment in Army (and Marine Corps) headquarters that the Air Force had not lived up to its promise of supporting ground reconnaissance, surveillance, and target acquisition (RSTA) requirements. In the face of that perceived shortfall, the growing Air Force interest in long-range strategic reconnaissance aircraft (including RPVs) riled the Army, which saw itself to be losing a "free" service.[162] Despite the impetus this should have provided the Army and Marine Corps to begin another round of RPV development, they resisted. Neither service had internal UAV constituencies that could generate support for development.

DARPA leaped into this gap and began several drone development programs. Those programs proceeded with very little service support but, to DARPA's credit, program managers linked their work to the services by tying their designs to existing service RSTA requirements. In particular, they based their research an Army requirement calling for an "elevated target acquisition system" (ELTAS).[163]

Oddly enough, DARPA's main partner in ELTAS was the Air Force, which was conducting virtually all the research and development for RPVs at the time. Foster's personal interest in ELTAS led to the world's first successful demonstration of an imagery data-linked "mini-RPV," called Primitae, by the Air Force Systems Command's Reconnaissance Engineering Directorate in 1971.[164] DARPA's successful demonstration and follow-on work with various RPV technologies led to greater confidence in the mini-RPV concept, prompting the Army to promote ELTAS to a remotely piloted aerial observation designation system (RPAODS) concept in January 1973.[165]

■ The Black UAVs

The Navy also participated in two very secret UAV programs that constitute important data points in the technological and programmatic evolution of UAVs. So-called "black" programs, shielded from public scrutiny by their classification, expanded rapidly in the 1980s during the Reagan Administration's military buildup.[166] All the services had black UAV projects in the 1980s and, as it had in the 1970s, Congress acted as a brake on UAV development as DARPA, the intelligence community, and the services attempted a technology push.

The first Navy black program, a medium altitude, over-the-horizon UAV called Amber demonstrated the circuitous path a UAV can take before operational acceptance. Amber started as a DARPA project backed by the Navy (and the CIA) that did not transition to production.[167] The second project was one of the most fascinating UAVs ever to reach flight test. Dubbed Condor due to its astonishing 200-foot wingspan (longer than that of a Boeing 747 jumbo jet), this very high altitude, seven-day endurance UAV was another Navy-backed DARPA project that failed to reach the fleet. Yet, as a UAV technology testbed Condor was unparalleled and showed the way to a future in which technology may not just challenge pilots, but render them extraneous.

Amber

After the failure of high altitude, long endurance UAVs like the Air Force's Compass Cope in the mid-1970s, DARPA in the late 1970s began a project called "Teal Rain" investigating high altitude engine performance. Based on that work, they commissioned Israeli inventor and iconoclast Abraham Karem to design a less ambitious project than Compass Cope, but one with medium altitude (15,000-25,000 feet), long loiter capability.[168] Still concerned about the cruise missile threat, the Navy took over partial sponsorship of the $40 million program as it showed promise for the

Teledyne Ryan RPV AQM-34 Combat Dawn on display at the National Museum of the US Air Force.

same mission its ill-fated "over the horizon" (OTH) UAV was slated to fill—long range Harpoon target acquisition.[169] DARPA's aircraft came to be called Amber.

Amber was a product of Karem's fertile but eccentric mind. He was, in some ways, keeping in the tradition of UAV designers, who tend to inhabit the fringes of the aerospace engineering world. Karem's prickly personality made it exceedingly difficult to work with him.[170] He designed Amber with a unique inverted "V" tail, a pusher propeller, and a long, thin, high-lift wing—it was an odd-looking bird. Amber was designed to be rocket-launched out of a torpedo tube as well as conventionally launched from a runway.[171] Karem reportedly produced a weaponized version as well as one for standard reconnaissance work. By 1986 Karem conducted successful flight tests, and by late 1987 the Navy decided to transition to operational trials.[172] On June 7, 1988, Amber demonstrated flight duration approaching 40 hours at altitudes exceeding 25,000 feet.[173] After several internal Navy failures to achieve a ship-launched endurance UAV, it appeared DARPA had achieved a workable prototype.

Amber got lost in the transition to the Congressionally mandated centralized UAV management system, however. The legislation that established the UAV Joint Program Office (JPO) and froze all UAV funds stemmed from what was perceived as a proliferation of single-service UAV projects, the failure of the Army's Aquila program, and Congressional frustration over the loss of an F-111 crew in the Libyan air strike conducted in April 1986.[174] As with other ongoing UAV programs such as the Navy's Pioneer, the budget freeze hamstrung Amber at a crucial moment, and it became clear that the Navy was not interested in Amber and that the new UAV management system would focus on battlefield reconnaissance. Amber was canceled after having demonstrated successful canister and runway launch and endurance of some 40 hours at 25,000 feet.

Amber is yet another example of how a weak, divided constituency combined with Congressional scrutiny kept a promising system from reaching the field. Congress first became suspicious of UAV projects with Lightning Bug and Compass Arrow. Amber, another black program, fit that same mold—another wasteful UAV program. The inability to make the case for the UAV lies in the Navy's weak advocacy for it, however. Tomahawk, a very long-range surface-to-surface cruise missile, still had a range exceeding the Navy's ability to target it effectively. Short of volley-firing the missile at untimely satellite updates of Soviet surface group positions in hopes of a lucky shot, Navy ships had to steam inside the lethal range of Soviet systems to get a good shot. Amber provided an innovative way to gain the kind of long-range aerial reconnaissance that proved critical in naval battles like Midway and Coral Sea, but the Navy surface community never found its voice for Amber. It may have been a combination of the "not invented here" syndrome or difficulty dealing with Karem's abrasive personality.[175] Today, several Amber prototypes and their sophisticated ground control stations sit idle in a China Lake, Calif. warehouse.

Many UAV programs end this way—a brilliant engineer builds a prototype in his garage, gains developmental funding, shows promise, and then vanishes in obscurity when the program falters—not so with Amber. Despite this setback Karem tried to forge ahead with the design in an attempt to find a foreign customer, pouring all his earnings from Amber into a conventional runway-launched version called Gnat 750. Out from under DARPA's helping hand, Karem's company was on the verge of bankruptcy.[176] A large defense contractor bought Karem's designs and continued to develop his Gnat 750 for foreign markets. Thus a well-designed system was allowed to mature over a decade, something few UAVs can manage. When events in the Balkans demanded the attention of Washington just after the breakup of the Soviet bloc, newly installed Pentagon acquisition chief Deutch conducted a review of current UAV projects and conceived the "Tier" concept of differentiating UAV programs that gave Karem's bird new life.

Two of the three UAV "tiers" had Amber derivatives in mind. Tier I was the low-level Gnat 750, a quick-reaction program funded by the CIA for deployment to Bosnia.[177] Gnat 750 was fielded quickly because the aircraft and relay systems were already built as part of a contract with Turkey.[178] Tier II started as a DOD and Joint Chiefs of Staff (no service involvement) initiative called the "tactical endurance UAV." Tier II, which later came to be called Predator, was a larger, more sophisticated version of the Gnat 750. It carried a synthetic aperture radar (SAR) that imaged the ground through cloud cover and, more importantly, had the ability to be controlled via satellite data link, allowing true beyond line-of-sight control for the first time.[179] These Amber derivatives also benefited from the maturation of GPS technology, which for the first time allowed a high degree of position accuracy at a very low cost, a problem that haunted UAV systems for the previous three decades. Predator went on to become an Air Force UAV system that, even before the eruption of the Global War on Terrorism in 2001, had logged more than 6,600 combat hours in five deployments.[180] Amber did not achieve any milestones on its own, but Karem's ambition to design an over-the-horizon system eventually translated into one that used satellites for control and position accuracy, innovations that freed the UAV for very long-range operations.

Condor

Amber was quite exotic for its time, but another UAV in DARPA's stable called Condor took exotic to a new level. The Condor UAV started as a DARPA initiative in the late 1970s to counter Soviet Backfire bombers delivering anti-ship cruise missiles.[181] Soon after taking office in 1981, Navy Secretary John F. Lehman Jr. proposed an aggressive naval strategy which involved sailing US carrier battle groups into the Norwegian and Barents Seas to defeat the Soviet Navy in its home waters. As it had since World War II, the land-based air threat to such an armada loomed large.[182] The Soviet Union employed long-range Backfire bombers loaded with anti-ship cruise missiles to counter such an incursion, and it was assumed the Soviets would volley-fire hundreds of cruise missiles from outside the range of the carrier's air wing. Condor was designed as a sensing platform for the Navy's "outer air battle," which involved firing large, ramjet-powered (Mach 3+) missiles to intercept the bombers prior to weapon release.[183] As with the Harpoon problem, the challenge for Navy planners was how to achieve long-range target acquisition commensurate with weapon range.

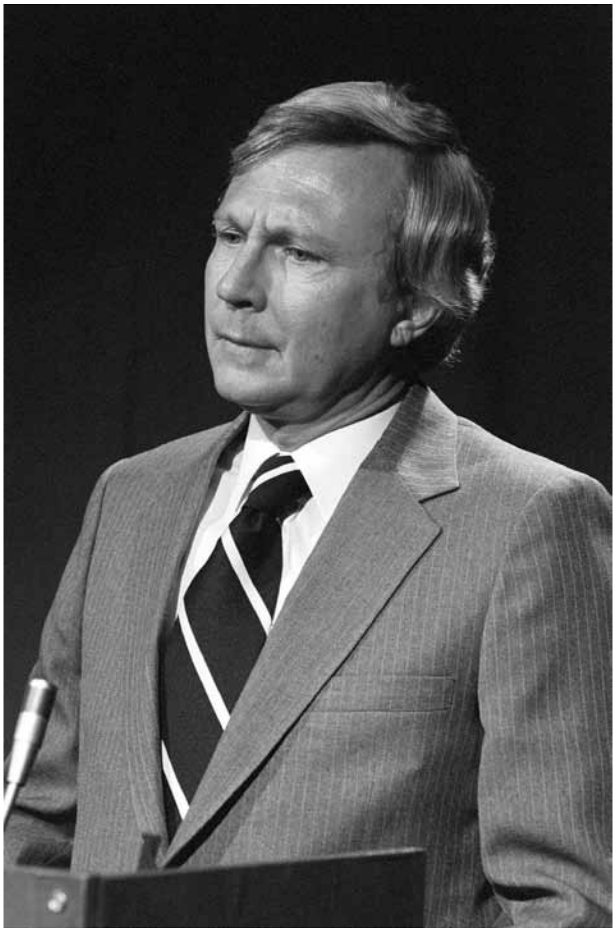
The aptly named Condor was designed to loiter for a week—well beyond the capacity of a human pilot—in the vicinity of potential Backfire ingress routes to cue long-range missile launchers.[184] It featured innovative high altitude propulsion concepts, non-metallic (composite) structures, and a new wing design. Its massive wings deflected 25 feet upward in flight and its all-composite airframe weighed only 8,000 pounds without fuel. With payload, Condor might have cost as much as $40 million per copy, which also gives an indication of how much autonomous, high-altitude, long-endurance flight costs.[185] Boeing's Condor program manager, Neil Arntz, said Condor was "by far the most exciting interesting program I've ever done, and I was at Boeing 42 years."[186] Previous UAV designs did not fill a niche where humans could not go, but Condor's seven-day, very-high-altitude loiter capability opened an avenue where robot technology had clear advantages.

Condor never entered the fleet, but is very important as a UAV technology testbed.[187] Its embedded technology marks an important step in the technological maturity of robotic flight control for large, reliable, conventional takeoff and landing UAVs.[188] Engineers designed a fly-by-wire flight control system in which redundant, high-speed computers and sophisticated software algorithms flew the aircraft autonomously.[189] From takeoff through landing, Condor performed test flights from the remote Moses Lake, Wash., airstrip with its own sensing and response mechanisms, flying to internally held waypoints.[190] The robotic monstrosity demonstrated flight endurance of 60 hours, at one point reaching more than 67,000 feet.[191] Amazingly, it did this without using GPS for position accuracy due to its immaturity at the time.

One in-flight emergency gives a glimpse of what an advanced automated flight control system can accomplish. An in-flight mechanical malfunction in the Condor air vehicle caused maximum deflection of the rudder. The flight control software automatically repositioned the other control surfaces to compensate and the UAV landed without incident.[192] The rudimentary in-flight compensation in Condor's "brain" is a foretaste of what digital automated flight control might achieve in the future.

Up to this point, various UAV technologies such as the gyroscope, the radio, television, inertial navigation, and rudimentary flight controls advanced at an evolutionary pace. Satellite control and more capable data links, software-controlled, digital autopilots, and GPS location systems have transformed UAV potential in a relatively short period of time. As our understanding of subsonic modeling improves, the opportunity for automated flight control algorithm formulation backed by very powerful, cheap computers may allow for redundant, self-healing systems that achieve the one percent attrition common in manned systems, or even better.[193] DARPA's Condor and Amber demonstrated that the information revolution accrues to UAVs in a significant way that might point to a time when technology renders the pilot extraneous to the achievement of reliable flight control.

DARPA has played a key role in UAV development since the mid-1960s, but compiled a poor record of transitioning UAV systems to operational status. DAR-



Edward C. "Pete" Aldridge, undersecretary of the Air Force and NRO director (August 1981-December 1988), and Air Force Secretary (1986-88).

PA's structural position outside the services explains both its success at developing niche technologies and its failure to transition whole systems. Because they are external to the services, DARPA engineers are free to explore non-standard paths to success. Yet, their position as a service outsider turns DARPA into an interloper when it tries to transition its independent programmatic vision into one that answers real service needs. Moreover, because of its charter, the UAV projects DARPA tended to pursue were precisely those with weak support in the services, making the transition process that much more difficult. All too often, however, DARPA got projects funded through OSD but its engineers failed to represent service interests in the design stages. As an external agency, DARPA UAV designs also undoubtedly suffered from service parochialism—the "not invented here" syndrome" that is a normal part of any structural cleavage. With all these structural impediments, DARPA UAV systems experienced difficulty being transitioned into the services.

That being said, the lack of success in progressing UAVs to operational status belies DARPA's large role in UAV and defense-wide technology development. Arguably, that has not been positive. DARPA's increasing budget since the Vietnam War can be seen as an indicator of the ongoing campaign to circumscribe the services in the weapon system acquisition process. By empowering agencies like DARPA that allow the services to outsource technological risk at an increasing rate, the services have been disincentivized from assuming risk except along traditional, evolutionary lines. The UAV story provides one indicator of that potential problem. Rather than diminishing the likelihood of technological surprise, DARPA could have the opposite effect despite its aggressive development record. Regardless of the source of a UAV's design, it can only achieve the final stage of innovation by being adopted and integrated into the armed services.

The Air Force's Own UAVs

Every service experienced decades of trouble fielding and employing UAVs as military instruments. The Air Force was no exception. Despite the problems the Air Force experienced in fielding UAVs, however, it retains the distinction of having been the first to develop a substantial UAV combat record. That happened 35 years ago, in the Vietnam War. Air Force drones flew more than 3,500 combat sorties in a wide variety of roles, prompting the Air Force to make a major commitment to UAV development in the early 1970s.

■ Lightning Bugs Over Vietnam

Although "national" (NRO) UAV systems operated in a world all their own, the Vietnam War gave those "special purpose aircraft" the opportunity to prove themselves in more conventional combat operations.[194] The 1960 U-2 shootdown and the 1962 Cuban Missile Crisis stimulated a drone reconnaissance program managed by the NRO. That program evolved into the Strategic Air Command-operated Blue Springs mission, which started flying over China in 1964. Blue Springs constituted the leading edge of a drone reconnaissance effort that continued to expand along with the war. Although the Air Force pursued various drone concepts for conventional combat operations after 1970, its wartime focus remained on the versatile Q-2C Firebee target drone variant known as Lightning Bug.[195]

Lightning Bug was a jet-powered aircraft very different from the UAVs developed by the other services.[196] It could attain high, subsonic speeds (500-600 knots) and altitudes over 50,000 feet after air-launch from under the wing of a specially configured DC-130 Hercules transport. Its versatile design accommodated numerous modifications depending on the mission, with fuselage lengths varying from 23 to 30 feet and wing spans ranging from 13 to 32 feet—smaller than a standard fighter aircraft, but still a large bird. Drone operators onboard the DC-130 monitored the drone, which could travel up to 1,300 miles, flying as low as 300 feet over areas of interest.[197] The standard reconnaissance drone carried a very sophisticated camera as its primary payload. These very high resolution 70 millimeter "wet film" cameras required an intact recovery and film development prior to analysis.[198] Because 1960s data link technology did not allow high-resolution picture transmission, especially at the ranges and low altitudes often flown by this drone, the time from tasking to the derivation of meaningful intelligence was measured in days.[199] The aircraft followed a preprogrammed flight path using self-contained navigation aids and returned to a recovery site where it deployed large parachutes to drift to earth. A large Air Force helicopter picked up the drone and returned it to base, where it was refurbished for another mission. Almost 30 people were directly involved in one Lightning Bug mission, and combat sortie rates were less than one per day.

The Lightning Bug's navigation system remained a weakness throughout the Vietnam conflict. In support of US combat operations prior to the 1973 cease-fire, Lightning Bug drone operations hit less than 50 percent of the planned reconnaissance targets, mainly due to navigation errors. Flight path accuracy depended on the location accuracy of the launch plane, which varied depending on crew proficiency. The nominal drift error for the Doppler navigation system was three percent of the distance traveled.[200] Accordingly, for a nominal 200-mile ingress, the drone had a 50 percent chance of straying six to nine miles from the planned track during a 100-mile photo run.[201] Early in the program when the drones were taking photographs from 50,000 feet, this was not a major problem. After 1967, however, when low-level operations became the primary tactical employment mode, the drone had to be within one half to one mile of the target to get useful photographs, leading to sub-par statistics. Location accuracy, a pivotal requirement for effective reconnaissance operations, would continue to plague UAVs until the early 1990s with the advent of the satellite-based GPS.

Other operational complications made Lightning Bug a very elaborate, intricate, and expensive undertaking. The DC-130 air-launch capability accommodated a variety of mission profiles that proved perfect for conditions in Vietnam—but recovery soon became a major problem. In 1966, the growing size and weight of new models led to greater damage on ground (parachute) recovery. In response, the Big Safari acquisition office that handled drone contracts for the NRO adopted the mid-air retrieval system (MARS) from the Corona satellite program.[202] As the drone descended under parachute, a large Air Force CH-3 helicopter snatched a special drogue chute in mid-air, reeled in the drone, and flew back to base.[203] MARS saved wear and tear on the drones, but added significant cost and complexity to Lightning Bug operations. Early MARS operations suffered numerous problems and 40 percent of the drones (and their film) were lost from recovery alone. By 1972, however, MARS recovery operations were more than 98 percent effective, as reflected in Lightning Bug loss rates.[204] In a relatively benign launch and recovery environment where Air Force and Navy fighters insured air supremacy, MARS was a workable, albeit expensive solution to the problem of drone reliability.[205]

A version of the General Atomics Aeronautical Systems Gnat 750 (originally developed by Abraham Karem) known as Tier I in OSD's RPV acquisition strategy of the early 1990s and employed by the CIA.

Like the Mach 4 D-21 Tagboard flights described earlier, Lightning Bug operations also proved to be extremely expensive. In 1969, low altitude drone operations consumed $100 million ($534 million in FY10 dollars) for procurement, and $250 million ($1.34 billion in FY10 dollars) for operations and maintenance.[206] Those figures include direct charges, but hidden operational costs abounded. In that same year, Air Force EB-66 Destroyers and Marine Corps EA-6 Prowlers provided 75 electronic warfare sorties per month in support of drone operations.[207] Navy fighters protected the DC-130 launch aircraft whenever it ventured close to the Gulf of Tonkin, and Air Force F-4 Phantoms provided combat air patrol for missions venturing into Laos.[208] Each flight required a T-39 courier jet to deliver the film to Tan Son Nhut AB, Vietnam, for film processing, and a DC-130 to fly to the recovery base for drone pickup.[209] The costs for MARS helicopter operations alone were astronomical. The immediate effect was not apparent, however, because the demand for drone sorties continued to rise and the program remained veiled in secrecy, supported by the seemingly endless flow of money from the NRO. Affordability is a persistent myth surrounding the UAV issue, but for the sophisticated types pursued by the Air Force, history shows that taking the pilot out of the cockpit costs money.

As the United States involvement in Vietnam grew, the Lightning Bug's mission composition changed from exclusively "national" intelligence to incorporate tactical missions requested by combatant commands. In these roles, Air Force drone operators reached the third stage of weapon system innovation, achieving combat effectiveness by using the drones' unique capabilities. This was the first such operational breakthrough for UAVs in combat. The following narrative highlights this important UAV story, picking up Lightning Bug operations as they moved to Vietnam from Okinawa in 1964.

■ Lightning Bugs as Bait

Drone operations in the Vietnam War proved to be a valuable complement to Air Force manned tactical reconnaissance assets, providing information impractical to get using manned platforms. Although the vast majority of combat drone flights involved photographic reconnaissance in denied areas, SAC also used the drones for various novel missions suited to the drone's unique capabilities, as demonstrated by the next example.

UAVs can be extremely useful when they accomplish important missions where pilots absolutely cannot go. Nothing illustrates this better that the drone suicide missions conducted under the codename United Effort. In this ingenious concept, a specially configured Lightning Bug served as bait for surface-to-air missiles to gain electronic intelligence.

Early in the Vietnam conflict, Soviet-built air defenses in North Vietnam mainly consisted of radar-guided anti-aircraft artillery. As the US commitment rose, however, the Soviets injected more advanced systems into the most vulnerable areas. In spring 1965, reconnaissance photos showed the deployment of very capable radar-guided surface-to-air missile batteries called the SA-2 (the same missile that shot down Francis Gary Powers) around Hanoi.[210] On July 24, 1965, those missile batteries shot down their first US aircraft, an Air Force F-4C Phantom fighter.[211] Although the Air Force gradually learned how to jam or out-maneuver the deadly system, it remained difficult to get good electronic signatures as Soviet engineers fielded improvements. The answer: send in the drone.

In response to this need, the CIA developed an electronics package that could record the SA-2's transmissions as it fuzed and exploded. The Big Safari office had the contractor squeeze this special payload into a large-model Lightning Bug ELINT drone. The employment concept was the same as that developed for the SA-2 threat over Cuba in 1963—the drone would take a direct hit from a missile while its data link transmitted the terminal firing data to a manned aircraft loitering a safe distance away.

On Feb. 13, 1966, the specially configured drone picked up good SA-2 fuzing, guidance, and overpressure data that allowed US electronics experts to build jammers that would throw off the missile. As the missile blasted it from the sky, the drone transmitted the SA-2's terminal emissions to a standoff aircraft (an EB-66 Destroyer). The electronic take was so important that the Assistant Secretary of Defense for Research and Engineering, Dr. Eugene G. Fubini, called this mission "the most significant contribution to electronic reconnaissance in the last 20 years."[212] Later that year, another specially converted drone flew over North Vietnam with a new Navy electronic defensive pod to test its utility against the actual threat, and the drone drew more than 10 missiles before it was brought down, confirming the pod's ability to spoof the missile.[213] As the electronic battle of countermeasures and counter-countermeasures continued to escalate, airmen could always sacrifice a drone to help keep their jamming equipment up to date.[214]

Another sacrificial drone mission deserves mention because of its historical significance. In 1966, when it became clear that the SA-2 sites in North Vietnam posed a serious threat to high altitude drone operations (16 of 24 were shot down in late 1965), the NRO asked for 10 radar-enhanced drones to be used deliberately as decoys to protect high altitude drone operations. The stripped-down decoy (costing around $520,000 in FY10 dollars) would fly in close proximity to the camera-carrying drone, but was programmed to split off near the target area to confuse enemy radar operators. SAC picked up on the idea, ordering 10 additional decoys to help cover B-52s flying into North Vietnam as part of Operation Rolling Thunder.[215] Although the program reportedly worked, it was short-lived because enemy radar operators soon learned to distinguish decoy from real. Still, the idea lived on.

The use of UAVs as decoys was later adopted by the Israeli Air Force, which employed US-made BQM-74 Chukar target drones as decoys for the first time in the 1973 Yom Kippur War, this time as part of a deliberate, phased attack plan designed to suppress missile defenses. The drones (looking like an attacking formation) prompted Egyptian missile radars to emit. Radar-homing missiles right behind the drones slammed into the radar sites, blinding them for the manned aircraft strike that dropped deadly ordnance on the missile sites. Israel repeated the trick in the 1982 Bekaa Valley strike using a variety of indigenously produced decoys. (In a deliberate reprise of those Israeli tactics, the US Air Force launched 40 Chukar target drones into Baghdad on the first two days of the Gulf War in 1991.[216] Whether as sacrificial data-gatherers or as a means of confusing enemy defenses, drones showed infinite courage in their role as protectors of US military pilots.

■ Buffalo Hunter

The single most important operational shift in Lightning Bug operations came from a request by the Commander in Chief of SAC, Gen. John D. Ryan. Through 1965, Lightning Bug had flown only high altitude photographic missions and stayed on the ground during bad weather. Cloud ceilings kept manned reconnaissance aircraft such as the RF-101 Voodoo and the RF-4 Phantom grounded due to the greater exposure to enemy ground fire at low altitude.[217] Consequently, American forces got very little reconnaissance imagery during the lengthy monsoon season in Southeast Asia. To solve that problem, Ryan turned to Lightning Bug.

The technical problems confronting the Lightning Bug team were not trivial. Big Safari's contractor had to figure out how to reliably fly the drone at altitudes less than 2,000 feet over varying terrain and attain much greater navigational accuracy. Because they had a basically sound airframe and worked with little oversight due to the secret nature of the program, the modification crew went from concept to combat in just over six months. Having solved most of the problems with low altitude control by incorporating a barometric altimeter into the flight control system (navigation improvements came later), the low altitude 147J model flew its first operational mission in the spring of 1966.[218] This flight was the first foray into what would become its dominant mission profile as the high altitude regime became too lethal. By 1971, the commander of 7th Air Force, Gen. John D. Lavelle, told his Vietnam chain of command that the "vehicle most effective under northeast monsoonal conditions is the Buffalo Hunter drone."[219] The Air Force now had a mix of reconnaissance assets, with satellites, the U-2, and SR-71 performing in a standoff role, the RF-101 and RF-4 squadrons doing high volume bomb damage assessment, and the drones performing in denied areas.

Now that the real value of the drone as a low-level penetrator had become clear, the Air Force asked for a large production run of low altitude drones with an improved camera. The first "S" models came off the production line in late 1967 (one year after initiation of the contract) at about $160,000 a copy ($938,000 in FY10 dollars), with orders in the hundreds rather than by the dozen.[220] The Air Force continued to ask for improvements to the "S" model due to navigation problems. Later models included better flight control and data links, which drove the average price of the more than 420 "S" series drones to $400,000 ($2.3 million in FY10 dollars), bringing the core of the low level drone program to a total procurement cost of about $977 million in FY10 dollars.[221]

Due to persistent navigation problems, the drones often missed their targets, so navigation accuracy was critical to system effectiveness and this shortcoming accounted for much of the cost increase. By 1972, for instance, SAC started flying a much more accurate model using long-range-aid-to-navigation (LORAN) technology that drastically improved reconnaissance effectiveness.[222] One of the most important additions to the "S" series capabilities was a real-time data link that had eluded drone designers for years. In June 1972, advances in micro-circuitry allowed the Air Force to field the "SC/TV" model with a television camera in the nose to enhance navigation accuracy. The airborne remote control officer, who used to fly "on instruments," so to speak, could now navigate using a low-resolution television image.[223] Still, both these technologies required radio transmissions that could be jammed in a combat environment, so the location accuracy program still plagued the drone's combat effectiveness.

■ The SAC-TAC Rift

The foregoing discussion focused mainly on technological issues, but the increasing value of Buffalo Hunter operations also led to organizational tension between "national" customers and SAC on one side, and tactical (fighter) commanders on the other.[224] It was, in fact, a microcosm of a larger intraservice rift between SAC (bombers) and TAC (fighters) that was exacerbated by the Vietnam War. TAC absorbed the brunt of wartime operations, which caused fighter commanders to push for various SAC resources which were dedicated to the thermo-nuclear deterrence mission. The combat experience gained by fighter pilots in the war provided them elevated warrior status, which in turn led to increasing assertiveness and ultimately, their successful bid for

Boeing's high-altitude, long-endurance Condor UAV did not enter operational service but was important as a technology testbed.

service hegemony.[225] The struggle for control over drone operations played out within this larger service context.

The tension between SAC, which operated the drones, and TAC, which assumed most of the risk against North Vietnamese air defenses, was evident as early as 1966. The commander of Pacific Air Forces (a TAC position) demanded organic reconnaissance drone capability and received permission to stand up a drone unit in April 1967 to gain elbow room in the upcoming turf battle.[226] The Air Staff in the Pentagon changed the drone unit's mission to chaff delivery and radar jamming, essentially an electronic countermeasures (ECM) mission. They felt that the fighter commanders would be supported by the increasing orders for low-level drones being paid for by the NRO, and Air Force crews were being lost in Vietnam conducting the chaff dispensing role.[227] TAC proceeded with that configuration under the codename Combat Angel. Using under-wing chaff dispensing pods mounted on wing hardpoints, the contractor delivered 24 drones within 90 days, with 43 production versions following soon thereafter.[228] The 4472nd Tactical Support Squadron (using almost exclusively contractor manning) went on alert with the special drones at Davis-Monthan AFB, Ariz. in August 1968, but were never called into combat due to the bombing halt enacted in November of that year.[229] This was another in a long line of bad external circumstances that stunted a drone operation before it could prove itself in combat.

The unit languished when its combat mission faded. The Chief of Staff during that period, Gen. John P. McConnell (a bomber pilot), only allowed TAC to share SAC assets when SAC could afford them, and most all its units were occupied in Vietnam. The chaff-dispensing drones could be delivered faster than TAC could modify and acquire launch and recovery aircraft. Furthermore, technical shortcomings dogged the program. The mission required accurate navigation and multiple aircraft formations to lay an effective chaff corridor to shield attacking bombers. Drones lacked the technology to reliably do this mission. As a result, the TAC drone unit remained essentially a shell. In fact, TAC did not even stand up an operational unit (the 11th Tactical Drone Squadron) until July 1, 1971, and even then it was so ill-equipped for its ECM mission that it never went into battle.[230] Eventually, the TAC unit's drones deployed to Vietnam as SAC assets used for leaflet dropping under a project called "Litterbug" during the last half of 1972.[231] Although TAC was on the rise, creating a transitory feudalism in the Air Force, the bomber generals were in charge and retained tight control over the drone program.

While TAC was attempting to develop an organic drone capability, the SAC-TAC conflict over drone reconnaissance heated up in Vietnam. By late 1970, 7th Air Force and Military Assistance Command Vietnam (MACV) requested greater control of drone operations to respond to time-sensitive targets.[232] SAC, on the other hand, wanted to maintain control via its Strategic Reconnaissance Center, located at Offutt AFB, Neb. With the help of former CINCSAC and then Air Force Chief of Staff Ryan, who was both a drone advocate and bomber pilot, SAC got its way, but streamlined its operations to speed up the tactical request cycle and accommodate 7th Air Force.

Abraham Karem, an Israeli inventor coopted by DARPA to work on Teal Rain which produced the Amber UAV.

One year later, however, the 7th Air Force commander reported to his Vietnam chain of command that that Buffalo Hunter targeting procedures were "insufficiently responsive to urgent [7th AF] requirements."[233] His replacement reported that by the end of American involvement in early 1973 (after the massive bombing campaigns of the preceding year) that "the Buffalo Hunter program has not been entirely responsive to the tactical air commander."[234] SAC's streamlined procedures never satisfied tactical commanders. Gen. John W. Vogt Jr., the commander of 7th Air Force which exercised control over fighter forces in Vietnam, summed it up by saying, "I think it is essential that we come up with a drone capability for the tactical commander, under his control, not subject to diversion, if he's to successfully carry on his air campaign with minimum loss of lives and maximum effect on the enemy."[235] The fact that fighter generals pushed hard for greater drone control indicates that the Lightning Bug operation had established a valuable niche that was worth fighting for, especially during weather conditions that withheld manned reconnaissance sorties.[236] It also shows that operational control leads to more support for the "home" unit, and TAC never forgot that fact when it made a bid for control of the drone operation after the war.

■ Buffalo Hunter at War

Despite the organizational rift, 1972 was the most prolific and important year for Buffalo Hunter drone reconnaissance operations. The eight years of trial and error leading up to 1972 set the stage for a banner year. With years of operational experience embedded in the now almost exclusively "blue-suit" (military-manned) operation, flight reliability rates soared, reaching about 90 percent. High reliability improved both the efficiency and effectiveness of the drones, inspiring the confidence of tactical commanders, who had come to rely on their unique capabilities. A big reason for that, and the reason it had been easier for SAC to switch to a blue-suit operation, was the stability and maintainability provided by the proliferation of the common "SC" drone model.[237] Common systems led to reliability, maintainability, and a consistent supply system. As Buffalo Hunter historian Paul Elder put it, "In addition to effecting a reduction in operating costs, [increased reliability] meant that less intelligence information would be forfeited because of lost drones."[238] Operationally, the methods for deconflicting and coordinating drone flights were well-understood, and as a result of all this, the system was in demand by military planners.

Low-altitude Lightning Bug drones flew almost 500 missions that year and registered their most important contributions to the US war effort. They proved fairly immune to enemy air defenses later in the conflict as tactics and electronic warfare methods improved, with enemy air defenses inflicting only two to three percent losses from 1970 through 1972.[239] Buffalo Hunter reconnaissance coups included the first pictures of the Soviet ATOLL heat-seeking missile attached to a MiG-21 Fishbed making an unsuccessful try at shooting down the drone, identification of the first optical tracking devices on the SA-2, and thousands of feet of high-resolution imagery.[240]

The real payoff, however, came at the end of 1972 with the Linebacker II bombing campaign. In December of that year, 75 Lightning Bug drones performed bomb damage assessment flights in support of the massive Linebacker II bombing campaign. During the peak of the attack, which happened to occur at the height of the monsoon season, SAC flew 77 drone sorties compared to 12 for manned RF-4C aircraft, covering 93 percent of the bomb damage assessment photographic targets in that campaign.[241] Due to the persistent overcast during that campaign, Buffalo Hunter drones proved to be the only reliable way to get crucial bomb damage information. Vogt, 7th AF commander during Linebacker II, commented, "The high altitude airplanes such as the SR-71 and our own [manned] tactical reconnaissance, which fly at altitudes considerably higher [than the drone], are not capable of doing this particular job."[242] Chairman of the Joint Chiefs of Staff, Adm. Thomas H. Moorer (himself an aviator), used crystal-clear photographs taken by Lightning Bug drones in his Congressional testimony concerning the Linebacker II campaign. Those photos proved the discriminate, precise nature of the bombing, but also publicly confirmed for the first time the use of drones in the Vietnam War.[243] Linebacker II was Buffalo Hunter's finest hour.

In its various guises—seven different models by the end of the war—the low altitude "S" series became the workhorse of Vietnam War drone operations, eventually flying 2,369 missions, comprising almost 70 percent of the total drone sorties in the Vietnam War.[244] In fact, although manned flights over Vietnam were suspended in 1973, Lightning Bug crews flew right up to the surrender of Saigon in 1975.[245] Buffalo Hunter had come of age and found its niche and had become a valued, fully-integrated part of military reconnaissance operations in Vietnam.[246]

The Lightning Bug drone was the most significant UAV operation in US history—and the most costly. The years of development since Red Wagon and Fire Fly allowed enough system maturation so that when the need arose, the Lightning Bug could respond. More than 1,000 drones were built with 200 lost in combat, at a total program cost of about $1.1 billion dollars (not including the substantial operations and maintenance costs), which translates to more than $5.8 billion in FY10 dollars—the most expensive UAV operation of its time.[247] It is clear the drones worked, but how important was drone reconnaissance to the overall effort?

Although there is little doubt that drone reconnaissance played a noteworthy, if inconspicuous, role in US combat operations during the Vietnam War, it must be placed in context with the entire US airborne reconnaissance effort. It would be a mistake to overestimate the operational significance of drone reconnaissance. Very dangerous manned tactical reconnaissance missions continued during 1972, totaling 3,853 sorties. Many aviators lost their lives or were imprisoned accomplishing those flights. In that same year, Buffalo Hunter drone flights comprised only 12 percent of the total reconnaissance sorties, up from an average of three percent over the conflict.[248] Drone advocate Gen. Robert T. Marsh, a rare four-star general who was not a pilot, directed the Air Force's drone acquisition from 1969 to 1973 and later became the head of Air Force Systems Command. Upon reflection over those years, he observed that the "neat little notion" of drones was really "more of a novelty in Vietnam than any real capability."[249]

What Marsh and the statistics miss, however, is that Buffalo Hunter operated in conditions impossible for manned aircraft. It is tempting to speculate about the number of pilot's lives saved by flying drones, and there arguably were some. The reality is that manned reconnaissance aircraft simply would not have been sent into the areas (like Hanoi during Linebacker II) covered by the drones, and certainly would not have conducted decoy or missile electronics intelligence missions described earlier. Furthermore, because drone operations were so heavily supported and electronically limited, very few sorties could be generated, resulting in manned aircraft assuming the bulk of the reconnaissance load. The payback was reconnaissance effectiveness, not lives saved.

At the zenith of drone operations in December 1972, the Air Force depended almost entirely on them for bomb damage assessment due to bad weather. If a drone failed to return, SAC just launched another one on the target. In the new age of sophisticated, radar-guided air defenses, the low altitude Buffalo Hunter was a remarkably effective response that helped maintain battlefield awareness over lethal areas in the worst weather. Drones occupied a small but very important niche in reconnaissance operations in Vietnam, and as that conflict wore down, the Air Force turned its attention to resolving the smoldering SAC-TAC battle over control of drone operations and the larger problem of transitioning drones to exclusive Air Force-control.

■ The Rise and Fall of Air Force UAVs

This section covers a pivotal time in Air Force UAV history. In the first few years of the 1970s, Lightning Bug drones worked the skies over Vietnam and Korea, having evolved into a fairly reliable, highly secret element of the US tactical airborne reconnaissance system. Air Force leaders supported, expanded, and even fought over the drones, but their gaze soon shifted to the Soviet threat in Europe. That shift changed operational requirements for remotely piloted vehicle systems in a monumental way.[250] The fact that the Air Force considered making RPVs a substantial part of its core combat capability speaks to the relative technological aggressiveness of Air Force leadership and its feudal arrangement during this decade. As we see, however, that aggressiveness did not translate into operational systems.

RPVs failed to make the transfer from Vietnam to the much more demanding European theater and simply cost too much for the limited capability they provided in that environment. Only the most wild-eyed futurist would have taken the RPV in light of the tradeoffs they required and the manifest operational problems they posed to Air Force planners. Furthermore, major breakthroughs in systems competing for RPV roles overshadowed RPVs, arms control agreements virtually excluded RPVs from carrying munitions, and even the worldwide air traffic control regime proved to be an obstacle to wider RPV adoption. During the decade of the 1970s, RPVs went through a euphoric period of industry and Air Force interest, only to be dashed by cost overruns, technological shortfalls, external obstacles, and more capable competitors.

Although the RPV euphoria of the 1970s ultimately imploded, it stemmed from a confluence of three external forces, the most important of which was the seemingly inexorable rise of the Soviet air defense threat. The simple, radar-guided, proximity-fuzed anti-aircraft artillery of the post-World War II era gave way to more sophisticated radar-guided missilery, exemplified by the SA-2. In quick succession, however, Soviet air defenses evolved into a multifarious complex of interlocking systems that threatened to, as air combat historian Lon O. Nordeen Jr. put it, "sweep the skies clean of enemy aircraft coming within their range."[251] In October 1973, the success of the next generation of Soviet air defenses against the Israeli Air Force reinforced the sense that manned combat aircraft faced an ominous, inexorably growing threat. Airpower historian Robert Frank Futrell noted (with chagrin) that interpretations of Yom Kippur War air combat produced the widely held impression that modern air defenses "rendered tactical aircraft obsolete."[252] That impression boosted the case for combat RPVs in the Air Force.

Two political developments in the early 1970s augured well for RPV development. First of all, the Soviet-designed, integrated, multi-layered air defense system resulted in hundreds of American aviators in North Vietnamese prisons, providing US adversaries with potent political leverage. A key element of the Paris peace accords which took affect Jan. 29, 1973, was North Vietnam's agreement to return 591 American prisoners of war (mostly aircrew) in exchange for complete US troop withdrawal.[253] Secondly, the rising cost of aircraft and tight budgets increased the attractiveness of cost savings from RPVs. Leading the charge in this regard was Foster, the DDR&E.[254] Foster was a seminal figure in early RPV development who emphasized the radically low costs possible with this technology. To a Congress more willing to intervene in traditional service prerogatives regarding weapon system acquisition, the prospects for cost savings sounded very attractive. McLucas, then Secretary of the Air Force, summed it up by stating that RPVs had the potential to minimize manned aircraft attrition, conduct "politically sensitive" missions, and cost much less than manned aircraft.[255] Political circumstances favored an RPV boom.

The other foundation underpinning the RPVs euphoria of the early 1970s was the advent of more complex integrated circuitry in the form of microprocessors, which demonstrated orders-of-magnitude increases

DC-130 with four BQM-34 RPAs takes off from Davis-Monthan AFB, Ariz.

in computing power and decreases in weight.[256] The Minuteman II ICBM guidance and control system was the first major weapon system to make extensive use of integrated circuitry in the mid-1960s. Microprocessors took that capability to a new level in the latter half of the 1960s in systems requiring sophisticated data links, such as the Defense Support Program (DSP) satellite, first launched in 1970.[257] In February 1969, the US had launched TACSAT 1, a tactical communications satellite of unprecedented capacity, and, in July 1969, the crew of Apollo 11 landed on the moon using a highly automated, computerized flight control system and complex data links to ground control.[258] The essentials of an RPV technical revolution were embedded in these projects—microprocessor-based, automated flight control and high-bandwidth, real-time communications. The only key element still missing was the thorny problem of location accuracy, although LORAN (a microprocessor-based radio timing system) provided one rather fragile answer for combat systems. For the first time, engineers could anticipate that the pilot's entire cockpit picture could be transmitted in near real-time to a ground station. In short, the threat, politics, and technology converged in an unprecedented way at the end of the 1960s, heralding the emergence of a major new weapon system type that had the potential to supplant manned combat aviation.

Already buoyed by these circumstances, the status of UAVs in the Air Force received a major boost in July 1970 with the release of a report from a jointly sponsored RAND corporation-Air Force Systems Command symposium advocating RPVs as the future of airpower.[259] The RAND/Systems Command report declared RPVs technologically feasible for roles as widely varying as logistics resupply, air-to-air combat, and interdiction.[260] It excluded very few Air Force missions. Numerous articles appeared in aerospace journals extolling the bright future of UAVs, and in anticipation of a windfall, the UAV industry formed an advocacy group.[261] The symposium catalyzed Air Force interest in the wider use of UAVs by stimulating the interest of two consecutive Chiefs of Staff and their research and development staffs.

The first was Chief of Staff Ryan, who had been extremely skeptical of drones when he first took over as CINCSAC in December 1964.[262] LeMay, the cigar-champing bomber pilot who had built SAC into a powerful institution, ordered Ryan, his new vice CINC, to become familiar with highly secret drones, to see them up-close, to touch them. To comply, Ryan flew his jet to Eglin AFB, Fla., marched off the plane, touched a Lightning Bug drone sitting in its cloistered hangar and said, "There, I touched that little son-of-a-bitch, now I can go home." He marched back on his plane and flew back to Omaha.[263] Over Ryan's time at SAC, however, Lightning Bug operations became more reliable and important to Air Force operations in the Vietnam War. His interest in drones undoubtedly increased when he left SAC to become the commander in chief of Pacific Air Forces in 1967, right during the transition to low-level operations.

Ryan became a believer during those two assignments, for as Air Force Chief of Staff from August 1969 through July 1973, he directed an amazing expansion of RPV activity. Although his service was transitioning to a more feudal arrangement with the rise of TAC, he exerted his power as Chief of Staff to stimulate drone development. As mentioned, he shifted control of Lightning Bug program management from the NRO-funded Big Safari office in 1969 and initiated a number of major RPV programs rivaled only by the Army's SD series drones of a decade earlier. Not long after the RAND report, Ryan decreed that the Air Force would "obtain both strategic and tactical drone reconnaissance systems" and ordered TAC to formalize its Combat Angel drone operations in the budget process.[264] Concerned

A CH-3 helicopter returns to home base after recovering an AQM-34 RPV.

that others might not share his enthusiasm, Ryan commissioned an advocacy briefing for Air Force four-star generals world-wide. Ben Crane, the officer chosen to deliver the briefing, reported the RPV "road show" was always well-attended by interested audiences. "When you get the Chief behind something, the others fall into place," said Crane.[265] By 1972, the Air Force completely dominated DOD RPV development, directing 14 of 16 major US RPV programs and funding 23 of 29 speculative RPV technology development programs.[266]

The second Air Force Chief of Staff to play a role in RPV development was Ryan's successor, Gen. George S. Brown.[267] Like Ryan, Brown had a close association with drone technology prior to his time as Chief of Staff. From 1966 to 1968, he served as assistant to the chairman, Joint Chiefs of Staff; JCS exercised control over "national" drone reconnaissance assets being operated by SAC. After that, he went to Vietnam as the commander of 7th Air Force, where he managed the transition of the highly secret drone mission to a low-altitude, tactical reconnaissance mode. In 1970, only months after the release of the RAND/Systems Command report, Brown assumed the leadership of Air Force Systems Command, where he presided over an impressive expansion in Air Force drone development before taking over the Air Force's top position from Ryan in August 1973. By 1974, the Air Force RPV research and development request was almost $40 million, 97 percent of the total armed services and DARPA submission for that year.[268]

Although both Chiefs of Staff exerted top-down influence in the process, the main engine of UAV development came from the internal tension between SAC and TAC. Aviators in the other services habitually deferred to other "barons" when it came to UAVs, then proceeded to circumscribe UAV flight operations. By contrast, the battle between the aging monarch, SAC, and the pretender to the throne, TAC, served to stimulate RPV development efforts. Pilots fought pilots for control of an unmanned system and pushed for greater freedom of UAV flight within civilian airspace.[269] The main impetus came from TAC, for as was the case in other services, the subordinate, but rising sub-group assumed technological risk as a possible avenue for gaining power in the system. TAC's bid to control RPVs amounted to a campaign against two Cold War giants (SAC and the NRO), therefore they conducted it with an energy that accrued in great measure to RPV development, but as author and bureaucratic analyst James Q. Wilson predicted, did not result in RPV adoption.

TAC commanders fought hard for jurisdiction over RPVs, but SAC did not budge. Letters between TAC and SAC commanders, and TAC appeals to the Air Staff became strident in the early 1970s. The TAC commander, Gen. Robert J. Dixon, was clearly frustrated with the inability to get a favorable resolution through entreaties to the bomber generals who dominated the Air Staff.

Instead, he took the bureaucratic route. TAC staffs established a number of formal RPV requirements.[270] Dixon made sure RPVs figured prominently in TAC's revolutionary PAVE STRIKE program, a wide-ranging electronic combat development program focused on overcoming increasingly strong, interlocking Soviet air defenses in Europe.[271] He even personally injected RPVs into TAC's study for the next generation fighter aircraft that later became the Advanced Tactical Fighter (now the F-22 Raptor).[272] By the middle of the 1970s, three of the four major Air Force RPV prototype development programs originated from TAC requirements focused on air battle against the Soviets in Europe.

The NRO transferred all responsibility and funding for the development, adoption, and operation of drones to the Air Force in 1974. The NRO's Program D, which oversaw all "national" airborne reconnaissance, was disestablished Oct. 1, 1974. According to NRO director McLucas, the transfer made sense for a variety of reasons, but the main motivation had to do with the rise in sophistication and cost of satellite technology (especially electro-optical satellites), the abandonment of airborne reconnaissance over China in 1971, and the end of the Vietnam War.[273] In the world of "national" systems, the flow of history naturally selected the satellite, and drone programs were left entirely to the Air Force, which had its own bureaucratic battle brewing.

In a well-crafted 1975 letter to Gen. Russell E. Dougherty, CINCSAC, Dixon played his cards. First, he noted that the battle in Europe was "the most demanding task for tactical air" and that mission should be the focus of Air Force drone management.[274] Second, the issue was not management of the "present small drone capability," which Dixon described as one that "couldn't respond properly to CINCEUR's [Commander in Chief, European Command's] needs." Instead, the issue was the future: "We in the TAFs [Tactical Air Forces] see and have articulated a need for a major expansion of our drone capabilities," said Dixon, adding that only a single manager should oversee that effort. Having staked out his turf in the research and development budget, Dixon said, "I don't think you want your people responsible for a development effort that is more than 75 percent tactical Air Force oriented."[275] Dougherty stalled initially, but in light of Congressionally mandated force drawdowns and faced with the prospect of having to pay for drone production due to the recent abdication of drone funding by the NRO, he finally acceded to Dixon's all-out campaign.[276] On July 1, 1976, almost a year after the letter and a decade since the first attempts to control the drone program, SAC transferred all its RPV assets and supporting aircraft to TAC.[277] In rapid succession, two of the giant Cold War establishments, the NRO and SAC, abandoned drone programs to the aggressive, acquisitive Tactical Air Command.

TAC finally achieved its goal of operational control of Air Force RPVs. Three years later, every single RPV program was dead and the drone group at Davis-Monthan AFB, Ariz. was disbanded. The following sections address the highly innovative RPV development programs pursued by TAC, and how the RPV euphoria of the 1970s came crashing down so quickly after the management change.

■ Air Force RPV Programs of the 1970s

The Air Force pursued three major RPV projects during the 1970s, all with the European Central Front in mind. The first was Compass Dwell, the third in a procession of high altitude, long endurance UAVs slated to accomplish combat support missions such as intelligence and communications relay.[278] Compass Cope, the second major RPV project of the 1970s, constituted the fourth high-altitude, long-endurance attempt. It was important because it originated from a company-financed project within aerospace giant Boeing, which signaled greater industry seriousness about the UAV concept. The third major RPV project was actually three related attempts to modify the Lightning Bug series to fit into the warfighting plans for Europe. All three concepts were aggressive, even novel approaches to the combat UAV.

Compass Dwell

The extremely high operating and acquisition costs associated with the Combat Dawn SIGINT program concerned Air Force planners, who wanted to use that technology to locate hostile air defense radars in Warsaw Pact nations. As early as 1968 a new program for a high-altitude, long-endurance SIGINT project called Compass Dwell (initially called Comfy Bee), was initiated by the Air Force Security Services, probably under the aegis of the NRO's Program D or a separate NSA contract.[279] The program was submitted for bids in early 1970 and six major aerospace companies competed to build flying prototypes in a "fly before buy" arrangement.[280]

With Compass Dwell, Air Force intelligence planners hoped to solve two problems encountered with the Combat Dawn program. The first was to decrease RPV development costs. The inefficiencies in the multi-billion dollar Lightning Bug program, and the gross overspending on the purpose-built Compass Arrow project were well-known even though they were hidden in the "black" portion of the Air Force budget. Compass Dwell, which operated under normal Air Force acquisition practices rather than those of the "quick reaction" Big Safari office, was designed to inject competition into what many saw as Teledyne Ryan Aeronautical's lock on the drone business. Two companies (Martin Marietta and Ling Temco-Vought's Electro-Systems) were eventually selected for a competitive "fly before buy" contract, which called for 28-hour endurance at 40,000 feet—two simple but very challenging standards. The altitude requirement was important, for the flight environment above 40,000 feet puts the aircraft above all commercial aircraft and problematic weather disturbances.[281]

The second problem addressed by the Compass Dwell program was the high operations and maintenance costs of the Lightning Bug program. The main sources of high operational cost were Lightning Bug's air-launch and MARS recovery schemes. Combat Dawn, for instance, required DC-130 launch and helicopter recovery, which provided operational flexibility at great cost.[282] Using nascent two-way (full duplex) data link technology, Compass Dwell engineers wanted to design a drone that could take off from and land on standard airfields using a pilot on the ground.[283] According to extensive cost analysis, operating from standard runways would slash costs to a manageable level.[284] Also, Compass Dwell prototypes were "optionally piloted," that is, had a cockpit for a ferry pilot (which also contributed to greater learning about flight characteristics during the test phase) and was designed to be disassembled and packed into an Air Force C-141 Starlifter jet transport to solve the deployment problems inherent in the helicopter recovery method.[285] This was the first attempt to build a "drone in a box" that could respond from the continental US to any spot on the globe, an important attribute for any US weapon system.

The Compass Dwell program accelerated in 1970 after the Air Force-sponsored RAND symposium touted RPVs as a breakthrough concept. The competing contractors used commercially available sailplanes extensively modified into propeller-driven RPVs.[286] The program may have been inspired by a secret Army surveillance aircraft called YO-3A, a very quiet, propeller-driven modification of a civilian sailplane used to observe Viet Cong night movements.[287] The mission for these RPVs was high-altitude, standoff photography and electronic eavesdropping missions on the NATO-Warsaw Pact border. Because they were programmed to carry real-time data links, Compass Dwell also promised to be an important early warning tool for NATO commanders.

Compass Dwell's key design innovation was conventional runway takeoff and landing, but the endurance and altitude goals proved even more difficult.[288] One contractor opted to concentrate on the high-altitude requirement, offering a turboprop-engined version. This particular version had a contractor-estimated cost of $500,000 for the aircraft and $1 million for sensors and ground control equipment ($7.8 million in FY10 dollars).[289] The competing contractor concentrated on the endurance requirement, using a more efficient piston-engine to power its prototype. This model set an unrefueled endurance record of just under 28 hours, but neither model could meet both the endurance and altitude standards.[290] Still, the performance standards were stretch goals, designed to see how readily available technology could be adapted to the task.

Ultimately, the concept of operations for this innovative design ran headlong into the manned aviation meta-system. Because of Compass Dwell's endurance and altitude capability, US planners wanted its staring electronic eyes on Warsaw Pact forces on a 24-hour basis. This meant it would operate just above congested civilian airspace. European air traffic control agencies would not clear the aircraft for regular operations in commercial airspace due to the fear of collision with airliners.[291] More than any other impediment, the lack of European airspace clearance led to Compass Dwell's demise. That did not dampen the Air Force's enthusiasm for the concept.

Although foreign airspace control contributed to Compass Dwell's demise, its derivative, propeller-driven design also did not fit the Air Force's image of a futuristic, unpiloted plane. Some evidence exists suggesting that the Air Force viewed Compass Dwell as a speculative technology demonstrator rather than a legitimate candidate for adoption. For instance, SAC was skeptical of Compass Dwell's 40,000-foot ceiling, which was not high enough to get above the jet stream and made it more vulnerable to high winds, thunderstorms, and enemy fighter aircraft.[292] None of this skepticism seemed directed at the unmanned aspects of the design, however, for the Air Force canceled Compass Dwell in 1973 in favor of a significantly upgraded RPV program called Compass Cope.[293]

Compass Cope

The Air Force's Compass Cope project is important because it represents the first time a major aerospace company committed itself to a UAV project. Boeing, which embarked on a company-funded high-altitude, long-endurance UAV project immediately after the RAND/Systems Command RPV symposium, took the kind of clean sheet, technology-stretching approach the Air Force found attractive.[294] Bringing its significant resources to bear, Boeing also designed the system with militarization in mind, in particular, deployment capability (one C-5A held an entire operational system that could operate for 30 days) and flight reliability.[295]

In July 1971, Boeing won a sole-source contract to develop the jet-powered RPV which came to be called Compass Cope.[296] Concerned with the increasingly encumbered acquisition process, the Air Force inaugurated the Compass Cope program by issuing a one-page statement of work—shorter, it was said, than the one issued to the Wright brothers for their first airplane contract.[297] As it had with the Compass Dwell program, the Air Force was keen to avoid the cost escalation experienced in the sole-source Compass Arrow project, so they issued a competing contract to Teledyne Ryan one year later.[298] It must be noted that, in contrast to the normal acquisition practices of the day, Teledyne Ryan produced two flying prototypes in 18 months, and Boeing started actual flight tests with its two models only two years after the company began the program. Boeing began its test flight program of its large, 90-foot wingspan bird in July 1973 and Teledyne Ryan in August 1974.[299] Both programs were treated as "technology demonstrations" and not a "fly-off," but both companies knew they were in a struggle against one another for the lucrative Compass Cope contract.[300] Boeing won the closely contested contract in what amounted to an empty victory, for Compass Cope never reached production. The following paragraphs describe the program's trajectory.

Tactical Air Command jumped into the Compass Cope program as its prime advocate in 1973 with a concept of operations calling for a high-altitude relay drone (HARD), but the program attracted many more customers. TAC planners originally envisioned a loitering, tactical battlefield surveillance RPV that operated from standard runways, carrying a 750-pound payload up to 70,000 feet for 30 hours while providing communications relay for voice and video.[301] Eventually, they converged on the idea of having the high-altitude, long-endurance RPV carry the Precision Emitter Location Strike System (PELSS), which would identify and locate air defense emitters by triangulation from multiple high-altitude standoff orbits over Europe.[302] SAC wanted Compass Cope to perform the RC-135 mission for locating Soviet radar sites that threatened bomber ingress routes or to serve as an electronic monitor of Soviet missile testing.[303] Even the NRO got involved through its "Program D" airborne reconnaissance office. NRO director McLucas reported witnessing a Boeing demonstration of satellite drone control—probably the first in history—in which controllers in Seattle directed a surrogate drone flying over Hawaii.[304] The magazine *Aviation Week & Space Technology* reported National Security Agency involvement in the project due to the signals intelligence mission.[305] The Navy expressed interest in the project for conducting fleet surveillance in the Mediterranean, although they did not participate in project funding.[306] While the number of interested parties seems impressive, the diffusion of interest may have contributed to the program's weakness.

Soon, however, the program began to unravel due to cost overruns and two crashes in test flights. In all, this high-profile RPV program (the airframe and ground control station) absorbed $156 million in development costs (double the original estimate—$503 million in FY10 dollars) and would have required an additional $408 million for a production run of 40 air vehicles and associated ground equipment. This would have resulted in $1.8 billion using FY10 dollars, or $46 million in per-aircraft costs.[307] TAC gave Compass Cope strong support in its budget submissions to the Air Staff through 1975, but decided to pull its support in 1976, just as they were about to assume control of all the Air Force's drone assets. It was at that time that they broached the possibility of performing the high-interest radar emitter location mission with the U-2.[308]

An important reason for suggesting the U-2 as a replacement was that TAC planners could not ignore the thorny political problem of achieving clearance for RPV operations in Europe. Like Compass Dwell, the Air Force wanted to operate the high-flying RPV from bases in the US, Germany, Belgium, Great Britain, Holland, and Italy.[309] Unmanned craft did not comply with international flight safety rules for "see and avoid" unless accompanied by a manned aircraft to altitudes well above commercial air traffic. US rules required manned escort up to 18,000 feet, which may have been workable, but the air traffic control agencies of Belgium and Germany expressed doubts that they would allow a robot craft regular, sustained access to their airways.[310] Unfortunately, the unique ability of these aircraft to loiter for hours at high altitude and the common characteristic of runway operations both ran afoul of long-standing, pilot-centered airspace control rules.

Eventually, TAC lost all interest in Compass Cope, casting its gaze instead to an improved, enlarged version of the venerable U-2 called the U-2R. Although human endurance limited the duration of U-2R missions to five to 10 hours and Compass Cope had a nominal 24-hour operational endurance, the upgraded U-2 had much greater altitude and payload capability and dodged the airspace control issue. The most compelling argument for the U-2 was that the primary payload (now called the Precision Location Strike System, or PLSS) exceeded the load-carrying capacity for Compass Cope due to weight growth in that program. Also, in a classical example of how an innovative system has to fight history, the U-2's peacetime attrition data showed a much higher flight reliability than was expected for the RPV.[311]

The Air Force canceled Compass Cope after the House Armed Services Committee deleted funds for the program in May 1977.[312] Aerospace reporter John Rhea noted Compass Cope "has consistently been rejected by Congress as an exceedingly expensive vehicle for the proposed reconnaissance mission."[313] The same report that canceled Compass Cope recommended reopening the U-2 production line to build 35 PLSS-capable versions later known as the TR-1, a cheaper, more capable, and more familiar platform.[314] Although the Air Force spent hundreds of millions on novel, long-endurance craft that represented a niche where human pilots could not go, in the end, only a piloted aircraft was left standing.

With the cancellation of Compass Cope, the story returns to the primary focus of the Air Force's RPV push in the 1970s. The fast, jet-powered penetrating reconnaissance drone, which had been so effective in the Vietnam War, seemed like a logical answer to the rise in Soviet air defense capability. The projections for pilot attrition in an all-out war in Europe were astronomical by any historical standard. In this environment, the Air Force pressed ahead with plans for an improved, militarized version of the NRO's Lightning Bug drone that included, for the first time since the Navy's drone anti-submarine helicopter, the provisions for a drone that delivered ordnance.

The "Multimission" Lightning Bug

The success of the Lightning Bug operation in the Vietnam War caused the Air Force to pursue three lines of development in hopes of arriving at an improved version that would be useful to air combat operations in the European theater.

The first entailed quick-reaction modifications of existing drones along the same lines that had been pursued by Big Safari for over a decade. Many of these served as technology demonstrators and proofs of concept. Of the "one off" models pursued by the Air Force, reconnaissance versions included the television-guided drones, ones using LORAN for precision guidance, and even several attempts at real-time imagery (electro-optical) models.[315] TAC continued to develop electronic countermeasures models and worked extremely hard after the RAND/Systems Command RPV symposium in perfecting a strike drone capable of launching Maverick television-guided missiles.[316] The Air Force was enthralled with the idea of an RPV that could strike critical targets early in a conflict, and spent almost $50 million pursuing strike drone technology in the mid-1970s.[317]

None of the modification programs, however, proved adequate in addressing the weather, terrain, and extreme combat environment expected in the European theater. For that reason, TAC's primary effort focused on a new production drone (the second avenue of approach) that would answer its needs in Europe—the so-called "multi-mission RPV."

TAC planners were so enthusiastic about the idea of employing fleets of multi-mission drones (discussed below) to perform high-mortality missions that they issued contracts for engineering studies on a follow-on generation of multi-mission RPVs called the "advanced drone."[318] This third penetrating drone initiative was the first and only time that a US armed service actually invested in one generation beyond a developmental UAV system, a luxury usually reserved for proven, core weapon systems.

Still, the focal point of the Lightning Bug upgrade, and the most serious effort to make UAVs an integral part of air combat, was the multi-mission RPV, the subject of the following paragraphs.

The BGM-34C, the so-called "multi-mission RPV," superficially resembled the Lightning Bug but was designed to overcome the manifest flaws in the old system. TAC wanted a common, supportable, affordable system that could take advantage of microprocessor breakthroughs to deliver the combat capability promised at the RAND/Systems Command symposium. The BGM-34C featured interchangeable nose-mounted modules designed for either reconnaissance, electronic warfare, or air-to-ground strike missions.[319] Unfortunately, the new RPV system also included some very high-priced ancillary items such as a new DC-130H, a multiple drone control system, and more MARS helicopters (CH-53s due to the inability of the CH-3 to lift the heavier drones at high-pressure altitudes), all financed by the Air Force budget rather than the deep pockets of the NRO.[320] The TAC acquisition plan called for 145 BGM-34C air vehicles over six years, and contracts were signed in 1975.[321]

Only eight months after contract award, an Air Force design review team found significant cost growth in the multi-mission RPV program. Within two years, during a period of severe post-Vietnam War budget cutbacks, the program suffered several untimely test losses related to parachute recovery, a method never favored by TAC planners due to the difficult air environment they forecast for a major war in Europe.[322] After TAC became the Air Force's single RPV manager in 1976, they immediately pursued a ground launch and airbag recovery system (instead of being hooked in mid-air by helicopters, the drone parachuted to the ground and the impact was attenuated by inflatable bags).[323] The concepts of operations for this system seemed even more unlikely for an air-centric organization, for it involved the formation of ground launch crews and some sort of ground recovery vehicle to return the RPV to a launch site.

Through various exercises and tests, the operational challenges of operating drones in Europe became clear. In particular, TAC drone operators flew as part of the Coronet Thor exercise in Germany to test the viability of various data-linked sensors. The sensors proved "marginally effective" due to their short range in typically overcast European weather. The exercise showed the drones needed de-icing systems as well.[324] Concepts of operations required vulnerable DC-130 launch aircraft to venture very close to the forward line of troops to gain the proper penetration behind enemy lines.[325] Recovery operations demanded that US MARS helicopter pilots operate at 50 knots and 10,000 feet, right in the most redundant, deadly envelope for Soviet integrated air defenses.[326] A deadly pincer now squeezed the multi-mission drone concept. Program overruns strained Air Force budgeteers even as various operational studies and exercises revealed problems. The Air Force's RPV euphoria was turning to skepticism.

As noted, the transition of the Air Force's operational focus from Vietnam to Europe had a big impact on the failure of RPVs. This paragraph examines some of the operational efficiency drawbacks of the improved BGM-34C in the electronic warfare role. First, the aerial RPV launch and MARS recovery system kept the RPV sortie rate well below operational requirements. A TAC study in early 1973 estimated a minimum of 18 electronic warfare RPV sorties per day were called for, requiring eight DC-130 launch aircraft and 25 MARS helicopters. The yearly operations and maintenance costs necessary to maintain this meager capability (a BGM-34C unit) would have been $35.3 million, half of that used for launch and recovery costs.[327] Compare this to the costs for one F-4E wing (72 combat aircraft) at $25 million, and an A-10 wing (72 aircraft), $16 million, each of which could generate hundreds of sorties per day.[328] The lack of hardened shelters in Europe for launch and recovery aircraft meant these aircraft were unlikely to survive a Central Front ground war, and MARS recovery was unlikely in the persistent European overcast. Moreover, the US did not expect to have the kind of air superiority it enjoyed over Vietnam, and both launch and recovery operations for a drone unit required an almost pristine air sanctuary.[329] The 11th Tactical Drone Squadron maintenance experience showed that it took 24 hours to turn around a reconnaissance RPV after recovery, whereas an A-10 had a three-hour turnaround time.[330] Finally, a RPV unit required 32 C-141s and three C-5s for deployment, about the same as a complete, 72 aircraft F-4E wing, and the F-4s would be ready for combat at least three days before the RPVs.[331]

Underpinning the lack of meaningful military capability inherent in the BGM-34C concept, RPV technology lagged in several important areas. RPV data link vulnerability had not been addressed in development and would certainly contribute to cost overruns. A study conducted by industry advocates stated, "There is an urgent need to initiate efforts that will culminate in an imagery system design with the ECCM [electronic counter-countermeasures] capability to operate successfully in the probable jamming environment."[332] In a letter to the TAC commander, Gen. Wilbur L. "Bill" Creech, Teledyne-Ryan president Teck A. Wilson admitted that the BGM-34C "is a good drone" but "it won't change the current RPV limitations of relatively low sortie rate and high operating costs."[333] RPVs in Europe were an alluring idea on paper, and TAC committed millions in an attempt to turn conceptual potential into combat power. The technical, "genetic" limitations of the RPV and the supporting technology never made the transition from Vietnam, where it was a niche capability, to a configuration that allowed them to compete for an integrated role in air combat on the Central Front.

A largely overlooked but important reason for the cancellation of the BGM-34C multi-mission RPV involved its effect on the US defense posture under the Strategic Arms Limitation Treaty (SALT) II negotiations that had been going on since 1972. In that treaty, the Soviet Union pushed hard for limits on the emerging

A BGM-34 RPV being loaded with two Mk-81 bombs at Hill AFB, Utah.

US cruise missile capability, and the eventual agreements, signed by President Carter on June 18, 1979 included limits on cruise missiles under a definition that included, or "captured" in arms control parlance, the BGM-34C as a strategic weapon. Section II, Article 8 of that treaty defined cruise missiles as "unmanned, self-propelled, guided, weapon-delivery vehicles which sustain flight through the use of aerodynamic lift over most of their flight path and which are flight-tested from or deployed on aircraft." The language further restricted the term "cruise missile" to those capable of more than 600 kilometers (372 miles) as defined by "the maximum distance which can be covered by the missile in its standard design mode flying until fuel exhaustion." The treaty went on to say that if a cruise missile "has been flight-tested or deployed for weapon delivery, all vehicles of that type shall be considered to be weapon delivery vehicles."[334] Hearings conducted in 1979 and 1980 confirmed the applicability of SALT II treaty language and Air Force RPV programs despite their lack of a nuclear role.[335] Since the BGM-34C had one-way endurance well in excess of 372 miles and had been tested in a weapon delivery mode, it would be counted against US nuclear cruise missile limits even though it had no nuclear mission. The practical, warfighting reasons for TAC's growing skepticism concerning the BGM-34C were obvious, but the SALT II treaty removed any doubt about the program's survival. The rise of another innovative unmanned weapon system, the cruise missile, only served to magnify the RPV's difficulties in addressing its substantial credibility gap.

In December 1977, the Air Force and the Army conducted a joint study to coordinate US reconnaissance capabilities as part of the "TAC-TRADOC Dialogue" that signaled the death-knell for RPVs.[336] Directed by Air Force deputy chief of staff for research and development, then Lt. Gen. Alton D. Slay, the Air Force/Army Reconnaissance Force Study recommended cancellation of the BGM-34C (and the associated DC-130H and multiple drone control system) due to high cost and limited operational capability.[337] Funds from that cancellation helped replenish dwindling stocks of spare aircraft parts that threatened to cut into force readiness.[338] As an additional measure, the entire TAC RPV group at Davis-Monthan AFB, Ariz. was disbanded in March 1979 to accelerate the EF-111A Raven electronic jamming aircraft program.[339]

As the primary Air Force advocate for RPVs, TAC vigorously opposed the Air Staff's budget submission, but the trend toward major RPV cutbacks went even farther.[340] As a final measure, the five-year Air Force RPV research and development budget was slashed from $500 million to $150 million.[341] Having fought for and taken control of RPV acquisition in 1970, and having wrested the entire RPV budget from the NRO in 1974, the Air Force had in the course of five years dropped all ongoing operations, closed its RPV group, and canceled all its major RPV projects. The Air Force RPV hysteria of the 1970s was dead.

Why the Air Force Abdicated on RPVs

Why had Air Force RPV programs cost so much, taken so long to reach flight test, and failed so miserably to make the transition from the Vietnam War to Europe? This study already has discussed specific reasons for the failure of each system, but there are additional issues that applied across the various RPV programs. They reveal some of the fundamental shortcomings of the large, fast, high-flying RPV types that the Air Force pursued throughout this period. After the Vietnam War, the RPVs had to compete with mainline projects instead of the more comfortable world of the NRO and the black, wartime budget that allowed for extravagances like Lightning Bug. The failure of RPVs in the 1970s is the story of a failure to compete in a very open, unforgiving peacetime environment.

The sequential abdication of drone reconnaissance by the NRO (1974) and SAC (1976) contributed to Air Force schizophrenia during the RPV push in the 1970s. On the one hand, the Air Force pushed hard for control of drones throughout the Vietnam War eventually turning them more into tactical rather than "national" reconnaissance tools. Moreover, TAC's attempt to "corner the drone market" through aggressive research and development stands out for its boldness. On the other hand, however, the NRO's deep pockets had provided an unreal world for RPV development and the Air Force was not prepared for the inefficiencies that accompanied those programs. "Some viewed NRO funding as extravagant, with too easy access to funds," said McLucas, who added that the rift between the NRO and the Air Force "hamstrung USAF learning" about applying NRO assets to combat.[342] Years of NRO stewardship constricted the formation of internal constituencies in the Air Force. Although TAC fought hard for leadership on RPV issues, it really only represented another futuristic part of its overall modernization plan. Air Force historian John I. Lumpkin noted the effect on TAC as a result of the withdrawal of "special [NRO] support," saying, "drones [now] had to be justified under strict cost effectiveness criteria."[343] Cost effectiveness, as it turned out, was not an attribute of any RPV program of that era.

The consistent cost overruns experienced by every single drone program seem odd, since affordability was supposed to be their key advantage. One reason for the failure of Air Force RPVs was the "normalization" of RPV acquisition after Big Safari. Although the piecework and heavy contractor manning used in the black, "quick reaction" Big Safari program had its inefficiencies, these began to appear small after RPV acquisition joined the "real" Air Force in 1970.[344] Whereas the NRO traded money (of which they had a seemingly endless supply) for time, the Air Force tried to save money. Whereas the TAC chaff-dispensing drone (developed by Big Safari) was developed in 12 months and the reliable Combat Dawn SIGINT drones were tested and deployed in four months (at great expense), improved Buffalo Hunter drones developed through normal acquisition channels took about five years to reach Vietnam, too late to make an impact. Col. John B. Rosenow, the chief of Air Force RPV acquisition during this period, noted the issue was time, which translated into money.[345] Not even the Packard initiatives of the 1970s (of which Compass Cope was an example) that attempted to circumvent burdensome acquisition rules kept RPVs from being very high-cost items.[346] So, even though "black" Big Safari costs drove Vietnam War drone development and procurement to a price tag more than $1 billion over 12 years and restricted competition due to its "sole source" arrangement with Ryan Aeronautical, the transfer to the "white" world brought with it its own inefficiencies and pitfalls.[347] Whether they go fast or go slow, UAV programs were always expensive because they were so technologically and operationally complex.

The myth of affordability that haunted UAV programs of the 1970s (and persists today) was a natural but pernicious byproduct of the innovator's dilemma. To break through the crust of resistance, RPV advocates aggressively and irresponsibly hawked their product as providing huge cost savings that could not be realized. Even as RPV programs ballooned out of control, a Brookings Institution report cited the RPV as "perhaps the best way of all to break out of the cost spiral in which manned US designs seem to be trapped."[348] Even though technologically simpler cruise missiles cost more than $1 million per copy, RAND predicted attack RPVs could be built for only $200,000 each.[349] As mentioned earlier, Foster exacerbated the problem.[350] In fairness, the 1970s economy contributed to the volatility of the environment in which UAV programs competed—inflation soared, the dollar fell, and the average cost overrun for major military programs was 36 percent.[351] Still, the lack of technological savvy or pure zealotry of many commentators caused them to ignore the complexity and cost of even rudimentary UAV systems.[352]

By 1975 the folly of those projections had become clear as RPV programs spilled over in cost and more importantly, schedule slippage. Those manifest problems drove away both the Air Force and major aerospace contractors. Air Force Undersecretary (and NRO director) James W. Plummer told an RPV industry audience, "The initial enthusiasm engendered by this 'lower cost' idea, perhaps, has been over-publicized and the 'dollar savings' potential improperly interpreted."[353] In this post-war environment, neither the government nor major aerospace corporations could be expected to invest large sums in speculative projects that habitually overran projected costs. By 1977, one executive from a major aerospace contractor estimated his industry had invested $50 million to $100 million in RPV development and had nothing to show for it.[354] Ironically for well-meaning enthusiasts, the unrealistic expectations they created, despite overwhelming evidence to the contrary, poisoned the RPV development environment.

A BGM-34 with two AGM-65 Maverick missiles at Michaels Army Air Field in Utah.

Unfortunately, the Air Force had to carry the RPV torch alone during this period. The lack of interest shown by the other services minimized interservice rivalry, always a goad to action on an emerging system. The post-Vietnam Congress, meanwhile, was more interested in cutting the defense budget and "wasteful" Air Force projects than stimulating interest in UAVs. Despite some sparse pro-UAV rhetoric, Congressional emphasis on jointness and efficiency ended up cutting ambitious Air Force UAV development budgets—spending that an innovative system requires to close the capability gap between it and competitive systems. Congress viewed RPVs as another in a long line of wasteful military programs and, buoyed by the anti-military environment after Vietnam, cut the Air Force's $8.4 million Fiscal Year 1974 RPV request, citing "past waste in this area" and "the resistance of the services to full cooperation in a tri-service effort."[355] This was the first glimmerings of the alluring concept of UAV "commonality," or the creation of one program with more than one service end-user. The Air Force's bid to convert intelligence RPVs to conventional military use remained a solo campaign for the greater part of a decade.

Finally, technology stimulated but failed to float the RPV revolution. Although microprocessors allowed the cockpit picture to be transmitted, that "kite-string" of radio control could be clipped quite easily by electronic countermeasures. Early generation microprocessor-driven flight control schemes could not approach the trained human's piloting skill—the task of automating flight operations required quantum increases in computing power and speed to approach flight reliabilities commensurate with RPV cost. Air vehicle location accuracy, moreover, still relied on very expensive inertial navigation systems, which still became less accurate as a function of flight time.

Ultimately, however, the shift from the relatively benign environment of the Vietnam War to the Central Front in Europe raised the technological bar so high that it highlighted all the RPV's deficiencies. The Soviet electronic warfare, integrated air defense, and manned aircraft threats in Central Europe posed an order of magnitude greater threat than the one presented by the North Vietnamese. It would have been impossible, for instance, to establish the air superiority necessary to conduct routine RPV flight operations over Europe. The RPV proved acceptable (if expensive) for limited intensity conflict, but failed entirely to show meaningful utility for the major focus of Air Force plans in the 1970s.

In 1973, *Aviation Week & Space Technology* editor Robert B. Hotz proclaimed, "The RPV appears to be one of those interesting things that emerge at a time when technology, economics and politics blend into an urgent feasible requirement."[356] Hotz may have been right about the elements of an innovative breakthrough, but not about its timing. The Air Force's aggressive attempt to integrate RPVs into its standard war plans amounted to a failed, multi-billion dollar technology development program. For specialized roles such as the support of national intelligence collection, the unmanned system had a certain attractiveness, and with the rise of satellites, even that faded. For the anticipated environment in Europe, as deadly as it would be for US pilots, the RPV still had physical and technological limitations that made them a bad investment. The years that followed revealed how the UAV, however alluring, still lacked the fundamental capacity to establish an enduring place in Air Force operations.

The 1980s—a UAV Hiatus

In the 1980s, UAVs were not pushed but were in fact eclipsed by other systems that emerged in this period of rapid Air Force transformation. A study of those competitive systems reveals that, rather than rejecting pilotless vehicles out-of-hand due to some deep-seated cultural resistance, the Air Force pursued more lucrative and equally innovative avenues for dealing with the Soviet air defense threat. In fact, RPVs may have stimulated those alternative innovations by providing a less useful contrast. Writing of the innovations in defense during the 1950s, Samuel P. Huntington concluded that some "grand schemes" actually "perform a useful, if negative function, by revealing their impracticality" because they can "clear the way and generate support for more modest steps to deal with more immediate problems."[357] So it was with the "grand scheme" of Air Force RPVs of the 1970s, and the 1980s only served to reinforce that point.

Air Force RPVs developed during the 1970s were to accomplish three missions in a major war in Europe against Warsaw Pact forces: 1) weapon delivery against heavily protected targets; 2) tactical electronic and optical reconnaissance (both high and low altitude); and 3) electronic combat (jamming and chaff dispensing). All three represented important capabilities contributing to the achievement of air superiority, an essential pre-condition of successful US military operations since World War II. How the Air Force accomplished these missions in the 1980s without RPVs makes for an interesting study in dynamics of weapon system innovation.

■ Weapon Delivery

In keeping with the military's demonstrated bias toward force application at the expense of support functions, the Air Force made its greatest strides in its ability to strike high-value targets in the enemy's rear areas. Although the RPV was to be a part of that capability, radar-evading "stealth" technology and precision-guided standoff munitions proved to be clearly superior to the RPV. The manned system that most exemplifies the Air Force's quest to deal with the problem of Soviet air defenses was the stealth fighter, designated the F-117 Nighthawk.

In response to the heavy aircrew casualties suffered during the Vietnam conflict, a variety of small experimental aircraft were tested in the 1960s and early 1970s to determine the feasibility of "stealthy" aircraft—air vehicles incorporating design and materials technologies to reduce radar detectability.[358] About the time the Air Force canceled all its RPV programs the stealth fighter had just demonstrated breakthrough low radar observability and was about to enter full scale development.[359] The F-117, despite its "fighter" designation, was actually a bomber whose core capability was delivery of its two 2,000-pound laser-guided bombs in heavily defended rear areas. This obviously diminished the RPV's attractiveness for the strike mission because the F-117 resolved the conflict between achieving military effectiveness and protecting US pilots in a way that UAVs could not. Although the stealth fighter caused great conflict in the Air Force due to its novelty, it avoided the substantial organizational perturbations inherent in UAV operations by placing the innovation in a comfortable package.[360] Despite all the internal conflict over the odd plane, the Air Force fielded it in time for it to make a monumental, disproportionate contribution to the air campaign against Iraq in the 1991 Gulf War. The highly secret F-117 "stealth fighter" absorbed almost $13 billion in FY10 dollars and produced a weapon system that revolutionized air war, saved lives, and eclipsed the Air Force's 1970s RPV technology push.[361]

An equivalent investment in RPVs would not have resulted in a similar breakthrough capability. The main reason for this has to do with the vulnerability of the RPV data link.[362] The low-altitude RPV required either a large constellation of satellites or loitering high-altitude aircraft to relay the high-bandwidth electro-optical and infrared imagery to RPV control sites.[363] The cost of the former would have been astronomical, and the survivability of the latter was highly suspect in the likely combat scenario. The optical RPV data links would have had to work in a hostile jamming environment. Furthermore, imagery and RPV flight control information would have required links stamped with distinct codes to operate multiple RPVs at one time. Although the F-117 incorporated an unprecedented level of au-

Dr. Eugene G. Fubini, Assistant Secretary of Defense for Research and Engineering in the early 1960s.

tomated flight control due to its awkward aerodynamic design, and relied on arcane technology to achieve its small radar cross-section, the pilot still controlled flight and guided the weapon to the target. This fact made countermeasures much more difficult than simply jamming the vulnerable data link to multiple attack RPVs.

Standoff munitions also came into their own in the 1970s and stole the force application role proposed for RPVs by the Systems Command/RAND symposium.[364] Among the standoff munitions that broke through to operational significance were the high-speed anti-radiation missile (HARM), the laser-guided bomb, and the cruise missile.[365] The most important to this discussion was the air-launched cruise missile (ALCM) because, although it was a nuclear weapon delivery system that did not replace the conventional RPV, it demonstrates how an innovative, unmanned system could bridge the credibility gap even as others (like the RPV) failed.[366]

Whereas the Air Force generally supported the RPV in the early 1970s, it resisted ALCM because it competed with SAC's B-1 bomber for the nuclear weapon delivery role.[367] The B-1 was slated to be the replacement for the aging B-52 and was the only serious intercontinental bomber program in more than a decade. Arguments over the B-1 polarized into pro- and anti-cruise missile advocates, turning the ALCM (and the Navy's Tomahawk) program into a battle between an unlikely group of civilians and the bomber pilots who ran the Air Force.[368]

Advances in electronics, fuels, and small turbofan jet engines (born in Air Force development projects) put the ALCM within reach, but politics put it across the gap. Technological developments were shepherded by people like John Foster and William Perry, both influential civilians working for the Secretary of Defense. Teaming with DOD insiders, however, was the powerful Secretary of State, Henry Kissinger. In 1973, Kissinger told Deputy Secretary of Defense William P. Clements Jr. that cruise missiles would be a great bargaining chip in the SALT talks, a move that kept the program alive.[369] ALCM also provided political leverage for President Jimmy Carter, who took office in 1977. As part of his desire to reinvigorate arms control and cut defense spending, he canceled the B-1 in favor of a force of B-52 cruise missile carriers.[370] Three tiers of very powerful civilians pushed ALCM through the process against Air Force and Navy objections. Operationally, the cruise missile fit into a comfortable operational mode that made it easy for the Air Force to make it work, paving the way for its innovative employment. Thus, ALCM bridged the innovation chasm because its technology was mature, the political impetus existed to break through service skepticism, and ultimately, the cruise missile required minimal operational adaptation.[371]

When cruise missiles gained operational status in the Air Force, they did more than steal a role from UAVs. They also stimulated a series of arms control agreements that constricted the expansion of UAVs into weapon delivery roles. SALT II arms control treaty language "captured" air-launched weapon-delivery UAVs (such as the BGM-34C) in US cruise missile totals. The 1992 Strategic Arms Reduction Talks (START) extended that ban, limiting any unmanned air vehicle with a range exceeding 370 miles.[372]

The 1988 Intermediate Nuclear Forces (INF) arms control agreement added to the problem for UAVs by including specific language prohibiting ground launch-capable cruise missiles for the purpose of force application—language unambiguously applying to ground-launched UAVs.[373] Specifically, the treaty excludes "an unmanned, self-propelled vehicle that sustains flight through the use of aerodynamic lift over most of its flight path," has demonstrated weapon delivery, and has an unrefueled, straight-line range between 310 to 3,410 miles.[374] Lt. Gen. Gordon E. Fornell, USAF (Ret.), who studied this issue for the Air Force Scientific Advisory Board, concluded, "Any decision to convert an existing UAV to a weapon-delivery role would subject all UAVs of the same type to needless arms control restrictions or possibly ban them altogether."[375]

US INF negotiators tried to retain wording that did not apply to returnable unmanned systems, but did not succeed. Joint Staff INF negotiation chief Michael O. Wheeler remembered that some in OSD "wanted to ban only nuclear-armed systems in order to keep open the option for the US of exploiting future generations of UAVs." But, he added, the Joint Chiefs of Staff agreed to a total ban because verification problems with a partial ban would be overcome by getting rid of all weapons of the type.[376] Wheeler noted at the time, "I see no way to broadly interpret the treaty so as not to consider GLCMs of INF range *which are weapon delivery vehicles,* whatever the nomenclature (RPVs, UCAVs, etc.), to be systems constrained by INF."[377]

What we see here in the contrast between the RPV boom and bust of the 1970s and the various other innovations of that same period demonstrates the chemistry that must exist between external and internal forces in the process of weapon system innovation. The RPV did not have an internal constituency, but neither did the ALCM. The ALCM had substantial political impetus behind it that allowed civilians to eclipse internal service resistance to adoption. Furthermore, internal operational practices were not violated by ALCM, which was just another fire-and-forget munition, and its technology was much more mature than the RPV's, making adoption less problematic. The stealth fighter enjoyed substantial (but not unilateral) internal support that allowed civilians to employ much less energy in pushing the system to operational status. Operationally, it caused very little organizational angst compared to that posed by the RPV.

■ Reconnaissance

In the area of electronic and optical reconnaissance platforms, the Air Force was not nearly as innovative. The tactical reconnaissance mission at which Lightning Bug excelled was neglected when the RPVs were canceled. The only low-level tactical reconnaissance platform left standing after the drone group was disbanded was the venerable RF-4C Phantom, a modified jet fighter that first entered service in 1964. The Air Force did not even modernize that force with any enthusiasm. For example, the RF-4C never received an electro-optical (data linked) imaging system even at the time of its removal from the field in 1994.

Airborne reconnaissance innovation came in the form of sensors, not platforms. Major post-1979 tactical reconnaissance improvements were realized by mounting highly sophisticated sensors on the old, reliable U-2. The Air Force bought 35 U-2R variants (called the TR-1) in 1979 ostensibly to carry the PLSS.[378] The PLSS was never fielded, but the TR-1 ended up carrying (among many other payloads) the highly classified Advanced Synthetic Aperture Radar System-2 (ASARS-2) that produced near-photographic quality ground images through the clouds at considerable standoff ranges.[379] Those images were transmitted by data link to ground stations (including Army mobile stations) at ranges of more than 200 miles, or stored onboard for later download. By the end of the 1980s, the TR-1 could transmit its ASARS-2 images via satellite to ground stations world-wide, a breakthrough of substantial proportions.[380]

The Air Force greatly accelerated the fielding of innovative sensors like ASARS-2 by mounting them on a proven manned platform like the U-2, an entirely rational choice. In doing so, however, it also deferred vexing operational issues (like integrating unmanned aircraft in controlled airspace) involved with operating UAVs. The TR-1 is another in a long line of "UAV killers" that succeeded in no small part due to their congruency with established service and aviation meta-system practice.

In a similar fashion, UAVs lost the electronic countermeasure role when special pods (chaff-dispensing or electronic) mounted on individual aircraft and extremely high-powered radar jamming technology favored manned aircraft. Laying down chaff corridors (dropping long strings of radar-spoofing materials) to protect strike aircraft, a technique used in the Vietnam War and the reason for TAC's drone fleet in the late 1960s and early 1970s, fell into disfavor because more sophisticated Soviet radars could quickly distinguish aircraft from the chaff.[381] Electronic countermeasures such as jamming or deception migrated from specialized platforms like drones to be mounted on individual attack aircraft. For specific roles where special electronic aircraft were needed, drones proved to be inadequate electronic countermeasures platforms. For brute-force standoff jamming, for instance, the small drone was simply not large enough to carry the electronic gear, nor was its small jet able to provide the necessary electrical power. The EF-111A Raven standoff jamming aircraft (built in part with money from canceled RPV programs) carried three tons of electronic jamming gear, had an operational radius in the thousands of miles, and still could operate at altitudes above 50,000 feet.[382] Its two powerful turbofan engines produced the wattage required to do standoff radar jamming, especially the massive power required to jam modern Soviet radars using frequency-hopping.[383] Like the F-117, the Raven had a steep cost but produced a jamming capability unreachable by the RPV technology of the day.

The programs highlighted here support a major finding of this study. After selecting from a menu of technical options for meeting an operational requirement, a service's success at achieving weapon system innovation with one option can have the side effect of choking off development of equally innovative and promising options. In each of the above cases, systems more capable and more congruent with established operational routines were adopted instead of the UAV. The threat posed by Warsaw Pact forces in Europe demanded fielded systems. By aggressively investing in UAV technology in the early 1970s, Air Force leaders came to the conclusion that the technological immaturity of UAV systems precluded their use in Europe. UAVs for general purpose forces had technological and operational shortfalls, solutions to which demanded more than just interest in the idea of a UAV. They required a national catalyst for development, a catalyst that did not exist.

The one remaining shortfall that could have been addressed by a UAV system was fast, low-altitude jet reconnaissance in heavily defended areas. Although the Air Force had eliminated that capability from its force structure, the effectiveness of Lightning Bug drones in Vietnam still weighed on the minds of some in the defense establishment. The Air Force soon found itself engaged in another "cooperative" project to develop an improved Lightning Bug. This time, however, the agency with which they had to cooperate was the Navy instead of the NRO.

■ The Joint UAV Experiment

Since the early 1970s, Congress and civilians in the defense department rapidly expanded advocacy for "commonality," a 1960s term for military programs that attempted to achieve efficiency by having multiple service customers. The logic behind commonality was simple. Both the Air Force and the Navy required a similar type of aircraft, for example, so one jet could fulfill the requirements of both services while achieving economies of scale in favor of the taxpayer.

Secretary of Defense Robert S. McNamara's flawed "tactical fighter, experimental," or TFX fighter of the late 1960s embedded the term "commonality" in the defense lexicon. McNamara and his "whiz kids" wanted the TFX program to demonstrate the wonders of commonality, unfortunately it ended up a highly politicized, highly public failure.[384] The TFX remains an object lesson in how the services' unique operational venues drive diverse technology solutions, and how the services will aggressively protect their control over the design of weapon systems their warriors use in combat.

The push for commonality, a term which in the 1980s transmogrified into "jointness," caused a consolidation of UAV development in the mid-1980s.[385] Anxious to shift the weapon system acquisition power center from the services, reformers ignored Harvard political scientist Graham T. Allison's admonition: "Government leaders can substantially disturb, but not substantially control, the behavior of these organizations."[386] Intrusive, extra-service management of UAV development, stimulated by the failed Air Force RPV spending spree in the 1970s and fueled by the growing Congressional staffs, now became an important part of the political and structural context for UAVs. The first program to test the ability of "joint" UAV management to either rationalize or disturb was one which met a glaring tactical air reconnaissance shortfall not addressed since Vietnam—the Medium Range UAV.

■ Medium Range UAV (BQM-145A)

On March 11, 1985, under direction of the Joint Staff, the Air Force signed a memorandum of agreement with the Navy to produce a jet-powered tactical reconnaissance UAV to support air operations.[387] The heart of the so-called MR-UAV (Medium Range UAV) system was a small, fast, jet-powered aircraft that amounted to a more stealthy, data-linked Lightning Bug. As with that system, the MR-UAV could be either air-launched from manned aircraft or ground-launched using an expendable rocket assist. In the memo, the Navy assumed the lead for the air vehicle and control system, whereas the Air Force took responsibility for developing a digital, electro-optical sensor with a data link called the Advanced Tactical Airborne Reconnaissance System (ATARS).[388] ATARS was planned to be a modular, "joint" payload, able to be used on the UAV and as a pod on manned replacements for the RF-4C Phantom (i.e., the Air Force's F-16 Fighting Falcon or the Navy/Marine Corps-operated F/A-18 Hornet).

Air Force planners gave the MR-UAV a unique mission profile and organizational structure. Because the air vehicle could be programmed to fly low-level missions that hindered real-time data links due to line-of-sight limitations, ATARS would record the low-level imagery and once back in friendly airspace, the UAV would zoom to high altitude and transmit the data to a ground station.[389] In 1989, an Air Force study solidified support for the MR-UAV program by identifying a future tactical reconnaissance shortfall (due to the imminent retirement of the RF-4C), and calling for a large commitment to both manned and unmanned tactical reconnaissance platforms.[390] In a novel organizational plan, the Air Force asked for five F-16R (tactical reconnaissance aircraft) squadrons employing 20 UAVs in each squadron.[391] Mixing both manned and unmanned jets in one organization had the potential to force resolution of air control issues and might have resulted in unique approaches to tactical reconnaissance.

As aggressive and innovative as the MR-UAV employment plan looked, the JPO acquisition structure and Congressional pressure hindered Air Force efforts by adding requirements to the airframe design that limited its utility for its planned UAV employment concept. Backed by a coalition of defense reformers, efficiency experts, and the GAO, the JPO pursued airframe commonality with a vengeance.[392] As the most visible piece of the UAV program, the air vehicle design suffered the most pressure to be a common solution, despite the low cost of that element of the program as a percentage of overall program cost, and the greater importance of commonality in other areas such as the data link and ground control system. The air vehicle, the component with the most sensitivity to different operating environments, was forced into a "one size fits all" mold to satisfy the push for jointness.

In 1989, that push had led to the establishment of the UAV Joint Program Office, which oversaw the fractured, diluted MR-UAV program until its demise in late 1993. Under JPO direction, the MR-UAV program unraveled in part due to Navy-mandated airframe modifications, major cost increases and time slippage, and irresolvable problems with ATARS. The MR-UAV development contract ballooned from $70 million in 1989 to $187 million in 1993. Airframe cost increases came due to Navy-unique stipulations including a MARS recovery system using the SH-60 Seahawk helicopter and a metallic body to minimize corrosion, electronic interference, and to handle the violent environment of carrier landing and takeoff when strapped under the wing of carrier aircraft.[393] The Navy's requirements, while wholly rational for its seagoing environment, gradually lessened range, speed, and altitude capabilities that the Air Force wanted and drove the price high enough to erase planned economies of scale. Delays in the Air Force-run ATARS program exacerbated program slippage, and in doing so, the MR-UAV missed a critical opportunity to prove itself in combat.

Unlike the Lightning Bug program, which was at least deployable (if not mature) when Vietnam escalated in 1964, MR-UAV was not close to production when the massive buildup for the Persian Gulf War kicked off in late 1990. As a result, the Air Force, when war came, was the only service to operate without a UAV, even in an experimental capacity.[394] As forecast by the Air Force study of a few years earlier, Gen. Charles A. Horner, USAF (Ret.), the coalition air chief as a lieutenant general, did not have enough tactical reconnaissance assets and commented after the war that the Air Force should buy a "cheap" UAV for that role.[395] Horner's comment reveals a key perceptual problem—the MR-UAV was far from cheap.

Not only had he unwittingly bought into the lore of "cheap" UAVs, but his comment also revealed the warrior's culturally based disdain for reconnaissance. The demands of ever more precise munitions and the speed of modern communications increased the importance—and price—of target reconnaissance and bomb damage assessment. Unable to resolve the cost-capability conundrum and in an environment where it had cut its tactical reconnaissance waiting for the F-16R, ATARS, and MR-UAV, the Air Force found itself lacking in wartime. Getting caught short in the Gulf War served to stimulate Air Force desires for MR-UAV and ATARS, and it forged ahead with its ambitious tactical reconnaissance plans. By the end of the Gulf War, the Air Force position was firm—they wanted the MR-UAV.

The war may have stiffened Air Force resolve, but diffused, weak management and the end of the Cold War crippled the program. The MR-UAV and ATARS programs spiraled out of control just as budgets were being slashed in the post-Cold War environment. The UAV JPO estimated the program's total cost (based on 525 air vehicles) had increased more than 300 percent to $2.3 billion ($3.5 billion in FY10 dollars), or $6.7 million per copy.[396] The cost increases and budget environment were remarkably similar to that of the mid-1970s when the MR-UAV's predecessor, the BGM-34C multi-mission RPV was canceled. An Air Force post-Cold War force structure reassessment slashed the F-16R request in half and reduced the MR-UAV total to 145 airframes.[397]

To make matters worse, the Navy-led JPO had apparently ignored the Air Force requirement for a ground launch system. Due to the expense required to bring the launcher up to specifications, the Air Force dropped the ground launch option entirely.[398] Despite this, the MR-UAV was a solid airframe, albeit a metal one with shorter range than the Air Force would have liked. ATARS was also in serious trouble, for its size and weight were still incompatible with the UAV's configuration and performance goals.[399] On June 23, 1993, Air Force Chief of Staff McPeak terminated ATARS after analyzing its significant cost, size, weight, and performance problems.[400]

Nevertheless, the Air Force retrenched, maintaining its advocacy for the MR-UAV for over four months despite the complete withdrawal of the Navy. Planners hoped to deploy the UAV using lesser-quality payloads than the too-ambitious ATARS, giving the low-level mission exclusively to the MR-UAV and the medium altitude job to the F-16R.[401] These amounted to tactical maneuvers in a hopeless budgetary and programmatic environment, however. The Navy's withdrawal and Air Force cuts to the F-16R buy sent per-unit costs skyrocketing. The entire MR-UAV project was terminated by new defense acquisition chief Deutch in October 1993 because it was "not affordable given its priority within the UAV family and resources available."[402] The Cold War's end certainly played a role in dampening the Air Force's enthusiasm for an unmanned penetrator, but ultimately the program failed due to over-reliance on jointness as a measure of air vehicle merit and the Air Force's own poor handling of ATARS.[403] The "perfect" tactical reconnaissance system ended up as a few minimalist pods on Marine Corps F/A-18 Hornets and eight low-rate production MR-UAVs sitting on the shelf at Tyndall AFB, Fla.[404]

The story of the MR-UAV brings the period of service-run UAVs to a close. Although reformists genuinely thought the centralized coordination scheme would result in breakthroughs, the UAV Joint Program Office failed to live up to its billing and was mortally wounded by the demise of its most substantial program. The services wanted the freedom to develop designs adapted to their particular operating environments and needs. Trying to make one system fit two or more services' needs diluted support and created insuperable integration problems. On the other hand, the MR-UAV's failure highlighted the frustrations of futurists who, not understanding the absolute or relative technological limitations of the breed, speculated that the Defense Department's federal structure was to blame. This left the Administration with a choice. Believing the former would lead UAV acquisition structure back along traditional lines with the services developing their own systems. The latter rationale, by contrast, suggested even more draconian centralization—an NRO-like manager of UAV systems with complete authority to rationalize UAV design and procurement. Under that arrangement, the services would become mere operational receptacles for systems developed and handed down by a central authority. The outcome was even more radical than the latter vision suggests.

In Summary

This study began by quoting the 1956 statement of an Air Force officer, Maj. Gen. David H. Baker, forecasting the demise of manned combat aircraft. Yet, some 35 years later, the Air Force had operated only one UAV system in combat. The general did go on to say, "We cannot predict the time at which this [the replacement of manned with unmanned] will happen. In the interim we must continue to advance as rapidly as possible in the quality of our manned aircraft."[405]

With regard to UAVs (the Air Force was pursuing ballistic and cruise missiles), that statement—more than the one which preceded it—characterized the Air Force of the intervening years. In 1970, a major Air Force study with the charter of looking 15 years into the future concluded that drones would "supplement and, in some cases, supplant manned aircraft in all the traditional missions of the tactical Air Forces."[406] Yet, by the 1985 target date of the study, the Air Force possessed no operational UAVs and had only recently been cajoled into joining a Navy-initiated effort to modernize a UAV system SAC proved in combat some 20 years prior.

What explains the wide disparity between rhetoric and performance? The statements quoted in the preceding paragraph serve more as an indicator of the Air Force's addiction to advancement of aerospace technology than as a benchmark by which to measure its performance. One's judgment about where the Air Force stands on the spectrum of obstructing an uncomfortable but viable system on the one hand, or irresponsibly bingeing on a seductive but immature system on the other, turns on an assessment of unmanned aviation technology, both in absolute and in relative terms. The evidence suggests external and internal explanations for how the Air Force could operate the most successful combat UAV ever in the Vietnam War, yet fail to extend that success to the strategic environment that followed.

The motivation for unmanned aviation continued to be the perceived relationship of manned aviation to the threat posed by enemy air defenses—a threat apparently perceived more sharply by the Air Force than by other services. Spurred by the rise of the Soviet air defense missile systems in the 1960s, virtually the entire Department of Defense RPV research and development budget request in the early 1970s came from the Air Force. So compelling was that threat, in fact, that the Air Force searched simultaneously in many different areas for an answer to what some prophesied as its looming demise as a service.

UAVs were simply one of the many avenues that held possibilities for answering the air defense challenge, and they lost the competition rather decisively. Although the systems (manned aircraft and standoff munitions) chosen in lieu of UAVs were more operationally and culturally comfortable, they were also undoubtedly more effective. Innovative investments such as the stealth fighter, laser-guided bombs, and electronic jamming aircraft made in the late 1970s and early 1980s crushed a very sophisticated Soviet-style integrated air defense system in the 1991 Gulf War, paving the way for a quick and relatively bloodless victory. It was a shattering takedown far more impressive in scale and complexity than the Israeli attack on Syrian air defenses in 1982 and it was done without UAVs. The failure of UAVs in the Air Force had more to do with their capability relative to competing systems than the cultural skepticism of pilots, as is often postulated.

As with the other services, the types of UAVs pursued by the service made a big difference in how the service refracted external forces. The types of UAVs the Air Force chose were functionally congruent with its preferred mode, but were also technologically immature. In every case, they fell below the threshold from which they could be pulled up to an operational configuration by an aggressive development program.

Vice President Hubert H. Humphrey talks with Gen. John D. Ryan, Commander in Chief of Strategic Air Command, May 1965.

The Air Force pursued two major types of UAVs and both types had substantial technological shortcomings.

The first type of UAV the Air Force pursued evolved directly from existing target drone technology and resulted in a jet-powered, tactical reconnaissance UAV in the mold of Lightning Bug and MR-UAV. Operated by Air Force pilots and crews, Lightning Bug drones of this type compiled the first substantial combat record of any UAV in history. The launch and recovery dilemma for this class of air vehicle has never been solved to a satisfactory level. Mid-air retrieval (MARS) recovery was operationally cumbersome and prohibitively expensive, ground (parachute) recovery was incompatible with sophisticated electronics and stealth, and runway recovery restricted payload capacity because it required landing gear. The larger and faster the vehicle, the more this became a problem. Low-level flight precluded real-time imagery due to line-of-sight limitations, requiring either a very high altitude relay aircraft or satellite links, and those links required substantial jam-proofing to make them viable in combat. The very narrow technologies embedded in Lightning Bug failed to make the transition to the stringent requirements of operation in Europe.

The second type of UAV pursued by the Air Force was the high-altitude, long-endurance UAVs such as Compass Dwell and Compass Cope. Both evolved from the U-2 design and were entirely novel creations in that designers attempted to leverage breakthroughs in computer technology to realize standard runway takeoff and recovery using digital, computer-controlled flight systems. For the very large, expensive UAV to find a niche, however, it had to operate with manned aircraft-caliber reliability and that required very sophisticated computer control that was only available for very expensive manned systems like the space shuttle.[407] The U-2, by contrast, represented a less expensive system that did not stress international airspace control regimes. Moreover, with the range capabilities of these types, satellite control was required (due to line-of-sight limitations) and was very immature, reaching the U-2 more than a decade after cancellation of Compass Cope.[408] The technology required by this type of UAV lagged the Air Force's lofty ambitions and fell below the budget threshold of Congress.

So, technological immaturity, and more importantly, the relative shortfall in military effectiveness and efficiency compared to competitive systems, rendered the UAV a system in search of a mission. Other innovations such as the cruise missile, which required much less in the way of technology, made breakthroughs that further obstructed the development of the UAV. Not only was the cruise missile suited for the critical nuclear delivery mission, one that allowed it to garner powerful political backing due to its value in arms control negotiations, but the result of those negotiations effectively circumscribed the UAV's ability to perform in weapon delivery roles. Both the SALT II treaty (and its follow-on, START) and the INF treaty specifically restricted cruise missiles in such a way that the US military could not even test, much less operationalize UAVs for those roles. Not only did that constrict concept and prototype development, it allowed UAVs to languish in the cultural (and funding) backwater of combat support.

The record also leaves little doubt about the effect of internal decision-making structure on innovation with UAVs. In the 1960s, the dominance of SAC allowed it to defer development to the super-secret NRO, but to operate RPVs with great dexterity. If not for SAC's substantial operational expertise, Lightning Bug may never have made a contribution to the Vietnam War. In the 1970s, the Air Force took on a transient feudal structure when the fighter community made a bid for ascendancy. Being the up-and-coming subgroup, TAC took risks to capture control of the UAV after its experience in the Vietnam War, and did so in 1976 after a long struggle with SAC. It is notable, however, that TAC was enabled by the presence of bomber generals in the office of the Chief of Staff who had experience with UAVs and encouraged a very aggressive UAV development program. Unfortunately, that program produced many novel designs but no operational systems.

The Air Force's tenuous relationship with the NRO provided a major structural feature of this period as well. The NRO contributed to the emerging feudal arrangement between SAC and TAC because the NRO had cognizance over a mission the Air Force wanted to own. Its presence induced a rivalry that stimulated the Air Force (mainly TAC) to action. Based on the actions of two Chiefs of Staff, Gen. John D. Ryan and Gen. George S. Brown, the Air Force wrested responsibility for airborne reconnaissance from the NRO in 1974.

The feudal structure stimulated development, but hindered adoption. The alien budgetary and developmental environment of the NRO made for a difficult shift to the "regular" Air Force that UAVs failed to make. Look no further than the fact that when strategic airborne reconnaissance came over to the Air Force from the NRO, the manned systems survived (in the case of the U-2, it thrived) and the unmanned systems died because they did not fit and could not compete.

Evidence shows that the reason for this disparate outcome lies not in pilot bias, but in the simple fact that the NRO, being a super-secret organization, was able

Gen. John W. Vogt Jr., Seventh Air Force Commander (April 1972-October 1973).

to develop a system lacking any principled standard of efficiency. The cost of the Lightning Bug program far outweighed its military effectiveness, and in the open, competitive environment in which the services develop and procure weapon systems, the drones could not hope to survive. The NRO acted, for all practical purposes, as a risk-taking surrogate for the Air Force, but technology simply failed to support its experiment. Their operational shortcomings were too apparent in the strategic shift to the European theater that occurred after the Vietnam War, and all the Air Force's efforts to find remedies fell short. Furthermore, knowledge and understanding of UAV operations was confined to a few very high-level officials and specialized SAC crews, contributing to the weak internal constituency within TAC that withered with test flight crashes and the overwhelming evidence of the UAV's operational problems. When the "rich uncle" went away with its cache of black money, the UAV of the 1970s became an anachronism by any rational standard.

The organizational picture was distorted further by the emergence of ever more aggressive civilian intervention that attempted to rationalize UAV development under the aegis of jointness. None of the services had well-developed organic constituencies for UAVs, and jointness only exacerbated the problem of weak service support. In the case of the MR-UAV, there can be no question that there was fractured program management, but stringent naval requirements constricted airframe design, alienating the Air Force and raising the cost. Airframe problems only illustrated the frustrations and diffusion of interest that results from the rush to jointness. In the final analysis, however, one cannot escape the fact that the Air Force's gross mismanagement of the MR-UAV's ATARS payload bode ill for the program in any case. Still, joint airframe issues that hobbled the MR-UAV program provided a foretaste of what was to come under even more stringent centralization in the 1990s.

Cultural issues affecting the Air Force UAV story include the clear observation that aviation organizations create the optimal operational atmosphere for UAVs. Lightning Bug operations in Vietnam were run by pilots like John Dale (the Compass Arrow engineer), and SAC insured aviation standards were met early in the program, which helped it get over the shakedown period in the first deployment. The record of Air Force operation of UAVs contrasts sharply with those of the other services for this reason. The implications are clear. The UAV is not a "truck," it is not a "sensor platform," it is first and foremost an airplane. When the Air Force imposes its aviation standards on UAV support and operations, it provides the best possible atmosphere for UAV operations.

This study has exposed a number of myths—for example, the myth that UAVs are low-cost aircraft. Among these many myths, however, none has been as persistent that the legend of the "white scarf syndrome"—that is, the proposition that USAF pilots culturally resisted UAVs because they wanted to protect their jobs and way of life. In researching this study, the author went to some pains to ferret out incidents of pilot obstruction. He found none of any consequence. In stark contrast to the aviators in other services, in fact, Air Force leaders seem to habitually, even reflexively pursued aerospace technology of all kinds, even that which might reduce cockpit numbers.

In the 1950s and 1960s, for instance, ICBMs threatened the Air Force's "essence" more than UAVs ever have.[409] In 1962, Defense Secretary McNamara, in a statement eerily similar to those made by UAV devotees today, called for the retirement of almost all of SAC's 700 B-52 bombers and their replacement by ICBMs. McNamara believed that Soviet anti-aircraft systems would make the penetrating bomber mission "untenable" by 1965.[410] Despite the clear threat posed by the ICBM to their way of life and core mission, bomber pilots like Gen. Bernard R. Schriever (called "the father of the ICBM," and all the commanders in chief of Strategic Air Command, including the legendary Curtis LeMay, consistently developed, upgraded, and nurtured ICBM systems throughout the Cold War. They may not have "liked" ICBMs, but as airmen who had weathered the fight for service independence, an aerospace platform like the ICBM fit their vision of the future. More tellingly, they did not envision a future in which another service controlled them. The same can be said for various unmanned standoff missile systems and satellites, each of which violated a narrow, parochial view of aviation.

In that same way, this research failed to find narrow, parochial resistance to UAVs on the part of Air Force aviators. Quite the contrary. The case can be made that the Air Force shamelessly, even irresponsibly pursued unmanned aviation technology in the early 1970s, long before it had a chance to be mature.[411] Gen. Robert T. Marsh, a major figure in the Air Force's RPV stir in the 1970s and a rare non-pilot who rose to four-star rank, agreed that the RPVs of that era were more of a novelty than a weapon system. As for pilot resistance, however, he emphatically stated: "I always thought that [the white scarf syndrome] was a bunch of baloney. I never ran into any resistance. General Ryan was enthusiastic as hell about RPVs, for instance, as were others."[412] Chief of Staff Brown, the enthusiastic RPV advocate serving after Ryan, was not worried about the effect of RPVs on the pilot-dominated service, telling a Senate committee: "We transitioned the ICBM force into the Air Force without any great impact to the rated force structure. I expect introduction of RPVs into the inventory to have about the same sort of effect."[413] A TAC commander who said, "you can always find a pilot who doesn't like drones" was nevertheless the very general who pushed hard for TAC to take complete control of Air Force drone programs.[414] In short, the data collected for this study found no parochial, pilot resistance standing in the way of UAV development in the Air Force, only a general enthusiasm for UAVs that in retrospect was not supported by the technology of the time.

Culturally, the greatest cross-service inhibitor to fielding UAVs has been the general unwillingness on the part of warriors to pursue support systems. Marsh, who commanded Air Force Systems Command in the early 1980s, said, "Tactical recce is like electronic warfare—when we're at war, everyone wants it, but in peacetime, nobody wants it."[415] As one senior fighter pilot said, summing up the prevailing mindset during the post-Cold War budget constriction, "With all these [budget] cutbacks, we can't afford to have anything but shooters."[416] This short-sighted perspective creates an even more strenuous environment for the UAV, since it has to compete for a very small budget share with established systems already primed to protect their turf. The budget share will not likely increase, so tradeoffs are made within the surveillance and reconnaissance community, creating a zero-sum game that makes competition against platforms like the U-2 an uphill battle. Furthermore, with the barriers posed by arms control, the chance of UAVs breaking out of their support role seemed slim until those treaties were dealt with directly.

In sum, the US Air Force has a checkered past with UAVs. They have served as consummate operators of UAVs, as evidenced by the more than 3,400 combat sorties in the 1960s and early 1970s. SAC even achieved the third stage of innovation in the Vietnam War (novel combat use), and the Air Force had dedicated combat drone squadrons and even a drone group at the high water mark for Lightning Bug drones. Sometimes overly aggressive to the point of attracting the ire of Congress, sometimes passive, again attracting the ire of Congress, the Air Force has nevertheless played a leading role in the development of UAV technology and prototyping.

What it lacked by the end of 1993 was an internal constituency for UAVs and the flightline-level support that is crucial for its operational survival. The Air Force now found itself facing a new, NRO-like organization called the Defense Airborne Reconnaissance Office (DARO), which established unprecedented, centralized control over UAV development. None of the services had been consistently successful at UAV adoption. Thus, high-level DOD officials embarked on a crusade to forcibly inject jointness into the military by stripping the services of their budgetary control over airborne reconnaissance. By association, this included UAVs. DARO was an experiment in weapon system management that radically altered the environment for innovation with UAVs.

The Strange DARO Interlude

"We all realized we were on the Titanic."

—Maj. Gen. Kenneth R. Israel, Director, Defense Airborne Reconnaissance Office[417]

Until the early 1990s, the armed services retained significant autonomy in the weapon system acquisition process. That changed drastically in the 1990s with the establishment of a centralized system of managing all the services' airborne reconnaissance assets. We now investigate how this substantial shift in weapon system acquisition, which left an OSD organization called the Defense Airborne Reconnaissance Office (DARO) in full control of service airborne reconnaissance budgets, affected UAV development.

The new structure served as both a punishment for the services' apparent lack of emphasis on this combat support specialty and as a supposed means of achieving greater integration and economy. It was a grand experiment in civilian intervention and centralized control and provides a rich source of insight about the role of the services and external agencies in the process of weapon system innovation in the US.

DARO opened its doors in November 1993. It represented one of the most substantial civilian incursions into major military system acquisition management since the establishment of the National Reconnaissance Office in 1961. In fact, its architects saw DARO as a tactical complement to NRO, which had always focused on strategic intelligence.[418]

Although it was only another data point chronicling the increasing intervention into service prerogatives that had been occurring since the end of the Vietnam War, DARO was different. It was given full budget authority over DOD UAV development and upgrades, thereby supplanting the Title X "equip" function of the services. The services retained full capacity to operate UAVs and participated in the DARO process, but lost a substantial degree of control over UAV development. DARO did not last long, because less than five years later, the entire centralized management structure collapsed, reverting once again to service-centric development, adoption, and operations.

■ Why DARO Was Formed

A constellation of reformers based its takeover of airborne reconnaissance on two propositions. First, Congressional staffers, high-level OSD appointees, and long-time OSD acquisition officials believed that the services' parochial blinders, hidebound nature, and appetite for gold plating left them unable to produce effective, cheap UAVs in a rapid fashion. They rejected the aerospace engineer's dictum that you can have any two of those attributes, but not all three. Rather than work through the services to effect change, they felt the services had to be marginalized to realize innovation. In a sense, the services had washed their hands of airborne reconnaissance by canceling several major tactical reconnaissance platforms as a response to post-Cold War budget cuts, leaving a vacuum that had to be filled. The issue was how to fill it. Second, reformers like OSD advanced technology chief Lynn argued the only way to circumvent the services' power was to set up a centralized UAV management structure controlled by civilians in OSD and made directly accountable to Congress. Taking a chapter from Barry R. Posen's *The Sources of Military Doctrine,* which argues that, short of catastrophic military defeat, only clear-sighted civilians can break through the military's endemic sclerosis, Congress blessed OSD's plan to bypass the services to achieve weapon system innovation. The only citadel the reformers did not storm was that of the services as ultimate end-user of the UAV.

The situation could not have been better set for DARO's success. OSD opened DARO's doors at a pivotal moment in UAV technology advancement and geopolitics. The satellite-based GPS offered a breakthrough cure for the persistent problem of location accuracy by providing an off-board, omnipresent, highly accurate location signal.[419] GPS revolutionized the UAV industry, but it was just one component of the microprocessor revolution that accrued asymmetrically to the UAV. Computing power and miniaturization improved by leaps and bounds, allowing UAVs to carry more capable payloads with more jam-resistant, higher bandwidth data links. The end of the Cold War brightened the political environment for UAVs as well. Although the threat-basis for UAV development waned with the dissolution of the Soviet Union and Warsaw Pact, the relatively bloodless Persian Gulf War and each of a growing number of US military interventions in the 1990s exposed an increasing unwillingness to accept casualties on the part of US military and political elites. The Gulf War and the rise in importance of precision-guided munitions also highlighted the need for more extensive tactical reconnaissance capabilities.[420] Moreover, the end of the Cold War drove deep, across-the-board military budget cuts that stimulated reformists to extol the UAV's money-saving potential. These propitious circumstances provided the most favorable UAV development environment since the Air Force UAV boom of the 1970s.

With the demise of the NRO's Advanced Airborne Reconnaissance System, the grandest UAV idea of them all, the intelligence community's involvement in UAVs faded to one very small tactically oriented CIA program. In contrast to the diminished role of the intelligence community, DARPA and Israeli-influenced designs played a larger role in UAV acquisition in the 1990s, yet neither produced a fielded system. In short, centralized UAV management did little to change the muted influence of non-service UAV developers.

DARO did change service UAV dynamics, and here we find a mixed record. In its most important UAV quest, DARO failed. Through the tangled web of centralized UAV management, the Army continued a Sisyphean quest for a UAV to see over the next hill, but never came as close to the pinnacle as they had with Aquila. "Jointness" exacerbated the structural dysfunction that stymied every Army UAV program since 1955. Unable to rationalize multiple branch requirements for its own UAVs, the Army now had to contend with Navy and Marine Corps stipulations, too. Stringent maritime requirements contributed to the demise of each Aquila descendant. As one might expect, the ambivalence of the maritime services toward UAVs worsened as they became entangled in the conventional designs favored by the Army, for they wanted a vertical takeoff and landing design. Still, they felt obliged to "team" with the Army on one-size-fits-all UAV projects to appear "joint." The Air Force, for its part, remained disinterested in UAVs during McPeak's tenure as Chief of Staff, which encompassed the first year of DARO's operation. By 1995, however, new Chief of Staff Gen. Ronald R. Fogleman saw UAVs as part of his service's transformation. He grabbed the still immature Predator away from the Army and signaled strong interest in Global Hawk and DarkStar, DARPA's high altitude endurance programs. In the broad sense, DARO became an NRO surrogate, assuming developmental risk for an Air Force that alone possessed the expertise to operate large, complex UAVs. In sum, DARO extended the general lethargy of US military UAV integration, and in the process, increasingly alienated the services and Congress. By the fall of 1998, after a decade of experimentation with weapon system innovation by fiat and under intense pressure from Congress, OSD relented, dismantling the system that had promised so much and produced so little.

Gen. George S. Brown as USAF Chief of Staff (Aug. 1, 1973-June 30, 1974).

■ The Five-Year Interval

Using the NRO as a model and using a construct laid out by political appointees working for new Secretary of Defense Les Aspin, the 1993 Congress adopted OSD-written language in setting up an orga-

Gen. Robert J. Dixon, Commander of Tactical Air Command (Oct. 1, 1973-April 30, 1978).

nization to oversee all defense-related airborne reconnaissance.[421] Under this construct, each service's airborne reconnaissance acquisition budget would be transferred to this office, which would have spending authority over programmed funds. On Nov. 6, 1993, Deputy Secretary of Defense Perry signed a memo establishing DARO under the Deputy Undersecretary of Defense for Advanced Technology, diminishing the role of the Navy-led UAV JPO and marginalizing the services.[422] As an OSD information paper put it, "A simple coordination body [JPO, ARSP] without budget authority is not sufficient."[423]

In a broad sense, DARO can be seen as a deepening of OSD and Congressional intervention into an area the services had neglected, but it had greater meaning for UAV development. First, DARO's budget and oversight authority relegated the services to operational implementers only. As the Perry memo put it, "DARO will be responsible for the development and acquisition of manned and unmanned platforms, their sensors, data links, data relays, and ground stations.... DARO will have no operational control over airborne reconnaissance assets."[424] DARO did not act as an airborne reconnaissance czar by any means, for it still had to gain service acquiescence through a complicated set of internal coordination venues.[425] By law, the services "organize, train, and equip," but in the area of airborne reconnaissance, DARO did the equipping.[426] This arrangement obviously alienated the services. The Air Force lost the most in dollar terms, losing control of more than $1 billion in annual programs, amounting to more than half of DARO's funds.[427] The Army particularly despised the move, for under the JPO arrangement they were able to exert substantial control over the short-range (Hunter) UAV project.[428] When OSD appointed Air Force Maj. Gen. Kenneth R. Israel as head of DARO, the Army saw itself fading to minority status despite the JROC's consistent direction that the battlefield UAV remain the top UAV priority in DOD.[429] The same sentiments applied to the maritime services, which were now convinced that only a vertical takeoff design would fit their functional requirements.[430] Moreover, the creators of DARO failed to delineate the role of the UAV JPO in relation to DARO. The uneasy relationship between those two organizations, which was never resolved, saddled the UAV world with a more deeply fragmented management structure than the one that handicapped Aquila.

In addition to the challenge it posed to the services, DARO combined manned and unmanned reconnaissance acquisition in an approximately $2 billion spin-off of the National Foreign Intelligence Program (a budgetary term encompassing the intelligence community to include the NRO) called the Defense Airborne Reconnaissance Program (DARP).[431] Approximately 75 percent of the DARP budget consisted of funding for manned assets, rendering the UAV a minority player in DARO. This also placed UAVs more sharply at odds with the manned reconnaissance community, which had developed fairly mature political and service constituencies in DOD and Congress. Any expansion of UAV budgets and programs would have to come from cuts in manned programs. The already gaunt airborne reconnaissance mission area now had to absorb a newcomer with the potential for expansion, setting up an internal fight that the UAV had already lost to satellites in the NRO.

Less obvious than fragmentation and direct competition, the new management structure also caged the UAV into peripheral reconnaissance and surveillance roles. Although DARO became the de facto UAV advocate upon its inheritance of UAV programming, it could hardly have been expected to advocate UAVs for force application due to its charter. While it is true that arms control restrictions still hindered the weaponization of UAVs, DARO allowed the services to outsource their UAV thinking, which included anything in the area of force application. Unwittingly, in an attempt to save UAVs, reformers threw them together with more mature competitors and limited their scope.

Israel, DARO's director, knew he and his skeleton crew were fighting an uphill battle. The short, almost five-year history of DARO was defined by Israel's aggressive manipulation of the DARP to increase the share going to UAVs.[432] His advocacy for UAVs brought him in direct conflict with Congressional staffers and contractors who saw their favored systems being cut.

In particular, the U-2 and the RC-135 Rivet Joint communities rose up in opposition to Israel's advocacy of high-altitude UAVs like Global Hawk and DarkStar. In the final analysis, DARO failed to field a battlefield support UAV, arguably its top UAV priority. It did, however, succeed in helping the Predator medium-altitude UAV reach operational status in the Air Force, and it also developed the high-altitude Global Hawk to a point where it had a good chance of adoption. By the time that DARO was disbanded in 1998 under an OSD initiative to cut defense agencies, it had few allies, almost no senior advocates, and only one very shaky operational UAV to show for its efforts.[433]

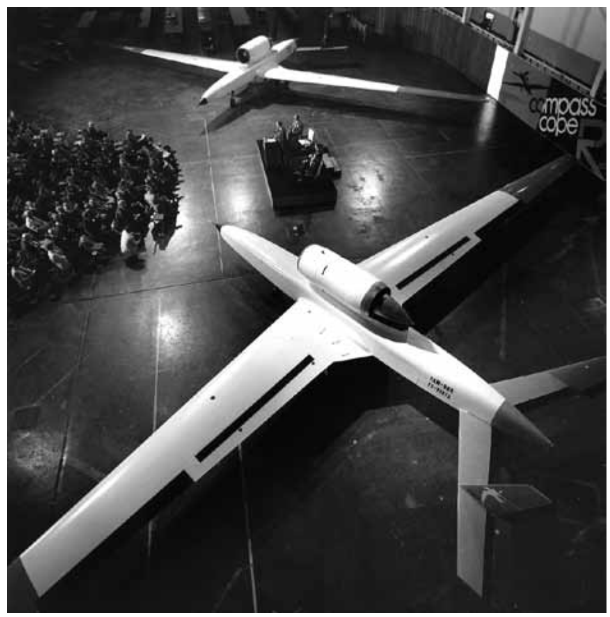
We turn now to higher-flying UAVs that fell under the stewardship of DARO but ultimately were slated for the Air Force. Here DARO achieved greater traction. Rather than presenting an obstruction, they actually stimulated the integration of UAVs into the US military.

■ RQ-1A Predator

A number of UAV programs made the jump from the UAV JPO to DARO in November 1993, and all but one failed to achieve operational status during DARO's tenure. The one that succeeded, a medium-altitude reconnaissance UAV called Predator, followed a circuitous, unlikely path to operational capability with the Air Force. Predator was an exclusive product of centralized UAV management and a technological bellwether. In fact, Predator was a UAV system developed with virtually no service input—it was the "anti-joint" UAV.

Three salient points emerge from the story of its development and adoption. First, Predator was the first operational UAV to use GPS satellites for navigation as well as being the first to truly cast off line-of-sight range limitations—again through use of satellite technology. It used commercial satellite data links for control and imagery transmission. These and other technology breakthroughs embodied in Predator were indicative of the monumental improvement in UAV capability ushered in by the 1990s. Second, Predator was the first Air Force UAV that held its own in the Air Force budget (rather than the NRO's), but it got there due to fortuitous timing, interservice rivalry, and the personal intervention of a visionary Chief of Staff. Predator reached the flightline through the side door, as it were, rather than through the conventional requirements process. Third, Predator required much more than one general's support to gain an operational foothold. Five years after program start, the high cost of bringing the program to an operational configuration—even after early models were used in combat—proves that while flying prototypes have a certain seductive charm, there are no shortcuts to a properly militarized UAV able to be fully integrated into service combat plans. That process takes time, money, and unwavering service commitment.

The idea for a long-endurance, loitering UAV emerged from the Joint Staff and OSD based on the need for surveillance over the troubled former Yugoslavia in the winter of 1992. The Joint Staff director of intelligence (called the J-2), Rear Adm. Mike Cramer, told Navy Capt. Allan Rutherford of the UAV JPO that the Chairman and Vice Chairman of the Joint Chiefs wanted more than episodic reconnaissance over trouble spots in the Balkans, they wanted loitering surveillance. Rutherford put together a proposal based on DARPA's failed Amber program, and he, Cramer, and new defense advanced technology chief Lynn embarked on a campaign to field what was called the Tactical Endurance UAV. OSD acquisition chief Deutch "bought off on it despite having laid waste to other UAV programs" according to Rutherford, who now found himself scrambling for service sponsorship. Only the Army and the Navy provided nominal support, but not enough to build a system.[434] With Deutch's support and with no input from the service acquisition bureaucracy, the program moved ahead rapidly but ran into yet another change in UAV management directed by Congress.



Teledyne Ryan's Compass Cope (YQM-98A) RPV prototype during 1974 rollout ceremony.

The UAV JPO had coordinated UAV projects, but DARO had service-caliber budgetary power when it came into being in late 1993. With Deutch and Lynn providing political topcover, DARO now assumed an unprecedented level of control over service airborne reconnaissance assets and, under their direction, became a staunch UAV advocate. Prior to DARO, OSD had outlined a UAV acquisition strategy that included three "tiers." Tier I was an offshoot of Amber called Gnat 750, a 35-foot wingspan, 40-hour endurance UAV that flew at 20,000 feet. The CIA was developing Gnat 750 as a quick-reaction program for deployment to the Balkans conflict.[435] Tier II was Rutherford's Tactical Endurance UAV and was expected to be more capable than Gnat 750, while Tier III was a classified

BQM-145A RPV known as the Medium Range-UAV.

high-altitude UAV that could loiter over defended territory for days. The "Deutch Memo" outlined the capabilities expected of Tier II—that it fly 500 nautical miles, stay on station 24 hours, carry a 400- to 500-pound payload, fly between 15,000 and 25,000 feet, and provide high-quality electro-optical and synthetic aperture radar imagery.[436] According to the program manager, the director of DARO did not jump on the Tier II bandwagon until it became evident that it would succeed. Like the services, DARO did not immediately embrace this odd program.[437] Eventually, the Tactical Endurance UAV made its way through this management structure by getting its budget directly from Congress instead of through the services.

In April 1994, the Tactical Endurance UAV was lumped under OSD's new quick-reaction ACTD program that was designed to bypass the normal acquisition process. After a competition, the system chosen for Tier II was the Predator, a derivative of Israeli designer Abraham Karem's Amber project and a much-improved version of the CIA's Tier I Gnat 750.[438] The program manager promised the first test flight for six months after contract award, and he delivered on that promise in July 1994. The maturity of the Predator air vehicle came from the millions of dollars sunk into Amber and Gnat 750. Only one year after its first test flight, Predator was flying in combat over the Balkans.

The technology demonstration lasted 30 months, during which Predator operated under the direction of a special Army military intelligence battalion composed of aviators. They flew Predator out of Gjadar Airfield, Albania in June 1995 in support of US European Command.[439] Both the Air Force and the Navy had rejected any sort of operational control of Predator operations in Bosnia.[440]

During April and May 1995, Predator flew in Roving Sands '95, a joint exercise in the southwestern United States. The success of Predator during Roving Sands played a substantial role in the decision to deploy it to the Balkans in the months that followed. The composite unit, led by the Army, flew out of Albania in support of Joint Task Force Provide Promise. UAV JPO's Rutherford, himself not an aviator, insisted that the Predator pilots be rated military pilots due to the complexities of operating such a large vehicle in mixed, foreign airspace.[441] Operated by flying professionals, the system recorded extremely high reliability despite the fact that the unit had to work out developmental bugs while the air vehicle flew in combat. The Predator deployment took place from July through November 1995 when they were pulled out due to problems with wing icing and after two aircraft were lost due to questionable circumstances that could have come from enemy ground fire.

Up to this point, the Air Force had no significant involvement in the ACTD process other than sending one pilot to fly the air vehicle.[442] Suddenly, the Air Force made an all-out bid to be the "lead service" for Predator. It did so for three reasons. First, combat operations over Bosnia had caused a stir and had crystallized Congressional support. Air Force Chief of Staff Fogleman could see that due to its success in Bosnia, Predator was going to be fielded and he wanted to control the UAV for doctrinal reasons. "Predator took on a life of its own," he said, "and I thought it best that airmen operated the system."[443] Second, interservice competition spurred Fogleman to action. Due to its leading role in operating the Predator unit, the Army looked the most likely to be the lead service, but Army operators at Ft. Huachuca in Arizona were crashing Hunter UAVs at an alarming rate. Fogleman bristled at the thought of the Army flying a system with performance even higher than that of Hunter. "If the Army took Predator, they would just screw it up and the program would go down the tubes; if anyone was going to make it work, we were," said Fogleman. To show Air Force commitment, he ordered the formation of a UAV squadron, the first since the drone group disbanded in 1979. Fogleman himself was the third reason for Air Force support. He saw himself as an agent for change, and the non-standard UAV fit his concept of a "transition point."[444] Fogleman's prior command of an air division at Davis-Monthan AFB, Ariz. during the standup of the ground-launched cruise missile in the 1980s gave him an appreciation of how one integrates an alien system into the organization.[445] He was the linchpin that tied the entire operation together. In what one aerospace publication called "a major policy shift," Fogleman mobilized the support of the senior generals and applied the full weight of his service to get Predator.[446]

The Air Force stood up the 11th Reconnaissance Squadron at Indian Springs Auxiliary Airfield near Nellis AFB, Nev. in August 1995—months before the decision to assign Predator to a service. It is interesting to note that only the monarchic services, the Marine Corps and the Air Force, have established true UAV units.[447] Fogleman followed up by sending experienced pilots to fly the UAV, saying, "if Predator fails, it won't be because of our pilots."[448] Having committed so thoroughly in such a short period of time, Fogleman now had to win the political battle. In the negotiations that ensued, the Army Chief of Staff ceded the medium-altitude UAV in exchange for Air Force assurances that they would be responsive to Army battlefield reconnaissance requirements.[449] On Dec. 16, 1995, the JROC selected USAF as the lead service, and the Secretary of Defense approved that designation on April 9, 1996.[450] On Sept. 2, 1996, the 11th Reconnaissance Squadron assumed operational control of Predator operations out of Taszar, Hungary. Predator has flown over Bosnia, Iraq, and Kosovo, 39 aircraft flew more than 6,600 combat hours.[451] Two years later, the 15th Reconnaissance Squadron (15th RS) stood up at Indian Springs. The Air Force was back in the UAV business for the first time since dismantling the drone squadrons in 1979, and this time, it was paying the bill.

The Air Force picked up Predator even though the ACTD process revealed serious questions about its operational "suitability," a term encompassing maintainability, reliability, safety, and supportability. This was a major conclusion, in fact, of a comprehensive RAND study of the Predator program.[452] Early operational assessments conducted by the OSD Director, Operational Test and Evaluation, determined Predator to be deficient in mission reliability, documentation, and pilot training support. Moreover, the tests did not include analysis of system survivability, supportability, target location accuracy, training, or staff requirements.[453] The Air Force was assuming responsibility for what amounted to an undeveloped prototype.

The OSD findings were reinforced by the travails of the first operational commander of the Air Force's Predator squadron, Lt. Col. Steven L. Hampton.[454] Hampton remembers that they literally had to "start from scratch ... we built everything from parts bins in our maintenance hanger to Functional Check Flight profiles to use every third flight when an engine overhaul was required."[455] The decision to move training to the squadron's remote location at Nellis came after senior Air Force officials saw the dismal conditions at the Ft. Huachuca flightline. Additionally, Federal Aviation Administration officials refused to grant any exemptions to the "see and avoid" rules in the airspace surrounding their first choice, Beale AFB, Calif.[456] Col. Harold H. "Bart" Barton Jr., chief of the Air Combat Command's UAV office, said that the Air Force's dedication to the program can be measured by the millions of dollars they spent turning the contractor into a mature aerospace company that can provide technical data and supportability products meeting Air Force standards.[457]

In the wake of DARO's mid-1998 demise, brought on by its extreme alienation from the services, the loss of its "godfathers" in OSD, and the evaporation of Congressional support after DARO meddled in manned reconnaissance programs, the services reestablished control over their airborne reconnaissance programs. The Air Force moved quickly to integrate Predator by transitioning it to its regular acquisition scheme in August 1998, with the program eventually ending up under special, streamlined Air Force Big Safari management later that month.[458] Air Force acquisition plans called for 13 Predator systems with four aircraft in each system, with funding of approximately $118 million from 1997 through 2002. The involvement of Big Safari completed a circle started in 1962 when they first got involved with the high-altitude Fire Fly UAV. This time, however, instead of receiving funds from the secret Peacetime Aerial Reconnaissance (PAR) program managed by the NRO, Predator had a place on the normal Air Force budget, competing against other mainline systems.

Interservice tension over this UAV persisted, however. Although the Army's decision to "trust" the

SSgt. Jeffrey Hicks in post-flight inspection of a General Atomics Aeronautical Systems RQ-1 Predator UAV at Ali AB, Iraq, in January 2004. (USAF photo/SSgt. Suzanne M. Jenkins)

Air Force seemed to contradict years of cyclical Army disillusion with Air Force tactical reconnaissance support, the decision differed from those of the past on two important counts. According to the agreement that turned Predator over to the Air Force, the Army retained the option to buy one Predator system. More importantly, however, the capability presented itself for another service to control Predator without having to pay for it. That opportunity existed through the design of the UAV Tactical Control System (TCS), a command and control system expected to replace one-of-a-kind UAV ground stations with common command and control, data link, and imagery interfaces. With TCS, another service could take control of the flight and sensors over its areas of interest using TCS ground stations, turning the Air Force into little more than an agency for Predator funding, takeoff, and landing.

That possibility rankled the Air Force, which wanted to exercise direct control of the aircraft and sensors at all times due to its expertise in coordinating aircraft flight operations. The services had agreed in high-level discussions that Predator was a joint asset, operated by the Air Force, which received tasking through the Joint Forces Air Component Commander (JFACC). Army and Marine Corps staff officers continued to argue that this arrangement would insulate the Air Force from other service reconnaissance requests, as the JFACC was normally an Air Force general. Furthermore, the other services feared that this ruling would free the Air Force to develop UAV employment concepts that directly supported Air Force combat operations.[459] A senior Air Force spokesman said his service "considers Predator an Air Force-owned and operated UAV under the tasking orders of the joint force commander, not individual field officers or other service commanders."[460] The Air Force successfully appealed a DOD Comptroller decision in October 1998 that had directed full TCS functionality with Predator, a clear setback to Army and Marine Corps plans.[461] Whereas interservice rivalry played a role in the Air Force's decision to adopt Predator, other service attempts to get UAV imagery "for free" without an investment served to erode the internal Air Force support so vital to embedding an innovative system into the organization.

A General Atomics Aeronautical Systems MQ-9 Reaper with its armament intact after a combat sortie in Afghanistan. (USAF photo/SSgt. Brian Ferguson)

Lt. Col. Steven L. Hampton (left), first operational commander of the Air Force's first Predator squadron.

In addition to these external threats, the Air Force's commitment to UAVs, so aggressive under Fogleman, would be sorely tested in the future due to the expense in bringing these systems to full maturity. Although Predator by 2000 had participated in other combat actions since Bosnia, flying in Operation Southern Watch over Iraq in 1998 and then over Serbia in Operation Allied Force in 1999, the Air Force took a long time to achieve a fully operational configuration with the system. The Air Force spent a considerable sum helping the contractor get the system up to minimum standards of supportability. The system is vulnerable to any radar-guided air defense system, and the initial ground control station could only control one air vehicle at a time, meaning that sortie rates remained low. Despite these questions, Predator was in 2000 one of only two operational UAVs in the US military, and despite its meandering pathway leading to Air Force adoption, it ultimately found a home.

Predator clearly "came out of nowhere," that is, it did not originate in any service. Its capabilities fell in-between the Army's battlefield range and the Air Force's preferred altitude and speed comfort zone. The only historical analogue was the little-known Compass Dwell program of the early 1970s, which the Air Force canceled in lieu of a higher, faster UAV. Predator's timing was particularly fortuitous—the conflict in Bosnia demanded no casualties but commanders wanted better reconnaissance information than satellites could manage. The services had given up so many tactical reconnaissance assets that theater commanders in the Balkans salivated for Predator video. Moreover, the conflict was so peripheral that Predator could depart the theater each winter without major impact. Its long development history as DARPA's Amber allowed for enough maturity that it worked as a demonstration even though it had little or no support structure. It is inescapable that Predator would never have been built under the service-centric approach, yet it is also evident that it required a massive Air Force commitment to make it work as an operational asset. A more serendipitous weapon system program is hard to imagine.

■ High Altitude Endurance UAVs

DARPA had played an increasing role in UAV development since the late 1960s. The 1990s continued that rise, as DARPA's involvement in UAVs came to encompass two major projects called DarkStar and Global Hawk. Both were products of the centralized UAV management concept, and both were a reaction to the perceived excesses of the giant AARS UAV program run by the Air Force and the NRO for most of the 1980s and early 1990s.

In 1994, OSD initiated another ACTD program run by DARPA to develop two complementary high-altitude endurance (HAE) UAVs. OSD had the Air Force in mind as the eventual operator and directed that USAF work closely with DARPA on program specifications. The twin programs, designed to provide rapid technology demonstrations at low cost, were the Tier II-plus Global Hawk, a non-stealthy airframe similar in many respects to the U-2, and the Tier III-minus DarkStar, an exotic but cut-down version of AARS. The key aspect of both was that DARPA imposed a $10 million flyaway (per-unit without development costs) cost cap that forced painful capability tradeoffs. Although the DarkStar contract was sole-source (i.e., not competed) due to its classified predecessor, the Tier II-plus competition was hotly contested by several major aerospace corporations and formidable industry teams.[462]

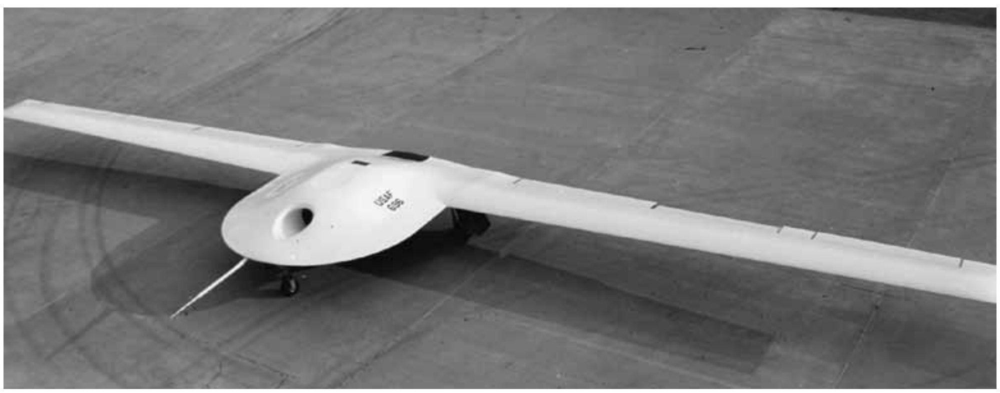
RQ-3A DarkStar

After being thwarted in the quest for the "perfect" national surveillance UAV, the builders of AARS would now have to endure the ignominy of tasting the "affordable" end of the UAV acquisition spectrum. AARS, once a giant 200-plus-foot-wing bird with intercontinental capability, now as DarkStar shrunk to a 69-foot wingspan with a 500-mile combat radius and eight-hour loiter, fell to a 45,000-foot operating altitude and shed some of its extreme stealth. Yet, in spite of the $10 million cost cap, it still had to take off, fly, and land with almost complete autonomy. Its predecessor was expensive for a reason, but this radically scaled-down version had even more significant cost-capability tradeoffs that posed severe, if not irresolvable, challenges to DARPA and the contractors.

A long list of experts called the scaled-down task impossible, with a more reasonable ceiling being $30 million for a production vehicle.[463] Kier, who was the last AARS program manager and had experience with the tradeoffs involved in downscaling that particular project, said: "The $10 million cap was ridiculously low and the platform's capability suffered. If you'd allowed the cost to float up a bit you might have had a reasonable platform."[464] Some saw the cap as a blatant effort to ensure its failure, but a DARPA official said the DarkStar contractor team presented "credible evidence they can bring [DarkStar] in for $10 million. Maybe it will be $12 million, but it will not be $30 [million]-40 million."[465] With the amount of research done on the craft up to that point (10 years and almost a billion dollars), albeit for the larger version, the two companies (Lockheed and Boeing) worked together to realize a truly autonomous, stealthy UAV that could compete in the world of press coverage, Congressional scrutiny, and very tight budgets. Although many were fixated on whether DarkStar could come in under the cost cap, the war fighter's question—the one the Air Force would have asked—was whether the cost restriction would drive DarkStar's capability below meaningful military requirements.

Although the Tier II-plus (Global Hawk) and Tier III-minus (DarkStar) were sold as complementary platforms that together would more efficiently achieve Tier III (itself a scaled-down AARS in the $150 million per copy range) military utility, the two programs competed against one another from the beginning. The exotic DarkStar made a splash in aerospace publications when it was unveiled in June 1995, and program officials hoped to get out ahead of Tier II-plus in the persistent expectation that DOD would eventually fold both programs into one $30 million to $40 million bird. Congressman Norm Dicks (D-Wash.) inserted an amendment into the 1997 budget that ordered concepts of operations be developed for an "improved" DarkStar, for instance.[466] Although DARO sold the two programs as complementary, it was clear from the beginning that at least one had to die.

The years of AARS development paid off when the DarkStar program experienced a successful test



Lockheed Martin/Boeing Tier III DarkStar UAV at Edwards AFB, Calif., in September 1995.

flight in late March 1996, well before the Tier II-plus program got off the ground.[467] Then, disaster struck. The prototype "flying clam" crashed on its second flight test that month due to problems associated with its stealthy design and inaccurate modeling of ground effect in its flight software.[468] The crash uncovered profound problems that took the contractors more than two years to correct, effectively muting further advocacy for a larger version. It was not until September 1998 that another flight test was attempted, and, although the test was a success, DarkStar still had some flight control software problems.[469] Its competitor, Global Hawk, had conducted successful flight tests in the meantime, so the tables were turned. Moreover, projected unit costs had increased enough to stress rapidly weakening support for the program, with estimates of production costs in the $13 million range.[470]

The single flight failure and cost overruns caused the program to unravel. Like any system lacking strong service advocacy, flight test failures crumbled its weak organizational support structure. Some senior Pentagon officials even broached the possibility that DarkStar be canceled and that stealthy features be incorporated into Global Hawk, a complete turnabout from the Dicks campaign.[471] In September 1998, Congressional Budget Office analysts recommended cancellation of DarkStar due to an overlap in capability with Global Hawk, which had a clean flight test record to that point.[472] The Air Force Chief of Staff, Gen. Michael E. Ryan, reportedly cut Air Force funds for DarkStar in a budget meeting at that time.

By the end of 1998 it was clear that DOD officials wanted to cancel DarkStar, and Congressional backers weighed in with a last-ditch effort to save the flagging program. In a letter to Undersecretary of Defense for Acquisition and Technology Jacques Gansler, the House intelligence committee's chairman and ranking minority member warned that any decision to cancel DarkStar would be "shortsighted" and "premature." Rep. Porter Goss (R-Fla.) and Dicks argued for giving the military forces an opportunity to test the system and determine its value. "DarkStar represents a truly unique stealthy reconnaissance capability to penetrate a target's airspace," the Congressmen wrote, adding, "The need for such a capability is the only approved mission need statement for high-altitude UAVs."[473] Their entreaties could not stem the opposition to the program, and Gansler canceled it in January 1999. Pentagon officials explained the cancellation of DarkStar by pointing to its cost growth and how "successful development of Global Hawk made DarkStar less necessary."[474] Additionally, and more ominously for both high-altitude endurance UAVs, the decision stemmed from the Air Force's recommitment to the U-2.[475] UAV fratricide as a result of budget cuts brought down DarkStar, essentially the fourth cancellation of UAVs with an AARS lineage.

AARS and its descendant, DarkStar, embodied three major veins of Air Force UAV development. First, AARS suffered from requirements growth due to the lack of a single, dedicated sponsor and the resulting need for support from many sponsors. Requirements growth inevitably results from this arrangement, and with AARS this quickly turned into gold plating, dragging the program into a fiscal quagmire. Second, in an effort to scale down the program after it had become a pariah, the program was squeezed mercilessly, driving it below an operationally useful capability as DarkStar. Ironically, although it was rejected previously for doing too much, it was canceled in its final form because it could not do enough. Finally, external agencies will never build the system most congruent with Air Force desires. AARS did too many things, and DarkStar could not do enough. The Air Force needed a loitering UAV that could operate over enemy territory with impunity, and that capability could not be built for $10 million per copy. If the Air Force had greater input into DARO's HAE program, they would probably have built a $30 million to $40 million DarkStar. Acting Secretary of the Air Force F. Whitten Peters, in a statement not weeks after DarkStar's cancellation, stated that a classified Air Force project could "fill the niche" proposed for DarkStar.[476] As it was, DarkStar was canceled and the Air Force was left with an unmanned platform that offered little more than the proven U-2, a UAV still in development called Global Hawk.

RQ-4A Global Hawk

Designed for extremely long transit and loiter times over intercontinental ranges, the very large (116-foot wingspan), conventionally designed Global Hawk carries a 2,000-pound payload to 65,000 feet at jet speeds in excess of 400 miles per hour. It has a 3,500-mile range and can loiter at that range for a day, or, if close to the target, can dwell for about 40 hours. As DARPA HAE program chief Charles E. Heber testified before the Senate, "The Global Hawk vehicle is optimized for supporting low-to-moderate threat, long-endurance surveillance missions in which range, endurance and persistent coverage are paramount."[477] Rather than achieving self-protection using stealth, Global Hawk uses onboard sensing devices coupled to new towed decoys that play out on fiber-optic cable to effect premature air defense missile detonation.[478] In contrast to all the gyrations most UAVs must go through to launch and recover, Global Hawk operates in a conventional manner from improved runways using autonomous flight control. It is the first UAV to realize scientist William Pickering's 1945 vision of a "black box" that would automatically navigate, "find the airport and land the plane."[479] This was an important, even pivotal technological advance that marked a transition to technological feasibility for large, very long-endurance UAVs.

The flight control innovations embodied in Global Hawk contributed substantially to the ease of conducting UAV flight operations, but the automatic flight control system depended on flight control software, which had to be created and made reliable. "As in so many other developmental programs," said Heber, "the design, coding, and testing of software has been the biggest driver to schedule growth."[480] Kent L. Copeland, USAF chief engineer for Global Hawk, said that computer modeling of various wing surfaces gave Global Hawk altitude and flight efficiency unimaginable in the 1970s. "All the various advances in manned aviation definitely accrue to UAVs," he said.[481] Because it benefits from information-age modeling and has a highly sophisticated, digital flight control system, Global Hawk is planned for a one in 200 peacetime attrition rate—a record for UAVs—yet this still lags behind manned combat aircraft. Although Global Hawk represented the state-of-the-art for UAV programs, it was hampered by the severe cost ceiling imposed by the ACTD and the natural shortcomings of pilotless aircraft at this stage in their technological evolution.

Global Hawk and DarkStar competed against one other. Both also competed against the workhorse of the aerial reconnaissance world, the U-2. The U-2 has survived numerous UAV threats during its long, 45-year career. Originally, Global Hawk designers took pains to say their project complemented the U-2, but Fogleman changed that in 1996 when he stated that by 2010, UAVs would entirely replace the U-2.[482] Based on the strong backing of his boss in OSD (Lynn), DARO director Israel echoed that sentiment in a series of briefings to various Congressional committees and staffers. Their aggressive advocacy of high-altitude UAV projects at the expense of legacy systems gained them the ire of the other services, Lockheed (maker of the U-2), and eventually Congress.[483] Both Lynn and Israel were merely echoing the sentiments of forward-looking Secretary of Defense Perry. Perry stated as far back as 1994 that "between unmanned satellites and unmanned drones, piloted reconnaissance airplanes will be squeezed out within the next five to 10 years."[484] The Secretary of Defense, key OSD executives, the lead service Chief of Staff, and the director of DARO all agreed that high-altitude UAVs like Global Hawk were the immediate future of reconnaissance and surveillance, but Congress did not.

There ensued furious lobbying, pitting Global Hawk against the U-2 for the small, hotly contested aerial reconnaissance budget. Lt. Gen. Buster C. Glosson, USAF (Ret.), a key figure in Gulf War air operations, said in 1996 that "a major stumbling block to success" for both high-altitude UAV projects was "too much help ... from Congressional U-2 mafias."[485] The aggressive campaign by Perry, Fogleman, and Israel to replace the U-2 was reportedly one of the reasons Congress killed DARO in 1998.[486] Even though the Air Force had stepped forward to stimulate a transition from manned to unmanned reconnaissance, the resistance by powerful defense contractors and Congress demonstrated the way in which entrenched manned aircraft advocates could obstruct UAV development.

The very careful development schedule for Global Hawk continued despite the political furor. Aware of how one crash had killed its rival, DarkStar, chief engineer Copeland stated, "We know that the future of UAVs depends on us doing our job right."[487] On Oct. 1, 1998, after DARO and the entire centralized UAV management structure had been dismantled, the Air Force assumed control of Global Hawk by establishing a high-altitude endurance project office at the Aeronautical Systems Center at Wright-Patterson AFB, Ohio.[488] After the initial shock of taking on Predator, where the Air Force found itself with a product that had very little support infrastructure, the Air Force assumed control of Global Hawk prior to its military utility assessment to build maturity into the program at an earlier stage.[489]

Northrop Grumman RQ-4 Global Hawk, also known as Tier II-plus.

The path to operational status was not to be easy. In late 1998, Peters, the acting SECAF, said, "Cost growth has been substantial, and it is not clear to me that we have achieved what we want to achieve" with Global Hawk.[490] The GAO reported to Congress in 1998 that the projected unit cost had risen to $14.8 million, nearly 50 percent higher than the original estimate.[491] Air Combat Command had formally stated that the ACTD air vehicle had an unsatisfactory operational configuration and submitted a budget "to make a variety of improvements to the airframe, engine, sensors, avionics, wing, and ground station" according to an Air Force spokesman.[492] As late as February 2000, Peters, a committed UAV advocate, stated that substantial changes would be required to bring the technology demonstrator up to Air Force minimum standards.[493] More significantly, Air Force Chief of Staff Ryan, who had replaced Fogleman in 1997, stated repeatedly that the Air Force would not afford (read: would not pay for) Global Hawk if it complements the U-2. Rather, he said, it must replace the high-flying manned airplane.[494]

Unmanned Combat Aerial Vehicle (UCAV)

Fogleman, who had pushed the Air Force to take Predator and advocated replacing the U-2 with UAVs, took further action to push along UAV development. He reprogrammed substantial USAF research and development money toward a DARPA-Air Force cooperative development of a strike UAV, something the Air Force had apparently not considered since the Have Lemon (Firebee) tests in the early 1970s. Just after Fogleman retired in August 1997, DARPA announced an Advanced Technology Demonstration (ATD), a scaled-down ACTD, for an "Uninhabited" Combat Aerial Vehicle (UCAV, later changed to Unmanned Combat Air Vehicle) for Suppression of Enemy Air Defenses (SEAD).[495] Four major aerospace corporations competed for the UCAV demonstrator project, and DARPA selected a winner of the 42-month, $110 million contract in March 1999.[496] According to DARPA, the Boeing UCAV design was a stealthy, 34-foot-wingspan aircraft resembling the B-2 bomber, and designed with a unit cost of $10 million, with 25 percent the maintenance and support costs of an F-16CJ SEAD model.[497] Fogleman personally ordered reprogramming that provided funds for this UCAV project.[498]

The Air Force moved quickly to secretly experiment with combat UAVs. In late 1998, Peters expressed skepticism about the UCAV project, saying,

Northrop Grumman artist's concept of next-generation Unmanned Combat Air Vehicle (UCAV).

"My own personal take on UCAVs is that the ones we have, have proved to be very expensive, cost growth has been substantial, lots of things about using UCAVs we really don't understand."[499] Fogleman himself was reticent about the direction of the UCAV project. As a retired general, he took an active role in only one project—a UCAV project very different from the one envisioned by DARPA. He believed the UCAV should carry a futuristic microwave weapon, not conventional bombs. "With DARPA's UCAV, you have to fly off a main operating base with the same munitions tail as the manned aircraft, in the end the only advantage is no pilot," he said.[500] He believed the UCAV would be important if it could find a niche and not add to the logistical tail. Perhaps the most daunting obstacles that confronted the UCAV were the numerous arms control treaties that restricted cruise missiles and, by specific language and negotiating record precedent, UAVs that deliver weapons. The most difficult language, as previously discussed, came from the INF treaty, which banned ground-launched, unmanned air vehicles with ranges more than 310 miles.

Conclusions

After five years of trying UAV innovation by fiat, the UAV acquisition process returned to its natural, if imperfect, state. At the beginning, OSD apparatchiks were sure they could break down the barriers to innovation by neutering the services, first marginally with the JPO, then more directly using DARO. They suffered from what defense organization historian Paul Hammond called, "the mistaken belief that service interests are not really real, and hence can be overcome by an act of will."[501] Despite its energetic and well-meaning efforts, the centralized UAV management artifice ran headlong into political and operational reality.

As increases in unmanned systems bit into upgrades to legacy (manned) systems, Congress grew increasingly negative. The services, never integrated when it came to airborne reconnaissance, agreed to resist this interloper. UAV-friendly Defense Secretary Perry retired in early 1997. DARO's vanguard—Deutch and Lynn and, later, Paul G. Kaminski (DOD acquisition chief, 1994-97) and Adm. William A. Owens (JCS Vice Chairman, 1994-96)—moved on to other government and private pursuits and no longer provided the high-level stewardship required by a system out of sync with its political and cultural context. DARO's vigorous but sometimes alienating director, Kenneth Israel, lacked the Adm. Hyman G. Rickover-esque qualities required to single-handedly navigate the many obstacles in his path. Perhaps DARO's high-level patrons simply distanced themselves from a losing proposition. Due to circumstances beyond its control, DARO had few friends when it started and proceeded to lose them in rapid fashion.

The UAV JPO and DARO failed because their organizations were built on false premises. Philosophically, one cannot expect any organization to assume ownership of a program and to successfully integrate it if they are denied or greatly infringed upon during the basic program definition and development phases. When the lives of people in that organization depend on it, this would seem even more important.

Structurally, the centralized management construct atomized an already sparse UAV constituency. Essentially, DARO "outsourced" UAVs, stripping whatever internal service advocacy existed and making integration that much more difficult.

The 1990s reinforced an immutable truth concerning weapon system innovation in the United States. The services, as end-users, require substantial autonomy at each stage of the weapon system innovation process. Although external advocates and agencies undoubtedly play an important role in weapon system development and adoption, the symbiosis between service and machine required for combat innovation depends on the mobilization of an internal constituency. The weapon system must be able to function in the service's peculiar environment, which implies not only unique air vehicle designs but also extensive, often expensive militarization. The service members must also adapt themselves to the machine, but typically the machine (through design, technology integration, and militarization) has to reach some minimum level of congruence before the service will begin to move.

Having said that, there remains little doubt that the services, like all organizations, will not change without an external catalyst. It is the nature of the catalyst that matters, however. Policies that stimulate internal, organic adjustments in a service and allow it control over the machine's design can encourage the man-machine symbiosis and enable innovation. The DARO saga showed that external containment of the prime implementers disassociates the services, dampens internal change processes, and ultimately hinders weapon system innovation.

In the final analysis, the vanguard of the UAV proletariat proved no more, and arguably less capable, of UAV development than the services. They did so in the most positive external environment encountered in the study. Weapon system innovation by containing the services and constricting funding ignored reality—it requires energetic service participation, weapon system differentiation and militarization, and the realization on all sides that UAVs are not cheap in dollars or manpower. The ultimate goal of weapon system innovation is its novel, effective use in combat, and as a byproduct, its enduring integration into a service's force structure. Centralized UAV management as practiced by DARO inhibited that process by putting UAVs in direct conflict with manned reconnaissance systems, by further diffusing internal structures in the Army and Navy, and by pushing UAVs into an idealized box into which they could not fit from a design, utility, or cost perspective. The meteoric rise and fall of centralized UAV management provided strong evidence that "pluralism and untidiness" indeed may be the only way for the US military to achieve weapon system innovation with the UAV. ■

Notes

1. Maj. Gen. David Hodge Baker, quoted in the "News and Comments" section of Army, Navy, Air Force Register, Nov. 3, 1956: 6.

2. The evolution of target drones started with the British Queen Bee in the mid-1930s, from which the term "drone" evolved.

3. Recall that UAVs possess characteristics so similar to manned aviation that they will inexorably improve as part of the aviation meta-system. There are no unique, UAV-specific technologies pertaining to large, fast UAV types that one can identify as being starved for development.

4. The single best discussion and analysis of the US intelligence community structure is Jeffrey T. Richelson's *The US Intelligence Community,* 4th ed. (Boulder, CO: Westview Press, 1999).

5. "National" intelligence is a Cold War euphemism for intelligence collection in the Soviet Union and China and is associated with assets developed or operated by the National Reconnaissance Office (NRO).

6. The CIA developed a few UAVs through the Directorate of Science and Technology's Office of Development and Engineering rather than through the NRO. The first was a stealthy propeller-driven, low altitude, anhedral-tailed UAV called Aquiline and designed for low-level electronic surveillance of the Chinese nuclear program. Aquiline was designed by McDonnell Douglas in the late 1960s and advanced to flight testing, but never saw operational use due to reliability problems. The aircraft was to be controlled by data link from a high-flying U-2. Jeffrey T. Richelson interview, Oct. 23, 1999; Sherwin Arculis interview, Feb. 21, 1999. For an upside-down picture of Aquiline (the McDonnell-Douglas Mark II), see Kent Kresa and William F. Kirlin, "The Mini-RPV: Big Potential, Small Cost," Aeronautics and Astronautics, September 1974: 61. The second was a 125,000-foot altitude, intercontinental, subsonic drone with hydrogen engines and very stealthy delta wing design built by Teledyne Ryan Aeronautical in the early 1970s. It was to be completely invisible to radar at that altitude because it had a radar cross-section of a dime. The proposed $400 million program, called Sandy Hook, never made it to flight test. The development costs for both UAVs probably never exceeded $30 million. Robert R. Schwanhausser, Ryan's Sandy Hook program manager, interview, July 7, 1999. The CIA was also reportedly involved in the early stages of the high altitude solar (HALSOL) UAV in 1983 that has since been passed to NASA. Curtis Peebles, *Dark Eagles: A History of Top Secret Aircraft Programs* (Novato, CA: Presidio, 1995) 201-202.

7. The primary advocates of national reconnaissance consolidation were James Killian and Edwin Land, both presidential science advisors. The NRO always focused on satellites even though some airborne systems fell under their aegis. Richelson, *The US Intelligence Community,* 37-38.

8. Program D, which acquired all the airborne reconnaissance programs such as the SR-71 and drones, was established in July 1962. Gerald Haines, "The National Reconnaissance Office: Its Origins, Creation, and Early Years," *Eye in the Sky: The Story of the Corona Spy Satellites,* eds. Dwayne A. Day, John M. Logsdon, and Brian Latell (Washington, DC: Smithsonian Institution Press, 1998) 151.

9. This arrangement was time-tested by the time UAVs came onto the scene due to the revolutionary U-2 program of the 1950s. The CIA developed the aircraft and US Air Force pilots flew them. For an interesting albeit heavily redacted official history of the U-2 program, see Gregory W. Pedlow and Donald E. Welzenbach, *The CIA and the U-2 Program, 1954-1974* (Langley, VA: Central Intelligence Agency, 1998).

10. Big Safari history goes back to 1952 when the Air Force ordered a specially configured YC-97A, codenamed Pie Face, that carried a 20-foot focal-length camera to collect intelligence into East Germany from the Berlin air corridors. Officially named and established in 1953, Big Safari managed low-number, high value programs like the RC-135 Rivet Joint electronic warfare aircraft and its predecessors (going back to 1955), the Lightning Bug drone program from 1961 to 1969, and the U-2 and SR-71 starting in 1978 after the CIA divested itself of those programs. No unclassified history of Big Safari exists. "Big Safari History at the Greenville Division," company pamphlet, (Greenville, TX: Raytheon E-Systems, April 1997); Joseph S. Stanton, "History¬–Detachment 3, 2762 Maintenance Squadron (Special)" unpublished manuscript, San Diego, CA: May 8, 1996, (Wright-Patterson Air Force Base, OH: Big Safari archives).

11. Robert R. Schwanhausser, "Unmanned Aerial Vehicles: From WWI Through Today," 1997-98, *International Guide to Unmanned Aerial Vehicles* (New York: McGraw-Hill, 1997) 12.

12. Program D was officially established on July 23, 1962 to manage aerial reconnaissance assets of the Director, CIA Reconnaissance Programs, and was dissolved on Oct. 1, 1974 when NRO aerial reconnaissance aircraft were transferred from the CIA to the Air Force. The four Program D directors were all Air Force colonels. "Program D," National Reconnaissance Office, undated (Richelson personal files).

13. The U-2's codename was Idealist. William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986) 21.

14. Burrows, 76. The CIA released a redacted version of "The CIA and the U-2 Program, 1954-1974" at a conference at the National Defense University recently. The document records various stealth measures taken to keep the Soviets from tracking U-2s, none of which worked. David A. Fulghum, "CIA Finally Talks About U-2 Flights," *Aviation Week & Space Technology,* Sept. 28, 1998: 29-31.

15. Kelly Johnson went to Washington in January 1956 with a proposal for a liquid hydrogen-powered aircraft called the

CL-400 based on fears of a similarly powered Soviet fighter aircraft that could shoot down the U-2. The program failed after sucking up over $100 million. Burrows, 149-150. Nor was it lost on Eisenhower. John Foster Dulles remembers the President approved the Idealist (U-2) program saying, "Someday one of these machines is going to be caught, and we're going to have a storm." (Quoted in Burrows, 77.)

16. William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, CA: Aero Publishers, 1982) 15, 16. Although "The U-2 Incident" had profound negative political ramifications for the US and the Eisenhower Administration, including cancellation of the Paris summit, less known is that the downfall of Khrushchev can be dated to the Powers shootdown as well. He had toned down the nature of the US threat to pave the way for reform, but Khrushchev remembered that "From the time Gary Powers was shot down in a U-2 over the Soviet Union, I was no longer in full control." Carl A. Linden, *Khrushchev and the Soviet Leadership* updated ed. (Baltimore, MD: The Johns Hopkins University Press, 1990) 91, 224.

17. The OXCART program went into development in August 1959 and flew its first operational mission on May 31, 1967. Pedlow and Welzenbach, 274, 305.

18. The SR-71 had an operational ceiling of 100,000 feet and exceeded Mach 3 in level flight. Pedlow and Welzenbach, 278.

19. Discoverer 14 flew on Aug. 18, 1960. Dwayne A. Day, "The Development and Improvement of the CORONA Satellite," *Eye in the Sky,* 59.

20. Original conversions to FY99 dollars computed using Department of Defense, "National Defense Budget Estimates for FY 1999," Washington, DC: Office of the Undersecretary of Defense (Comptroller), March 1998, Table 5-9, "Department of Defense Deflators—Outlays," using deflators for procurement, excluding pay and fuel. Subsequent conversions to FY10 dollars computed using Robert Sahr, *Inflation Conversion Factors for Dollars 1774 to Estimated 2019*, Department of Political Science, University of Oregon.

21. The SR-71 connection comes from the testimony of Ryan executives who went to Washington to find out what happened to their program. There is no reason to doubt their story, since Red Wagon had no test record--it was a paper program at this point. Wagner, 18. The CIA awarded Lockheed the contract for OXCART on Feb. 11, 1960 after they showed significant reductions in radar reflectivity on their Mach 3 design. Pedlow and Welzenbach, 278. The SR-71, an Air Force variant of the CIA program, was later revealed by President Lyndon B. Johnson as a production program of $1 billion dollars, which works out to $6.1 billion in FY10 dollars. Johnson quoted in Clarence L. "Kelly" Johnson, *More Than My Share of It All* (Washington, DC: Smithsonian Institution Press, 1985) 134.

22. Wagner, 17. Boeing Wichita also proposed an unmanned reconnaissance aircraft codenamed Blue Scooter, which was not approved. Barry Miller, "USAF Widens Unmanned Aircraft Effort," *Aviation Week & Space Technology,* Nov. 9, 1970: 45.

23. Ryan had just over 90 days to complete the modification. Navigation consisted of a timer and one gyrocompass that had to be wind-compensated on the ground before flight. Ryan simply added wing length, more fuselage to accommodate a larger fuel load, and a camera in the nose. Most of the contractor-government relationship was personal with little paperwork. Wagner, 23, 26.

24. The drone flew with a B-57 chase plane to fulfill FAA concerns and was recovered by parachute. Wagner, 27, 29.

25. Stealthy enhancements included a wire mesh over the jet intake and radar-absorbent blankets over the fuselage. Wagner, 32.

26. Lloyd Ryan interview, Dec. 4, 1998. (Ryan was USAF's deputy chief of reconnaissance operations at the time.) Wagner, 32.

27. Lloyd Ryan interview, Dec. 4, 1998; Wagner, 32.

28. Lloyd Ryan interview, Dec. 4, 1998.

29. Lloyd Ryan interview, Dec. 4, 1998.

30. Lloyd Ryan interview, Dec. 4, 1998.

31. Air Force Col. Doug Steakley, a reconnaissance expert in the Pentagon, told Chairman of the Joint Chiefs of Staff, Army Gen. Maxwell D. Taylor, about the drones in a car on the way to the White House for a briefing. Taylor, amazed that there were only two such drones, asked what it would take to get the program going. The first Fire Fly production contract came directly from that conversation. Wagner, 41; Schwanhausser, Ryan Aeronautical Fire Fly program manager, interview, July 7, 1999.

32. By contrast, unit prices for modern reconnaissance UAVs run from $2.5 million for a Predator to $15 million for Global Hawk. Operations and maintenance costs were even higher for the 147B drones due to the inclusion of the special C-130 launch aircraft. The NRO contract asked for two test aircraft and seven production air vehicles. Wagner 42.

33. Note the short timelines from the end of the Cuban Missile Crisis at the end of October 1962 to the operational "silver bullet" capability in December of that same year. The credit for this quick turn-around goes to the contractor, Ryan Aeronautical, the manager, Big Safari, and the no-paperwork, handshake-based system allowed by the NRO's black budget.

34. These 147B models later served as expendable decoys in Vietnam. A later E version developed to collect ELINT on North Korean SAMs also never reached deployment. Wagner, 46, 48.

35. Wagner, 49.

36. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 57.

37. The civilian (Ryan) contractor support team performed damage repair due to ground impact after each mission.

Schwanhausser, a senior Ryan engineer and former Air Force officer who was sent along with SAC senior aircraft maintainer Maj. Gen. A. J. Beck to fix the many problems at Kadena, reported Chinese fighters intercepted most of the missions, but were unable to shoot down the drone. He said they were operating a "Chinese William Tell," referring to the Air Force fighter competition that used Q-2 drones as targets. Wagner, 54-57, 64.

38. Drones would stray far from the recovery site or would be damaged by high winds when the chutes failed to disengage on landing. Wagner, 58.

39. Wagner, 58-61. Although there was some SAC bluster about cutting the drone operation, the decision did not lie entirely in SAC's hands. Backing and financing for the operation came from the NRO and the national security elite in Washington, and they were pulling out the stops to get imagery of the Chinese nuclear program.

40. Wagner, 65.

41. Wagner, 67, 72. The Nationalist Chinese lost some 10 different aircraft (with crew) to SAMs by the time the Lightning Bugs showed up. Their U-2s flew the dangerous 2,000 mile Lop Nor mission for which the D-21 was built. Wagner, 57, 65.

42. "Pilotless US Plane Downed, China Says," *New York Times,* Nov. 17, 1964: A1, A14; "Report Baffles Officers," *New York Times,* Nov. 17, 1964: A14.

43. A Ryan official operating the drones reported: "About the occurrence of the past week-end, this was more or less expected here. Possibly the goal was a deliberate attempt to find out exactly what they could or could not do." Some 16-20 MiG fighters attacked in what Ryan people called "virtually a 'William Tell Weapons Meet' " against the sacrificial drone. Wagner, 74.

44. "US Said to Base Jet Photo Drones In South Vietnam," *New York Times,* Nov. 19, 1964: A1, A2; "Silent on Peking Report," *NYT,* Nov. 19, 1964: A2; "Hanson W. Baldwin, "Many Uses for Drones," *NYT,* Nov. 19, 1964: A2.

45. The 100th SRW also flew the U-2 over Vietnam. Wagner, 112.

46. A recently declassified CIA history of the U-2 revealed that the CIA had flown U-2s over China in 1958 during the Quemoy island dispute. Although the broad outlines of operations over China during this period made it through the CIA's classified review process, Taiwanese participation in U-2 operations was redacted. Pedlow and Welzenbach, 211.

47. Ben R. Rich with Leo Janos, *Skunk Works: A Personal Memoir of My Years at Lockheed* (New York: Little, Brown and Company, 1994), 263.

48. "Special projects" being a generic term for NRO programs. Ryan Aeronautical engineer Schwanhausser said Big Safari conducted a competition between three companies, Ryan, General Dynamics (which had the high altitude RB-57 contract with Big Safari), and Litton bid on the supersonic, high altitude drone that became the D-21. Lockheed did not compete originally. Schwanhausser interview, July 7, 1999.

49. The SR-71/D-21 combination (called the M-21) had a radar cross-section of only 24 square inches, whereas the B-52's was 200 square feet. James Goodall, *SR-71 Blackbird* (Carrollton, TX: Squadron/Signal Publications, Inc., 1995) 31. Black programs such as the D-21 still hamper the researcher, as most government documents remain classified. Goodall and Rich have the most comprehensive D-21 historical information, but pieces of the D-21 story can be found in Jay Miller, *Lockheed SR-71* (A-12 / YF-12 / D-21) (Austin, TX: Aerofax, 1983); Paul Crickmore, *Lockheed SR-71 Blackbird* (London, Osprey, 1986); "High Performance D-21 Drone Used with Blackbird, B-52," *Aviation Week & Space Technology,* Jan. 22, 1990, 42-44.

50. Rich, 264; Goodall, 38. Apparently the D-21 program used the same infrastructure for recovery of satellite photography. The JC-130 was the same aircraft tasked with snagging the capsules containing film from early Corona reconnaissance satellites using the mid-air retrieval system (MARS). Jeffrey T. Richelson, *America's Secret Eyes in Space: The US Keyhole Spy Satellite Program* (New York: Harper & Row, 1990) 146 (photo).

51. Brown saw it as a good way to deliver nuclear weapons as well, apparently upon suggestion by Kelly Johnson, who had proposed the drone for this role upon its design. Rich, 265, 23.

52. The flight test phase of the Tagboard development program cost much more than production. Production slipped from 50 air vehicles to only 33 to stay inside the budget.

53. Rich, 265.

54. The "D" in D-21 stood for "daughter" while the "M" in M-12 stood for "mother." The basic launch design for Tagboard probably evolved from the Convair proposal for Oxcart dubbed Fish that called for launch of a small, manned, ramjet-driven (Mach 4.2) vehicle by a supersonic B-58 Hustler. For references to that equally exotic program and Convair's Kingfish, the primary competitor to Lockheed's entry in the Oxcart program, see Johnson, 135 and Pedlow and Welzenbach, 264, 267-270, 291.

55. Rich, 266.

56. Goodall, 29-30; Rich, 267.

57. Norris, 333.

58. The Lockheed booster itself was 44 feet long and weighed 34,000 pounds. The B-52 was the only aircraft capable of carrying two D-21s. Goodall, 31.

59. Rich, 267.

60. Norris, 334.

61. Operational sorties to China were launched over international airspace and recovered near the Hawaiian

Islands, most covering thousands of miles. Some launched from Beale AFB, Calif., others from Area 51 at Groom Lake in Nevada. Goodall, 34.

62. A team of CIA and Air Force analysts recommended "hot" missions to the Executive Committee of the National Security Council (EXCOM), which passed its recommendation to President Richard Nixon. Rich, 268.

63. Goodall, 34.

64. Rich, 269.

65. Rich, 269. In 1986, a CIA operative received an engine mount from the D-21 on this mission from a KGB agent, who told him the aircraft was found by a shepherd in Siberia. Rich, 270.

66. SR-71 expert James Goodall wrote, "It was assumed that the D-21B encountered very heavy air defenses and was shot down on its final leg of the return flight." Goodall, 38. It is hard to imagine a Mach 4 drone at 95,000 feet being intercepted by anything, so a more likely explanation was a drone failure of some kind.

67. The "U-2 Incident" in 1960 sabotaged the Paris summit for President Dwight Eisenhower, and the Nixon Administration was not about to let an aerial slip-up damage the anticipated foreign policy coup. William Beecher, "US Spy Flights Over China Ended to Avoid Incident," *New York Times,* July 29, 1971: A1.

68. The Compass Arrow AQM-34N model was a very sophisticated high altitude drone that incorporated SA-2 jamming, contrail suppression, automatic threat recognition, and automatic missile and fighter evasion. Its operating altitude, above 65,000 feet, caused a myriad of problems that plagued the program. Wagner, 118-120.

69. "SAC Reconnaissance History, January 1968-June 1971 (U)," Offutt AFB, Neb.: History Division, Headquarters Strategic Air Command, Nov. 7, 1973: 110.

70. William Wagner and William P. Sloan, *Fireflies and Other UAVs* (Arlington, TX: Aerofax, Inc., 1992) 36; Barry Miller, "USAF Widens Unmanned Aircraft Effort," Nov. 9, 1970: 45. Ryan's design was derived from its original submission in 1960, but unlike the other Firebee derivatives, it was a new drone from the ground-up. Schwanhausser, Ryan Aeronautical chief engineer for drones and special projects, interview, May 24, 1999.

71. Gen. Robert T. Marsh, USAF, (Ret.), who had served as chief of Air Force Systems Command's Reconnaissance/ Strike organization which took over cognizance of the 147 series and Compass Arrow program, interview, April 19, 1999. Wagner and Sloan, 37, 39. The award of the Compass Arrow program to the Air Force was a result of perceived cost overruns in the Lightning Bug program run by the NRO's Program D. Schwanhausser, "Unmanned Aerial Vehicles," 14.

72. Wagner and Sloan, 39.

73. "History of SAC Reconnaissance (U) July-December 1967," Offutt AFB, Neb.: Headquarters Strategic Air Command, September 1968: 48.

74. Air Force flight tests revealed numerous problems with the aircraft such that two years after it was to be operational, it still recorded a dismal 71 percent reliability rate. Tests also showed it to be vulnerable to new Soviet radar missiles. SAC nevertheless argued the system should be retained "even at the expense of other programs." "SAC Reconnaissance History, January 1968-June 1971 (U)," Offutt AFB, Neb.: History Division, Headquarters Strategic Air Command, Nov. 7, 1973: 113.

75. Program costs come from the statement of James W. Plummer, undersecretary of the Air Force and NRO director, address to National Association for Remotely Piloted Vehicles (NARPV), June 3, 1975, 6. Eight other developmental vehicles were also produced, for a total of 28 air vehicles. Wagner and Sloan, 40.

76. Plummer, 6. The electronic countermeasures package slated for Compass Arrow never worked, although Ryan officials reported that captured SA-2 radars could not pick up the drone on test flights over western flight test ranges. Wagner and Sloan, 46.

77. William Beecher, "US Spy Flights Over China Ended to Avoid Incident," A1.

78. John L. McLucas, NRO director from 1969-74, interview, Sept. 26, 1999.

79. Schwanhausser, "Unmanned Aerial Vehicles," 15 and interview, 1999.

80. Teledyne Ryan Aeronautical company historian William Wagner said the production aircraft "went under the guillotine and ended up as ingots, except for their engines." Wagner and Sloan, 110; "Israelis Want AQM-91s," *Aviation Week & Space Technology,* Jan. 21, 1974: 54; Samuel L. Hall, "Weapons Choices and Advanced Technology: The RPV," Peace Studies Occasional Papers, No. 10, (Ithaca, NY: Cornell University, 1978) 31; John Dale interview, March 27, 1998.

81. Wagner, 166-167.

82. These ELINT models carried E-Systems payloads that provided emitter location data through a microwave data link, and had an eight-12 hour mission endurance. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59.

83. Wagner, 166-171.

84. The story noted the suspension of flights over Soviet airspace instituted by Eisenhower in 1960 at the Paris summit was still in effect. Satellite reconnaissance continued, as it was considered "relatively non-provocative since they are well above the airspace of China." The only technical advantage enjoyed by Lightning Bug drones was the more detailed imagery possible due to its low altitude. William Beecher, "US Spy Flights Over China Ended to Avoid Incident," A1.

85. Drone operations were a compartmented, highly classified program. The only direct acknowledgment other than Beecher's article was testimony to the House Appropriations Committee about bombing effectiveness by Chairman of the Joint Chiefs of Staff, Adm. Thomas H. Moorer in January 1973. Wagner, 202.

86. The high-altitude COMINT 147TF model performed the last overseas mission out of Osan on June 3, 1975. Wagner, 200. The satellites that displaced the drone mission included the Canyon, Rhyolite, and Jumpseat systems, each of which intercepted communications and spied on missile tests and air defenses. Canyon was first launched in 1968 and the first Rhyolite reached orbit in 1970. Jumpseat SIGINT satellites first reached operational status in 1971. Presumably all three had assumed enough coverage by 1975 that Compass Dawn was superfluous. Richelson, *The US Intelligence Community,* 187-189; Burrows, 183-185, 215-216.

87. UAVs had no unique features and were held captive by shortcomings in navigation and flight control that computing power of the day could not possibly handle. Satellites, on the other hand, were not so constrained and proved to be an area that responded to investment.

88. According to Burrows, President Jimmy Carter viewed the first real-time satellite photos on his first day in office, Jan. 21, 1977. Burrows, 217-242.

89. Gen. Russell E. Dougherty, USAF (Ret.), Commander in Chief, Strategic Air Command from 1974-77, interview, Sept. 20, 1998.

90. The NRO's Program D office undertook a study in February 1974 to determine the future of UAVs in the NRO. This review led to the release of all airborne National Reconnaissance Program (NRP) assets to the Air Force (Strategic Air Command) and the dissolution of Program D. Memorandum for Brig. Gen. [Donald R.] Keith, Director of Developments, OCRD [Office of the Chief of Research and Development], Army, from the Office of the Deputy Director, NRO, Subject: RPVs, 26 February 1974, and Memorandum for Colonel [deleted in original], the Inspector General, USAF, from the Office of the Deputy Director, Subject: RPVs, 26 February 1974; NRO Program D director files (Richelson personal files).

91. McLucas interview, Sept. 26, 1999.

92. The convergence of these technologies clearly favored the UAV, yet they relied on software to perform increasingly complex flight tasks previously accomplished by the pilot. The emergence of stealth technology and automated flight control in the Air Force's F-117 is chronicled by David C. Aronstein and Albert C. Piccirillo in Have Blue and the F-117A (Reston, VA: American Institute of Aeronautics and Astronautics, 1998). For digital fly-by-wire autopilot references, see Chapter 2. On GPS, see George W. Bradley III, "Origins of the Global Positioning System," *Technology and the Air Force: A Retrospective Assessment,* eds. Jacob Neufeld, et. al. (Washington, DC: Office of Air Force History, 1997) 245-252.

93. Reconnaissance implies brief glimpses of an intelligence target. Airborne or satellite reconnaissance imagery usually requires extensive interpretation to gain insight. Surveillance, on the other hand, is the extended observation of one area through loitering and usually results in a much higher level of understanding of the target area.

94. One of the solutions was to develop "radar camouflage" for the U-2 using thin wire and ferrite beads and a plastic material with embedded printed circuit boards to capture and weaken radar impulses. Both concepts barely reduced radar reflectivity and only served to reduce the U-2's high altitude performance, making it more vulnerable to the SA-2. The experiment was soon dropped. Pedlow and Welzenbach, 128-133.

95. The propulsion technology of this approach seems highly improbable, for the lack of air and the extreme low temperatures at that altitude present a formidable challenge for engine designers even today. And, 75,000 feet represents somewhat of a high altitude barrier for subsonic aircraft. Pedlow and Welzenbach, 259-260. Note: The CIA formally published the U-2 portions of the Pedlow and Welzenbach airborne reconnaissance history, but simply declassified the (also heavily redacted) the Oxcart chapters, which this section references.

96. Jay Miller, *Lockheed's Skunk Works: The First Fifty Years* (Arlington, TX: Aerofax, 1993) 114.

97. Possible reasons for rejecting Gusto 2 include doubts about true stealth, very long mission durations that strained human pilots, and lack of computer-controlled flight systems to allow aerodynamically problematic stealth shapes to fly reliably. True stealth technology (the achievement of radar cross-sections on production aircraft low enough to render radar-based air defenses impotent) only became a reality in the late 1970s with the F-117 stealth fighter.

98. US Department of Defense, Soviet Military Power (Washington, DC: US Government Printing Office, 1986) 35-37.

99. Although the Air Force had operated or developed four high altitude, long endurance UAVs by the mid-1970s (Combat Dawn and the Cope series—Arrow, Dwell, and Cope), all were canceled by 1977.

100. There is some anecdotal evidence that the Air Force began working on a stealthy loitering system in the late 1970s (perhaps as an extension of Compass Cope), but no supporting documentary evidence was found. Donald C. Latham, the assistant secretary of Defense for command, control, communications, and intelligence from 1981-88, thought AARS may have dated back to the late 1970s. Latham interview, April 9, 1999.

101. J. William Middendorf II, former Navy Secretary, led the team. Other team members included Edward Rowney, Ed Henley, ex-CIA officers John Bross, Walter Pforzheimer, and George Carver, and three staff members of the Senate Committee on Intelligence—Angelo Codevilla, Mark Schneider, and Kenneth deGraffenreid. John Ranelagh, *The Agency: The Rise and Decline of the CIA* (New York, Simon and Schuster, 1986) 659.

102. Ranelagh 666-667. The Washington Post referenced the UAV aspects of the "top-secret report" in 1983. Jack Anderson, "Remote-Control Superspy," *Washington Post,* Sept. 18, 1983: C7.

103. Edward C. "Pete" Aldridge was in a position to manage both NRO and USAF "black" projects in his position as NRO director and undersecretary (later Secretary) of the Air Force. The remainder of this section operates under the assumption that the "black" USAF budget and the NRO are one and the same for reasons of simplicity.

104. McLucas interview, Sept. 26, 1999. It is entirely possible that, in addition to AARS, the USAF/NRO/CIA airborne reconnaissance investments also included at least one supersonic, manned SR-71 replacement project.

105. A 1995 report on the stealthy DarkStar UAV, a direct descendant of AARS, said, "Most of the design was developed in technology work conducted over the last decade or more." Michael A. Dornheim, "Mission of Tier 3- Reflected In Design," *Aviation Week & Space Technology,* June 19, 1995: 55.

106. Caspar W. Weinberger, preface to: US Department of Defense, *Soviet Military Power* (Washington, DC: US Government Printing Office, 1986) 3.

107. In addition to ICBMs, the proliferation of strategically important mobile targets included intermediate range missiles, air defense sites, and command and control headquarters in Warsaw Pact territory. The deployment of the SS-20 long-range intermediate nuclear missile in 1977 so shocked NATO that the US fielded two new mobile weapon systems—Pershing II and the Ground-Launched Cruise Missile (GLCM). Those deployments resulted in the complete removal of the SS-20 in the Intermediate Nuclear Forces (INF) agreement in December 1987.

108. Basing for this exotic aircraft presented a political and design dilemma. If it operated from a remote site in the western US, its configuration could be kept secret, but the range would cut down on loiter time over the target. If, on the other hand, it operated from overseas bases such as in England or Okinawa, security was an issue but loiter time would be increased. It is possible that this UAV would have operated from a covert US base in peacetime and forward deployed in a crisis.

109. Stealthy designs do not offer total radar invisibility. It is possible that AARS had a much higher standard of stealth than either the F-117 or B-2. The autonomous flight operations alone would require very powerful computation capabilities. An article concerning Air Force laboratory work on a leading-edge computing initiative mentioned, "Other [operational] possibilities include incorporation of 32-bit computers in new types of unmanned autonomous vehicles currently in early stages of definition." John Rhea, "The Airborne Supercomputer," *Air Force* Magazine, May 1990: 162.

110. Aerospace reporter John Boatman was told by unnamed government officials that the name for AARS started with the letter "Q," the letter insiders used as a shorthand name for the program. Boatman's report remains the best single open-source account of the AARS program although it made no splash at the time. John Boatman, "USA Planned Stealthy UAV to Replace SR-71," *Jane's Defence Weekly,* Dec. 17, 1994: 1. AARS may have been associated with the codename Teal Cameo, reportedly a highly secret program to replace the U-2. "Eyes in the Sky," *Newsweek,* Nov. 17, 1986.

111. Keith R. Hall, NRO director, March 1997-December 2001, gave this testimony on June 15, 1993 when he was deputy assistant secretary of Defense for intelligence and security and about six months after AARS had been canceled by its sponsors. From 103rd Congress, 1st Session, United States Senate Committee on Armed Services, "Department of Defense Authorization for Appropriations for Fiscal Year 1994 and the Future Years Defense Program," Senate Hearing 103-303, Part 7: Nuclear Deterrence, Arms Control and Defense Intelligence (Washington, DC: US Government Printing Office, May 11, 19, 25, 26, 1993 and June 9, 10, 15, 29, 1993) 477.

112. Congress canceled the SR-71 due to its high operations and maintenance costs and on the recommendation of the Air Force. Its last mission was a record-setting 68-minute crossing of the US that ended at Dulles International Airport outside Washington, D.C. on March 6, 1990. Patrick E. Tyler, "SR-71 Plane Roars Into Retirement," *Washington Post,* March 7, 1990: A4.

113. From Senate Hearing 103-303, Part 7: Nuclear Deterrence, Arms Control and Defense Intelligence, 477; Neil Munro, "Taking Off: A New Airborne Reconnaissance Office Hits the Pentagon," *Armed Forces Journal International,* June 1994: 46.

114. This funding was probably for the engineering and manufacturing development (EMD) phase to prepare for production. From 103rd Congress, 1st Session, United States Senate Committee on Armed Services, "National Defense Authorization Act for Fiscal Year 1994," Report 103-112 (Washington, DC: US GPO, July 27, 1993) 110. The Conference Committee directed termination of AARS but recommended reprogramming of the money to address the tactical broad-area imagery shortfall, which logically became the Tier II-plus Global Hawk and the Tier III-minus DarkStar. From 103rd Congress, 1st Session, "National Defense Authorization Act for Fiscal Year 1994," Report 103-357 (Washington, DC: US GPO, Nov. 10, 1993) 599.

115. Defense Advanced Research Projects Agency (DARPA) briefing by Charles E. Heber Jr., Director, High Altitude Endurance (HAE) UAV Program Office to Lt. Gen. James L. Jones, then military assistant to Secretary of Defense, "DARPA HAE UAV Overview," Oct. 27, 1998 (DARPA files) 2, 4. David A. Fulghum, "Stealthy UAV Is A Flying Wing," *Aviation Week & Space Technology,* July 11, 1994: 21. Israel's and DARPA's figures probably represent development costs for the air vehicle and control system. Given the normal ratio of air vehicle development costs to sensor and data link costs, AARS development probably came close to $2 billion.

116. David A. Kier has a history with unmanned aviation, serving as the program manager for the HIMAT highly maneuverable unmanned technology demonstrator in

the late 1970s and as last program manager for AARS, interview, May 10, 1999. Another industry insider called AARS "DarkStar on steroids."

117. Bruce R. Wright, program manager for DarkStar, quoted in Michael A. Dornheim, "Mission of Tier 3-Reflected in Design," *Aviation Week & Space Technology,* June 19, 1995: 54. The sophisticated computer programs derived by DOD and Lockheed scientists during F-117 development allowed for computer modeling of radar returns, thus many different airframe shapes could be analyzed without radar testing of scale models. The odd shape of AARS and DarkStar derived from its unique radar reflectivity characteristics and mission. Unlike the B-2, this particular design minimizes returns from the side, allowing the aircraft to loiter at right angles to a threat. It probably produces some radar returns to the front and back (mainly due to the huge straight wing), but mission planning could minimize the time spent in that orientation to enemy radar systems.

118. Kier interview, May 10, 1999.

119. In 1985, the President's Foreign Intelligence Advisory Board criticized the fragmentation of airborne reconnaissance, and the mandate for the Airborne Reconnaissance Support Program (ARSP) was to forcefully coordinate planning, research and development, and acquisition. The first public acknowledgment of ARSP was a public comment by Frank Conahan, head of the General Accounting Office's national security division in the 1980s. Tim Weiner, Blank Check: The Pentagon's Black Budget (New York: Warner Books, 1990) 16. One aerospace journalist pegged the NRO's Defense Support Program Office (under which ARSP operated) as handling DARPA's black UAV programs Amber and Condor. David A. Fulghum, "USAF Stresses UAVs for Recon," *Aviation Week & Space Technology,* Sept. 27, 1993: 44; "Sorting Out UAVs," *AW&ST,* Sept. 13, 1993. The Congressional conference committee that canceled AARS additionally agreed with a DOD decision to fold ARSP into what later became the Defense Airborne Reconnaissance Office (DARO), probably because the Advanced Airborne Reconnaissance System (AARS) was ARSP's main program. From 103rd Congress, 1st Session, "National Defense Authorization Act for Fiscal Year 1994," Report 103-357, 599.

120. Before Congress dismantled the Airborne Reconnaissance Support Program (ARSP), some members had been critical of the office in part because "it focused only on a single big program." Rich Tuttle, "Airborne Sensors Draw New Interest," *Aviation Week & Space Technology,* Jan. 10, 1994: 61.

121. Kier interview, May 10, 1999. Kier's dates are confirmed by reports of USAF's interest in an SR-71 replacement at that time. The Air Force was apparently looking at various manned platforms for that mission—this article mentions the manned Lockheed Aurora project as one possible competitor. Studying the various competitors for AARS probably ate up valuable time, ultimately making it more vulnerable when the post-Cold War budget cuts came in 1992. Jane Callen, "Air Force Battle Brews Over Using Unmanned Vehicles For Coveted Spy Mission," *Inside the Pentagon,* June 9, 1989: 1, 8.

122. "Stealth Recce," *Aviation Week & Space Technology,* Nov. 28, 1988: 19.

123. All three were subsonic, long-loiter UAVs. An unnamed source said these were "prototype experimental unmanned aerial vehicles with great sensor packages to gather a host of information. When you talk about those sensor capabilities, in addition to flying at an altitude of 100,000 feet, it's not hard to figure out what kind of role they're going to play." Amber had a ceiling of 25,000 feet, Condor's was 70,000 feet, so the unnamed source was talking about AARS. Jane Callen, "Air Force Battle Brews Over Using Unmanned Vehicles for Coveted Spy Mission," *Inside the Pentagon,* June 9, 1989: 8.

124. The Joint Requirements Oversight Council (JROC) was a panel chaired by the vice chairman of the JCS and the vice chiefs of staff of each service. They acted as a clearing house to prevent unnecessary overlap in military acquisition projects. JROC briefing quoted in Geoffrey Sommer, et al., *The Global Hawk Unmanned Aerial Vehicle Acquisition Process* (Santa Monica, CA: RAND, 1997) 12.

125. Gen. Larry D. Welch, July 12, 1989 testimony in front of House Armed Services Committee, "Hearings on National Defense Authorization Act for FY90: H. R. 2461 and Oversight of Previously Authorized Programs. Authorization and Oversight." (Washington, DC: GPO, 1989) 201.

126. The Air Force's Aeronautical Systems Division (ASD) listed, among other related projects, a "Strategic Reconnaissance Aircraft" for a "trans- and post-SIOP data-collection role." The Air Force Association, *Almanac of Airpower* (New York: Arco Press, 1989) 232. Strategic Air Command listed "Locate/Strike Strategic Relocatable Targets (SRTs)" as the top "user capability need" in 1990 and ASD opened a Strategic Relocatable Target Advanced Concepts Development Program Office in June 1990. "The Air Force Science and Technology Program," Headquarters Air Force Systems Command, Deputy Chief of Staff/ Technology, Oct. 1, 1990; 10; Breck W. Henderson, "Boeing Developing Millimeter Wave Radar To Spot Soviet Union's Mobile Missiles," *Aviation Week & Space Technology,* Oct. 8, 1990: 55.

127. Even within this cloistered world, black program managers may still have to compete for scarce dollars. "Kier's Bird," as some called it, lacked a quality called "time-to-station," or sheer intercontinental speed in the event of a crisis. A military official interviewed in 1994 said another very fast alternative to AARS was dropped in the 1980s, possibly the enigmatic Aurora. Boatman, "USA Planned Stealthy UAV to Replace SR-71," 1.

128. Martin C. Faga, director, National Reconnaissance Office, "Report to the Secretary of Defense and Director of Central Intelligence Regarding NRO Restructure," Jan. 8, 1990 (TOP SECRET—declassified and obtained by intelligence expert Richelson): 10.

129. This number tracks with leaks reported in 1994. Boatman, "USA Planned Stealthy UAV to Replace SR-71," 1.

130. A "senior Air Force official" revealed this fact when the

Tier III's smaller cousin crashed several years later. James R. Asker, "Told You So," *Aviation Week & Space Technology,* April 29, 1996: 23. The fallacy in this position lies in the fact that, with modern, software-driven fly-by-wire systems, the pilot has much less control over the aircraft than in the past and can cause pilot-induced malfunctions by fighting the flight control program. For example, "pilot-induced oscillation" (PIO) caused the crash of the highly automated YF-22 advanced tactical fighter in 1992. The test pilot's frenzied stick inputs in response to low-altitude oscillation actually caused the crash—had he taken his hand off the stick the software would have saved the plane. Michael A. Dornheim, "Report Pinpoints Factors Leading to YF-22 Crash," *AW&ST,* Nov. 9, 1999: 53.

131. Kier interview, May 10, 1999.

132. David A. Fulghum and John D. Morrocco, "CIA To Deploy UAVs in Albania," *Aviation Week & Space Technology,* Jan. 31, 1994.

133. Lt. Gen. Brett M. Dula, USAF (Ret.), former vice commander of Air Combat Command and commander of 2nd Air Force, interview, May 11, 1999. 2nd AF inherited strategic reconnaissance after the inactivation of Strategic Air Command on June 1, 1992. As ACC vice commander, Dula oversaw the incorporation of the Predator UAV in 1996.

134. The B-2 was fighting for its life in Congress during this period. David A. Fulghum and William B. Scott, "Sensor Package Could Allow B-2 Bomber To Find, Attack Targets Independently," *Aviation Week & Space Technology,* March 16, 1992: 19. Don Latham, assistant secretary of Defense for command, control, communications, and intelligence from 1981-88, wrote a fictitious scenario in which "mobile SS-27 ICBMs" are engaged by a US stealth bomber with onboard target recognition systems. He also described a "high-altitude surveillance drone." Donald C. Latham, "The Photon War," Armed Forces Journal International, February 1988: 48.

135. A likely candidate for a program fitting Kier's description was a moderately stealthy (all-composite) high altitude German airframe called Egrett that was built in cooperation with a major American electronics firm. Egrett was an optionally piloted 55,000-foot loitering aircraft and went by the codename Senior Guardian. The aircraft was very successful in flight testing (the German program went by the name of LAPAS, for Luftgestutztes Abstandsfahiges Primar Aufklarungssystem) but was canceled by the German government in 1993 after they had promised an $800 million production contract. "Three Firms Develop All-Composite Egrett-1," *AW&ST,* April 20, 1987: 23; "Germany finally cancels LAPAS," Flight International, Feb. 10, 1993; David Silverberg, "Future of Spy Plane May Hinge on German EFA Decision," *Defense News,* June 29, 1992: 46.

136. Although AARS was a major program, both the B-2 and Milstar were much larger. The Air Force received only 20 "silver bullet" models of the B-2 at a total program cost of $45 billion. General Accounting Office, "B-2 Bomber: Cost and Operational Issues," (Washington, D.C.: GAO/NSIAD-97-181, Aug. 14, 1997). To give a sense of Milstar's scope, Defense Secretary Les Aspin's 1993 "Bottom Up Review" cut the program back to $14 billion in space segment costs for fiscal years 1994-99, although it had already accounted for $7 billion in development costs. Each individual satellite cost in the range of $800 million—comparable to AARS's unit cost had it been built. Department of Defense, "Report on the Bottom Up Review," October 1993: 65-68; "Paying the Price for Early Warning," The National Journal, Feb. 18, 1989: 408; GAO, "Military Satellite Communications: Milstar Program Issues and Cost-Saving Opportunities," (Washington, DC: GAO/NSIAD-92-121, June 1992).

137. Kier interview, May 10, 1999. Milstar was probably the secure, high-bandwidth communications link between the loitering AARS and the attacking B-2. Only one month before, the Air Force awarded a $1.7 billion contract for development, test, and production of one Milstar 2 spacecraft. Michael A. Dornheim, "Milstar 2 Brings New Program Role," *Aviation Week & Space Technology,* Nov. 16, 1992: 63.

138. Allan Rutherford, Predator program manager, interview, April 30, 1999.

139. Sommer et al, 12.

140. Kier interview, May 10, 1999. Even US nuclear forces were thinking about how to adapt to the new environment, contemplating for the first time refocusing their assets on regional wars and conventional strike. Barbara Starr, "Targeting Rethink May Lead to Non-nuclear STRATCOM Role," *Jane's Defence Weekly,* May 22, 1993: 19.

141. For a four-aircraft buy, production costs would be $600 million to $1.6 billion. These models were apparently scaled down to about 150-foot wingspan versions with limited sensor payloads. David A. Fulghum, "Secret Flying Wing Slated For Rollout," *Aviation Week & Space Technology,* Sept. 19, 1994: 28; Fulghum, "Stealthy UAV is a Flying Wing," *AW&ST,* July 11, 1994: 21; John A. Tirpak, "The Robotic Air Force," *Air Force* Magazine, September 1997: 70.

142. Sommer, et al, 12. The characterization of the summer study as being loaded against Tier III comes from two anonymous interviews, neither individual having vested interest in the Tier III program. The Defense Science Board summer study was co-chaired by Robert J. Hermann (the NRO director under Carter) and Verne L. "Larry" Lynn. "Report of the Defense Science Board Task Force on Global Surveillance (U)," Office of the Under Secretary of Defense for Acquisition and Technology, December 1993. This citation is for reference only, no information from the study appears in this work.

143. David A. Fulghum, "UAV Contractors Plot Stealthy Redesigns," *Aviation Week & Space Technology,* Aug. 15, 1994: 60.

144. Boeing was one of the companies who vied for the AARS contract in the early 1980s and had worked on their own version of AARS up to the point of their consolidation with Lockheed around 1990. Condor was essentially a technology demonstrator for Boeing's composite wing and body construction techniques, digital flight control and mission planning aspects of their AARS design. Congressman Norm Dicks was probably instrumental in

joining the Boeing Condor and AARS teams with Lockheed when the decision to team the contractors was made.

145. Anonymous interview.

146. Tier III was still a very secret project, probably still under the control of ARSP and the strict BYEMAN compartmented classification system of the NRO. The open use of the nomenclature "Tier II plus" and 'Tier III minus" begged the question: What was Tier III?

147. In the endless quest for new ways to structure programs to either avoid cost overages associated with floating contracts (best characterized by the Army's Aquila UAV) or severe contractor stress associated with fixed-cost contracts (ATARS), the idea for these two Advanced Concept Technology Demonstrations (ACTDs) was called "cost as an independent variable." The government set the cost and broad parameters of capability, and the end-user and contractor made tradeoffs within that cost limit. Earlier attempts to use the same concept ended with cost growth no different than conventionally managed programs, however. Sommer, et al, 17-18.

148. Sommer, et al, 18.

149. Fulghum, "UAV Contractors Plot Stealthy Redesigns," 60; Ramon Lopez, "Pentagon Under Tier Pressure," *Flight International,* Sept. 28, 1994; anonymous interview. Kier mentioned that his program was called Tier III and Tier IV, interview, May 10, 1999.

150. John Entzminger, DARPA high altitude endurance UAV project manager, quoted in Lopez, "Pentagon Under Tier Pressure."

151. David A. Fulghum, "Stealthy UAV Is A Flying Wing," *Aviation Week & Space Technology,* July 11, 1994: 21.

152. The Advanced Research Projects Agency was established on Feb. 7, 1958 and endorsed by Congress in Public Law 85-325 on Feb. 12, 1958. The agency had its name changed periodically from ARPA to the Defense Advanced Research Projects Agency, back to ARPA, and back to today's DARPA. Throughout this work the current acronym, DARPA, will be used. There exists no definitive history of this interesting organization. The closest approximation is "The Advanced Research Projects Agency, 1958-1974," Washington, DC: Richard J. Barber Association, December 1975 (available through DTIC, No. ADA154363, or NTIS, No. AD-A154363/6). For a glossy overview of notable DARPA projects, see James C. Goodwin, et al, *Technology Transition* (Alexandria, VA: Defense Advanced Research Projects Agency, January 1997).

153. Paul Y. Hammond, *Organizing for Defense: The American Military Establishment in the Twentieth Century* (1961; Westport, CT: Greenwood Press, 1977) 371.

154. William J. Perry, Secretary of Defense, in the foreword to Goodwin, et al, *Technology Transition.*

155. H. H. Bailey, "Report of the Reconnaissance Panel Symposium on Remotely Piloted Vehicles (U)," Santa Monica, CA: RAND Corp., WN-7054-PR, September 1970.

156. J. H. Brown, R. G. Ollila, and R. D. Minckler, "A Survey and Technical Systems Assessment of Drone Aircraft for Tactical Reconnaissance and Surveillance," Vol. 1, Battelle Columbus Laboratories Tactical Technology Center, Columbus, OH, Advanced Research Projects Agency Report 1541, February 1972: 18 (hereafter referred to as "DARPA UAV Assessment")

157. "The Advanced Research Projects Agency, 1958-1974," Barber Association, VIII-52-53, IX-39.

158. Philip J. Klass, "Mini-RPVs Tested for Battlefield Use," *Aviation Week & Space Technology,* Jan. 22, 1973: 76.

159. The term "drone" was coined by US Navy Lt. Cmdr. Delmar S. Fahrney and Dr. Albert Hoyt Taylor, senior scientist and head of the radio division of the Naval Research Laboratory, in November 1936. The term came from the first true remotely controlled target aircraft, the British Queen Bee. Fahrney and Taylor selected "drone" after analyzing various names of insects and birds. Rear Adm. Delmar S. Fahrney, USN (Ret.), "History of Pilotless Aircraft and Guided Missiles," c. 1958 (Naval Historical Center archives, Naval Aviation History Branch, Pilotless Aircraft History file) Chap. 12: 12-13.

160. DARPA UAV Assessment, 18.

161. The DARPA report addressed extant technological hurdles. One of which was the problem of complex, cumbersome ground stations. "Off-loading" the pilot had, up to this point, multiplied the manpower required to operate drones. Firebee required up to 40 people for a single mission, and Overseer's cancellation stemmed in part from its massive, 19 vehicle platoon structure. DARPA UAV Assessment, 2.

162. DARPA UAV Assessment, C-2.

163. The Army requirements were for an "unattended aerial surveillance system" and an "elevated target acquisition system (ELTAS). "AMCA Concept F6002, Elevated Target Acquisition System (ELTAS) (U)," Alexandria, VA: US Army Advanced Materiel Concepts Agency (AMCA), April 29, 1971.

164. Klass, "Mini-RPVs Tested for Battlefield Use," 76.

165. RPAODS competitors were Melpar's E-35 (the RPV version of Melpar's Axillary radar-homing drone) and the Philco-Ford Praeire II. US Army "RPV Briefing to Maj. Gen. McAuliff (U)," May 1974 (Sherwin Arculis personal files) 5.

166. Black programs blossomed in the 1980s due to a re-heating Cold War, the phenomenal complexity and encumbrances of the formal acquisition process, the intensity of Congressional oversight and public pressure on defense programs, and the availability of money in the Reagan defense buildup. One investigative journalist reported that the black budget increased 800 percent from 1981 to 1985, reaching a peak of $36 billion in 1989. Tim Weiner, *Blank Check: The Pentagon's Black Budget* (New York: Warner Books, 1990) 10, 16. By 1996 with the end of the Cold War, the DOD comptroller said they had "dramatically fewer" black programs. David A. Fulghum,

"Stealth Investments Worry ACC Planners," *Aviation Week & Space Technology,* April 29, 1996: 42.

167. Amber was kept alive by its inventor and under the name Gnat 750 became an export to the Turkish armed forces. When that contract fell through, it filled a quick-reaction capability for the CIA in Bosnia in the early 1990s, and finally ended up in an improved version as an operational Air Force UAV called Predator. Each UAV will be covered in other chapters.

168. Curtis Peebles, *Dark Eagles: A History of Top Secret US Aircraft Programs* (Novato, CA: Presidio, 1995) 207.

169. DARPA also pursued an expendable OTH UAV called Sea Ferret in the early 1980s. Alvin Ellis, the father of the Israeli Mastiff mini-RPV, designed a state-of-the-art digital autopilot for Sea Ferret that, although very expensive, led the way to a series of increasingly effective digital flight control systems. Ellis, personal documents and interview.

170. DARPA had so many problems with Abraham Karem that they insisted his daughter act as chief financial officer and spokesperson for Frontier Systems, the company building his current UAV project—the A160 Hummingbird helicopter— for DARPA. Anonymous interview, Frontier Systems executive, Oct. 26, 1998.

171. Amber's odd-looking inverted V-tail was designed for optimal stowage and deployment from torpedo tubes, but that odd design persists in Amber's purely land-based operational descendants Gnat 750 and Predator. Rutherford interview, April 30, 1999.

172. John D. Morrocco, "Navy Plans Operational Trials for Amber RPV in 1989," *Aviation Week & Space Technology,* Dec. 14, 1987: 25-26.

173. Peebles, 208.

174. Critics said the loss of the crew could have been prevented by an unmanned strike. Norman Friedman, *World Naval Weapons Systems* (Annapolis, MD: Naval Institute Press, 1989) 52.

175. DARPA officials and Navy acquisition officials declined comment, so much of the evidence is anecdotal and inferential. Amber did have a weaponized version, the A45 model. Peebles, 207. This model may have raised arms control concerns, for although the cruise missile language in the Intermediate Nuclear Forces (INF) arms control agreement excluded sea-launched weapons, Amber was demonstrated as a ground-launched UAV. For testimony concerning the ramifications of the INF treaty on weaponized UAVs, see "NATO Defense and the INF Treaty," Hearings before the Committee on Armed Services, United States Senate, 100th Congress, 2nd Session, Part 5 (Washington, DC: GPO, 1989) 283.

176. Peebles, 211.

177. Gnat 750 was a misnomer because the air vehicle was quite large. Gnat 750 had limited over-the-horizon capability by way of a relay airplane whose altitude allows greater line-of-sight range. Gnat 750 used a manned Schweitzer RG-8, a powered sailplane and descendant of the Air Force Compass Dwell program of the early 1970s, for relay. CIA missions were limited by the endurance of the relay aircraft crew, not the UAV. "Gnat Goes Splat," (Washington Outlook) *Aviation Week & Space Technology,* Nov. 1, 1993: 23; David A. Fulghum and John D. Morrocco, "US Military to Boost Tactical Recon in 95," *AW&ST,* Jan. 9, 1995: 22.

178. Turkey later defaulted on payments for their UAV systems. The Gnat 750 systems cost $800,000 for an air vehicle and $1.2 million for the ground station, making a three aircraft system cost approximately $3.6 million. The CIA operated one air vehicle over Bosnia in January 1994 from an air base in Albania but experienced problems with the data link and weather. The system completed only 12 of 30 missions. "CIA to Deploy UAVs in Albania," *Aviation Week & Space Technology,* Jan. 31, 1994: 20; "Spying on Bosnia," (Washington Outlook) *AW&ST,* June 6, 1994: 23; "Spy Ops," (Washington Outlook) *AW&ST,* Nov. 14, 1994: 17.

179. The satellite system provided obvious range advantages, allowing Predator to use its full range capabilities. Predator is still used mainly in line-of-sight mode due to the larger bandwidth data link that allows higher fidelity digital imagery, so satellite operations does have drawbacks. Rutherford interview, April 30, 1999.

180. Michael A. Dornheim, "Novelty Continues—Regional Jets, Solar Aircraft," *Aviation Week & Space Technology,* Dec. 20/27, 1999: 124.

181. Amber and Condor were part of DARPA's "Teal Rain" program. Norman Friedman, *World Naval Weapons Systems 199-92* (Annapolis, MD: Naval Institute Press, 1989) 134; Joseph A. Lovece, "Big plans, high hurdles for UAV Joint Program Office," *Armed Forces Journal International,* July 1990: 48; DARPA, "Teal Rain Security Classification Guide" (DARPA Strategic Technology Office, Arlington, VA: March 6, 1979; from Richelson files, National Security Archives).

182. For a navalist slant on the decisive role of air power in attacking ships, see David Hamer, *Bombers Versus Battleships* (Annapolis, MD: Naval Institute Press, 1998).

183. The resemblance of this mission to those required by the Strategic Defense Initiative (SDI) may not be incidental. SDI backers had proposed a similar UAV as mid-course tracking platform for Soviet ICBMs in 1984. Clarence A. Robinson Jr., "Army Will Test Airborne Space Sensor," *Aviation Week & Space Technology,* July 2, 1984: 47, 48.

184. One problem with the "outer air battle" scheme was the range deficiency of Navy interceptor aircraft. In 1991, the Navy contemplated a novel operational concept using Condor for target acquisition and a submarine with surface-to-air missiles. Linked by a blue-green laser, the UAV could pass enemy aircraft plots to the submarine, which could ambush the bombers in the Norwegian Sea. Friedman, *US Naval Weapons Systems 1991-92,* 133.

185. Henderson, "Boeing Developing Millimeter Wave Radar To Spot Soviet Union's Mobile Missiles," 37.

186. Neil Arntz once briefed Navy Undersecretary Melvin

R. Paisley on the Navy's proposal to buy 200 Condors and Paisley "came out of his chair" and said they would buy nine at most. Neil Arntz interview, April 17, 1999.

187. Condor was a victim of the Congressionally mandated shrinkage of UAV programs. Because Condor came under the secretive Airborne Reconnaissance Support Program, it lost out to the stealthy but not yet flight-tested AARS program being developed by the NRO at the production decision point in 1990. Condor program manager Neil J. Arntz said his program, "lost out in Congressional choices to take the other [Boeing] bird vice ours." Arntz interview, April 17, 1999. An aerospace journalist pegged the NRO's Defense Support Program Office (under which ARSP operated) as handling Amber and Condor. Condor ended up a Lawrence Livermore Laboratories as part of their work on UAV-based boost-phase ballistic missile intercept. David A. Fulghum, "USAF Stresses UAVs for Recon," *Aviation Week & Space Technology,* Sept. 27, 1993: 44; "Sorting Out UAVs," AW&ST, Sept. 13, 1993; Kier interview, May 10, 1999, Maj. Gen. Kenneth R. Israel, USAF (Ret.), former director of the Defense Airborne Reconnaissance Office (DARO), interview, Jan. 21, 2000.

188. Arntz, "Condor," internal Boeing document (Arntz personal files), John Dale interview.

189. Two computers "vote" on flight control actions, while the third takes over in case one fails. Some 60,000 lines of code controlled Condor, which would be a fraction of that required for future UAV flight control algorithms. Henderson, 37. The flight control software was based on that developed for the Short Range Attack Missile (SRAM), a nuclear cruise missile employed by the B-52. "Altitude Record for 'Endurance' UAV," Sea Power, August 1990: 27

190. Landing did involve a precision approach system on the ground. Arntz interview, April 17, 1999.

191. "Altitude Record for 'Endurance' UAV," *Sea Power,* August 1990: 27; Friedman, *World Naval Weapons Systems 1991-92,* 133; Henderson, "Boeing Developing Millimeter Wave Radar To Spot Soviet Union's Mobile Missiles," 36. Before Arntz took over as Condor program manager, the former manager had spent all of DARPA's $300 million on the airframe, which left the contractor with the bill for the flight control system. Boeing's eventual investment in Condor reached $100 million. Arntz interview, April 17, 1999; Henderson, 37.

192. Arntz interview, April 17, 1999.

193. Every airplane is unique, so each flight control algorithm requires custom design and, up to now, many flight test hours to work out. Modeling the air flow across a particular wing or fuselage section involves very high-speed computers. As each day passes and computer speed and memory capability expands, the requirement for flight testing may diminish and the opportunity for highly reliable flight algorithms will help UAVs achieve higher reliability.

194. One of the names commonly used as a cover for NRO drones in this timeframe was "special purpose aircraft," or SPA. The drones covered in this section were considered "national" systems because mission tasking came from decision-making bodies higher than the military commands and from the same body that conducted spy satellite tasking. However, combat flights related in this section were largely in support of combat headquarters requests, such as 7th Air Force or Military Assistance Command, Vietnam (MACV). Paul W. Elder, "Buffalo Hunter 1970-1972," Project CHECO Report, (San Francisco CA: Headquarters PACAF, July 24, 1973) 12-18.

195. The Air Force provided funding for exploratory drone programs using the Navy's drone anti-submarine helicopter (DASH) in DARPA-managed programs called Nite Panther and Nite Gazelle.

196. The Army attempted analogous systems (i.e., SD-5 Osprey and SD-4 Swallow) in the early 1960s, although both were slated for ground launch.

197. The electronics allowed the drone flight crew to monitor only one drone at a time.

198. The low altitude mission employed a panoramic, horizon-to-horizon camera capable of 120 miles of photographic images recorded on 1,800 feet of 70 millimeter film. Resolutions ranged from six inches to one foot at operating altitudes of 1,000-1,500 feet. Elder, 3.

199. Data link range is a function of antenna configuration and transmitter power, while the curvature of the earth restricts data link range due to the "radio line-of-sight." Although early versions conducted pre-programmed maneuvers only, later modifications to the drone's control system allowed the DC-130 mothership to communicate via microwave when in radio line-of-sight with the drone, allowing remote piloting. Elder, 6.

200. Elder, 4.

201. The airborne remote control officer (ARCO) had some limited ability to correct this drift using the microwave command guidance system (MCGS), which was deployed in 1966. Stanton, "History–Detachment 3, 2762 Maintenance Squadron (Special)," 28; William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, CA: Aero Publishers, 1982) 73.

202. The standard target drone had an 82-foot main parachute, and Big Safari increased the parachute size to 100 feet, but the forces of impact and salt water contamination from sea landings damaged the sensitive internal components of the reconnaissance drones. Additionally, the drones sometimes drifted into hostile territory, where recovery teams might find a booby-trapped aircraft. Stanton, 22. Stanton interview, March 27, 1998.

203. Wagner, 108-109.

204. In the first few years, MARS recovery success was a dismal 60 percent, so the goal was raised to 80 percent, finally reached in 1969. In 1970, the recovery success goal was raised to 98 percent after technical improvements, and recovery operations from 1972 to 1974 achieved 98.1 percent success. Briefing, "Remotely Piloted Vehicles, Recovery History," Air Force Systems Command System Program Office (SPO), October 1974 (AFMC archives).

205. In a document declassified for this study, SAC historians explained the reliability improvements by noting the increase in learning by SAC planners with regard to route planning and MARS. They tended to fly the drones over populated areas when they noted the reluctance of North Vietnamese missile crews to shoot the large SA-2s due to collateral damage caused by expended rocket motors and warhead shrapnel. Also, drone programmers changed the flight path of the drone every 30 seconds because enemy Fan Song radars took that long to acquire target lock. "SAC Reconnaissance History, January 1968-June 1971 (U)," Offutt AFB, NE: History Division, Headquarters Strategic Air Command, Nov. 7, 1973: 37, 40-41.

206. Barry Miller, "RPVs Provide US New Weapon Options," *Aviation Week & Space Technology,* Jan. 22, 1973: 39.

207. SAC received less than half the electronics countermeasures support they requested of TAC's EB-66 unit, the 42nd Tactical Electronic Warfare Squadron. Elder, 24.

208. Elder, 7.

209. In addition, the in-theater intelligence analysis section forwarded the film to the US for analysis by other members of the intelligence community. Elder, 11.

210. Robert F. Whitney, "Hanoi is Building Sites for Missiles," New York Times, April 16, 1965: A1; Lon O. Nordeen Jr., *Air Warfare in the Missile Age* (Washington, DC: Smithsonian Institution Press, 1985) 15. A very good study of the massive Soviet effort to develop the SA-2 can be found in Steven J. Zaloga, *Soviet Air Defence Missiles: Design, Development, and Tactics* (Surrey, England: Jane's Information Group, 1989).

211. Two days later an SA-2 shot down a drone as well. Secretary of Defense Robert S. McNamara did not allow US airmen to attack the SA-2 sites for fear of escalating the war. Kenneth P. Werrell, *Archie, Flak, AAA, and SAM: A Short Operational History of Ground-Based Air Defense* (Maxwell AFB, AL: Air University Press, 1988) 103; Nordeen, 15-16; "SAMs Down F-4C, Damage Three Others," *Aviation Week & Space Technology,* Aug. 2, 1965: 27. The first Navy jet (an A-4 Skyhawk) downed by an SA-2 soon thereafter on Aug. 11, 1965. Norman Polmar, et al, *Chronology of the Cold War at Sea 1945-1991* (Annapolis, MD: Naval Institute Proceedings, 1998) 95.

212. Dr. Eugene G. Fubini added that this one mission "paid for the entire drone program up to that date." The quote showed how substantial the SA-2 threat looked to the Air Force. Several years later, a CIA official confirmed that the electronic countermeasures equipment carried by US combat aircraft were still using the information gathered from that one flight. Wagner, 102. The SA-2 accounted for two allied losses in Desert Storm, more than 30 years after its first famous victim.

213. Wagner, 102.

214. SAC resurrected the United Effort mission under the codename Compass Cookie in 1972. With extensive Linebacker missions in the offing, the Air Force needed an update on SA-2 arming and fuzing sequences in case the Soviets had a surprise waiting. On Sept. 28, 1972, a Lightning Bug drone once again drew a fatal missile and transmitted good data, confirming the ECM gear used by the B-52 crews in the upcoming offensive. Wagner, 198.

215. The decoys used a technology called "traveling wave tubes" to provide a bigger radar target, but Soviet and Vietnamese missile crews soon learned to distinguish the decoys from actual camera-carrying drones and B-52s, which put a stop to the program. Many of the decoy drones made it back to base on the early NRO missions, so SAC had theirs configured with parachutes and cheap cameras on the chance they might be recovered. Wagner, 110-111.

216. The Air Force's Big Safari office managed the program, codenamed Scathe Mean. Air Force Col. John Warden requested the decoys to replicate the Israelis' successful Bekaa Valley strike. William D. Grimes, Big Safari chief, interview, March 19, 1998. See also, Michael R. Gordon and Bernard E. Trainor, *The General's War* (Boston, MA: Little, Brown and Company, 1995) 112-114, 217-220; David A. Fulghum, "US Air Force Target Drones Baffled Iraqi Defense Radars," *Aviation Week & Space Technology,* Aug. 19, 1991: 65; "BQM-74 Drones Operated by Former GLCM Unit Played a Key Role in Deceiving Iraqi Military," *AW&ST,* April 27, 1992: 20.

217. Anti-aircraft fire was most dangerous below 4,000 feet. Flight ceilings were well below that altitude during the rainy season. Anywhere from two-thirds to three-quarters of all US aircraft downed in the Vietnam War came from anti-aircraft artillery as opposed to missiles. Nordeen, 13.

218. Wagner, 107, 213.

219. Quoted in Elder, 17.

220. Wagner, 135. This figure is extremely low because the first "S" models used a "borrowed" Army reconnaissance camera. Stanton interview, 1998. Omnipresent flight control engineer Alvin Ellis, the father of the Israeli mini-RPV, designed the low altitude control flight control system for later "S" models. Ellis, personal papers.

221. Stanton, "History-Detachment 3," 33; Stanton interview, March 27, 1998.

222. LORAN is a navigation system in which a receiver measures the difference between radio signals from two or more surveyed transmitters. In the early 1970s it allowed accuracies in the hundreds of feet and did not suffer from "drift" as did inertial systems. Conceptually, LORAN was a precursor to today's highly accurate, satellite-based GPS, which uses satellites as transmitters rather than stationary sites. Both LORAN and GPS depended on microprocessor technology. Scott Pace, et al, *The Global Positioning System* (Santa Monica, CA: RAND, 1995) 237.

223. The term "electro-optical" refers to a camera that records images that are converted to signals rather than transferred to film. Wagner, 213. The Buffalo Hunter's "Speedlink" data link had a range of 200 miles line-of-sight and was developed for the same mission Fahrney's TDR television drones envisioned in World War II—as

terminal guidance ship attack. The television data link was demonstrated in 1971 and used in Vietnam in 1972, years prior to former Ryan Aeronautical engineer Ellis putting a data link on the Israeli Mastiff RPV. Wagner, 178.

224. Lightning Bug drones were officially a “national” asset controlled by the Joint Chiefs of Staff and the US Intelligence Board. The Joint Chiefs, however, delegated their control to SAC. Elder, 12.

225. While true from a purely cultural perspective, fighter ascendancy clearly benefited from a national strategy that emphasized conventional warfighting in Europe, while bomber influence declined with decreases in bomber numbers caused by the rise of ICBMs. Deployed ICBMs exceeded bombers just about the time LeMay departed as Chief of Staff in 1965. Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership* (Maxwell AFB, AL: Air University Press, 1998) 124. This transition of power was not complete until a fighter pilot, Gen. Charles A. Gabriel, became Chief of Staff in 1982. Fighter generals subsequently held that post until 2008 when Gen. Norton A. Schwartz, an air mobility and special operations pilot, became Chief.

226. John I. Lumpkin, “The Tactical Air Command and Drones/RPVs 1966-1978,” (Langley AFB, VA: Headquarters Tactical Air Command, 1979 [declassified]) 17. Teledyne Ryan Aeronautical proposed the use of Lightning Bugs for attacking heavily defended targets, but TAC declined due to the vulnerability of the launch aircraft, drone control unreliability, and lack of precision. Lumpkin, 18.

227. Since World War II, airmen knew that dropping strands of metal foil confused enemy radars. Chaff dispensing aircraft preceded strike aircraft into the target area and had to fly at high enough altitude that the chaff would remain airborne long enough to protect the incoming fighter-bombers. This made them vulnerable to radar-guided missiles and gunfire, thus the mission was conceptually attractive for drones.

228. Wagner, 153.

229. President Lyndon B. Johnson ordered a halt to all bombing north of the demilitarized zone, where all the radar-guided missile sites were located, reducing the need for chaff-carrying drones. Wagner, 154.

230. The 11th Tactical Drone Squadron’s assets were part of the tactical electronic warfare system (TEWS). Since 1967, they could only conduct drone flights with borrowed SAC launch and recovery aircraft, sometimes going two years between missions. They had some drones, but they lacked organic launch and recovery capability. Lumpkin, 26. Sixteen of the unit’s 43 drones were lost in training and testing. The unit failed its first operational evaluation in 1970 due to DC-130 launch aborts and “poor reliability, maintainability, and performance.” Wagner, 154-155. The unit did not receive CH-3E MARS recovery helicopters until April 1972. USAF Unit Lineage and Honors History, 11th Tactical Intelligence Squadron, Aug. 26, 1991 (Bolling AFB, DC: Air Force Historical Research Agency) 8.

231. Lumpkin, 28, 30; Wagner, 197.

232. The coordination process took over 36 hours. Elder, 13, 15.

233. Gen. John D. Lavelle, quoted in Elder, 17.

234. Gen. John W. Vogt Jr., quoted in Elder, 18.

235. Quoted in Elder, 36.

236. Vogt’s quote also suggests this type of weapon system gains more of a following during combat than it does during peacetime. The drone is a weapon of the weak, requiring the warrior to confront his mortality. This happens in a more clear-headed way during war when death is imminent, but gets lost in peacetime when fantasies of invulnerability, which are crucial to the warrior culture, tend to dominate.

237. Wagner, 192.

238. Elder, 27.

239. Derived from RPV Briefing, October 1974, AFSC System Program Office (SPO), slide titled “Operational Activities, Combat Dawn, Combat Angel, Compass Bin” and 1974 RPV Program Assessment Review, Sept. 16, 1975, Col. Ward W. Hemenway, “Combat Dawn Operations” (AFMC archives).

240. Tactical Air Command’s chaff-dispensing drones never dispensed chaff in combat, but they were used for the novel task of leaflet dispensing in July 1972 in operation known as Field Goal, or the “Litterbug” project. Elder, xi; Wagner, 197.

241. Linebacker II raids commenced on Dec. 18, 1972 and ended on Dec. 29 of that year. Elder, 29, 30.

242. Vogt, quoted in Elder, 29.

243. Wagner, 202. Drone veteran and Air Force pilot John Dale remembers: “In Linebacker, North Vietnam was overcast, so we sent in drones because you had to have 2,500 feet for manned recce because they had to be able to jink, so the only pictures briefed to Congress on how we didn’t hit any bad targets during Linebacker II came from drones. Dale interview.

244. Buffalo Hunter low altitude sorties comprised almost 75 percent of the total, which includes the early “J” and “N” model drones. These figures were computed based on the table of SAC’s 100th Strategic Reconnaissance Wing operational drone sorties. Wagner, 213.

245. The treaty, signed on Jan. 13, 1973, stated, “The United States shall cease immediately, completely, and indefinitely aerial reconnaissance over the territory of the Democratic Republic of Vietnam.” Nan Robertson, “New Accord on Vietnam Calls for Halt Tomorrow on All Cease-Fire Violations,” *New York Times,* Jan. 14, 1973: A18. However, when a complete bombing halt was enacted Jan. 15, 1973, a Pentagon spokesman also announced that drones would continue to conduct reconnaissance flights, as had become the custom in the bombing surges of previous years. The last drone sortie flying out of U-Tapao, Thailand flew over Saigon on April 30, 1975. Wagner, 198, 200.

246. As a historical note, the Air Force also operated an "optionally piloted" aircraft called Pave Eagle. When the North Vietnamese accelerated their use of the Ho Chi Minh trail, the Air Force developed the Igloo White remote sensor program to monitor trail activity. Igloo White ground sensors transmitted movement information to loitering aircraft. The Lockheed EC-121R Super Constellations that previously gathered the data were too vulnerable, so the Air Force converted about three dozen Beech Model 36 Bonanza aircraft to an unmanned configuration to collect Igloo White transmissions. Designated the QU-22B, the aircraft operated out of Nakhon Phanom, Thailand. Pave Eagle carried one pilot who took off and landed the aircraft, but the rest of the mission was automated. The program was canceled because of aircraft losses associated with engine failure. "Bonanzas Used in Special Surveillance Program" *Aviation Week & Space Technology,* Aug. 31 1970: 17; John W. R. Taylor, ed., *Jane's All the World's Aircraft 1973-74,* (New York: McGraw-Hill, 1974) 526; Barry Miller, "USAF Widens Unmanned Aircraft Effort," *AW&ST,* Nov. 9, 1970: 52.

247. "Remotely Piloted Vehicle Effort Pressed," *Aviation Week & Space Technology,* Feb. 6, 1978: 176. Cost estimates come from various Ryan company sources including chief engineer Schwanhausser and Big Safari head Stanton.

248. OSD Comptroller's Southeast Asia Statistical Summary, Table 321, "Sorties and Losses—North Vietnam," July 25, 1973. Wayne Thompson, formerly at the Air Force History Support Office, provided this information.

249. Marsh was not a pilot. His comments may be colored by the dispute over Big Safari versus Air Force acquisition management. Marsh interview, April 19, 1999.

250. Just at this time the acronym RPV, for remotely piloted vehicle, took over from "drone" as the new moniker for UAV systems.

251. Nordeen, 207. Nordeen's Air Warfare in the Missile Age remains the classic account of the evolution of Soviet air defenses up to the point where American technology vanquished it using a "combined arms" approach employing stealth, electronic countermeasures, and precision weaponry as demonstrated in the 1991 Persian Gulf War.

252. Robert Frank Futrell, *Ideas, Concepts, Doctrine Vol. II* (Maxwell AFB, AL: Air University Press, 1989) 485. This belief was vigorously opposed in public statements by NATO air chiefs. "A Tactical Fighter for Tomorrow? Opinions of the Commanders in Chief," *Aerospace International,* January/February 1977 (part 1): 4-5, and March/April 1977 (part 2): 6-7.

253. John Schlight, "Vietnamization and Withdrawal, 1968-1975," *Winged Shield, Winged Sword: A History of the United States Air Force Vol. II* (Washington, DC: Air Force History Office, 1997) 329.

254. The DDR&E oversaw DARPA. Philip J. Klass, "Mini-RPVs Tested for Battlefield Use," *Aviation Week & Space Technology,* Jan. 22, 1973: 76; "The Advanced Research Projects Agency, 1958-1974," Washington, DC: Richard J. Barber Association, December 1975 (available through DTIC, No. ADA154363, or NTIS, No. AD-A154363/6) VIII-52-53, IX-39. Dr. John S. Foster was also instrumental in the development of the cruise missile, another innovative weapon system which enjoyed a constituency among technically oriented civilians in DOD. Ronald H. Huisken, *The Origin of the Strategic Cruise Missile* (New York: Praeger, 1981) 34-36.

255. Secretary of the Air Force John L. McLucas added, however, that "drones do not offer an escape from the demanding requirement for high reliability." McLucas, "The Role of RPVs in the Air Force," Commander's Digest, Jan. 16, 1975: 12, 14, "Air Force Plans Steady Growth in RPV Effort, *Aerospace Daily,* May 6, 1974: 1.

256. Integrated circuits were developed in 1958, but expanded in complexity and shrunk in size until the first true microprocessor, which could function as the central processing unit for a computer, the Intel 4004 hit the market in 1971. Prior to that, the first standardized microprocessor, the PDP-10, produced in 1969 and used in many military systems, is considered by many to be a bellwether.

257. Integrated circuits (microchips) allowed so-called "full duplex" data links, which maintained simultaneous communication between the ground station and the craft on the same frequency. This allowed the operator in the ground control station to receive data from the aircraft and respond in real-time. Launch date for Defense Support Program satellite, Susan H. H. Young, "Gallery of USAF Weapons," *Air Force* Magazine, May 2000: 160.

258. In 1965, the US launched Intelsat 1, which allowed 240 voice circuits. By 1971, Intelsat 4 carried a 4,000-voice circuit capability into space. "Communications Satellite," Encarta Encyclopedia 2000. In 1970, the government also launched Darpanet, the predecessor to the Internet, establishing the first glimmerings of digital communications. The imminent explosion in digital communications fueled the technological optimism by suggesting the acceleration in information technology would continue. TACSAT 1, National Museum of the US Air Force Fact Sheet, Tactical Communications Satellite (TACSAT 1) (http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=547); Apollo 11 mission description (http://www.nasa.gov/mission_pages/apollo/missions/apollo11.html)

259. RAND hosted the symposium in Santa Monica, Calif., on May 19-21, 1970, followed by reports of the various committees at a conference June 30 through July 1. Barry Miller, "Remotely Piloted Aircraft Studied," *Aviation Week & Space Technology,* June 1, 1970: 14; Barry Miller, "Tests of Remotely Piloted Fighter Likely," *AW&ST,* Sept. 28, 1970: 20. RAND played a similar role in stimulating the Army Air Force's interest in satellites in the 1950s with their engineering report titled, "Preliminary Design of an Experimental World-Circling Spaceship," which also popularized the term "satellite." William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986) 58-59.

260. Edgar Ulsamer, "Remotely Piloted Aircraft—Weapon System of the Future?" *Air Force* Magazine, October 1970, 40-44; briefing, RAND/AFSC Symposium on Remotely Piloted Vehicles, Manager's Report, July 1970, Melvin Tanchel, HQ/

AFSC, William B. Graham, RAND Corp. (AFMC archives). In an editorial in *Aviation Week & Space Technology,* Robert B. Hotz said the RAND/AFSC symposium "first sparked major industry interest." Hotz, "The Promise of RPVs," *AW&ST,* Jan. 22, 1973: 7.

261. Military and industry insiders formed the National Association of Remotely Piloted Vehicles (NARPV) in December 1972. It exists today with a broader focus as the Association of Unmanned Vehicle Systems International. William Wagner and William P. Sloan, *Fireflies and Other UAVs* (Arlington, TX: Aerofax, 1992) 17-18.

262. Gen. John D. Ryan served as CINCSAC from Dec. 1, 1964 to Feb. 1, 1967. Roger R. Trask and Alfred Goldberg, *The Department of Defense 1947-1997: Organization and Leaders* (Washington, DC: Office of the Secretary of Defense Historical Office, 1997).

263. Stanton (eyewitness) interview, March 27, 1998.

264. Ryan ordered the Air Staff to study centralizing all RPV operations under one command after the Vietnam War, which maintained SAC as the sole operator for the time being. Lumpkin. 23.

265. Ben Crane, Air Force drone advocate in the 1970s, interview, Sept. 15, 1998.

266. These statistics were derived from tables in the special RPV issue of *Aviation Week & Space Technology,* Jan. 22, 1973: 54-56.

267. Gen. George S. Brown was a B-24 Liberator pilot in World War II and received the Distinguished Service Cross for his actions on the dangerous raid on Ploesti, Rumania in August 1943. Both Ryan and Brown were West Point graduates, as were many of the Air Force Chiefs of Staff prior to the mid-1990s.

268. US Congress, Senate, "History of Fiscal Year 1975 Department of Defense Research, Development, Test, and Evaluation Authorization and Appropriation," Congressional Record Vol. 120 (Oct. 11, 1974) S19090-S19091. This is reminiscent of the Army Air Forces domination of guided missile research after World War II. Most of those ambitious projects were dropped to meet the 1946 budget cuts. Kenneth P. Werrell, *The Evolution of the Cruise Missile* (1985; Maxwell AFB, AL: Air University Press, 1996) 81.

269. This is not to suggest that Air Force RPV testing occurred in an environment free of restrictions, but in order to operate the long-range UAV types they were developing, the Air Force had to work with civilian airspace control authorities to loosen airspace control rules to allow unmanned flight operations.

270. In 1972, TAC established a requirement for a multi-purpose drone system that could perform reconnaissance, electronic combat, and strike missions, and conducted extensive studies that constituted a "master plan" for an enlarged drone force. Lumpkin, 30.

271. PAVE STRIKE symbolized a rejuvenation of the tactical air forces after Vietnam and was stimulated by the 1973 Yom Kippur War. Gen. Robert J. Dixon, TAC commander, wanted to re-focus his command on the European Central Front and Soviet air defense capabilities. PAVE STRIKE projects emphasized operations in night and bad weather, in addition to defense suppression. Along with RPVs, projects included detection and location of air defense emitters (the precision emitter locator strike system to be mounted on an RPV), EF-111A jammers, F-4 Wild Weasel aircraft, and laser-guidance for Maverick and other standoff munitions. Futrell, 488-489.

272. The explicit tasking from Dixon and the commander of Air Force Systems Command led to a study (called the Strike Systems Study or S3, later the Synergistic Strike System) that explored tradeoffs between standoff missiles, RPVs, and manned strike aircraft. Letter, HQ AFSC/XRLA to ASD/XRL, April 2, 1975, Subject: AFSC Directive A-180-1-74-40, Aug. 27, 1973, "Advanced Tactical Fighter (ATF) Alternatives and Technology Options," (AFMC archives, supporting document I-13 to AFMC ATF history). Later, the Improved Tactical Attack System (ITAS) program planned for a mix of manned and unmanned strike aircraft for the post-1990 timeframe called the Advanced Tactical Attack System (ATAS). ASD/XRM history report, July-December 1978 (AFMC archives) 3. By 1981, however, unmanned systems were dropped entirely from far-term planning for the ATF, mainly due to arms control conflicts raised later in this chapter. History of the Tactical Air Command, January-June 1981 (ACC archives) supporting document 678. The foregoing information is covered tangentially in David C. Aronstein, Michael J. Hirschberg, and Albert C. Piccirillo, *Advanced Tactical Fighter to F-22 Raptor: Origins of the 21st Century Air Dominance Fighter* (Reston, VA: American Institute of Aeronautics and Astronautics, 1998) 10, 15-17.

273. "Program D," National Reconnaissance Office, undated (Richelson personal files). Pedlow and Welzenbach, 257; McLucas interview, Sept. 26, 1999.

274. This passage correctly implied that SAC drones had little to do with the execution of the Single Integrated Operational Plan (SIOP), the nuclear war plan and SAC's overriding focus.

275. Gen. Robert J. Dixon, letter to Gen. Russell E. Dougherty, July 23, 1975 (ACC archives, "TAC Drones/RPVs" Vol. II, SD #17); Lumpkin, chapter 3.

276. Dougherty remembered the transfer as non-controversial, but the documentary record tells a different story as does its decade-long duration. Dougherty interview, Sept. 20, 1998.

277. The 11th TDS continued in the Combat Angel ECM role, while the 22nd TDS took on the SAC reconnaissance drones from Vietnam. They both fell under the 432nd Tactical Drone Group at Davis-Monthan AFB, Ariz. Wagner, 104.

278. The first two high-altitude, loitering UAV programs included the Combat Dawn ELINT drones, Compass Arrow, the ill-fated "perfect" drone, described earlier.

279. SAC took operational responsibility for the program in 1970. "SAC Reconnaissance History, January 1968-June

1971 (U)," Offutt AFB, Neb.: History Division, Headquarters Strategic Air Command, Nov. 7, 1973: 37, 116.

280. "New Drone Program," *Aviation Week & Space Technology,* Jan. 5, 1970: 22.

281. High-altitude flight requires an increasingly complex engine configuration to achieve meaningful thrust. For subsonic flight, modern reciprocating engines can achieve 60,000 to 70,000 feet only with heroic and complex modifications.

282. Not generally discussed in the literature was the fact that helicopters not only hooked the drones upon mission termination, but also had to get airborne for the launch phase, because many times the drone popped its chute immediately upon launching from the underwing pylons of the DC-130. The cost of fuel required for one launch and recovery may very well have exceeded the price of one drone. Jim Callard, drone recovery helicopter pilot in the mid-1970s, interview, March 10, 2000.

283. The full duplex data link allowed real-time control of the plane even as flight telemetry was transmitted to the ground control station.

284. "SAC Reconnaissance History, January 1968-June 1971 (U)," 116.

285. "New Drone Program," *Aviation Week & Space Technology,* Jan. 5, 1970: 22.

286. Sailplanes use high aspect ration wing designs that attempt to achieve laminar airflow over much of the wing's length, thereby achieving very efficient, high-lift flight characteristics. High altitude and long endurance are traded for low-speed stability, however, making takeoff and landing a very difficult task. Since the remote pilot did not have instantaneous kinesthetic feedback, only visual cues could be used to accomplish takeoff and landing. This problem plagues all high-aspect-ratio-wing aircraft (such as the U-2).

287. The YO-3 project started in 1966 and saw combat in 1970, but it did not survive the Vietnam War. Doug Richardson, *Stealth Warplanes* (London: Salamander, 1989) 100.

288. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59.

289. Erwin J. Bulban, "LTV Develops High-Altitude Recon Drone," *Aviation Week & Space Technology,* Feb. 2, 1970: 56.

290. The E-Systems aircraft reached 40,000 feet using a more powerful turboprop engine, but could not demonstrate the endurance standard. Barry Miller, "RPVs Provide US New Weapon Options," Jan. 22, 1973: 41, 43.

291. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59.

292. SAC actually resisted the idea of launching and recovering RPVs on an airfield, wanting instead to retain the air-launched Combat Dawn despite its much shorter (eight- to 10-hour) loiter time. Most of the service initiative came from TAC and air intelligence. "SAC Reconnaissance History, January 1968-June 1971 (U)," 117.

293. Barry Miller, "Remotely Piloted Aircraft Studied," *Aviation Week & Space Technology,* June 1, 1970: 14; Barry Miller, "USAF Widens Unmanned Aircraft Effort," *AW&ST,* Nov. 9, 1970: 47; "RPVs to Play Electronic Warfare Role," *AW&ST,* Jan. 22, 1973: 59; Cecil Brownlow, "Operational Decisions Pace Advance," *AW&ST,* Jan. 22, 1973: 51; Kenneth Munson, *Jane's World Unmanned Aircraft* (London: Jane's, 1988) 169.

294. Boeing also investigated a low-altitude, jet-powered RPV in the mold of Lightning Bug, but chose to pursue the high-altitude idea first. Richard O'Lone, "Boeing Pushes Compass Cope Reliability," *Aviation Week & Space Technology,* Jan. 22, 1973: 83.

295. Boeing may have been motivated to pursue speculative projects like Compass Cope due to its desperate situation. In June 1970, they lost the lucrative B-1 bomber contract to Rockwell and found themselves with no major military projects for the first time since the early 1930s. In their desperation to maintain contact with the Air Force, Boeing jumped on the RPV bandwagon signaled by the AFSC/RAND symposium, which convened one month after the B-1 decision. Although it was rumored that the Air Force gave the sole-source Compass Cope contract to Boeing to stimulate competition with Teledyne Ryan Aeronautical, it also probably served as a consolation prize that helped prop up Boeing's position in the defense industrial base.

296. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59; Cecil Brownlow, "Operational Decisions Pace Advance," *AW&ST,* Jan. 22, 1973: 51; Munson, *Jane's World Unmanned Aircraft,* 169. Ironically, Boeing's prototype used the General Electric J-97 engines built exclusively for the Teledyne Ryan-built Compass Arrow. Wagner and Sloan, 110-111.

297. O'Lone, "Boeing Pushes Compass Cope Reliability," 81.

298. Wagner and Sloan, 111.

299.1145 The flight test standards required 24-hour endurance, takeoff and landing from a conventional runway under normal visual flight rules clearance, a 750-pound payload, and safe engine-out glide recovery from 100 miles away. Both companies lost one aircraft in flight testing. The Teledyne Ryan prototype set an unmanned, unrefueled endurance record of 28 hours, 11 minutes in November 1974, eclipsing the record of 27.9 hours set by a Compass Dwell prototype. The first Boeing prototype crashed on its second flight, but the second flying prototype successfully completed the first night runway landing of an RPV. Wagner and Sloan, 114; Lumpkin, 141.

300. The contract winner would be tasked to design a production vehicle that incorporated lessons learned from the demonstration.

301. The original requirement asked for a 1,200-pound payload, but concern over pushing RPV technology too fast resulted in the requirement being lowered. By 1974,

the TAC requirements list for Compass Cope expanded to include over-the-horizon drone control, tactical weather monitoring, and laser designation, among others. Lumpkin, 140-142.

302. The PELSS radar-location technology, also called Pave Nickel, became the prime focus of the Compass Cope program and reflects the increasing importance placed on killing Soviet air defense radars. The concept of operations for PELSS involved several widely-spaced aircraft triangulating electronic emissions using microprocessor-based distance measuring techniques. The system required extreme location accuracy which could only be achieved using ground-based emitters upon which the entire system depended. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 61.

303. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59. The RC-135 Cobra Ball (a Big Safari project using a converted Boeing 707) that collected Soviet missile telemetry flew with multiple flight crews to achieve its long 12-hour missions over the Arctic. Rivet Joint aircraft (also converted Boeing 707s) also collected electronics emissions. The large passenger aircraft with its large crew and capacity for expansion and electric power generation proved to be an enduring platform and mission marriage. "Big Safari History at the Greenville Division," company pamphlet, (Greenville, TX: Raytheon E-Systems, April 1997) 16-19, 20-22.

304. According to NRO director McLucas, the program employed satellite data links used by SAC to communicate with B-52 bombers flying over the North Pole. This meant that Program D, the NRO's airborne reconnaissance office, was a partner in the Compass Cope program. McLucas interview, 1999. The term "surrogate" drone is used for aircraft wired to fly autonomously that also have a human pilot onboard for reasons of reliability and test feedback. Boeing reported using a piloted Cessna 172 for automated takeoff and landing tests in conjunction with the Compass Cope project, noting that the pilot was never forced to take over airplane control in the last eight months of the 10-month flight test period. O'Lone, "Boeing Pushes Compass Cope Reliability," 83.

305. Barry Miller, "RPVs Provide US New Weapon Options," Jan. 22, 1973: 41.

306. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 61.

307. The aircraft was also slated for a side-looking radar for identifying ground targets through overcast. "Compass Cope Engineering Development Cost Set at $156.1 Million," *Aerospace Daily,* May 31, 1977: 1.

308. TAC's own "feudal lords" in US Air Forces in Europe (USAFE) and Pacific Air Forces (PACAF) disagreed on Compass Cope. TAC headquarters and USAFE wanted the RPV, while PACAF maintained that the U-2R could do the mission at much less cost and without the problem of getting airspace clearance from key allies Japan and South Korea. Lumpkin, 143, 144.

309.1155 General Accounting Office, "Status of the Remotely Piloted Aircraft Programs," PSAD-77-30, Feb. 18, 1977: 4. SAC planned to operate Compass Cope from Elmendorf AFB, Alaska, as a replacement for RC-135 electronic eavesdropping aircraft. "RPVs to Play Electronic Warfare Role," *Aviation Week & Space Technology,* Jan. 22, 1973: 59.

310. The Air Force considered putting television and onboard collision avoidance sensors on Compass Cope to answer airspace safety concerns, but these systems required additional, expensive development and reduced the air vehicle's useful payload capacity. GAO Report PSAD-77-30: 5.

311. Futrell, 545.

312. Lumpkin, 145.

313. Rhea said that "nobody has been able to convince Congress that it's more than a solution looking for a problem." John Rhea, "RPVs: Waiting for the payoff on a gold mine," *Electronic Business,* August 1977: 12, 14.

314. The implication here is that when the U-2 became an exclusive Air Force program on Aug. 1, 1974, it competed directly against programs like Compass Cope. Pedlow and Welzenbach, 257. The TR-1 was essentially a renamed U-2R, which had a 2,000-pound payload capacity compared to 750 pounds for Compass Cope. Wagner and Sloan, 111. Tactical Air Command wanted PLSS in the field quickly, and an operating capability for the RPV seemed too far in the future. The TAC commander, Gen. Wilbur L. "Bill" Creech, called PLSS "a critical element of our overall approach to defense suppression" and compared it to the importance of AWACS in identifying air threats. Futrell, 545, 546. On the Compass Cope project, Stanton remembers pressure from Lockheed and the PLSS manufacturer to wait for the TR-1 (TR stands for tactical reconnaissance, a designation change due to the fact that some countries would not allow the U-2 to land inside their borders because of its role as a spy aircraft), which was a higher cost airframe ($20 million), but cheaper because it did not require development and could attain much higher flight reliability. Stanton interview, Feb. 28, 1999.

315. Here we can see the contrast between the Israeli approach to real-time optical downlinks and that of the US. Because the Israeli mini-RPVs loitered at 5,000-10,000 feet, they achieved radio line-of-sight to ground stations inside Israel with RPVs in combat. The US jet RPVs, however, penetrated at more than 400 knots and lower than 1,000 feet. This required an extremely high-speed camera, lots of data to pump through the data link, and some sort of high-altitude relay platform to achieve radio line-of-sight to the RPV. Additionally, the US could assume the Soviets would employ more savvy electronic countermeasures, requiring a much higher degree of jam-proofing. The technological hurdles faced by Air Force engineers was much higher.

316. Israeli Prime Minister Golda Meir prompted the US Air Force to pursue various means of suppressing deadly new Soviet air defense missile systems in late 1970. That request led to the "Have Lemon" program, which demonstrated drone-launched precision guided munition employment in 1971. The Air Force persisted along this line, producing

"strike drone" prototypes used in major exercises and tests in 1974. In pristine desert conditions, the drones demonstrated acceptable performance, but exercises in Germany showed drone sensors to be inadequate and wing icing to be a major problem. Although many of these modifications were simply testbeds, an improved electronic countermeasures drone achieved operational status just prior to the Davis-Monthan Air Force Base drone group being disbanded in 1979. Lumpkin, 100-110; Wagner and Sloan, 98-104; Wagner, 180; "Improved RPV Ready After 3 Years," *Aviation Week & Space Technology,* Feb. 6, 1978: 175-176.

317. Lumpkin, 110.

318. Lumpkin, 161-162; "Remotely Piloted Vehicle Effort Pressed," *Aviation Week & Space Technology,* Feb. 6, 1978: 173 (the three advanced drones, from Northrop, Rockwell, and Boeing were pictured in this issue on pages 170, 175, and 176, respectively).

319. The Air Force's enthusiasm for the multi-role capability led to immediate studies for the generation of RPVs beyond the BGM-34C, called the "advanced drone." Lumpkin, 161-162.

320. Lumpkin, 112-122 (DC-130H, multiple drone control system), 122-127 (MARS helicopters).

321. Lumpkin, 111.

322. The BGM-34C suffered several mishaps, the third happening during Air Force budget deliberations in July 1977, leaving only two test aircraft remaining.; Message from HQ USAF to HQ TAC, Subject: RPV/Drone Program Realignment (U), Jan. 13, 1978 (ACC archives, "TAC Drones/RPVs" Vol. II, supporting document #83); Lumpkin, xxv, 113.

323. Lumpkin, 48.

324. Lumpkin, 107-108.

325. The drones had to fly in far enough to kill integrated air defense and command and control centers and then return well behind US lines to be recovered by helicopters that were even more vulnerable than the launch aircraft. Callard interview, March 10, 2000.

326. Callard interview, March 10, 2000.

327. The limitations posed by air launch and recovery drove the Air Force to explore both Compass Dwell for Eastern Europe and Compass Cope for Alaskan ELINT operations—both UAVs launched and recovered conventionally. Barry Miller, "RPVs Provide US New Weapon Options," Jan. 22, 1973: 41; Samuel Hall, 21; Joseph R. Johnson, "Limitations on the Acquisition of RPVs: Technical, Political or Managerial?" Air Command and Staff College, May 1975, 77. Sortie rate problems still plague tactical drone proposals. In a letter to the DOD Inspector General in 1993, the Air Force stated a sortie rate of one vehicle every six hours as a reason to defer ground launch requirements and reduce the planned buy of the Medium Range UAV built by Teledyne-Ryan. Maj. Gen. Larry L. Henry, letter to Assistant Inspector General of Auditing, April 16, 1993, (DOD IG Audit #93-102, 50, 51).

328. The current operations and maintenance cost of the 432nd Tactical Drone Group (two squadrons) was $26.3 million per year. Samuel Hall, 21.

329. "US drone phase-out accelerated," *Flight International,* Jan. 13, 1979: 74.

330. Samuel Hall, 21.

331. The main reason for logistical delays was the disassembling and reassembling of the CH-3 MARS helicopters. Samuel Hall, 20-21.

332. "A Study of Command, Control, and Communications for Unmanned Air Vehicles in Tactical Air Operations," Teledyne-Ryan Aeronautical and Hughes Aircraft Company Ground Systems Group, March 1973, Electronic Systems Division, Hanscom AFB, MA (AFMC archives, microfiche document #8064) 6.

333. Teck A. Wilson, letter to Gen. Wilbur L. Creech, July 14, 1978 (ACC archives).

334. Treaty language comes from *Arms Control and Disarmament Agreements* (Washington, DC: US Arms Control and Disarmament Agency, 1982) 252-253.

335. Congressional hearings noted the standoff "harassment drone" did not fall under the treaty due to insufficient range, but that follow-on studies of mid-range RPVs (the "advanced drone") might. US Senate, Committee on Foreign Relations, "FY80 Arms Control Impact Statements," (Washington, DC: US GPO, March 1979) 205-212; US House of Representatives, Committee on Foreign Affairs, "FY81 Arms Control Impact Statements," (Washington, DC: US GPO, March 1979) 402, 408.

336. The "TAC-TRADOC Dialogue," established in 1973, constituted an early version of jointness in which the Air Force and Army leadership held high-level talks and studies to cooperate against what was viewed as a "dynamic quantitative and qualitative edge" Warsaw Pact forces had built in Europe. For a good synopsis of the first five years of that relationship, see Gen. Robert J. Dixon's article, "TAC-TRADOC Dialogue," Strategic Review (Winter 1978) 45-54. For a concise analysis of the airpower implications of that relationship, see Hotz, "Writing a New TAC Book," *Aviation Week & Space Technology,* Feb. 6, 1978: 13 (the entire issue was devoted to this subject).

337. Ironically, the report suggested DARPA's mini-RPV efforts would be able to fill the Army's reconnaissance needs near the forward edge of the battle area, thus freeing manned reconnaissance for conducting deeper imaging in the areas where the Air Force thought it could contribute more to the battle. Throughout modern history, the Army tended to defer to the Air Force in this area due to its own cultural disregard for airborne reconnaissance. Futrell, 544-545.

338. Wagner, 107. The issue of spare parts was not trivial during this period. Gen. Brice Poe II, commander of Air Force Logistics Command, had to be talked out of quitting over "a budget request for only 15 percent of the Air Force's validated requirement for spare parts in the first

30 days of war." Gen. Brice Poe II, USAF (Ret.), quoted in Wayne Thompson, ed., "Air Leadership: Proceedings of a Conference at Bolling Air Force Base," April 13-14, 1984 (Washington, DC: Office of Air Force History, 1986) 113.

339. Message, CSAF to TAC, subject: "RPV/Drone Program Realignment," Jan. 13, 1978 (ACC archives, "TAC Drones/RPVs," Vol. II, SD #137; Barry Goldwater, personal letter to Gen. Wilbur L. Creech, Commander, Tactical Air Command, June 1, 1978 (ACC archives, "TAC Drones/RPVs, Vol. II, SD #102). The EF-111A was another part of the PAVE STRIKE initiative. Futrell, 489. One major advantage of the EF-111A over smaller drone jammers was brute power (kilowatts). The Soviets demonstrated the capability to "burn through" low-power jammers in Vietnam. Steven J. Zaloga, *Soviet Air Defence Missiles: Design, Development, and Tactics* (Surrey, England: Jane's Information Group, 1989) 59. The ignominious end to this story is that the 432nd drones went back to target drone duty testing F-15 air-to-air capability, while the last two EF-111A Raven aircraft were flown to the Aerospace Maintenance and Regeneration Center in Arizona on June 19, 1998. Lumpkin, 60, 95; www.amarcexperience.com.

340. In a memo to the Chief of Staff, Dixon blasted the measures, saying: "The net effect is a stagnation and decline of both TEWS [Tactical Electronic Warfare Squadron] and recce drone capability. The chaff and EW mission will have to be carried by increased dedication of fighter aircraft diverted from their primary missions." The memo warned of an ominous gap in ECCM capability until the EF-111A could be brought on line. Memo, Commander, TAC to Chief of Staff, Subject: AF FY 79 Budget Decrement Submission, Sept. 17, 1977 (ACC archives, "TAC Drones/RPVs" Vol. II, SD #75).

341. Samuel Hall, 33.

342. John L. McLucas, "The US Space Program Since 1961: A Personal Assessment," *The US Air Force in Space: 1945 to the 21st Century,* eds. R. Cargill Hall and Jacob Neufeld (Washington, DC: US Air Force History and Museums Program, 1998) 86.

343. Lumpkin 169.

344. The Air Force got "drone envy" as one Big Safari proponent quipped, when it saw the billions being spent on them during the Vietnam War.

345. Col. John B. Rosenow, staff summary sheet, Subject: "Personal Evaluation of Drone Development," Oct. 22, 1976 (ACC archives, "TAC Drones/RPVs, Vol. I, SD #13). He also mentioned Compass Arrow as a program plagued by delays.

346. David Packard (of Hewlett-Packard fame) was the Deputy Secretary of Defense under Melvin Laird starting in 1969. Packard instituted a series of remarkable initiatives designed to streamline the weapon system acquisition process. He later chaired a Blue Ribbon panel on weapon system acquisition reform during the Reagan years. Those initiatives were the forerunners of today's advanced concept technology demonstrator (ACTD) programs, under which many UAV programs fall.

347. William E. Krebs, "Did We Err in the Development of Remotely Piloted Vehicles (RPVs)?" Maxwell Air Force Base, AL: Air War College Research Report MS 018-79, April 1979: 26.

348. William D. White, *US Tactical Air Power* (Washington, DC: The Brookings Institution, 1974) 59.

349. Crane interview, Sept. 15, 1998.

350. In testimony, Foster suggested that aerospace contractors deliberately inflated these programs for profit. In fact, many of the RPV programs of the 1970s were contractor-funded, and companies like Boeing absorbed large losses pursuing what amounted to a chimera. Their disillusionment was part of the downturn of UAV enthusiasm in the 1980s. Senate Armed Services Committee, "FY74 Authorization for Military Procurement, Research and Development, Construction Authorization for the Safeguard ABM, and Active Duty and Selected Reserve Strengths," Part 6, Washington, DC: GPO, 1973: 2827.

351. Allan R. Millet and Peter Maslowski, *For the Common Defense: A Military History of the United States of America,* 2nd ed. (New York: The Free Press, 1994) 597, 598.

352. Crane interview, Sept. 15, 1998.

353. Plummer, NARPV convention address reported in "Air Force's Plummer Notes Problems in Acceptance of RPVs," *Aerospace Daily,* Sept. 3, 1975: 1.

354. In 1977, a Boeing manager stated that his company invested $12.5 million in RPVs since the RAND report. The RPV manager at Lockheed, however, noted that managers and engineers at these companies had not completely committed to RPVs, but were simply waiting for the next "bandwagon" to come along. "Industry Wants Clarification of RPV Missions, Funding," *Aerospace Daily,* June 10, 1977: 1.

355. The past waste referred to here was Compass Arrow, a $300 million UAV program ($1.7 billion in FY10 dollars) that produced only a "silver bullet" force of 20 aircraft and never flew an operational flight due to the Nixon Administration's rapprochement with China. The House Appropriations Committee also criticized the Navy's failure to build a joint target drone control system that met Air Force requirements. US Congress, House of Representatives, Committee on Appropriations, "Report, Department of Defense Appropriations Bill, 1974" (Report #93-662), 93rd Congress, 1st Session (Washington, DC: GPO, Nov. 23, 1973) 216.

356. Hotz editorial, January 1973.

357. Samuel P. Huntington attributed this idea to Albert O. Hirschman. Huntington, *The Common Defense: Strategic Programs in National Politics* (New York: Columbia University Press, 1961) 368.

358. It is interesting to note that, although the Navy accounted for a large percentage of the prisoners of war in Vietnam, they did not pursue either RPVs or stealthy aircraft in the 1970s. Not until the F-117 had proved itself and

Navy Secretary John F. Lehman forced them to consider a UAV for tactical reconnaissance (the failed medium range UAV) did they pursue both options in the late 1980s. The advanced tactical bomber, otherwise known as the A-12, was the Navy's failed attempt at a stealthy carrier-based aircraft.

359. Aronstein and Piccirillo, *Have Blue and the F-117A,* 58.

360. Submariner James H. Patton Jr. has this important observation, "Two platforms that had high loss rates in World War II—the attack submarine and the long-range bomber—are the weapon systems benefiting most from the application of stealth technologies. ... Today, these are the platforms most assured of returning safely from a combat mission." Patton, "Stealth Saves Lives," US Naval Institute *Proceedings,* June 1999: 78.

361. In then-year dollars, the program cost $2 billion for research and development and $4.3 billion for production, totaling more than $110 million per aircraft, although unit fly-away costs were $53 million. Aronstein and Piccirillo, 267. Upon completion of the program, official Air Force sources put the FY91 cost at $8.2 billion, amounting to $12.5 billion in constant FY10 dollars. Richard G. Davis, "Strategic Bombardment in the Gulf War," *Case Studies in Strategic Bombardment,* ed. R. Cargill Hall (Washington, DC: Air Force Office of History, 1998) 532. This program was the leading edge of a massive Air Force commitment to stealth technology that led to the multi-billion dollar B-2 stealth bomber, stealthy cruise missiles, and the stealthy F-22 Raptor air superiority fighter. By way of comparison, Congress capped the F-22 program at $18.7 billion for development and $43.4 billion for production of the planned 339 aircraft buy, a total of $80 billion in FY10 dollars. National Defense Authorization Act for Fiscal Year 1998, PL-105-85, Title II, Sec. 217: F-22 Aircraft Program, Nov. 18, 1997.

362. Other problematic technology areas include the lack of a GPS-like location accuracy system, the impracticality of the aircraft launch and helicopter recovery system, and the lack of sufficiently sophisticated flight control technology that would have allowed for flight reliability appropriate for a hypothetically high-priced system.

363. Even a stealthy UAV that operated much like the F-117 would have required high-altitude relay due to long distance line-of-sight limitations at the ranges required by the European scenario. The combat radius of the F-117, for instance, is much farther than the 150 to 200 miles that a line-of-sight data link could accommodate at the operational altitudes required for employment of its laser-guided bombs.

364. One of the RAND/AFSC symposium panels to explore UAV applications was the Interdiction and Close Air Support group. Barry Miller, "Remotely Piloted Aircraft Studied," *Aviation Week & Space Technology,* June 1, 1970: 14.

365. One series of standoff systems that did not reach operational status was a family of small, very RPV-like radar-homing aircraft. The first of these was the tactical expendable drone system (TEDS), which was canceled due to high unit cost in the late 1970s. TEDS comprised two systems, one a jet-powered decoy, and the other, an orbiting jammer. The program's aggressive goal was to keep unit costs below $25,000. "USAF Deletes Constant Angel Funds," *Aviation Week & Space Technology,* Oct. 23, 1972: 16; "RPVs to Play Electronic Warfare Role," *AW&ST,* Jan. 22, 1973: 60; Futrell, 544. Next came a promising program named Seek Spinner, an extremely low-cost radar-attacking "harassment" drone favored by TAC commander Dixon. The Seek Spinner died in the 1970s, but was resurrected as Pave Tiger in the early 1980s. The Air Force planned to buy 1,000 Boeing Pave Tiger mini-drones in 1983, but that program also failed to perform and stay within cost goals, so USAF attempted to cut the program several times. Congress continued to override the Air Force's wishes, funding the harassment drone through 1987, including an $80 million Boeing factory for Pave Tiger production. The program was finally cut in 1988. Benjamin F. Schemmer, "US RPVs Back in Production as USAF Buys 1,000 Boeing Pave Tigers," Armed Forces Journal International, July 1983: 10; "Congress Cuts Seek Spinner Drone Funding in Favor of Tacit Rainbow," *AW&ST,* Aug. 8, 1988: 19.

366. Another very sophisticated, RPV-like program that failed in the 1980s was the Tacit Rainbow air-launched, battlefield loiter, radar-homing killer drone. Tacit Rainbow was a very secret, tri-service program that the Air Force planned to launch from B-52 rotary launchers, the Navy would drop from under-wing hardpoints on the A-6E Intruder, while the Army would employ its multiple launcher rocket system (MLRS). The jet-propelled system flew to a specific geographic grid and went into a loiter profile, from which it would pounce on active radars. Full-scale development started in 1981 with a unit cost goal of $100,000. It came out of the "black" along with the B-2 in April 1987, and public scrutiny revealed its persistent flight test problems, a 14-month program lag, and a 600 percent cost overrun. By 1990, the program was four years behind schedule, and development costs ballooned to more than $400 million. Sen. Sam Nunn (D-Ga.) was the powerful chairman of the Senate Armed Services Committee, and Tacit Rainbow was built in Nunn's home town of Perry, Ga. Nunn's backing kept the program afloat until Congress finally killed it in 1990. Barbara Opall, "DOD Kills 2 Antiradar Missiles," Defense News, Jan. 7, 1991: 1. Tony Capaccio, "New Failure May End Tacit Rainbow's Misery," *Defense Week,* Sept. 24, 1990: 7.

367. A number of good cruise missile studies exist. See Kenneth P. Werrell, *The Evolution of the Cruise Missile* (1985; Maxwell AFB, AL: Air University Press, 1996); Richard K. Betts, ed., *Cruise Missiles: Technology, Strategy, Politics* (Washington, DC: The Brookings Institution, 1981); Stephen E. Ockenden, "Patterns of Innovation in Weapons Acquisition Decisions: The Case of the Long Range Cruise Missile," dissertation, University of Minnesota, 1987.

368. Cruise missile historian Werrell calls it "a classic, if tragic, example of service parochialism." Werrell, 230. The CINCSAC of that era, Gen. Russell E. Dougherty, disagrees—he believes it was a classic, if tragic case of civilian meddling. Dougherty still bristles at having ALCM "forced down our throats" by politicians. He said the missile was ineffective, experienced wing icing and other reliability problems that would have severely limited its performance over frigid

Soviet airspace, yet Deputy Secretary of Defense William P. Clements Jr. ordered him to write up a requirement for it, saying "it worked fine." It was, he said, "a huge push to keep us from buying the B-1" rather than a drive for innovation. Dougherty interview, Sept. 20, 1998.

369. Cruise missiles ended up providing negotiators with significant leverage. Werrell, 154, 172-176.

370. Werrell, 177. The 668th Bombardment Squadron, 416th Bombardment Wing, Griffiss AFB, N. Y., was the first cruise missile-capable unit in the Air Force in December 1982. Werrell, 187.

371. The Air Force's Ground Launched Cruise Missile (GLCM) is another example of technology already in hand, but brought to operational status through political events. President Reagan deployed GLCM to induce an agreement in the Intermediate Nuclear Forces (INF) arms control talks. Air Force leaders did not oppose INF treaty provisions banning GLCM, and the system vanished when the political reason for its adoption vanished. James Q. Wilson said, "GLCMs were not seen by any military service as part of its core mission." James Q. Wilson, *Bureaucracy: What Government Agencies Do and Why They Do It* (New York: Basic Books, 1989) 226.

372. Treaty language uses 600 kilometers. START wording does not specifically exclude non-nuclear ALCMs, but does require on-site inspection and verification for those systems. Lt. Gen. Gordon E. Fornell, USAF (Ret.), "International Treaty Implications , Intermediate Nuclear Forces, and Strategic Arms Reduction Treaty," UAV Technologies and Combat Operations, US Air Force Scientific Advisory Board Report SAB-TR-96-01, Vol. 2, November 1996, 7-17, 7-18. (hereafter cited as USAF SAB UAV report)

373. Sea-launched and air-launched UAVs would not fall under these stipulations. "NATO Defense and the INF Treaty," Hearings before the Committee on Armed Services, United States Senate, 100th Congress, 2nd Session, Part 5 (Washington, DC: GPO, 1989) 283—hereafter referred to as "SASC INF Hearings."

374. Listed ranges are converted from the treaty's 500 to 5,500 kilometers. The INF Treaty excludes a "weapon delivery" vehicle in these ranges, meaning one that could carry "any warhead, mechanism, or device which, when directed against any target, is designed to damage or destroy the target." INF Treaty stipulations for range are also very tight, being the fully fueled, straight-line flight to fuel exhaustion. Michael O. Wheeler, letter to author, former chief of the Nuclear and Space Negotiations Division of the Joint Chiefs of Staff, Jan. 4, 1997, 1.

375. Fornell, 7-17.

376. Other reasons included the US advantage in air- and sea-launched cruise missiles and the threat of Soviet cruise missiles in chemical or biological delivery roles. "SASC INF Hearings" 282-284; Wheeler letter, 1.

377. Emphasis in original. Wheeler believes an amendment to the treaty may be the only viable long-term solution. Wheeler letter, 2. As evidence of the power of that treaty wording, the US military considered using an Israeli-built air defense radar-attack drone called Harpy in the 1999 Kosovo air campaign, but declined due to concerns over its apparent violation of INF restrictions on cruise missiles. US defense officials considered modifying Harpy for sea-launch to bypass the INF treaty language. Steve Rodan, "South Korea buys 100 IAI Harpys," *Jane's Defense Weekly,* Jan. 19, 2000: 5. The 1990 Conventional Forces in Europe (CFE) treaty further put a damper on weapon-delivery UAV development. CFE sets a 700 aircraft limit on the number of "fixed-wing or variable-geometry wing aircraft armed and equipped to engage targets." At the time, the US had about 200 aircraft in Europe, so CFE limits would not appreciably limit UCAV adoption.

378. Lockheed handed the first TR-1 over to the Air Force by September 1981, a remarkable accomplishment. The last of series was delivered in October 1989. Chris Pocock, "U-2: The Second Generation," *World Air Power Journal,* Vol. 28, Spring 1997: 64, 70.

379. The original Advanced Synthetic Aperture Radar System (ASARS) was a more primitive radar imaging system deployed on the SR-71 in the mid-1960s. ASARS-2 substantially improved on that system by using 20 years of exponential improvement in computing power. Pocock, 64.

380. The so-called "Senior Span" satellite uplink system spent four years in development before achieving an operational configuration due to the stringent requirement for location accuracy (the antenna has to track the satellite within a few degrees). The first deployment of satellite-capable U-2s occurred in 1989, although its restricted bandwidth keeps the line-of-sight downlink the preferred mode. Pocock, 76.

381. Chaff consists of a cloud of wires, glass fibers, or aluminum foil cut to specific lengths and dispensed in clouds to confuse enemy radars. Jamming involves interfering with enemy radars by transmitting the same frequency to overwhelm the radar receiver. Pulse-Doppler filtered radars could distinguish aircraft from chaff, although an individual aircraft still carried chaff dispensers because they could cause a radar to break lock momentarily due to the initial velocity of the chaff after release. Nordeen, 228.

382. By contrast, the large Compass Cope RPV had a 750 pound payload. The EF-111A program cost about $25 million to modify each aircraft ($91 million in FY10 dollars) and had an overall program cost of $1.5 billion (about $5.6 billion in FY10 dollars).

383. As Soviet radars became more sophisticated, jammers had to adapt from the old technique of spot jamming (on a discrete frequency) to what was called "barrage" jamming on various frequencies at once. This technique required very high wattages, which required a large, powerful aircraft. Nordeen, 229.

384. The TFX program was highly politicized because Defense Secretary Robert S. McNamara overruled the services' choice of contractor, choosing instead one located in President Lyndon Johnson's home state of Texas. On the heels of the TFX's failure, the Navy procured the F-14

Tomcat air defense fighter and the Air Force bought highly modified versions of the TFX called the F-111 Aardvark. For more on the TFX (F-111) program, see Robert F. Coulam, *Illusions of Choice: The F-111 and the Problem of Weapons Acquisition Reform* (Princeton, NJ: Princeton University Press, 1977) and Robert F. Art, *The TFX Decision: McNamara and the Military* (Boston: Little, Brown, 1968).

385. Gen. Jack N. Merritt, Army (Ret.), director of the Joint Staff from 1983-1985, remembers the Joint Chiefs set up the predecessor to today's Joint Requirements Oversight Council (JROC), and the first program they attempted to rationalize was UAVs. He commented, "I said, well, that dooms the [UAV] program right there." Merritt interview, Feb. 19, 1999.

386. Graham T. Allison, *Essence of Decision* (New York: Harper-Collins, 1971) 67.

387. "Unmanned Aerial Vehicles 1994 Master Plan," Washington, DC: UAV Joint Project Office, May 31, 1994: 3-29. (DTIC No. ADA321288) The Air Force called the new UAV the Unmanned Air Reconnaissance System (UARS). Thomas Lydon, *RPVs/DRONES/TARGETS Worldwide Market Study and Forecast 3rd ed.* (Greenwich, CT: Defense Marketing Services, 1987) 252.

388. "DOD Joint UAV Master Plan 1988," Washington, DC: DOD Joint UAV Program Working Group, June 27, 1988: 22, 44. (DTIC No. AD-A197751)

389. The use of satellite data links would have entailed too much cost and technological uncertainty for a program with the MR-UAV's cost goals.

390. The imminent retirement of the RF-4 necessitated the study. "US Air Force Major Commands: A New Era," Airman, September 1992: 12. The MR-UAV is an autonomous, high-speed, low profile, ceramic body UAV capable of ground or air launch. The contractor modified a ground-launched UAV they built for Egypt called the Scarab to win the MR-UAV contract, proving again the strength of some system maturity. Department of Defense Office of the Inspector General, "Acquisition of Unmanned Aerial Vehicles," Audit Report #93-102, May 27, 1993: 25; Wagner and Sloan, 175-193.

391. The F-16R squadrons would operate and maintain the UAVs, adding 290 billets to the five squadrons. Eighty percent of the UAVs would be ground launched using three launchers per squadron, and 20 percent would be configured for air launch. The total Air Force buy of 260 UAVs called for 100 operational units, 150 wartime spares, and 10 training vehicles. DOD IG, "Acquisition of UAVs," 8-9.

392. For an example of the general line of "jointness" advocates, see "Joint Major System Acquisition by the Military Services: An Elusive Strategy," General Accounting Office report GAO/NSIAD-84-22, Dec. 23, 1983.

393. Wagner and Sloan, 183-184, 189; DOD IG, "Acquisition of UAVs," 25.

394. As previously mentioned, the Air Force did use UAVs in a non-returnable decoy role in the first two days of the air war.

395. David A. Fulghum, "UAVs Pressed Into Action To Fill Intelligence Void," *Aviation Week & Space Technology,* Aug. 19, 1991: 59.

396. This figure is in then-year dollars and covers the UAV system, not just air vehicles. DOD IG, "Acquisition of UAVs," 25. General Accounting Office, Report # GAO/NSIAD 91-2, "Unmanned Aerial Vehicles: Medium Range System Components Do Not Fit" (Washington, DC: GPO, March 25, 1991).

397. The F-16R force was also realigned. Of the remaining three squadrons, two would be in the Air National Guard, and the other 18 aircraft scattered to three composite wings. Only the ANG F-16R units would employ the UAV-MR. DOD IG, "Acquisition of UAVs," 9, 50, 51.

398. DOD IG, "Acquisition of UAVs," 16-17.

399. GAO, "Unmanned Aerial Vehicles: Medium Range System Components Do Not Fit," 2

400. DOD, "Unmanned Aerial Vehicle 1994 Master Plan," 3-29.

401. "ATARS Sensors Likely To Find New Homes," *Aviation Week & Space Technology,* July 5, 1993: 28.

402. The top UAV priority by this time was the Short Range UAV called Hunter. UAV 1994 Master Plan, 3-29.

403. Lockheed Skunk Works had a project called LightStar, its name an apparent reference to the larger DarkStar UAV mentioned later in this study, that could fill this mission area. Lockheed's internal designation is P-420, and it is a medium-altitude (5,000 to 25,000 feet), stealthy vehicle that looks like a small B-2. Lockheed engineers patented the vehicle in May 1996 under patent D382851, which can be viewed on the Internet at http://www.uspto.gov/patents/process/search/. Terry Mahon provided the original patent information.

404. The Marine Corps got Congress to give them money to turn the remaining ATARS equipment into reconnaissance pods at very low cost, and the MR-UAV contractor delivered air vehicles with infrared line scanners as part of contract termination in 1997. "ATARS sought for USMC Hornets," *Jane's Defence Weekly,* Oct. 23, 1993: 19. On disposal of BQM-145 air vehicles, see Bruce A. Smith, "Air Vehicles From Canceled Program To Be Delivered," *Aviation Week & Space Technology,* Feb. 10, 1997: 26. There is some indication that the stored BQM-145s will be used as a testbed for UAV delivery of a high powered microwave or other directed-energy weapon. David A. Fulghum, "Computer Warfare Offense Takes Wing," *AW&ST,* Jan. 19, 1998: 56.

405. Baker quoted in "News and Comments," 6.

406. Lumpkin, 167.

407. The space shuttle, for instance, had an autonomous, redundant, hands-off flight control system developed at tremendous expense. For the important role of the space shuttle in advance of computer-controlled flight, see William Elliott, "The Development of Fly-By-Wire Flight

Control," Air Force Materiel Command Historical Study No. 7, (Wright-Patterson AFB, OH: Air Materiel Command Headquarters, December 1996), and Rick Gore, "When the Space Shuttle Finally Flies," *National Geographic,* March 1981: 328.

408. Recall that Boeing had demonstrated low data-rate satellite control of a surrogate UAV in the early 1970s. The technology existed, but was quite immature and very expensive. The cost of a satellite-linked UAV with a space shuttle-caliber flight control system would have been astronomical, and it would have lacked location accuracy (which GPS provided by the mid-1990s).

409. Bureaucratic politics guru Morton H. Halperin defined an organization's "essence" as "the view held by the dominant group in the organization of what the missions and capabilities should be." The Air Force's "essence," he says, "is the flying of combat airplanes designed for the delivery of nuclear weapons against targets in the Soviet Union." Halperin, *Bureaucratic Politics and Foreign Policy* (Washington, DC: The Brookings Institution, 1974) 28.

410. In the estimation of McNamara's "whiz kids," the ICBM enjoyed significant cost effectiveness advantages over manned bombers. Almost 40 years after McNamara's statement, the B-52 still retains the nuclear delivery mission as well as making substantial conventional contributions to the conflicts in the 1990s. Larry Booda, "More Minutemen Sought to Replace B-52s," *Aviation Week & Space Technology,* Nov. 26, 1962: 27.

411. The same can be said for the Signal Corps' pursuit of the SD series drones in the late 1950s and early 1960s, and the intelligence community's UAV programs in each of the decades covered by this study. Each was pursuing a futuristic vision that amounted to conducting basic research instead of weapon system development. This picture contrasts sharply with the view of many scholars that the services are endemically hidebound.

412. Marsh interview, April 19, 1999.

413. US Congress, Senate, Committee on the Armed Services, Hearings on Fiscal Year 1975, Authorization for Military Procurement, et al., Part 3 (Washington, DC: GPO, 1974) 884.

414. TAC commander, Gen. Robert J. Dixon, *Aerospace Daily,* Sept. 28, 1976: 1.

415. Marsh interview, April 19, 1999.

416. Anonymous F-16 pilot, brigadier general-select, interview, Feb. 20, 1999.

417. Israel interview, Jan. 21, 2000.

418. The distinction between tactical and strategic intelligence was mainly an artifact of the Cold War. Strategic, or "national," intelligence referred to data gathered in support of high-level government agencies and US nuclear forces, whereas tactical intelligence supported military forces by providing enemy order-of-battle information and other data important to the theater commander.

419. GPS represented a revolution in location accuracy for several reasons. First, the Air Force absorbed virtually all the cost by building, launching, and operating GPS satellites. Since GPS receivers are several orders of magnitude cheaper than an inertial navigation system providing the same accuracy, UAVs get all the benefits without the cost. Second, GPS does not lose accuracy (drift) like an inertial navigation system or the radio location technology used in short range UAV systems like Pioneer. Third, GPS has inherent jam resistance due to its frequency-hopping technology, providing a high degree of position accuracy assurance in a hostile environment. Using GPS, UAVs enjoy unprecedented levels of cheap, light, accurate, and redundant location accuracy that greatly increases their military utility.

420. A comprehensive study of air power in the Gulf War found tactical airborne reconnaissance "deficient" and called the belief that national systems could compensate for this shortfall "misplaced." Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis, MD: Naval Institute Press, 1995) 163-164.

421. Deputy Undersecretary of Defense for Advanced Technology Lynn co-chaired a major study of tactical airborne reconnaissance in summer 1993 due to the unfulfilled requests of theater commanders in chief. The recommendation for creation of DARO came from that study. The language called for a "tactical reconnaissance office" in the mold of the NRO. The 103rd Congress, House of Representatives, "National Defense Authorization Act for Fiscal Year 1994," Conference Report 103-357, Nov. 10, 1993: 599. "1997 Tactical Unmanned Aerial Vehicles Overview," Nov. 30, 1997, Program Executive Office, Cruise Missiles and Joint Unmanned Aerial Vehicles, 1-1.

422. The JPO still coordinated the programmatics of the UAV budget, but DARO provided substantial oversight. Deputy Secretary of Defense memorandum, "Establishment of the Defense Airborne Reconnaissance Office (DARO)," Nov. 6, 1993 (hereafter called "Perry memorandum"). See also, DOD Directive 5134.11, "Defense Airborne Reconnaissance Office (DARO), Undersecretary of Defense for Acquisition and Technology, April 5, 1995.

423. OSD Information Paper, "DOD Support for the Defense Airborne Reconnaissance Program (DARP)," (DARO files).

424. Perry memorandum.

425. DARO's decisions were vetted through the Joint Requirements Oversight Council, which was chaired by the vice chairman of the Joint Chiefs and consisted of the vice chiefs of the services, and went through "Tank" sessions where service chiefs and operations deputies gave their blessing.

426. DARO also reviewed and reported on the services' operations and maintenance funding. House of Representatives, Hearings before a Subcommittee of the Committee on Appropriations, "Department of Defense Appropriations for 1995," Washington, DC, 1994: 788.

427. Terry Ryan, deputy to Israel at DARO, interview, March 8, 1999.

428. The Army was not managing that joint program well, as the narrative below reveals, but still wanted to retain more control over it.

429. The JROC retained its role throughout this process, ostensibly setting joint military requirements and certifying the joint suitability of various large defense projects, including UAVs.

430. Laurence Newcome, DARO staff officer, interview, June 10, 1998. The Army Missile Command program office at Huntsville, Ala., ran the Hunter program, as they had the latter phases of Aquila.

431. House of Representatives, Hearings before a Subcommittee of the Committee on Appropriations, "Department of Defense Appropriations for 1995," Washington, DC, 1994: 786.

432. Israel did not embark on that path without the firm backing of his immediate boss, advanced technology chief Lynn, acquisition chief Deutch, and the Secretary of Defense, William Perry, himself. Perry, a long-time technology innovator, thought UAVs would supplant manned reconnaissance in a short span of time. Mindful of his origins, Israel also had the backing of Air Force Chief of Staff Fogleman, who saw UAVs as a "transition point" in air operations and who labeled the U-2 as a "legacy system" to be replaced by UAVs like Predator, DarkStar, and Global Hawk. Fogleman interview, May 26, 1999.

433. DARO was killed in the main by 1997 Congressional language that eliminated it and the JPO, sending budget authority back to the service acquisition executives. The Senate had supported DARO, but the House was adamant that it be eliminated. The House prevailed in the conference committee, effectively stripping DARO's budget execution authority. As a matter of record, incoming Secretary of Defense William S. Cohen closed the now emasculated DARO on Oct. 1, 1998 on the recommendation of his Task Force on Defense Reform, which studied ways of streamlining the bloated OSD staff. Robert Holzer, "Task Force: Purge Some OSD Functions," *Defense News,* Aug. 18, 1997: 1.

434. 1361 Rutherford interview, April 1999.

435. The CIA's Gnat 750 did not fall under the DARO-controlled DARP, but instead fell under the National Foreign Intelligence Program (NFIP). Michael R. Thirtle, Robert V. Johnson, and John L. Birkler, *The Predator ACTD* (Santa Monica, CA: Rand, 1997) 8-9.

436. Thirtle, et al, 11.

437. House of Representatives, Hearings before a Subcommittee of the Committee on Appropriations, "Department of Defense Appropriations for 1995," Washington, DC, 1994: 791; Rutherford interview, April 1999.

438. Department of Defense, "Unmanned Aerial Vehicle 1994 Master Plan," May 1994.

439. Thirtle, et al, 24. Rated pilots from all four services conducted early Predator missions over Bosnia, but the Air Force provided only one pilot. The Army dominated early Predator operations by dedicating pilots from their Military Intelligence Battalion (Low Intensity) [MIBLI], based out of Orlando, Fla. The Navy provided Navy Reserve pilots with intelligence backgrounds. Most of the initial pilots for Predator were Army warrant officers with helicopter experience. Steven L. Hampton, first commander of USAF's 11th Reconnaissance Squadron at Indian Springs AAF, Nev., e-mail, Sept. 28, 1998.

440. The program manager "shopped around" the project and found a sponsor in Lt. Gen. Paul E. Menoher, head of Army intelligence, who gave him a whole company of Army aviators transitioning from another platform. The Navy sent one pilot and several maintenance people. All the air vehicle operators were FAA-certified aviators by direction of the program manager, who was not a pilot himself. Rutherford interview, April 1999.

441. Rutherford interview, April 1999.

442. That pilot was Dave Schaefer, a B-52 pilot who would later develop Predator concepts of operations at Air Combat Command. Schaefer interview, Jan. 20, 2000; Rutherford interview, April 1999.

443. Fogleman interview, May 26, 1999.

444. Fogleman interview, May 26, 1999. Fogleman also pushed the rather radical proposition that the Air Force must prepare itself to transition into a heavily space-oriented force in the future.

445. Fogleman interview, May 26, 1999. Fogleman was the commander of the 836th Air Division at Davis-Monthan AFB, Ariz. from 1984 to 1986.

446. *Jane's Defence Weekly* said that on Fogleman's initiative the Air Force was already investigating how both high-altitude UAVs would coordinate with their other intelligence aircraft. By doing so, he hoped to get the inside track on lead service status for both high-altitude endurance UAVs being developed at that time. John Boatman, "Tier II-plus: Taking the UAV to New Heights," *JDW,* Aug. 12, 1995: 34.

447. The Army had planned to make their UAVs a part of reconnaissance units rather than place them in dedicated units. The Navy used "composite" squadrons that also operated other systems as home units for DASH and Pioneer.

448. Steven L. Hampton interview, June 12, 1998.

449. This decision was second in a disastrous chain of UAV events for the Army. They gave up Hunter due to crashes, gave up Predator to the Air Force, and signed on with the Navy to a compromise program called Outrider, leaving them with no battlefield UAV of any kind.

450. Thirtle, et al, 34-35, 57; "1997 Tactical UAV Overview," 3-12.

451. Michael A. Dornheim, "Novelty Continues—Regional Jets, Solar Aircraft," *Aviation Week & Space Technology,* Dec. 20, 1999: 124.

452. The RAND analysts criticized the late award of lead service status because it stunted development of the myriad items required for full service incorporation. Thirtle, et al, 78.

453. GAO basically accused DOD of forcing Predator into low-rate production (LRIP) status prematurely. Louis J. Rodrigues, "Advanced Concept Technology Demonstration Program Can Be Improved," Washington, DC: General Accounting Office report (GAO/NSIAD-99-4) 7.

454. Hampton, a navigator, was selected after numerous pilots turned down the command according to sources involved in the process.

455. Hampton e-mail.

456. The Army planned to put the Air Force Predator training operation into an abandoned hangar in a remote location near the airfield. The Air Force built hangars at Indian Springs instead. Dula interview, May 11, 1999.

457. Barton intoned that the Air Force was scrambling to catch up to the many shortcomings of the ACTD process and that this caused undue staff tension over the commitment to the system. Col. Harold H. "Bart" Barton Jr. interview, April 24, 1998.

458. "UAV Annual Report FY1997," Defense Airborne Reconnaissance Office (DARO), Nov. 6, 1997, 19; Ed Huling, e-mail to author, Sept. 30, 1998. Barton at ACC emphasized that Big Safari does not have associated with it the shortcomings that affected Lightning Bug after 1969. First, the program competed for Air Force dollars like any other. Second, Predator will be a "blue suit" operation, and ACC spent a lot of money to bring the system up to Air Force standards with regard to technical data and other standard operating procedures. Barton e-mail, Oct. 1, 1998.

459. This conflict reflected a very old doctrinal struggle that stemmed from the scarcity of air assets in war. Air commanders adhered to the doctrine of "centralized control, decentralized execution," which stems from a belief that theater-wide needs should be controlled by an airman who thinks more broadly than a ground commander, who is mainly concerned with what lies directly in front of him. They argue that history shows each Army commander's interest in what lay immediately before them subverts theater-wide strategy. The Army, on the other hand, maintained that the Air Force neglected their legitimate needs. Thus far, the only resolution to this philosophical conflict had been the possession and control of aircraft. As a result, all the services bought their own air force. New electronics technology and the UAV in particular challenged this long-standing means of resolving this dispute.

460. Lt. Gen. Gregory S. Martin, in Gigi Whitley and Erin Winograd, "US Atlantic Command Appeals Tactical Control System Decision to OSD," *Inside the Air Force,* Dec. 11, 1998: 1.

461. Whitley and Winograd, *Inside the Air Force,* Dec. 11, 1998: 1.

462. Fourteen industry teams submitted proposals including major industry names like Motorola, Boeing, Hughes, Raytheon Lockheed, TRW, Israel Aircraft Industries, Rockwell, and Lear. Both Boeing and Lockheed, who were specifically excluded from bidding due to their sole-source contract for Tier III-, still submitted bids. Loral, Northrop Grumman, Orbital Sciences, Raytheon, and Teledyne Ryan headed the five groups who survived the early selection. "US Bidders Line Up For Threatened Contract," *Jane's Defence Weekly,* Aug. 2, 1994: 6; "ARPA Picks Tier II Teams," *Flight International,* Oct. 12, 1994.

463. Fulghum, "UAV Contractors Plot Stealthy Redesigns," 60.

464. Kier interview, May 10, 1999.

465. John Entzminger, DARPA long endurance program director, quoted in David A. Fulghum, "Secret Flying Wing Slated for Rollout," *Aviation Week & Space Technology,* Sept. 19, 1994: 27-28.

466. The amendment included an additional $22 million for this project as well as a replacement vehicle for the prototype that crashed not one month prior. "House Passes Intel Bill, Big Plus-Ups For DarkStar, JSTARS, and RC135," Inside the Air Force, May 24, 1996: 10. The other competitors did not stand idly by. Rep. Randy Cunningham, the Republican Congressman from California who represented the Tier II and Tier II+ contractors, offered a counter-amendment that would require the DarkStar contract be re-competed if it slipped over its $10 million per copy target. James R. Asker, "Shot At DarkStar," *Aviation Week & Space Technology,* May 13, 1996: 19.

467. Although the DARPA contract called for a test flight by October 1995, the first flight was delayed five months due to flight software problems. "Software was a big headache," said DarkStar's program manager, "We had to think through all the opportunities to fail. Being autonomous, you have to tell it every little thing." Michael A. Dornheim, "DarkStar Makes 'Solo' First Flight," *Aviation Week & Space Technology,* April 8, 1996: 20.

468. The flight test crash was a result of DarkStar's highly problematic design. A flying wing without a tail section can be very stealthy from the side, but has severe flight stability problems that make takeoff and landing very difficult even for lightning-quick, software-controlled fly-by-wire autopilot systems. Like Aquila, the stealthy design of DarkStar made autonomous flight control a reliability issue that was never fully addressed. Other stealthy designs like Israel's HA-10 may incorporate features to mitigate this flight control problem, erring on the side of reliability at the cost of some stealthy features.

469. Huling e-mail, Sept. 18, 1998.

470. "Prices Rise As High Altitude UAVs Go Up," *Flight International,* Sept. 23, 1998: 16.

471. Bruce D. Nordwall, "Dark Hawk," *Aviation Week & Space Technology,* June 22, 1988: 23.

472. The report projected DarkStar's acquisition costs at $600 million and its operations and maintenance costs at $400 million; thus their recommendation would save $1

billion. The decision was based on the assumption that the US faced relatively benign air defense environments, ones that they could defeat easily to enable the non-stealthy platform's use. The three air vehicles produced by the ACTD could be used for "rare" missions where denied-area surveillance was required. Eric J. Labs, et al., "Options for Enhancing the Department of Defense's Unmanned Aerial Vehicle Programs," Washington, DC: Congressional Budget Office Paper, September 1998: 60-64.

473. Gigi Whitley, "Pentagon Move To Cancel Stealthy DarkStar UAV May Run Into Opposition," *Inside Washington,* Jan. 30, 1999: 1. Air Force Chief of Staff Gen. Merrill A. McPeak confirmed an Air Force operational requirement for a stealthy, long-loiter capability in 1994, to which the letter referred. David A. Fulghum, "USAF Pursues Stealthy UAV To Improve Reconnaissance," *Aviation Week & Space Technology,* Jan. 17, 1994: 44.

474. "DarkStar of Little Utility," *Defense Daily,* Feb. 8, 1999: 1.

475. According to a Lockheed official, the Air Force had seen the U-2 as a "sunset system" (certainly DARO did), but has now decided upgrades to the U-2 must continue due to worries about how UAVs might mature. Lockheed is even lobbying to re-open the U-2 production line. David A. Fulghum, "Will New Elusive Craft Rise From DarkStar?" *Aviation Week & Space Technology,* Feb. 22, 1999: 28; Peter LaFranchi, "Lockheed Martin Sees Focus of UCAV Shifting to Surveillance," *Flight International,* June 1, 1999: 19.

476. "DarkStar of 'Little Utility,'" *Defense Daily,* Feb. 8, 1999: 1. Air Force officials said, "They will likely use the remaining DarkStars as test vehicles in developing a new, larger-payload, stealth UAV that better suits their needs." David A. Fulghum and Robert Wall, "Pentagon Budget Up, But Research Withers," *Aviation Week & Space Technology,* Feb. 8, 1999: 28. The Air Force apparently told DarkStar contractor teams to retain their people, a sign that the larger stealthy UAV will spin off from that program. Fulghum, "Will New Elusive Craft Rise From DarkStar?" *AW&ST,* Feb. 22, 1999: 27-28. Boeing backed completely out of the program by laying off even the core development group in mid-1999, handing the AARS baton back to the Lockheed Skunk Works, which reportedly has some stealthy UAV prototypes under development. Fulghum, "Long-Term Stealth Project Gets the Ax," *AW&ST,* May 24, 1999.

477. Heber, statement before the Subcommittee on AirLand Forces of the Senate Armed Services Committee, April 9, 1997, (http://www.darpa.mil/testimony/heber_04_09_97.doc).

478. These towed decoys reportedly saved several Air Force fighter planes against high performance surface-to-air threat missile systems in the skies over Serbia in Operation Allied Force in May 1999.

479. William H. Pickering, "Automatic Control of Flight," Toward New Horizons Vol. VI-6, Dec. 7, 1945 (Air Force Materiel Command archives).

480. Heber statement before Senate Armed Services AirLand Subcommittee. Modern airliners such as the Boeing 777 and the Airbus A340 have autopilots that can execute autonomous flight from brake release through landing, so the technology of precision autopilot systems continues to advance. Due to the cost constraints imposed on Global Hawk, however, engineers have to use a much less sophisticated version of the software found on those airliners even though the UAV has no human backup. Kent L. Copeland, chief USAF engineer for Global Hawk, interview, March 20, 1998.

481. Copeland interview, March 20, 1998.

482. Fogleman interview, May 26, 1999.

483. Curt Osterheld, Lockheed public affairs, Washington, DC, interview, Nov. 6, 1998; Michael Harper, Teledyne Ryan Aeronautical public affairs, Washington, DC, interview, Oct. 21, 1998; Terry Ryan interview, March 8, 1999; Newcome interview, June 10, 1998.

484. Rich and Janos, Skunk Works, foreword.

485. Lt. Gen. Buster C. Glosson, USAF (Ret.), quoted in David A. Fulghum, "Glosson: US Gulf War Shortfalls Linger," *Aviation Week & Space Technology,* Jan. 29, 1996: 58.

486. Israel had also enraged Congressional staffers interested in the RC-135 Rivet Joint modernization program by transferring money from that program to UAVs. DARO's alienation from the services, major contractors, and Congress was a virtual certainty once Israel pursued OSD's aggressive UAV agenda.

487. Copeland interview, March 20, 1998.

488. "UAV System Program Office To Take Over Air Force Programs," *Defense Daily,* Aug. 26, 1998: 1.

489. Predator, once the darling of ACTD advocates, now "has proven far more expensive than expected in procurement, personnel, training and operations once they were handed off to the Air Force." David A. Fulghum and Robert Wall, "Pentagon Budget Up, But Research Withers," Aviation Week & Space Technology, Feb. 8, 1999: 28.

490. F. Whitten Peters, acting Secretary of the Air Force, Defense Writers Group, Washington DC, Dec. 17, 1998.

491. "Unmanned Aerial Vehicles: Progress Toward Meeting High Altitude Endurance Price Goals," Dec. 15, 1998, Washington, DC, GAO report (GAO/NSIAD-99-29): 3.

492. Maj. Scott J. Scherbenske, Program Element Monitor for Global Hawk, e-mail, Jan. 27, 1999.

493. Paul Proctor, ed., "Long-Haul Hawks," in "Industry Outlook," *Aviation Week & Space Technology,* Feb. 21, 2000: 33.

494. Scherbenske e-mail, Feb. 21, 2000.

495. As a scaled-down version of the ACTD, under which Predator, Outrider, Global Hawk, and DarkStar were developed, an ATD has much less chance reaching production than even an ACTD.

496. The other competitors were Lockheed Martin,

Northrop Grumman, and Raytheon/Teledyne Ryan. Like many of the UAV projects since 1970, contractors absorbed some of the costs in anticipation of production, only to be frustrated. Boeing planned to invest $21 million of its own money in the DARPA UCAV project, with hopes it would later turn into a production contract. Robert Wall, "Boeing Wins UCAV Contract," *Aviation Week & Space Technology,* March 29, 1999: 84.

497. Wall, "UCAV Contract" 85.

498. Fogleman interview, May 26, 1999.

499. Peters, Defense Writers Group, Dec. 17, 1998.

500. Fogleman interview, May 26, 1999.

501. Hammond, *Organizing for Defense: The American Military Establishment in the Twentieth Century,* 348.

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1501 Lee Highway
Arlington VA 22209-1198
Tel: (703) 247-5800
Fax: (703) 247-5853