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Airborne Intelligence, Surveillance & Reconnaissance (ISR): The U-2 Aircraft and Global Hawk UAV Programs

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Airborne Intelligence, Surveillance & Reconnaissance (ISR): The U-2 Aircraft Program

Summary

The ability to gather accurate and timely information on enemy forces is an essential enabler of modern military operations. The growing use of precision guided munitions (PGMs) which can destroy specific targets without extensive collateral damage depends upon the availability of precise information. No single platform or technology can satisfy the needs of the Department of Defense (DoD) for information at all times in all scenarios. However, airborne platforms will likely continue to satisfy a large portion of DoD's ISR requirements over the next several decades.

Among airborne ISR platforms, the U-2 Dragon Lady and the RQ-4A Global Hawk are especially valuable. The U-2 stands out for its proven track record of providing vital near-real-time intelligence to military theater commanders in the 1991 war with Iraq (Operation Desert Storm), the 1999 conflict in Kosovo (Operation Allied Force), and other conflict areas.

Global Hawk, a soon to be fielded unmanned aerial vehicle (UAV), has been considered a complement to, and potentially a replacement for the U-2. While the unproven Global Hawk appears to offer some advantages over the U-2 – such as greater range and endurance, and not exposing a pilot to danger – as currently designed it does not currently match the U-2's intelligence gathering capabilities. The Air Force is seeking to upgrade these designs so the second generation of Global Hawks would be more similar to U-2s in capability.

Both Congress and DoD face important decisions regarding current and future mix of U.S. airborne intelligence, surveillance, and reconnaissance capabilities. An overarching line of inquiry is: Over the next 20 to 30 years, what mix of existing and planned manned and unmanned ISR aircraft can most effectively satisfy DoD's requirement for timely and accurate information on enemy forces?

An important immediate issue to be resolved is how to best introduce Global Hawk platforms into the U.S. ISR inventory and at what pace, relative to planned or unplanned U-2 attrition. Key concerns are whether manned aircraft can be completely replaced by UAVs, the time that it will take to integrate the Global Hawks into the operating force structure, and the availability of adequate funds to support the acquisition of Global Hawks without compromising vital operational capabilities for an extended period.

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Background

Intelligence, Surveillance and Reconnaissance (ISR)

The ability to gather accurate and timely information on enemy forces is an essential enabler of modern military operations. *Joint Vision 2010*, the Pentagon's "conceptual template...to achieve new levels of effectiveness in joint warfighting" specifically highlights the importance of achieving information dominance: "We must have information superiority: the capability to collect, process and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."[1] The growing use of precision guided munitions (PGMs) which can destroy specific targets without extensive collateral damage depends upon the availability of precise information. As the Department of Defense (DoD) transforms itself into the force envisioned in Joint Vision 2010 and organizes its components consistent with "network centric"warfighting concepts, the importance of accurate and timely information will grow.

There is a consensus among defense policy makers that no single platform or technology can satisfy DoD's need for information at all times in all scenarios. The United States currently employs a variety of satellites that collect information on enemy forces. These systems are valuable, and their effectiveness and role in intelligence, surveillance and reconnaissance (ISR) is projected to grow. However, airborne ISR platforms can be more rapidly and flexibly deployed than current satellites, and an aircraft's unpredictable deployment and flight pattern makes it difficult for adversaries to effectively conceal themselves from observation. Thus, airborne platforms will likely continue to satisfy a great deal of DoD's ISR requirements over the next several decades.

Both Congress and DoD face important decisions regarding current and future U.S. ISR capabilities. An overarching question is: Over the next 20 to 30 years, what mix of existing and planned manned and unmanned ISR aircraft most effectively satisfies DoD's requirement for timely and accurate information on enemy forces? The information they collect will be integrated (or "fused") with information from satellites, ground-based signals intelligence (SIGINT) intercept sites, human agents,

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[1] U.S. Joint Chiefs of Staff, *Joint Vision 2010*, p.16. On May 30, 2000, the Joint Staff released an updated version, *Joint Vision 2020*.

and other sources. The particular mix of platforms will depend upon which sensors they can utilize, geopolitical conditions, and the nature of planned operations.

Many observers believe that ultimately unmanned aerial vehicles (UAVs) will replace manned aircraft for collecting imagery, radar data, and signals intelligence for operational commanders. It is not, however, clear that manned airborne reconnaissance is completely obsolete. Some observers believe that a pilot can react faster than a distant UAV operator to unexpected targets of opportunity and take evasive actions that might not otherwise be possible. Also, pilots may be less susceptible than remote UAV operators to some information warfare techniques. There remain a variety of manned reconnaissance aircraft in the inventories of the Air Force and the other services and some attack aircraft can be equipped with reconnaissance "pods" containing sensors of various types to enable them to serve on reconnaissance missions.

The U.S. ISR inventory is comprised of a variety of manned and unmanned aircraft, which have various strengths and weaknesses. (See Table 1 below). Presently, the U-2 *Dragon Lady* forms the backbone of this fleet.[2] Although based on a design developed in the 1950s, U-2s have performed admirably in recent operations. They provided 50% of all imagery during Operation Desert Storm, and 90% of ground forces targeting information. During Operation Allied Force, the U-2 provided more than 80% of the imagery needed for air strikes.[3] There is, however, only a limited inventory of U-2s, they are heavily used, and the plane is expected to be retired from the Air Force inventory at some point during the next two decades.

Global Hawk UAVs are often suggested as a replacement for U-2s and are portrayed as the main airborne reconnaissance platform of the future. The first test version of these planes has been undergoing test and evaluation and there is an apparent consensus that it should be acquired for the operating forces. The Global Hawk can operate at altitudes of 65,000 feet and for periods in excess of 30 hours. Although having the important advantage of not putting pilots at risk, Global Hawks do not now match all the capabilities of U-2. No Global Hawk is currently in the operational inventory. Furthermore, current acquisition plans do not call for sufficient numbers of Global Hawks to replace the hours-on-station that can be maintained by existing U-2s.

Thus, if Air Force ISR capabilities are to be maintained (and some believe they need to be expanded if current operations tempos are to be maintained in the future), a number of serious acquisition and budgetary issues need to be addressed.

- What are the current and anticipated requirements for airborne surveillance platforms?

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[2] David Atkinson, "Air Force, CIA Celebrate U-2 Spy Plan History, but Problems Loom." *Defense Daily*. September 18, 1998, p.4.

[3] Gigi Whitley, "Air Force Official Praises U-2's Operation Allied Force Performance." *Inside the Air Force*. October 1, 1999, p. 3.)

- Can Global Hawks be designed to have the capabilities now possessed by the U-2? Or, should multiple UAVs be acquired to replace a single U-2?
- If a larger or accelerated Global Hawk acquisition effort is approved, where will funding be identified?
- Should U-2s or other manned aircraft be maintained in the Air Force inventory even as Global Hawks become operational?
- Are additional U-2s needed, regardless of the introduction of the Global Hawk?
- What would be the implications for ISR if U-2s were to be decommissioned at a faster rate than planned to free up funds for additional or accelerated Global Hawk acquisition?

These questions, and others, will be discussed in the context of the FY2002 Defense budget which the next administration will forward to Congress early in 2001. Although significant budgetary issues are involved, there are also important implications for the future effectiveness of ISR and the success of defense planning for achieving military goals while minimizing the loss of life.

Table 1. USAF Reconnaissance & Surveillance Aircraft Active Inventory (May 2000)[4]

Platform	Role	Number
U-2 Dragon Lady	Ground and electronic reconnaissance	30
RQ-4A Global Hawk	Ground reconnaissance	0
E-8 JSTARS	Ground surveillance, Battle Management, C^2	5
RQ-1A Predator UAV	Ground reconnaissance	6
RC-135 Rivet Joint	Electronic reconnaissance	22
F-16	Ground surveillance (SEAD)	-

U-2 *Dragon Lady*

The U-2 is a single-seat, single-engine, high-altitude, reconnaissance aircraft. It provides continuous all-weather, day or night, stand-off intelligence through all phases of conflict in direct support of theater military commanders. Long, wide, straight

[4] The E-3 AWACS and E-2C Hawkeye also perform surveillance functions in the air-to-air regime.

wings give the U-2 the appearance and characteristics of a glider. The U-2 is a reliable aircraft with a high mission completion rate.[5]

U-2s are based at Beale Air Force Base, California and support theater commanders from four operational detachments located throughout the world, which have included in recent years: Osan Air Base, South Korea; RAF Akrotiri Air Base, Cyprus; Sigonella, Sicily; Istres Air Base, France; and Taif and Prince Sultan Air Bases, Saudi Arabia. U-2 detachments can deploy to other operating locations if necessary.

Intended to overfly the vast expanses of the Soviet Union at a time when there were no satellites, the U-2 was designed to fly at very high altitudes to avoid detection and attack.[6] Beginning in the 1980s an updated version of the U-2 began to replace the earlier models.[7] From 1994 to 1999, U-2R aircraft were upgraded with the General Electric F-118-10 engine, which burns less fuel, reduces weight and increases power. The upgraded aircraft were re-designated as a U-2S/ST. The Air Force expects this airframe and engine combination to last until 2050.[8]

Figure 1. U-2 Dragon Lady

[5] U-2 squadrons in Vietnam achieved a 98% reliability rating. Thornborough, Anthony. *Spy Planes and Other Reconnaissance Aircraft*. Arms and Armor Press. London. 1991:44

[6] In actuality, however, the Soviets were able early on to track U-2 missions. See Gregory W. Pedlow and Donald E. Welzenbach, *The CIA and the U-2 Program, 1954-1974* (Washington: Central Intelligence Agency, Center for the Study of Intelligence, 1998).

[7] The original version of the U-2 made its first flight in August 1955. A significantly larger and more capable version, the U-2R, first flew in 1967. A tactical reconnaissance version of the U-2, the TR-1A, first flew in August 1981. (U-2s currently operational are TR-1As.) Designed for stand-off tactical reconnaissance in Europe, the TR-1 was structurally identical to the U-2R. The last U-2 and TR-1 aircraft were delivered to the Air Force in October 1989. In 1992 all TR-1s and U-2s were re-designated U-2R.

[8] Bruce Rolfson, "Enhancements Ready U-2s for Years of Duty," *Defense News*, June 26, 2000, p. 66.

The U-2 can carry a variety of sensors and cameras depending on its assigned mission. It is capable of collecting multi-sensor photo, electro-optic, infrared and radar imagery, as well as performing other types of reconnaissance functions such as SIGINT collection. Photographic sensors include the HR-329 high resolution camera and the Optical Bar camera. Electro-optic systems include the Intelligence Reconnaissance Imagery System III, and the Senior Year Electro-Optical Reconnaissance System (SYERS), which also collects information in the infra red (IR) wavelength. These systems vary in resolution and aperture, but when combined, can capture images of territory on the order of 33 x 21 nautical miles.[9] The Advanced Synthetic Aperture Radar System (ASARS) gives the U-2 real-time, high resolution – although not as high as EO systems – capability at night and in bad weather (when the EO systems cannot function effectively) with an improved capability to detect moving targets.[10]

The U-2's Senior Glass SIGINT capability is composed of the Senior Ruby electronic intelligence (ELINT) sensor and the Senior Spear communications intelligence (COMINT) sensor. These systems can acquire signals and telemetry at 300 nautical miles, downlink data to ground stations 300 nautical miles away, giving the U-2 a real-time "reach of 600 nautical miles (690 statute miles, 1,110 km). The Senior Span pod, which is attached to the top of the fuselage allows the U-2 to transmit SIGINT data via satellites to global ranges."[11] The Senior Spur pod, performs the same function for ASARS data.[12]

The U-2 is notoriously difficult to fly. Pilots called the U-2 "Dragon Lady" because of its unforgiving handling characteristics at altitude.[13] Landing the U-2 is a complex ballet that often entails intentionally stalling the aircraft, employing runway "chase cars,"and oftentimes deliberately dragging the plane's wingtip down the runway.

A major challenge for the Air Force is maintaining an adequate supply of U-2 pilots. U-2 pilots face physical rigors that are unique in the aviation world. Flying at extreme altitudes, pilots must wear pressure suits similar to those worn by astronauts. The pilots have to engage in special training and pre-flight preparations (e.g., special diets and inhaling 100% oxygen 1 hour prior to take-off) to help ward off the profuse sweating, fatigue and dizziness caused by 10 hour missions. There are only some 50 pilots currently qualified to fly U-2s and they have to spend significantly higher percentages of their tours of duty on temporary flying assignments than other Air Force officers. Some observers believe that extended deployments and the dangers

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[9] Anthony Thornborough, *Sky Spies: Three Decades of Airborne Reconnaissance.* London: Arms and Armour Press, 1994, p. 24.

[10] Bruce Nordwall, " A Raytheon Program to Improve the Radar for the U.S. Air Force's U-2 Aircraft," *Aviation Week & Space Technology*, March 1, 1999, p. 60.

[11] David North, "Venerable U-2 Forges on to Y2K and Beyond," *Aviation Week & Space Technology*, April 12, 1999, p. 60.

[12] Col. Bruce Carmichael (Ret) L3 Communications Inc.

[13] Anthony Thornborough, *Spy Planes and Other Reconnaissance Aircraft*. London: Arms and Armor Press. London. 1991, p.44.

and hardships involved in flying U-2s may contribute to significant retention problems that could affect overall capabilities. The General Accounting Office (GAO) concluded that "It is difficult to find pilots with the aptitude required to master the difficult handling characteristics of the U-2."[14] The Air Force has, however, taken steps to reduce the average temporary additional duty (TAD) rates of U-2 pilots to bring them into line with other pilots. Improved U-2 pilot morale may have been influenced by the aircraft winning the Collier Trophy in 1998, awarded by the National Aeronautic Association for the "greatest achievement in aeronautics or astronautics in America...."[15]

U-2s in Post-Cold War Combat Operations.

The U-2 was originally designed to fly over the Soviet Union to acquire information about strategic targets such as airfields and missile bases. Information acquired from the U-2 was of importance to the U.S. Intelligence Community's ability to provide adequate assessments of Soviet strategic forces, but the utility of the platform for this purpose was virtually destroyed by the diplomatic embarrassment following the shoot down of a U-2 in May 1960 and the public trial of its pilot, Francis Gary Powers. Beginning in the 1960s this mission was taken over by surveillance satellites that presented no danger of captured pilots. U-2s were not especially valuable in Vietnam where photography of triple-canopy jungle often provided little useful intelligence on troop movements along the Ho Chi Minh Trail underneath. It was not until Desert Storm in 1991 that U-2s demonstrated their value as the platform that could provide the near-real-time intelligence that allows military commanders to place bombs on the exact targets intended. The greater use of the U-2 derived from improvements in surveillance and communications technologies as well as the much greater availability of precision guided munitions that benefit from U-2-derived data.

Desert Storm saw the largest U-2 operation in history with nine aircraft and thirty pilots flying some five sorties a day. Primary missions were Iraqi Army field positions, bomb damage assessment (BDA), and searching for SCUD missile launching sites. Photography and other data collected from U-2s was for the first time rapidly available to tactical commanders. Inevitably, there were arguments about collection priorities, and, especially, demands by operational commanders for larger volumes of photographic coverage (especially wide-area coverage) even though some intelligence officials believed that electro-optic and radar collection was a better use of assets. There were difficulties with developing photography in-theater and with disseminating hard copies. Nonetheless, according to one estimate, U-2s provided 30% of total intelligence, 50% of imagery intelligence, and 90% of all Army targeting intelligence for the entire theater.[16]

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[14] U.S. General Accounting Office, "Contingency Operations: Providing Critical Capabilities Poses Challenges," (GAO/NSIAD-00-164), July 2000, p. 18.

[15] "Lockheed Martin's U2-S/ER-2 high-altitude wins the Collier Trophy," *Aerospace Daily*, February 11, 1999.

[16] Coy F. Cross II, *The Dragon Lady Meets the Challenge: the U-2 in Desert Storm* (Beale

(continued...)

Military operations over the former Yugoslavia in the mid-1990s saw continued reliance on the U-2 by military commanders. Balkan missions were initially related to gathering information on treaty verification, troop dispositions, and missile sites. During the NATO attack on Serbian forces in the spring of 1999, known as Operation Allied Force, U-2s were used to identify Serbian targets and to conduct BDA to determine the accuracy of Allied strikes. Data collected by an airborne U-2 was transmitted back to Beale Air Force Base in California for analysis[17] and then sent back to operations centers and thence to aircraft which could attack the target. Admiral Daniel Murphy, Commander of the U.S. Sixth Fleet during Allied Force, recalled having satellite positioning data on key Serbian early warning radars.

> But that was insufficient for targeting a Tomahawk missile, which was the weapon that we intended to employ. So I walked into the intelligence center and sitting there was a 22-year-old intelligence specialist who was talking to Beale Air Force Base via secure telephone and Beale Air Force Base was driving a U-2 over the top of this spot. The U-2 snapped the picture, fed it back to Beale Air Force base where that young sergeant to my young petty officer said, we have got it, we have confirmation. I called Admiral Ellis [Commander, Allied Forces Southern Europe], he called General Clark [Supreme Allied Commander, Europe], and about 15 minutes later we had three Tomahawk missiles en route and we destroyed those three radars.[18]

Another senior Air Force general wrote after the Kosovo campaign, "We never dropped a bomb on a target without having a U-2 take a look at it."[19]

To meet requirements for Allied Force, U-2 pilots and support personnel were transferred from other theaters. As one senior Air Force commander noted, U-2s were "stretched to the limit during Allied Force."[20] Observers suggest that if the Air Force were required to conduct operations on a scale larger than Allied Force, limits on U-2 availability would have to be faced and could constrain the effectiveness of precision bombing campaigns.

In addition to missions in the Balkans, U-2s continue to fly collection missions over Iraq and the Korean peninsula. In those regions they supplement collection by satellite and other systems and are intended to provide early warning of attacks. Their chief defense is their ability to operate at altitudes above 70,000 feet, far higher than most military aircraft and out of the range of most SAMs. U-2s are not, however, by any means invulnerable. Besides the celebrated shootdown of the plane carrying Gary

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[16] (...continued)
AFB, CA: 9th Reconnaissance Wing), 1996.

[17] At a facility known as a Distributed Common Ground Station (DCGS).

[18] U.S. Congress, 106th Congress, 1st session, House of Representatives, Committee on Armed Services, Military Readiness Subcommittee, *Operations in Kosovo: Problems Encountered, Lessons Learned and Reconstitution*, Hearing, October 26, 1999, p. 18.

[19] Maj. Gen. William T. Hobbins, quoted in Peter Grier, "U-2 a `Mainstay' of Allied Force," *Air Force*, December 1999, p. 14.

[20] *Operations in Kosovo*, p. 56.

Powers, a number of other U-2s were lost flying classified missions over the Asian mainland in the 1960s and 1970s. In the current environment, U-2s can in many cases collect required information by remaining in international airspace. U-2 overflights of Iraqi territory, however, have raised concerns about their vulnerability. Fighter escorts have been assigned to cover them and stiff warnings have been delivered to Bagdad, threatening dire consequences should efforts be made to attack U-2 missions. The availability of SAMs to various governments that can reach usual U-2 flying

Figure 2. RQ-4A Global Hawk

altitude represents a standing threat that air force planners must take into consideration.

RQ-4A *Global Hawk*

The RQ-4A Global Hawk is a high altitude, long endurance, long range unpiloted aerial vehicle designed to perform many of the same functions as the U-2. Global Hawk is the product of an advanced concept technology demonstration (ACTD), a program designed to quickly transition emerging technology from the laboratory to the warfighter.

The program started in May 1994 when the Defense Advanced Research Projects Agency (DARPA) solicited industry for submissions for a competitive procurement effort. Phase 2 of the program began in May 1995, when Teledyne Ryan/E-Systems was selected as the sole contractor (Ryan Aeronautical was subsequently acquired by Northrop Grumman).[21] The Global Hawk undertook its first flight on February 28, 1998. It flew a second and third time in May 1998. On March 29, 1999, Global Hawk #2 crashed during a flight at China Lake Naval Weapons Center, when it "inadvertently received a test signal for flight termination

[21] Steven Zaloga. RQ-4A Global Hawk, World Missile Briefing, Teal Group Inc. June 1999.

from a test range on Nellis Air Force Base, Nev." [22] Global Hawk completed its ACTD phase in June 2000 and moved into a "normal" acquisition program in engineering, manufacturing and development (EMD).[23] As of October 2000, the Global Hawk has logged 62 flights for a total of 737 flight hours, 301 of which have been in airspace controlled by the Federal Aviation Administration (FAA). The Global Hawk has flown as high as 66,000 feet and for as long as 31 hours at one time.[24]

The Global Hawk's ground-based support is composed of a Mission Control Element (MCE) and a Launch and Recovery Element (LRE). These elements are composed of people (4 in the MCE, 2 in the LRE), computers, communications gear and shelters.[25] Together, the MCE and LRE can operate up to three aerial vehicles simultaneously. The LRE needs to be deployed to the Global Hawk's operating base, but the MCEs could theoretically be based anywhere. It takes two C-17 Globemaster aircraft to deploy the two ground elements. The Global Hawk, as evidenced by a recent flight from the United States to Portugal, can self deploy.

As currently designed, the Global Hawk can carry electro-optical, IR, and synthetic aperture radar sensors. It is not designed to carry SIGINT sensors. While the Global Hawk's EO and IR capabilities are on-par with the U-2s, its SAR capabilities are not. Due to greater power and a larger antenna, the U-2 can more effectively use its SAR to detect moving targets than can the Global Hawk. If used to find static targets however, the U-2 and Global Hawk SAR capabilities are more comparable.

DoD's current plan is to manufacture twelve Global Hawk air vehicles between FY2003 and FY2009. These UAVs would carry the EO/IR/SAR sensor payload, and are described by the Air Force as a complement to the U-2. In FY2009, the Air Force wants to produce four of the next generation Global Hawks, which could carry SIGINT sensors, instead of either the EO/IR or the SAR payload. The Air Force describes the capabilities of this next generation as being on par with the U-2 and asserts that they could replace the U-2.[26]

Summary: Platform Comparisons

A review of Table 2 below highlights the key similarities and differences between the U-2 and Global Hawk. On a one-to-one basis, a comparison of these

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[22] Sue Baker. "Results of Global Hawk Accident Investigation Board Released, *Air Force News*. December 23, 1999.

[23] Endurance Unmanned Aerial Vehicles. Exhibit R-2 (PE0305205F), Department of the Air Force, February 2000:1427.

[24] LtCol Ken Bray. Briefing on the Global Hawk System: Program Overview, Department of the Air Force, AQIJ. October 19, 2000.

[25] Like manned aircraft, the Global Hawk also requires operations and maintenance and logistical manpower and support.

[26] LtCol Ken Bray. Briefing on the Global Hawk System: Program Overview. Department of the Air Force, AQIJ. October 19, 2000.

characteristics is important for policy makers to consider when making decisions on the overall size and composition of the U.S. airborne ISR force structure. There are significant similarities. The platforms are of similar physical dimension. They fly at approximately the same altitude and at similar speeds. Yet, there are important differences between the platforms that stand out when comparing the U-2 and Global Hawk on a platform-to-platform basis. These differences include (1) pilot requirements, (2) range and endurance, and (3) mission payload.

The first difference between the platforms is the Global Hawk's lack of a pilot. While not putting a pilot in danger appears obviously beneficial, there are a number of associated issues that merit discussion. One potential downside to being pilotless is that the platform is not as responsive to changing circumstances as a piloted aircraft. Remotely located mission control personnel cannot, in theory, make decisions and take action as quickly as a pilot on the scene. However, during a mission, U-2 pilots infrequently take action based on what they personally observe from the cockpit. Rather, they typically make adjustments to their pre-planned mission profile based on warnings and orders from mission control elements. Thus, unmanned aircraft may not suffer from a lack of responsiveness in the high altitude ISR mission as they would if performing other missions.

The lack of a pilot may be more of a hindrance when flying through civil-controlled U.S. and foreign-country airspace than it is when overflying a combat area. Civil authorities are concerned that in the event of an unforeseen emergency, such as an engine burnout, or malfunction, a pilotless aircraft would be less able to take corrective action, such as making a controlled landing at a local airfield. Instead, they fear that a pilotless aircraft would be more likely to crash into inhabited areas. Therefore, civil authorities currently impose very demanding mission planning requirements on unmanned systems; if they allow them to overfly at all. This exhaustive mission planning takes time, manpower and money.

Finally, the Global Hawk's lack of a pilot doesn't necessarily confer increased operational utility. The Global Hawk's size, flight profile and lack of stealth features suggest it is approximately as survivable as the U-2. It will likely be employed as the U-2 is – outside of high threat environments such as long-range SAMs. At approximately $50 million each, the Global Hawk is too expensive to be considered expendable.

The second difference between the Global Hawk and U-2 that bears discussion is that of range and endurance. The Global Hawk has superior range and endurance to the U-2. Global Hawk can fly approximately twice as far as the U-2, and its loiter time is three times that of the U-2. This suggests important ramifications for the number of platforms required in the overall ISR inventory. All other things being equal, fewer platforms with long endurance can do the same job as more platforms with less endurance.

The third noteworthy difference between the platforms is payload. The U-2 enjoys an advantage in payload over the Global Hawk of more than two-to one. This allows it to carry more and different payloads. A larger payload capability also provides more potential for unforseen upgrades and tradeoffs. Generically speaking, a larger volume on an aircraft presents engineers with more choices and opportunities than a smaller volume. Additionally, the U-2's large engine provides more electrical

power than the Global Hawk's, which in turn increases the capabilities of some of its sensor payloads. All things being equal, fewer platforms with more sensors can do the same job as more platforms with fewer sensors.

Table 2. Comparison of Key Characteristics

	U-2	Global Hawk
Contractor	Lockheed Aircraft Corp	Northrop Grumman/Raytheon
Pilot	1	0
Dimensions	Length: 63 feet Height: 16 feet Wingspan: 103 feet	Length: 44 ft Height: 15 ft Wingspan: 116 ft
Performance	Range: >7,000 mi Speed: >475 mph Ceiling: >70,000 ft Payload: 4,700 lbs Endurance: 10+ hours (pilot limited)	Range: 14,400 mi Speed: 400 mph Ceiling: 65,000 ft Payload: 2,000lbs Endurance: 35 hours
Engines	1 F118-GE-101 Turbofan (17,000 lbs thrust)	1AE 3007 Turbofan (7,200 lbs thrust)
Payload (lbs)	4,700	2,000
Sensors	SAR-MTI/SIGINT or EO/IR/SIGINT	EO/IR/SAR-MTI
Cost ($M/FY01)	Estimated Procurement Unit Cost: $52.8/aircraft[27]	Estimated Procurement Unit Cost: $51.6/aircraft[28]

Congressional Action

Overview

Congress has long taken a special interest in U-2 programs. In the past decade, the planes have been re-engined to enable them to fly at higher altitudes for longer periods. A variety of improved sensors and communications data-links have been acquired or funded and necessary steps are being taken to install them on aircraft. A

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[27] The USAF refurbished 35 U-2/TR-1s from FY80-FY87 for $1.738 billion in constant FY96 dollars. This figure does not include amortized R&E spending nor procurement spending since 1997. (Source: *Table of Actual and Projected Weapons Purchases 1974-1997.*Congressional Budget Office Mimeo, Washington, DC, March 17, 1995.) FY96-to-FY01 adjustment made using DoD Deflator of 93.9.

[28] This figure is derived from dividing the weapon system cost by the number of Global Hawk's procured (8) FY2002 to FY2005. It does not consider the 8 additional aircraft the Air Force wants to procure from FY2006 to FY2009 (data unavailable), nor does it factor in the $188.5 million that has been spent on Global Hawk RDT&E. This money, the $306.6 million in RDT&E funds requested from FY2001 to FY2005 and additional RDT&E funds that will be requested beyond FY2005 (if any) will need to be amortized across the entire Global Hawk program to achieve a total program unit cost figure.

cockpit upgrade is underway that will bring control systems in the U-2 up to current Air Force standards. The U-2 has been declared a "congressional interest item."

The need of the regional military commanders (CINCs) for tactical airborne intelligence capabilities is universally acknowledged within DOD. U-2s and UAVs are both in high demand and the inventories ("density") of both types of platforms are low. Although, according to some observers, the Clinton Administration may have been somewhat more inclined to deploy forces in "peacekeeping" missions than either of its likely successors, most analysts believe that U.S. military forces will not escape the types of missions in disparate countries that will require precise intelligence of potential targets. These missions are as likely to occur in the next few years as they are in 2010 or 2020.

DoD's current plans aim to provide today's and future warfighting CINCs with adequate ISR. Planning envisions the continued upgrading of the U-2, possibly augmenting it, and eventually replacing it with the Global Hawk UAV. ISR for the foreseeable future will inevitably be limited by availability of airborne platforms. At present there are only some 35 U-2s, the number of pilots and ground crew is limited; and there no operational Global Hawks. Many observers believe that, even if UAVs can ultimately replace the entire U-2 force, many more units than currently envisioned will be required as well as an extensive period of operational familiarization and training.

DoD Budget FY 2001

In considering the FY2001 Defense budget, the four major oversight committees – House Armed Services, Senate Armed Services, House Appropriations, and Senate Appropriations – expressed concern regarding U-2 procurement issues such as the Senior Year Electro Optical Reconnaissance System (SYERS), the Joint Signals Intelligence Avionics Family (JSAF), and the acquisition of a two-seat training aircraft.

Some oversight committees expressed concern that the administration's budget request underfunded initial deployment spares for the SYERS upgrade by at least $3.0 million. Authorization conferees recommended a $3 million increase to remedy this concern, while appropriations conferees did not. Also, there was consensus among the defense oversight committees that the Air Force required additional RDT&E funds to adequately support continued development of the U-2 SYERS. A polarization technique that would provide the SYERS with increased ability to penetrate foliage and camouflage was expressly supported in congressional language.

The JSAF would provide an upgraded information collection capability for the U–2s. Yet, the administration's request was insufficient to procure an entire JSAF suite and required spares and cabling. Therefore, appropriations and authorizations conferees recommended an increase to the Defense Airborne Reconnaissance Program (DARP) of $8 million for an additional JSAF unit for the U-2.

There are currently four two-seat U-2 training aircraft in DoD's inventory, and, as discussed earlier, producing sufficient numbers of U-2 pilots is a constant concern. To remedy this, House authorizers recommended making available an additional $10

million and $14 million respectively to procure a fifth two-seat U-2 trainer; and House appropriators supported that authorization. Appropriations and authorization conferees noted that $111.6 million and $14 million had already been made available for U-2 sensor improvements and a U-2 trainer respectively in the FY2000 Supplemental Appropriations Act (P.L. 106-246) enacted on July 13, 2000. (H.R. 4425, 106-710. p 133) Appropriations and authorization conferees therefore reduced funding for U-2 related procurement below the administration's request.

While supporting the Administration's request for $373.1 million in U-2 (and RC-135) operations and maintenance funding, House authorizers expressed concern that "funding for many Intelligence Community programs, including intelligence surveillance and reconnaissance (ISR) aircraft are regularly transferred from the programs for which funds were authorized and appropriated to fund shortfalls in other programs, often not related to ISR requirements."[29] Noting testimony by regional CINCS that shortfalls in ISR aircraft and systems were a top priority, the House Armed Services Committee directed that the RC-135 and U-2 programs be designated as congressional interest items.

Table 3: Summary of U-2 & Global Hawk Funding FY2001
(in millions $)

	Request	HASC	SASC	Auth. Conf	HAC	SAC	Approps. Conf.
Aircraft Procurement, Air Force							
SYERS Spares	0	3.0	8.0	3.0	0	3.0	0
U-2 DARP (Line 56)	165.5	243.7	168.5	152.3	180.2	276.6	159.2
U-2 DARP (Line 80)	98.4	128.6	106.4	11.1	136.7	98.4	14.0
HAE UAV (Global Hawk)	22.3	22.3	0	22.3	22.3	22.3	22.3
RDT&E, Air Force							
U-2 JMIP	27.5	31.5	33.5	32.5	31.5	33.5	32.5
Endurance UAV (Global Hawk)	109.2	109.2	127.2	109.2	109.2	127.2	127.2

The Air Force FY2001 budget requested $22.3 million in procurement funding and $109.2 million in RDT&E funding for the HAE UAVs. The $22.3

[29] U.S. Congress, 106th Congress, 2d session, House of Representatives, Committee on Armed Services, *Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001*, H.Rept. 106-616, May 12, 2000, p. 330.

million would be used for procurement of long lead items for the first two production Global Hawk UAVs and one common ground station. Continued development of the Global Hawk would be supported by $103.2 of the $109.3 million total for this line item. All defense oversight committees except the Senate Armed Services Committee supported the procurement request. The SASC concurred with a recent GAO report that found it premature to enter into production in FY 2001 and zeroed out the request.[30]

The House Armed Services and Senate Appropriations committees matched the administration's request for RDT&E funding. Expressing interest in the potential of Global Hawk to support counter-drug activities, the Senate Armed Services committee increased the RDT&E request by $18 million so Global Hawk engineers could explore the integration and use of an AESA (advanced electronically steered array) radar.[31] The Senate Appropriations Committee and Appropriations conferees also supported an $18 million increase; but the House did not. Authorization conferees adopted the AESA provision language but did not increase funding accordingly.

Intelligence Budget FY 2001

Some information on actions taken by the Congress on intelligence programs associated with the U-2 and the Global Hawk is available from committee reports on intelligence authorization bills. The published reports are, however, accompanied by classified annexes that provide greater detail and have legal authority. The reports also provide a sense of congressional opinion. In May 2000, the House Intelligence Committee concluded:

> In the area of Intelligence, Surveillance and Reconnaissance (ISR) assets, we continue to see extensive over-utilization of very limited, but critical airborne assets, with little relief in sight. While planning for deployment of new ISR airborne capabilities into the theaters, the Department of Defense has taken money from existing, supposedly complementary, platforms to pay for future capabilities. The result: our overall ISR capabilities and resources are decreasing at a time when our military forces are relying on them more and more.[32]

The House Committee approved the Administration's total request of $373.1 for operations and maintenance of the U-2 and RC-135 while designating them as congressional interest items. It also recommended increased funding for various U-2 modifications, including $3 million for initial deployment spares for the SYERS upgrade and $8 million for JSAF as well as the conversion of one U-2 into a trainer. Taken together the House Intelligence Committee recommended $132.6 million, an increase of $34.2 million for U-2 modifications. The Senate Intelligence Committee

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[30] U.S. Congress, 106th Congress, 2d session, Senate, Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 2001*, S.Rept. 106-292, May 12, 2000, p. 139.

[31] S.Rept. 106-292, p. 401-402.

[32] U.S. Congress, 106th Congress, 2d session, House of Representatives, Permanent Select Committee on Intelligence, *Intelligence Authorization Act for Fiscal Year 2001*, Report, May 16, 2000, H.Rept. 106-620, p. 9.

did not provide similar details on its views on the U-2 or the Global Hawk nor were these actions reflected in the intelligence authorization conference report.[33] It is likely, however, that House Intelligence Committee actions were consistent with those taken by the House Armed Services Committee.

The budgeting and funding of airborne reconnaissance programs are complicated by overlapping roles of intelligence agencies and congressional intelligence oversight committees on one hand and, on the other, by the military departments (in this case the Air Force) and their congressional overseers in the armed services and appropriations committees. There is coordination between intelligence and defense programs both within the executive branch and among congressional committees, but some observers believe that the ISR platforms inevitably come out second best in competition with bombers and fighter aircraft. In May 2000 the House Intelligence Committee stated that it "is concerned that funding from many intelligence Community programs, including intelligence surveillance and reconnaissance ISR) aircraft are regularly transferred from the programs for which funds were authorized and appropriated to fund shortfalls in other programs, often not related to ISR requirements."[34] In this as in other areas, current pressures on defense spending inevitably complicate efforts to provide adequate resources for U-2s, Global Hawk UAVs, and other ISR programs.

There are also longstanding concerns that the relationships between space-based and airborne surveillance platforms, and between "national" and tactical systems are not always well balanced. Some observers question the extent to which systems have been designed to maximize the usefulness of systems to both national and tactical consumers, suggesting that bureaucratic obstacles more than technological limitations may inhibit use by multiple consumers.

Issues and Options

The Air Force, persuaded that Global Hawk will meet many, if not all, its airborne surveillance requirements, is inclined to accelerate the acquisition effort beyond the twelve Global Hawks planned for FY03-FY09. To supply the $960 million required in additional funding, Secretary of the Air Force Whitten Peters has said that he is considering reductions in the U-2 program beginning in FY2006 and retirement of all U-2s by FY2011.[35] This will inevitably be a controversial decision. The U-2 is one of the most heavily deployed aircraft in the Air Force's inventory, widely acclaimed by the CINCs, and the beneficiary of a series of expensive upgrades in recent years that have elongated its service life. A "congressional interest item," the U-2 is the "bird in the hand" whereas the Global Hawk has yet to be fielded. A

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[33] U.S. Congress, 106th Congress, 2d session, House of Representatives, Committee of Conference, *Intelligence Authorization Act for Fiscal Year 2001*, October 11, 2000, H. Rept. 106-969.

[34] Ibid., p. 27.

[35] Amy Butler. "Peters: Global Hawk Acceleration Needed for Key 2004 Decision Point," *Inside the Air Force*, October 27, 2000.

formal decision to retire the U-2 early to free up funds for additional UAVs will likely be given close scrutiny by Congress and the public.

Advocates of the proposal note that Global Hawks have performed well in tests. They argue that the Global Hawk's long endurance gives it the ability to perform the U-2's imagery collection missions with fewer platforms. Furthermore, future upgrades and reconfigurations will give Global Hawk the U-2's SIGINT collection capability. To lay the groundwork for future airborne surveillance capabilities, it is reasonable, according to this view, to retire the U-2s beginning in 2006 rather than gradually phasing them out by attrition and make instead the investment in the next generation of airborne reconnaissance platforms.

Air Force options on Global Hawks and U-2s appear to be based on the assumption that funding must be adjusted within overall limits on spending for ISR programs. Apparently an early termination of the U-2 effort is the most acceptable way for the Air Force to identify funding for a trade-off to fund accelerated acquisition of the Global Hawk within its budgetary constraints. Some observers suggest that Air Force officials may anticipate that, at some point, funding might be identified elsewhere within the defense budget or that Congress might provide funding specifically for additional Global Hawks. One report noted, "some service sources say it is unlikely the Air Force will be able to come up with the money without significant help from OSD [Office of the Secretary of Defense] or Congress."[36]

Opponents of the proposal believe that the two systems should operate simultaneously. They argue that, considering the very high demand for today's innumerous airborne ISR assets, it is essential that the Air Force increase today's ISR capabilities, not just replace them on a one-to-one basis. Opponents of Secretary Peters's proposal also argue that the U-2 should not be phased out until the Global Hawk is produced and employed in large numbers, and its operational capabilities and limitations are well understood. This, they say, would ensure a smooth transition from today's ISR fleet to tomorrow's, and would ensure that the replacement of U-2s does not result in a loss of an essential capability.

Opponents also argue that decommissioning all U-2s which, as a result of extensive investment in upgrades have an expected service life of up to 50 more years, would be wasteful of an important capability. They note that whereas fewer UAVs than U-2s might be needed for the same mission if they were identically equipped, the actual number of Global Hawks required might vary since they cannot (at least at present) carry the same set of collection systems as the U-2. Furthermore, they contend, it is unclear when Air Force scientists will be able to overcome the technological impediments that currently limit the Global Hawk's payload.

There may be other options that could be pursued to maintain or improve DoD's aerial ISR capability until the Global Hawk is optimally configured, and produced in sufficient quantities, to replace the U-2. These options include (1) increasing the number of operational U-2s; (2) more effectively managing the existing U-2 inventory;

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[36] Amy Butler, "Peters Accelerates Global Hawk Sensor Development, Block 10 Buys," *Inside the Air Force*, September 29, 2000, p. 6.

(3) attracting and retaining more U-2 pilots; or (4) returning the SR-71 aircraft to active service.

There are currently 31 operational U-2s with another four used as trainers. At any one time, three of the 31 operational U-2s are in depot for maintenance. Since it takes five U-2s to maintain a 24 hour orbit[37], these 28 U-2s can theoretically operate in five to six different spots on the globe at the same time. Given the limited inventory of U-2s, a key concern is the foreseeable loss of aircraft through accidents and attrition. In recent years, one U-2 has been lost through attrition every two years. If this rate persists, by 2008 the Air Force would only have enough U-2s to provide 24 hour coverage of four to five different spots at any one time.

Some urge the procurement of additional U-2s by reopening the production line. This idea has received some congressional attention.[38] Some observers believe that this may be a cost-effective way to make additional platforms available in a relatively short period of time. The technology is well-proven under operational conditions and acquiring new platforms would not require long lead-times for research and development and costs would be relatively manageable.

Others argue that such a step would be counterproductive in that the Air Force would have a fleet of U-2s of varying ages which would present maintenance problems at some point. Furthermore, they suggest that the U-2 is representative of decades-old technology and is difficult to fly. Also, the U-2 production line has lain fallow for approximately 20 years. Is re-opening this line feasible? If so, at what cost? Another key consideration is manning; the U-2 requires specially trained pilots whose employability in other Air Force positions becomes limited. Most importantly, it places pilots at risk of death or capture. Proponents of re-opening the U-2 line counter, however, that it should be possible to manufacture future U-2s that don't require a pilot. The additional costs of re-designing the U-2 to fly without a pilot are unclear, but advances and technologies developed under the Global Hawk and other UAV programs could probably be exploited.

Another important action that could be taken to relieve the high operational tempo felt by the U-2 force would be to attract more pilots to the program and better retain the ones already qualified to fly the *Dragon Lady*. U-2 proponents suggest that Congress may wish to enquire about steps the Air Force has or has not undertaken to attract more pilots into the U-2 program. What, for example, would be the impact on overall recruitment and retention if the Air Force were to dictate that a greater percentage of its pilots enter the U-2 program?

Options may also exist to more effectively manage DoD's current U-2 inventory. For instance, only four U-2 training aircraft exist. This lack of trainers could slow the

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[37] Each aircraft flies an 8 hour mission. To maintain three U-2s in theater for an extended period of time, the Air Force needs to rotate five aircraft through the mission. At any one time three U-2s will be in theater, a fourth is deploying to theater, and the fifth is returning home.

[38] U.S. Congress, 106th Congress, 2d session, House of Representatives, Conference Report, *Making Appropriations for the Department of Defense for the Fiscal Year Ending September 30, 2001, and For Other Purposes*. July 17, 2000, H. Rept. 106-754. p.199.

pace of preparing new U-2 pilots for their missions. It is feasible that two-seat training aircraft could be used to fly operational missions if required, though with diminished capabilities. However, the 31 single-seat aircraft used to fly operations can't be used to train new pilots. Therefore, the reduction in ISR capability caused by converting a handful of single-seat U-2s to two-seat trainers may be outweighed by the improvement in training capabilities.

Another inventory management issue that might be examined is the U-2's foreign basing arrangements. In addition to bases in the United States, U-2s currently operate from five air bases located in France, Cyprus, Spain, South Korea, and Saudi Arabia. The Air Force is currently withdrawing the U-2 from the French and Cypriot locations. Fewer forward bases may mean that U-2s could spend a greater percentage of their 10 hour missions transiting to and from the theater to be observed, and less time collecting intelligence. Additional U-2s would be required to overfly the theater to maintain the same amount of coverage. Base consolidation has been justified by the dissolution of the Soviet Union. Yet there has also been a proliferation of smaller scale contingencies in which the United States has an interest. This raises questions about the efficacy of reducing the U-2's operational basing by two fifths at a time of high operational tempo. Some observers have suggested that examining the utility of opening additional U-2 bases in different theaters may be in order.

Another inventory management issue pertains to the Expeditionary Air Force concept. To increase deployment predictability and more evenly distribute the deployment burden, the Air Force is dividing its people and forces into 10 Air Expeditionary Forces (AEFs). These AEFs are loose amalgams of resources that will rotate through set training and deployment cycles. Currently, the Air Force does not have a similar strategy for its "high demand, low density" (HD/LD) assets such as the U-2. Instead, U-2s are sent to a given theater as demand rises. Some within DoD have suggested that the U-2 and other ISR assets could be included in the current AEF concept and thus increase U-2 deployment predictability. This idea may help distribute the deployment burden throughout the U-2 force, but may not reduce the deployment tempo, due to low numbers of operational platforms. Another suggested option is to devise an AEF-like inventory management scheme specifically for the U-2.

Different variants of the Global Hawk may have to be developed and other UAVs or manned aircraft may be acquired. The Global Hawk is not the only UAV potentially available, but it has been designed to meet certain DoD requirements for range and endurance. Configuring smaller UAVs, such as the Predator, to accomplish at least some of Global Hawk's mission capabilities might be feasible, but would entail considerable delays and could come at the cost of other operational capabilities. Yet, this idea may merit further investigation.

A final option that may bear investigation is to "un-retire" a handful of SR-71 *Black Bird* aircraft. Proponents of this approach point out that the SR-71 was a very capable ISR asset. Its very high speed contributed to the SR-71's survivability, and increased the potential volume of territory that could be surveilled. Also, several SR-71 airframes still exist. They have been preserved at the Air Force facility in Palmdale, California. Also, SR-71 aircraft have been "un-retired" in the past. Opponents of this idea point out that the SR-71 was a very expensive aircraft to fly

and maintain, and that flying just a handful would not be cost effective. Also, the airframes may exist, but what about pilots? Are there any pilots qualified to fly the aircraft? Are there any pilots qualified to teach and train pilots? Opponents of this idea argue that un-retiring the SR-71 would be too expensive a measure to simply bridge the gap between the U-2 and Global Hawk.

Conclusion

It is likely that Congress will play a key role in dealing with the futures of the Global Hawk and the U-2. Direct congressional interest in UAVs is longstanding and funding and policy direction for the Global Hawk has been reflected in a series of appropriations and authorization acts. Similarly, Congress has also monitored the U-2 program closely in recent years, identifying funding for upgrades to the aircraft and for additional surveillance and communications equipment. Plans for the early retirement of the U-2 force will undoubtedly be viewed with care and there will be interest in the progress of Global Hawk acquisition and its integration into the operating forces.

Appendix 1: Abbreviations and Acronyms

ACTD	Advanced Concept Technology Demonstration
AEF	Air Expeditionary Force
ASARS	Advanced Synthetic Aperture Radar System
BDA	Battle Damage Assessment
CINC	Commander In Chief (of a U.S. Unified or Specified Command)
COMINT	Communications Intelligence
DARP	Defense Airborne Reconnaissance Program
DoD	Department of Defense
ELINT	Electronic Intelligence
EMD	Engineering, Manufacturing and Development
EO	Electro Optical
FAA	Federal Aviation Administration
GAO	General Accounting Office
HD/LD	High Demand, Low Density
IOC	Initial Operational Capability
IR	Infra Red
ISR	Intelligence, Surveillance, and Reconnaissance
LRE	Launch, Recovery Unit
JSAF	Joint Signals Intelligence Avionics Family
MCE	Mission Control Element
PGM	Precision Guided Munition
RDT&E	Research, Development, Test and Evaluation
SAR	Synthetic Aperture Radar
SIGINT	Signals Intelligence
SLAR	Side Looking Airborne Radar
SYERS	Senior Year Electro Optical Reconnaissance System
TAD	Temporary Additional Duty
UAV	Unmanned Aerial Vehicle