

Report for Congress

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Unmanned Aerial Vehicles: Background and Issues for Congress

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Unmanned Aerial Vehicles: Background and Issues for Congress

Summary

Unmanned Aerial Vehicles (UAVs) have been referred to in many ways: RPV (remotely piloted vehicle), drone, robot plane, and pilotless aircraft are a few such names. Most often called UAVs, they are defined by the Department of Defense (DOD) as powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.

The war on terrorism has put a high premium on the primary mission of UAVs, intelligence gathering. Furthermore, the military effectiveness of UAVs in recent conflicts such as Iraq (2003), Afghanistan (2001), and Kosovo (1999) has opened the eyes of many to both the advantages and disadvantages provided by unmanned aircraft. Long relegated to the sidelines in military operations, UAVs are now making national headlines as they are used in ways normally reserved for manned aircraft. Conventional wisdom states that UAVs offer two main advantages over manned aircraft: they are considered more cost-effective, and they minimize the risk to a pilot's life. However, the current UAV accident rate (the rate at which the aircraft are lost or damaged) is 100 times that of manned aircraft.

UAVs range from the size of an insect to that of a commercial airliner. DOD currently possesses five major UAVs: the Air Force's Predator and Global Hawk, the Navy and Marine Corps's Pioneer, and the Army's Hunter and Shadow. Other key UAV developmental efforts include the Air Force and Navy's unmanned combat air vehicle (UCAV), Navy's vertical takeoff and landing UAV (VTUAV), and the Broad Area Maritime Surveillance UAV (BAMS), and the Marine Corps's Dragon Eye and Dragon Warrior. The services continue to be innovative in their use of UAVs. Recent examples include arming UAVs (Predator, Hunter), using UAVs to extend the eyes of submarines, and teaming UAVs with strike aircraft and armed helicopters to improve targeting.

In the past, tension has existed between the services' efforts to acquire UAVs and congressional initiatives to encourage a consolidated DOD approach. Some observers argue that the result has been a less than stellar track record for the UAV. However, reflecting the growing awareness and support in Congress and the Department of Defense for UAVs, investments in unmanned aerial vehicles have been increasing every year. The Fiscal Year 2001 (FY01) investment in UAVs was approximately \$667 million, while the FY03 funding totaled over \$1.1 billion dollars. The Pentagon has asked for \$1.39 billion in procurement and development funding for FY04, with much more planned for the out years.

Congressional considerations include the proper pace, scope, and management of DoD UAV procurement; appropriate investment priorities for UAVs versus manned aircraft; UAV future roles and applications; and aerospace industrial base considerations. This report will be updated as necessary.

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Unmanned Aerial Vehicles: Background and Issues for Congress

Background

Unmanned Aerial Vehicles (UAVs) have been referred to in many ways: RPVs (remotely piloted vehicle), drones, robot planes, and pilotless aircraft are a few such names. Most often called UAVs, they are defined by the Department of Defense (DOD) as powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles, cruise missiles, and artillery projectiles are not considered UAVs by the DOD definition.¹ UAVs differ from RPVs in that some UAVs can fly autonomously. UAVs are either described as a single air vehicle (with associated surveillance sensors), or a UAV system, which usually consists of three to six air vehicles, a ground control station, and support equipment.

The military effectiveness of UAVs in recent conflicts such as Iraq (2003), Afghanistan (2001), and Kosovo (1999) has opened the eyes of many to the advantages and disadvantages provided by unmanned aircraft. Long relegated to the sidelines in military operations, UAVs are now making national headlines as they assume missions normally reserved for manned aircraft. UAVs are thought to offer two main advantages over manned aircraft: they are arguably cheaper to procure, and they eliminate the risk to a pilot's life. UAVs protect the lives of pilots by performing the "3-D" missions - those dull, dirty, or dangerous missions that do not require a pilot in the cockpit. However, the lower procurement cost of UAVs must be weighed against their greater proclivity to crash, while the minimized risk should be weighed against the dangers inherent in having an unmanned vehicle flying in airspace shared with manned assets.

There are a number of reasons why UAVs have only recently been given a higher priority. Technology is now available that wasn't available just a few short years ago. Some say that the services' so-called "silk scarf syndrome" of preferring manned aviation over unmanned, has diminished as UAVs entered the mainstream. UAVs might have gained momentum earlier if a crisis had occurred, such as an extreme shortage of surveillance and reconnaissance aircraft during a conflict. The lack of such a crisis, along with the paradigm shift that needed to occur before unmanned vehicles were accepted, meant that UAVs have evolved as technology has become available.

¹Joint Publication 1-02, "DoD Dictionary of Military and Associated Terms."

Although only recently procured in significant numbers by the United States, UAVs have had a century-old history in aviation. First included in *Jane's All the World's Aircraft* in 1920, UAVs were tested during World War I, but not used in combat by the United States during that war. Germany's use of the simple yet deadly V-1 "flying bomb" during World War II, laid the groundwork for post-war UAV programs in the United States. However, it was not until the Vietnam War that UAVs such as the AQM-34 Firebee were used in a surveillance role. The Firebee exemplifies the versatility of UAVs – initially flown in the 1970s, it was recently modified to deliver payloads and flew its first flight test as an armed UAV on December 20, 2002.²

The Israeli Air Force pioneered several UAVs in the late 1970s and 1980s that were eventually integrated into the United States's UAV inventory. U.S. observers noticed Israel's successful use of UAVs during operations in Lebanon in 1982, encouraging then-Navy Secretary John Lehman to acquire a UAV capability for the Navy. Interest also grew in other parts of the Pentagon, and the Reagan Administration's FY1987 budget submission included increased UAV procurement.³ This marked the transition of UAVs in the United States from experimental projects to acquisition programs.

One of the UAVs acquired from Israel, Pioneer, emerged as a useful source of intelligence at the tactical level during Desert Storm. Pioneer was used by Navy battleships to locate Iraqi targets for its 16-inch guns. Following the Gulf War, military officials recognized the worth of UAVs, and the Air Force's Predator became a UAV on a fast track, quickly adding new capabilities.⁴ Debuting in the Balkans conflict, the Predator performed surveillance missions such as monitoring area roads for weapons movements and conducting battle damage assessment. Operations in Afghanistan have featured the Air Force's newest UAV, Global Hawk, as well as adding a new mission for Predator that allows the UAV to live up to its name — armed reconnaissance. There are currently five major UAVs in the U.S. inventory: the Navy and Marine Corps's Pioneer, the Air Force's Global Hawk and Predator, and the Army's Hunter and Shadow UAVs.

Reflecting a growing awareness and support in Congress for UAVs, investment in unmanned aerial vehicles has increased annually. The FY01 investment in UAVs was approximately \$667 million, while the FY03 funding totaled over \$1.1 billion dollars. The Pentagon has asked for \$1.39 billion in procurement and development funding for FY04, with much more planned for the out years.

Congress's role in UAV development has been one of strong encouragement tempered with concern. Taking a proactive stance in UAV program management,

²Jefferson Morris. "Northrop Grumman Modifies BQM-34 Firebee To Drop Payloads." *Aerospace Daily*, January 22, 2003.

³For more on the early history of UAV use, CRS Report 93-686 F, *Intelligence Technology in the Post-Cold War Era: The Role of Unmanned Aerial Vehicles (UAVs)*, by Richard A. Best, Jr., 1993, p. 7-10, is available from author on request.

⁴Jim Garamone. "From U.S. Civil War To Afghanistan: A Short History Of UAVs." *American Forces Information Service, DefenseLink.mil*, April 16, 2002.

Congress has in the past directed the formation of joint program offices to ensure commonality between the services' UAV programs. Congress has also expressed concern that DOD's "growing enthusiasm may well lead to a situation in which there is no clear path toward the future of UAVs", and so has required DOD to submit a UAV roadmap.⁵ In some instances, Congress has advocated a more aggressive approach to fielding UAVs. For example, in 1996, the House Armed Services Committee (HASC) supported legislation directing DOD to weaponize both the Predator and Hunter, but DOD opposed the initiative.⁶ The scope of Congress's support and confidence in UAV technology can be gleaned from the National Defense Authorization Act for Fiscal Year 2001, which stated that, "Within ten years, one-third of U.S. military operational deep strike aircraft will be unmanned."⁷

Congressional Considerations

UAVs have been labeled as transformational technologies that could change how wars are fought and won. President Bush used the UAV as an example of a technology that is changing the face of the battlefield during a speech to the Citadel in December 2001. Speaking of the conflict in Afghanistan, Bush stated:

The Predator is a good example. This unmanned aerial vehicle is able to circle over enemy forces, gather intelligence, transmit information instantly back to commanders, then fire on targets with extreme accuracy. Before the war, Predator had skeptics, because it did not fit the old ways. Now it is clear the military does not have enough unmanned vehicles. We're entering an era in which unmanned vehicles of all kinds will take on greater importance.⁸

Because they are labeled transformational programs, UAVs could be given higher priority and corresponding funding increases. This will likely cause the **pace and scope** of DOD UAV efforts to increase in the years to come. How should these efforts be managed so that they are cost-efficient, effective, and interoperable? Are DOD UAV plans on track to meet congressional direction? How do UAV programs compare to manned aircraft programs?

Investment priorities could change as the introduction of UAVs into the U.S. inventory shifts the balance between manned and unmanned capabilities. Congress, as part of its defense oversight responsibilities, may assess DOD's current UAV efforts to verify that they match up with new investment goals and strategies.

⁵U.S. Congress, 2d Session, House of Representatives, Committee on Appropriations, Department of Defense Appropriations Bill for Fiscal Year 2003, H.Rept. 107-532, p.207.

⁶Hearing of the Tactical Air and Land Forces Subcommittee of the House Armed Services Committee. "Fiscal Year 2004 Budget Request for Unmanned Combat Aerial Vehicles and Unmanned Aerial Vehicle Programs." March 26, 2003.

⁷U.S. Congress, 106th Congress, 2d Session, Senate, Committee on Armed Services, National Defense Authorization Act for Fiscal Year 2001, S.Rept 106-292, p.141.

⁸"President Speaks On War Effort To Citadel Cadets." *Whitehouse.gov*, Remarks by the President, December 2001.

Conventional wisdom states that UAVs are cheap, or cost-effective. Is this true today? How do UAV costs compare to manned aircraft costs?

UAVs have traditionally been used for reconnaissance and surveillance, but today they are being employed in **roles and applications** that their designers never envisioned. The unanticipated flexibility and capability of UAVs has led some analysts to suggest that more, if not most, of the missions currently undertaken by manned aircraft could be turned over to unmanned aerial platforms, and that manned and unmanned aircraft could operate together. Congress may soon have to contemplate the replacement of a significant portion of the manned aircraft fleet with unmanned aircraft that have yet to be designed.

Industrial base issues also need to be considered. If defense companies devote more of their time and expenses to develop unmanned aircraft, will the skills and technologies needed for manned aircraft design erode? Those who argue that UAVs will replace manned aircraft in the future are not as concerned with the industrial base issue as those who feel manned aircraft will still be needed to combat future threats.

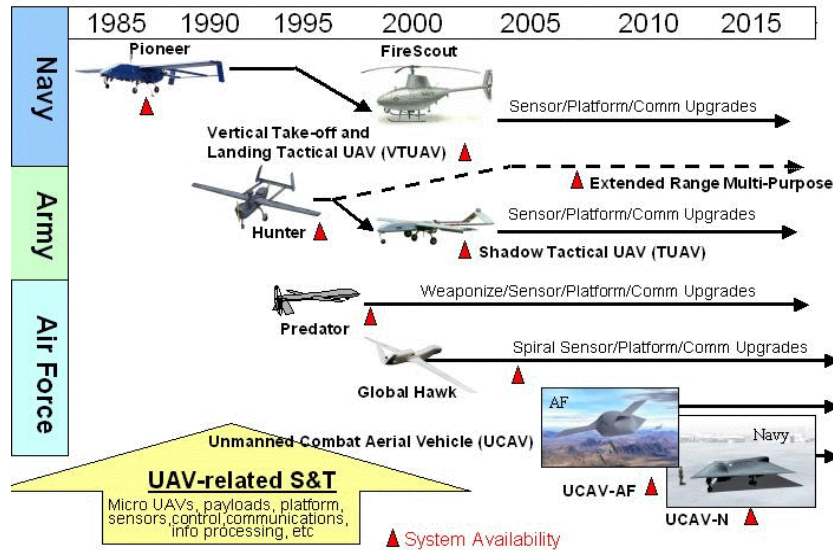
Pace, Scope, and Management of DOD Efforts

UAV programs range from the combat tested — Pioneer, Hunter, Predator and Global Hawk — to the not yet tested — the Air Force and Navy's Unmanned Combat Air Vehicles. Sizes and ranges of UAVs also vary greatly: the Pioneer at 14 feet long has a combat radius of 100nm, while the Global Hawk at 44 feet long (the size of a medium sized corporate jet) has a combat radius of 5,400nm. **Figure 1** shows the evolution of UAVs and provides a useful reference to DOD's major UAV programs.⁹

⁹For a more comprehensive treatment of these UAV programs, see "Current DoD UAV Programs" on p.18 of this report.

Figure 1. UAV Programs, 1985-2015

UAV Evolution - Where are we?



Source: DODBackground Briefing on UAVs, [http://www.defenselink.mil], October 31, 2001.
***Note:** “Navy” includes Navy and Marine Corps; Navy VTUAV Firescout program cancelled in 2001, causing the Navy Pioneer program to be extended through 2010.

DOD UAV procurement efforts have been often criticized in the past for being slow, expensive, and inefficient.¹⁰ However, operational success has stimulated DOD to accelerate the pace and widen the scope of its UAV efforts. As of April 2003, the services operated five major UAVs — the Air Force’s Global Hawk and Predator, the Navy and Marine Corps’s Pioneer, and the Army’s Hunter and Shadow — comprising 163 vehicles. **Table 1** indicates current inventories.

Table 1. UAV Platforms

UAV	Sponsoring Service	Inventory (Feb 03)
Global Hawk	Air Force	4
Predator	Air Force	48
Pioneer	Navy/Marine Corps	47
Hunter	Army	43
Shadow	Army	21
Total		163

Source: OSD UAV Planning Task Force, February 2003

¹⁰To cite just one example, U.S. Congress, 102d Congress, 1st Session, House of Representatives, Committee on Appropriations, Department of Defense Appropriations Bill, 1992, H.Rept. 102-95, p.214, where Congress noted: “with displeasure, that despite...the appropriation of \$350 million in R&D funding since 1988, the JPO has yet to produce a single UAV system.”

This compares to an operational fleet of 90 vehicles in June 2000. Projected UAV procurement is expected to bring the total number of UAVs in the military inventory to 249 by the end of Fiscal Year 2007.

Although Pioneer and Hunter are no longer being produced, at least one new UAV program will be introduced in this decade, the Air Force's UCAV, in the 2008-2010 timeframe. The overall UAV inventory could also increase if emergency or supplemental funds for future conflicts are added to UAV programs, as happened in the 2003 budget. Instead of the expected procurement of seven Predators in FY03, 25 Predators were acquired to meet operational demands in the war against terrorism. In addition, these figures do not include the category of small UAVs, which DOD expects to see the most rapid growth and fielding in future years.

The services are likely to continue adding missions to their existing and future UAVs. Predator B (nicknamed "Hunter-Killer") is being designed with a strike capability, and some Predator As are being modified to carry weapons. The Air Force and Navy UCAV designs will target air defenses (missiles, artillery, air bases, and command-and-control facilities). The UCAV, which is the first UAV developed primarily for combat, is expected to be flown by the Air Force in 2010, and by the Navy in 2015.

Table 2 provides an overview of the five UAV programs mentioned above.

Table 2. Characteristics of Current UAV Programs

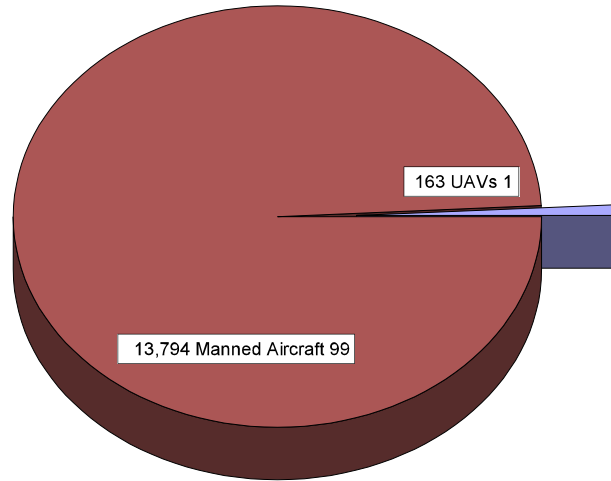
UAV Model	Pro-ducer	Radius (nm)	Max. Alt. (ft)	Endur-ance (hours)	Pay-load (lbs)	Wt. (lbs)	Est. Unit Cost per vehicle (\$)
Pioneer	AAI	100	15,000	5	75	452	1M
Hunter	Northrop Grumman	144	15,000	11.6	200	1,600	1.2M
Shadow	AAI	27	15,000	4	60	327	350,000
Predator	General Atomics	400	25,000	24+	450	2,250	4.5M
Global Hawk	Northrop Grumman	5,400	65,000	32	1,950	26,750	57 M

Source: OSD UAV Roadmap, December 2002; Teal Group Corporation, World Missiles Briefing.

DOD's UAV research and development (R&D) programs are numerous for a variety of reasons: UAVs are considered a growth industry, many UAVs are relatively inexpensive to produce and new technology in miniaturization has helped accelerate the development of many UAV types. Research and development costs continue to approximately double that of procurement costs. In FY03, procurement costs for the Global Hawk, Predator and Shadow were \$394 million while R&D costs were \$805 million.

Comparing unmanned to manned aircraft systems, **Figure 2** reveals that UAVs make up only one percent of the United States's aircraft inventory. Both fixed and rotary wing aircraft are used in this comparison.

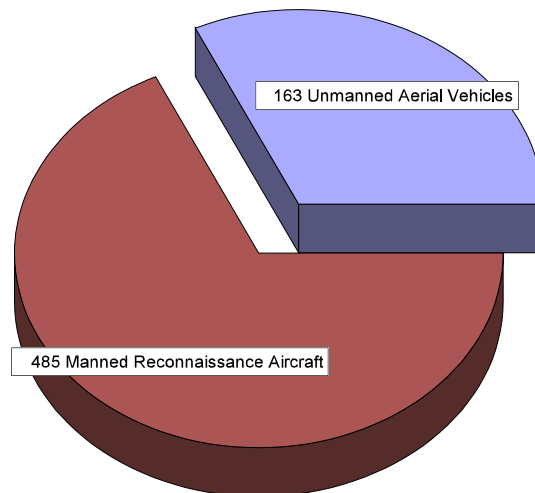
Figure 2. Comparison of Total Numbers of Manned vs. Unmanned Aircraft-Feb03



Source: Table 1, UAV Platforms; *The Military Balance 2002-2003*

UAVs comprise a more significant percentage of aircraft, 32%, when compared only to manned fixed wing reconnaissance aircraft as seen in **Figure 3**. This comparison is chosen because the primary mission of UAVs is reconnaissance.

Figure 3. Comparison of Total Numbers of Manned Reconnaissance vs. Unmanned Aircraft-Feb 03



Source: Table 1, UAV Platforms; *The Military Balance 2002-2003*

Congressional direction has provided both challenges and goals to accelerate the pace and scope of DOD UAV efforts. One of the more ambitious challenges came from the Senate Armed Services Committee in the FY01 defense authorization conference report, which set as a goal one-third of the military's operational deep strike aircraft (defined as the B-2 Spirit bomber and the F-117A Nighthawk stealth fighter) be unmanned by 2010. In 2010, there will be an estimated 75 B-2s and F-117As in the inventory.¹¹ The Air Force plans to have 14 UCAVs flying by 2010. By this measure, DOD will be slightly short of the 1/3 goal.¹²

There are four paths to Congress's goal: Accelerate the UCAV program, retire manned aircraft, weaponize existing UAVs, or rapidly develop a new combat UAV. DOD dismissed the first option, stating that UCAV development depends upon unpredictable cutting-edge technology.¹³ However, others argue that UCAV development could be accelerated by additional funding. The Air Force does not plan to retire manned aircraft to make room for more UCAVs, as they view the UCAV as an augmentation aircraft, not a replacement. The last two options appear more feasible, considering UAVs such as Predator and Hunter are already being weaponized and R&D programs are developing new combat aircraft.

Although supported by both Congress and DOD, UAV programs in the past had the reputation of rarely progressing past the development phase. In some cases, this was the result of having to choose funding unmanned systems over manned systems in an aviation culture that was built around manned systems. Also, requirements for joint systems have not always been easy to satisfy, as it is difficult to find a UAV that meets the distinct needs of the Navy, Marine Corps, and Army, for example. The Navy needs a longer range, ship launched UAV, while the Marine Corps and Army require a shorter range platform.

Over the years, management of UAV programs has gone full circle from the military services, to a Navy-run Joint Program Office (JPO), to the Defense Airborne Reconnaissance Office (DARO) and then back to the services, under the auspices of OSD. The JPO was established in 1988, but met criticism in Congress. In 1992, Congress expressed its:

serious reservations over the management of these [UAV] programs by the joint program office. Remarkably little progress has been registered during the past

¹¹Air Force Fact Sheets on B-2 and F-117, www.af.mil. Inventory on fact sheets is for current year. However, since the B-2 and F-117 are no longer being procured, the assumption made is that there will be no attrition and the inventory will remain the same in 2010 as it is currently.

¹²DOD is less likely to meet the 1/3 goal if a different definition of deep strike aircraft is used. Using the assumption that the Air Force's three bomber aircraft, the B-1, B-2 and B-52, comprise the military's deep strike aircraft, unmanned deep strike aircraft would have to equal 63, or one-third of the bomber inventory in 2010. See Pierre Bernasconi and Christopher Bolkcom's CRS Report RL31544, "Long Range Bombers: Background and Issues for Congress, August 22, 2002, p.4, for bomber inventory.

¹³See CRS Report RL31014, *Unmanned Combat Air Vehicles: Issues and Outlook*, by Robert E. Chapman II, June 14, 2001, p.15.

five years in this area. The conferees believe the Secretary of Defense should undertake a comprehensive review of the joint [project] office.¹⁴

The JPO was replaced by the Defense Airborne Reconnaissance Office (DARO), created in 1993 to more effectively manage DOD's disparate airborne reconnaissance programs, including UAVs. DARO was disbanded in 1998, amid further criticism of problems, redesigns, and accidents with the family of systems that it was formed to develop.¹⁵ Some argue that DARO was dissolved due to resistance to UAVs in favor of manned aircraft.

Since DARO's demise, there has been no single procurement focal point to manage DOD UAV efforts; the Office of the Assistant Secretary of Defense for Command, Control, Communications and Intelligence (OASD(C3I)) provides oversight, while the military services manage program development and acquisition. In 2001, a UAV planning task force was stood up under the Pentagon's acquisition chief to help promote a common vision for future UAV-related efforts. The task force's vehicle for this has been the UAV Roadmap, published in March 2003 and signed by both the Under Secretary of Defense (AT&L) and the Assistant Secretary of Defense (C3I). Another DOD initiative is the DOD UAV Interoperability Working Group, stood up in 2003 to pursue joint-service and international cooperation in UAV programs to support systems development. Congressional concerns with UAV acquisition management, program duplication, interoperability, and other issues continue.¹⁶

To encourage commonality of systems, Congress has directed JPOs again be established to promote interoperability and to reduce duplication of effort.¹⁷ Most recently, a UCAV JPO was stood up in December 2002 to address joint Air Force and Navy issues. This office's goal is to create standards that will allow UCAVs to be built along common lines, in hopes of decreasing costs. Additionally, some of the services have been working towards a common ground control system, called the Tactical Control System (TCS), which is software that would be used to control multi-service UAV systems.¹⁸ However, there are still major UAV programs like Global Hawk, which do not have plans to move towards the common ground system.

¹⁴U.S. Congress, 102d Congress, 2d Session, Committee of Conference, National Defense Authorization Act for Fiscal Year 1993, H.Rept. 102-966, p.635.

¹⁵Bill Sweetman. "DARO Leaves A Solid Legacy," *Journal of Electronic Defense*, June 1998, p.43.

¹⁶For example, in 2002, the House Committee on Armed Services noted: "The committee expresses its concern about proper program management elsewhere in this report, and is specifically concerned that UAV programs adhere to the same standards as other acquisition programs." U.S. Congress, 107th Congress, 2nd Session, House of Representatives, Committee on Armed Services, Bob Stump National Defense Authorization Act For Fiscal Year 2003, H.Rept. 107-436, p.243.

¹⁷These JPOs for various UAVs should not be confused with the single JPO that existed from 1988-1993, which served as the focal point for all UAV programs.

¹⁸TCS is a Navy-developed and managed program.

The variety of UAV acquisition processes has added to the difficulty of managing the programs. UAVs have been acquired in three ways: through the traditional acquisition pipelines, as Advance Concept Technology Demonstrations (ACTDs), and through evolutionary acquisition with spiral development (EA/SD). UAV programs have at times been accelerated by circumventing traditional development milestones. Instead, UAVs such as Predator and Global Hawk have gone through the shorter ACTD timelines (three to five years instead of a decade or more), or been considered an EA/SD program like Global Hawk, adding capabilities incrementally as new technology becomes available. The remaining three major UAV programs, Pioneer, Hunter, and Shadow, have been acquired through traditional acquisition means.

The success of programs like Predator and Global Hawk has meant their non-traditional acquisition methods have also been looked upon favorably. This could lead DOD to manage new UAV programs using these methods. One potential implication of using ACTDs and EA/SD is that they lack traditional program development milestones, which may make it more difficult for DOD to provide benchmarks for congressional oversight. On the other hand, these acquisition methods have proven successful in getting technology into the warfighters' hands more quickly than traditional acquisition pipelines.¹⁹

UAVs and Investment Priorities

The significant investment considerations for UAVs may be to find the most effective balance between manned and unmanned aircraft funding, determining how to balance UAV cost with capability, and even determining how best to characterize UAV costs.²⁰

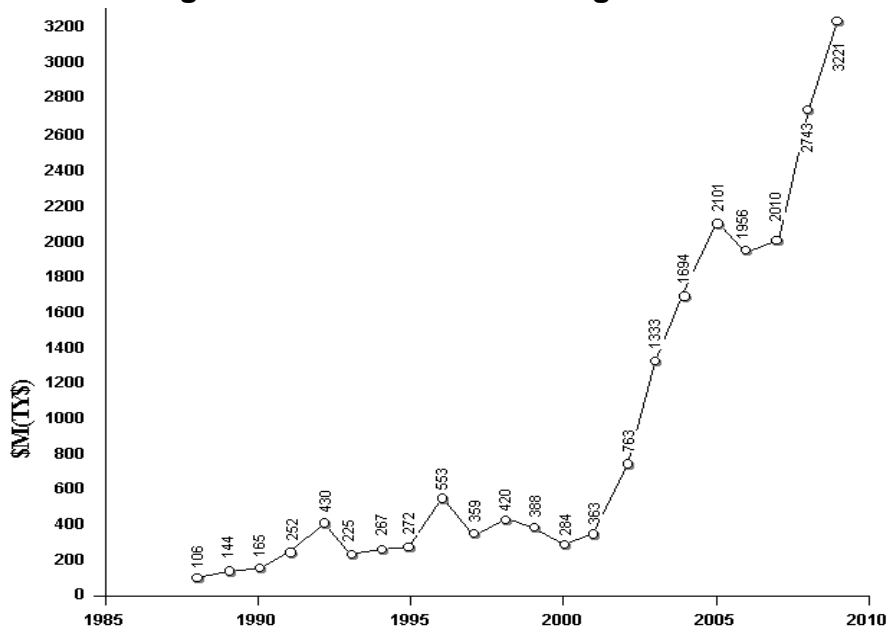
If the upward trend in UAV funding continues, as shown in **Figure 4**, DOD is projected to invest over \$10 billion in UAVs in the first decade of the new century. This is triple what it did in the previous decade.²¹

¹⁹For more on EA/SD and how it differs from the traditional weapon acquisition process, see CRS Report RS21195, *Evolutionary Acquisition and Spiral Development in DoD Programs: Policy Issues for Congress*, by Gary J. Pagliano and Ronald O'Rourke, January 23, 2003.

²⁰UAV cost can either be defined by unit cost of an individual air vehicle, or by system cost. System cost could include one to six air vehicles, the sensor package, the ground control station, and various support equipment. Acquisition cost is one measure, to include research and development and procurement costs, but operation and maintenance (O&M) cost is another factor. Costs stated are acquisition costs unless otherwise noted.

²¹OSD, UAV Roadmap 2002-2027, December 2002, p.19. Each number in the chart represents the amount DOD invested in UAVs per fiscal year.

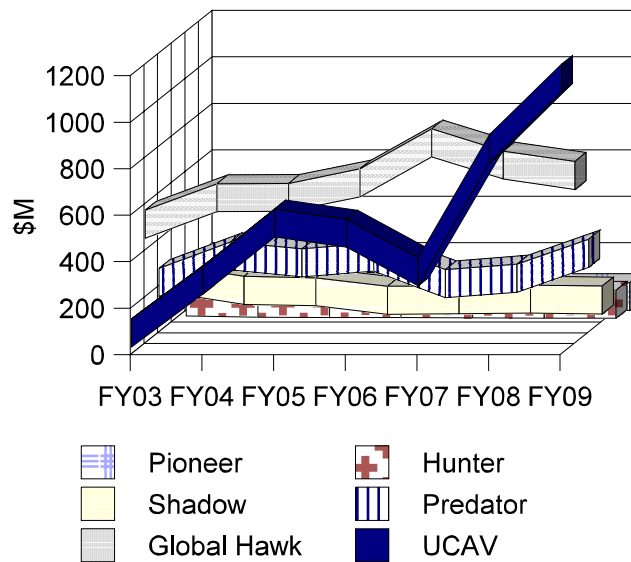
Figure 4. UAV Annual Funding Profile



Source: OSD, UAV Roadmap 2002-2027, December 2002, p.20.

Figure 5 breaks out the planned funding for each UAV throughout the Future Years Defense Plan (FYDP):

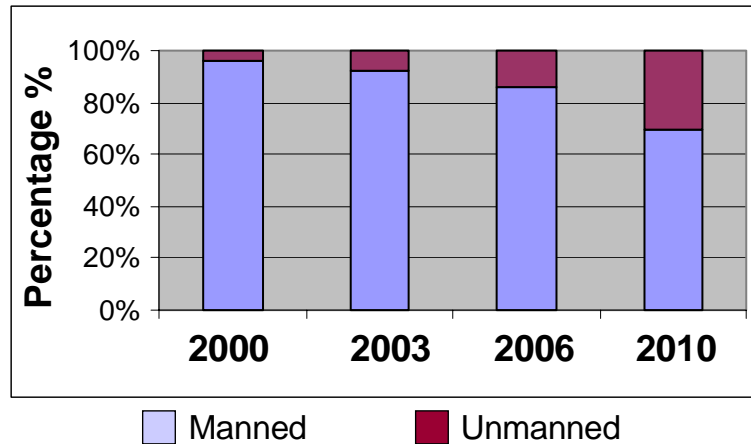
Figure 5. UAV Funding Over the FYDP, by Platform



Source: DOD UAV task force data sheet

Figure 6 compares manned to unmanned funding from 2000 to 2010.²² The chart reveals that UAVs will make up an increased portion of aircraft funding over the FYDP, growing from 4% in 2000 to 31% in 2010.

Figure 6. Manned vs. Unmanned Funding Comparison



Source: DOD UAV Roadmap 2002-2027; Teal Group Corporation, World Military and Civil Aircraft Briefing

Cost savings have long been touted by UAV advocates as one of the advantages offered by unmanned aircraft over manned aircraft. However, critics point out that the cost savings are often negligible if you consider that money saved by not having a pilot in the cockpit must be applied to the “ground cockpit” of the UAV aircrew operating the UAV from the ground control station. So although the air vehicle might be cheaper than a manned aircraft, the UAV system as a whole is not always less expensive.²³ On the other hand, UAV ground control stations can be capable of simultaneously flying multiple UAVs, somewhat restoring the advantage in cost to the unmanned system.²⁴ Congress has noted that, “while the acquisition per unit cost may be relatively small, in the aggregate, the acquisition cost rivals the investment in other larger weapon systems.”²⁵

DOD has stated that one of its major UAV challenges is to balance cost with capability. A significant concern with some UAVs is their rising price tag. At what threshold does an “expendable” UAV cost too much to lose? Sensors are starting to

²²UAV funding data extracted from the DOD UAV Roadmap 2002-2027, p.20. The three aircraft chosen to represent manned aircraft in this comparison, the F/A-22 Raptor, the F/A-18 E/F Super Hornet, and the Joint Strike Fighter (JSF), were selected because they are the three major aircraft acquisition programs.

²³As an example, the Predator air vehicle costs \$4.5 million while the Predator system, consisting of four air vehicles, cost \$30 million.

²⁴DOD UAV Roadmap 2000, p.53.

²⁵U.S. Congress, 107th Congress, 2nd Session, House of Representatives, Bob Stump National Defense Authorization Act for Fiscal Year 2003, H.Rept. 107-436, p.243.

dominate the cost of the air vehicle, according to Air Force Secretary Jim Roche.²⁶ These costs are increasing due to the basic law of supply and demand: growing demand matched up with a shortage of competition, and a lack of commercial sensor equivalents means that UAV sensor producers can set their own price. Global Hawk is an example of a UAV whose sensor costs have caused the total cost of the UAV to increase.²⁷

UAV costs compared to manned aircraft costs is a topic that has been the subject of debate. Two studies have addressed the manned vs. unmanned cost issue. The first, a CBO study, showed that replacing Army manned attack helicopters with UCAVs would produce no significant savings in steady-state procurement costs relative to current plans.²⁸ DOD also studied the comparative costs of manned vs. unmanned aircraft in their UAV Roadmap 2000. They found that development costs were essentially the same while there was a cost savings in procurement costs when an F-16 was compared to a UCAV.²⁹

Manned combat aircraft costs range from \$37 million for the Joint Strike Fighter to \$1.2 billion for the B-2 Spirit bomber.³⁰ UAV costs, on the other hand, range from the Marine Corp's developmental Dragon Eye at \$30,000 per unit to Global Hawk at \$57 million. However, the less expensive UAV systems must be replaced or restored at a greater rate than manned aircraft, adding to their total cost³¹.

Growing costs have even prompted some to recommend equipping UAVs with self-protection devices, suggesting those UAVs are no longer considered expendable. There are two schools of thought for UAV employment that could help balance cost with capability. One is to field many cheaper, less capable UAVs commanded and controlled by robust communications networks.³² A second school of thought advocates fielding fewer, more expensive and more capable UAVs that are less networked with other systems, such as the autonomous Global Hawk.

²⁶U.S. Congress, 107th Congress, 2nd Session, Senate, Committee on Armed Services, "Department of Defense Policies and Programs to Transform the Armed Forces to Meet the Challenges of the 21st Century," Senate Hearing 107-771, April 9, 2002, p.124.

²⁷See p.24 of this report for more information on Global Hawk's rising price tag.

²⁸A CBO Study. "The Long-Term Implications of Current Defense Plans." January 2003, p.94.

²⁹DOD UAV Roadmap 2000, p. 51-54.

³⁰"JSF Holds Costs Steady Despite First Production Cuts," Aerospace Daily, February 11, 2003, p.7. \$37 million is the unit cost in Fiscal Year 2002 dollars, for the Air Force's JSF variant.

Air Force B-2 Fact Sheet, www.af.mil. Unit cost is in Fiscal Year 98 constant dollars.

³¹UAVs are employed in high-risk environments and are lost at a much higher rate than manned aircraft. Nevertheless, 20 percent of UAV losses are due to human error, not enemy action, and DOD is studying how to reduce this noncombat loss.

³²Some have referred to this option as the "swarming UAV" concept.

UAV Roles and Applications

UAVs have traditionally been used as Intelligence, Surveillance and Reconnaissance/Target Acquisition (ISR/TA) assets. However, DOD has recently broadened this into new missions such as armed reconnaissance. Due to its ability to perform multiple missions as well as its success in recent military operations, the UAV has demonstrated surprisingly fast exploration of new roles.

The five major UAVs flown today are still used primarily for reconnaissance purposes. These aircraft provide commanders with imagery intelligence, electronic intelligence, and streaming video. This information can be used for everything from directing fighter aircraft to their targets, to monitoring enemy troop movements, to conducting battle damage assessment.

Predator is the first UAV to add the strike mission to its repertoire, stalking Taliban and Al Qaeda leaders in Afghanistan and Yemen and striking these targets with Hellfire missiles.³³ Most recently, the Predator has been credited with two strikes in Operation Iraqi Freedom in March 2003. One strike targeted an anti-aircraft vehicle while another fired its Hellfire missile at a TV satellite dish in downtown Baghdad.

DOD plans for other UAVs are not far behind. The Army has experimented with firing Brilliant Anti-Armor Technology(BAT) submunitions³⁴ from Hunter UAVs in October 2002 and Northrop Grumman has stated plans to fire a dummy Hellfire missile from its RQ-8A Firescout unmanned helicopter. Another role that has emerged from operations in Afghanistan is special operations support. The Predator has been used to feed imagery to AC-130 special operation gunships and special operations teams on the ground.

UAVs in the future will likely be lethal by design. R&D platforms such as theUCAV are being developed with a primary offensive mission of strike and suppression of enemy air defenses (SEAD). DARPA, along with the Army, is developing a helicopter called the Unmanned Combat Armed Rotorcraft (UCAR). The new and improved Predator, the Predator B, will have the capability to carry eight Hellfire missiles instead of two Hellfires.

DOD plans call for UAVs to play an integral role in battlefield operations. UAVs will team up with manned aircraft to carry out operational missions. The Navy is considering pairing a UAV such as Global Hawk or the Predator B with its planned multi-mission maritime aircraft (MMA), as a replacement for its aging long range patrol aircraft, the P-3C Orion. The Army envisions helicopters such as the AH-64 Apache controlling UAVs and receiving direct video feeds from the UAV. It has also been directed by DOD to add a companion UAV to its newest helicopter purchase, the RAH-66 Comanche. To make this a reality, the Army procurement

³³The laser-guided Hellfire missile was originally designed to provide heavy anti-armor capability for attack helicopters.

³⁴BAT is a self-guided submunition that uses on-board sensors to seek, identify and destroy moving tanks and other armored combat vehicles.

plan for the armed reconnaissance helicopter was halved to 650 Comanches in 2002. The intention is that the companion UAV, such as the Shadow or UCAR, would make up for the canceled Comanches. This is significant in that it is likely the first time procurement of a manned aircraft system has been scaled back to allow for the introduction of an unmanned capability.

Additional roles for UAVs in the near future may include homeland security and medical resupply. The Coast Guard and Border Patrol, parts of the newly formed Department of Homeland Security, already have plans to deploy UAVs to watch coastal waters, patrol the nation's borders, and protect major oil and gas pipelines. Congressional support exists for using UAVs like the Predator for border security. During a Senate Armed Services Committee hearing on homeland defense, it was stated that although it would not be appropriate or constitutional for the military to patrol the border, domestic agencies using UAVs could carry out this mission.³⁵

Another potential role is long-duration law enforcement surveillance, a task performed by manned aircraft during the October 2002 sniper incident near Washington, D.C. The Transportation Department has looked at possible security roles for UAVs, such as following trucks with hazardous cargo, while the Energy Department has been developing high-altitude instruments to measure radiation in the atmosphere.³⁶ On the medical side, UAVs such as the Army's Shadow have been studied as delivery vehicles for critical medical supplies needed on the battlefield.

Not all of these new applications have been approved — UAV advocates state that in order for UAVs to take an active role in homeland security, Federal Aviation Administration (FAA) regulations concerning the use of UAVs will have to change. The Coast Guard will most likely take the lead in resolving UAV airspace issues with the FAA.³⁷ The National Aeronautics and Space Administration (NASA) and the UAV industry will also be working with the FAA on the issue, as they are joining forces in an initiative to achieve routine UAV operations in the national airspace within a few years.³⁸

Further in the future, large UAVs could take on the aerial refueling task now performed by KC-10 and KC-135 tanker aircraft. Although DOD has not expressed plans for exploring the aerial refueling role, it appears to some to be a mission well suited for unmanned aircraft. The flight profiles flown by KC-10 and KC-135 aircraft are relatively benign compared to many other aircraft, and they tend to operate far from enemy air defenses. Except for operating the refueling boom (to refuel Air Force aircraft), the refueling crew's primary job is to keep the aircraft flying straight,

³⁵Marc Selinger. "Sen. McCain Says Predator May Be Useful For Border Security," *Aerospace Daily*, April 9, 2003.

³⁶*National Journal's Congress Daily*. "Pilotless Aircraft Makers Seek Role For Domestic Uses," December 17, 2002.

³⁷Jefferson Morris. "Coast Guard Leaning Away From Global Hawk, Manager Says," *Aerospace Daily*, January 14, 2003.

³⁸Jefferson Morris. "NASA, UNITE Group Planning Details Of New UAV Initiative," *Aerospace Daily*, March 13, 2003.

level, and at a steady speed. The Global Hawk's recent trans-oceanic flights (from the United States to Australia and from the United States to Portugal) demonstrate the ability of current UAVs to fly missions analogous to aerial refueling missions.

Another, far more difficult future task, could be air-to-air combat. DOD is experimenting with outfitting today's UAVs with the sensors and weapons required to conduct such a mission. In fact, a Predator has reportedly already engaged in air-to-air combat with an Iraqi fighter aircraft. In March, 2003 it was reported that a Predator launched a Stinger air-to-air missile at an Iraqi MiG before the Iraqi aircraft shot it down.³⁹ While this operational encounter may be a "baby step" on the way toward an aerial combat capability, it appears significant. Aerial combat is often described as the most challenging mission for manned aircraft to perform, and, some say, one that UAVs will never be able to accomplish. Though embryonic, the recent Predator launch of an air-to-air missile will likely hearten UAV advocates who wish to see more aggressive missions for unmanned aircraft.

Are UAVs always the preferred platforms for these new roles and applications? Other options could include manned aircraft, blimps, and space satellites. Each platform offers both advantages and disadvantages. Manned aircraft provide a flexible platform, but risk a pilot's life. Some of the country's largest defense contractors are competing to develop unmanned blimps that may be capable of floating months at a time at an altitude of 70,000 feet and carrying 4,000 pounds of payload. These blimps would be used in a surveillance role to spot incoming enemy missiles and planes. The goal is to develop an operational system by 2010 which could carry out such missions for homeland security.⁴⁰

Space satellites offer many benefits — they are relatively invulnerable to attack, and field many advanced capabilities. However, tasking the satellites can be cumbersome, especially with competing national priorities. The limited number of systems can only serve so many customers at one time. Additionally, satellites lack the loitering capability of UAVs, only passing over the same spot on Earth about once every three days. Due to the high costs of space launches, UAVs like Global Hawk are being considered for communication relays as substitutes for low-orbiting satellite constellations.⁴¹

One of the primary concerns about UAV roles and applications is "gold plating." Some have declared that if the military does not control requirements creep, UAVs will be priced out of business. The fear is that good designs will become loaded up with more sensors, more weapons, and more missions until they become too expensive to build or too valuable to use (and risk losing) in combat. Additional potential impediments include negative aviation culture mindsets and command, control, and communications bandwidth limitations and constraints.

³⁹David Fulghum. "Predator's Progress." *Aviation Week & Space Technology*. March 3, 2003.

⁴⁰Peter Pae. "A Rebirth For Blimps; Military Has Plan For Cousin of Hindenburg," *Los Angeles Times*, November 4, 2002.

⁴¹David Fulghum. "Air Force Chief Predicts Growth of UAV Use By Military," *Aviation Week and Space Technology*. March 17, 2003.

It has not always been easy for the aviation culture to adapt to flying aircraft from the ground vice in the air. Deputy Secretary of Defense Wolfowitz, during a hearing on transformation, stated that:

Not long ago, an Air Force F-15 pilot had to be persuaded to forego a rated pilot's job to fly Predator. Now Air Force leadership is working hard to encourage this pilot and others to think of piloting UAVs as a major mission and to become trail blazers in defining new concepts of operations.⁴²

The Air Force has realized the retention implications of requiring rated pilots to fly their UAVs⁴³, and has offered enticements such as plum assignments after flying the UAV, and allowing pilots to keep up their manned flying hours during their UAV tour of duty.

The requirement for bandwidth grows with every war the U.S. fights⁴⁴. Since September 11, 2001, the need has increased eight-fold in Central Command due to the war in Afghanistan and the pursuit of terrorists in the region.⁴⁵ UAVs are major consumers of bandwidth. Some sources say that the military does not have enough bandwidth to download video and radar images via satellite communications from more than one UAV at a time. DOD is working on solving this problem through a \$200 million program called Extended Tether, which is not scheduled to be in place until FY05.⁴⁶

The director of intelligence, surveillance and reconnaissance systems for OSD has stated that UAV and network centric operations are a primary reason the Defense Department has earmarked \$3 billion starting in FY03 for the Transformational Communications program, as OSD does not want UAV operations limited by bandwidth. New developments such as satellite laser communications could streamline space data links so that three satellite links are no longer needed to support a single Global Hawk mission over Afghanistan, as is the case now.⁴⁷ DOD has testified that a more autonomous UAV would require less bandwidth, since more data are processed on board and less data are being moved.⁴⁸ However, it is unclear

⁴²U.S. Congress, 107th Congress, 2d Session, Hearing Before the Committee On Armed Services United States Senate. *Department of Defense Policies And Programs To Transform The Armed Forces To Meet The Challenges Of The 21st Century.* April 9, 2002, p.10.

⁴³Currently the Air Force is the only service to require rated pilots to fly their UAVs.

⁴⁴Bandwidth is defined as the amount of data that can be transmitted over a communications link in a fixed amount of time.

⁴⁵David Hughes. "Pentagon Targets Bandwidth Expansion." *Aviation Week and Space Technology*, January 27, 2003, p.57.

⁴⁶Andrew Koch. "Air Reconnaissance Assets Still In Short Supply." *Jane's Defense Weekly*, February 12, 2003.

⁴⁷Craig Covault. "Military Satcom, Relay Programs Boost Industry, Enhance Warfare." *Aviation Week & Space Technology*, January 6, 2003, p.43.

⁴⁸Hearing of the Tactical Air and Land Forces Subcommittee of the House Armed Services (continued...)

that autonomy will actually decrease bandwidth requirements since Global Hawk, an autonomous UAV, is currently the most aggressive bandwidth user.

One solution to alleviating the bandwidth problem is allowing UAVs to be operated from a manned stand-off aircraft such as a command and control aircraft. Stationing the mission control element of the UAV system in another aircraft instead of on the ground would reduce the reliance on satellites for beyond line of sight communication, simplifying command and control. Not only would this help overcome the bandwidth issue, but it would also combat another problem area, which is the pilot retention issue. Pilots in this case would still get to “fly” while operating the UAV. Experimentation is currently ongoing in this area, with the first step being controlling the UAV’s sensor payload from the air.

Industrial Base Considerations

Another issue that may confront Congress is the concern that increased pursuit of UAV development could have an effect on the U.S. aerospace industrial base. If UAVs are increasingly designed and built at the expense of manned aircraft, then some fear that the technical expertise required to design, and perhaps build manned combat aircraft could erode. Many point out that the ability to produce world class combat aircraft is a distinct U.S. comparative advantage, and should be guarded closely. Others disagree that the pursuit of UAVs could harm the industrial base. They argue that the Joint Strike Fighter is likely to be the last manned tactical fighter, and that the industrial base is naturally evolving toward the skills and processes required to make increasingly advanced UAVs.

Those who fear manned industrial base atrophy argue that the future of UAVs is overrated, and that there will be a demand for tactical manned aircraft in the post-JSF timeframe. In their eyes, crucial skills and technologies could thus be lost by concentrating only on unmanned aircraft design, possibly causing U.S. dominance in tactical aircraft design to wane. These proponents point out that UAVs have been around for almost a century, yet only recently became operationally effective, and are not likely to replace manned aircraft in the near future.⁴⁹

UAV advocates argue that critical manned aircraft design skills are not jeopardized by increased pursuit of UAVs because there is considerable commonality between manned and unmanned combat aircraft. Except for the obvious lack of a cockpit, unmanned combat aircraft may require stealthy airframes, advanced avionics, and high performance engines just like manned combat aircraft. Also, major defense contractors have already begun to shift to unmanned aircraft design in order to stay competitive. This is because UAVs are beginning to play a prominent role in warfare, as seen in Operation Enduring Freedom in 2001 and Operation Iraqi

⁴⁸(...continued)

Committee. “Fiscal Year 2004 Budget Request for Unmanned Combat Aerial Vehicles and Unmanned Aerial Vehicle Programs.” March 26, 2003.

⁴⁹For more information on the arguments for and against future demand of tactical aircraft, see CRS Report RL31360, *Joint Strike Fighter (JSF): Potential National Security Questions Pertaining to a Single Production Line*, by Christopher Bolcom and Daniel Else.

Freedom in 2003. The same skills and technologies required for building manned aircraft will likely lend themselves to unmanned aviation design as well. Companies that have lost out in recent aviation contracts, such as Boeing and the Joint Strike Fighter (JSF) in 2001, are looking towards unmanned bombers and fighters as prospects for growth.⁵⁰ If Boeing were to design manned aircraft in the future, the critical skills needed would still be present, according to this argument.

The Pentagon's decision regarding UCAV design and production could affect the UAV industrial base and be indicative of future UAV production decisions. With the Pentagon deciding not to follow the same philosophy as the JSF, and have a single company like Lockheed Martin design the aircraft, vendors will instead be encouraged to compete throughout the life of the effort. This would combat the concern in the aerospace industry after the JSF contract — namely, that expert product teams in companies other than Lockheed Martin would disappear. OSD has also stated that there are requirements which could be filled by smaller companies as well as the three large vendors: Lockheed Martin, Boeing and Northrop Grumman.⁵¹ Competition is expected to encourage cost reduction and aircraft design innovation.

Current DOD UAV Programs

Overview

In the past, tension has existed between the services' efforts to acquire UAVs and congressional initiatives to encourage a consolidated DOD approach. Some observers argue that the result has been a less than stellar track record for the UAV. However, DOD funding for UAVs has increased dramatically over the past few years. During 1998-2001, DOD spent an average of \$363 million a year on UAVs.⁵² In FY02, this number rose to \$970 million while in FY03 it increased again to \$1.1 billion. In FY03, Congress either matched the DOD budget requests for each UAV program or added funds. In FY03, \$52 million was added to the Predator, Pioneer, and Shadow UAV programs. UAV successes in recent conflicts have contributed to the increase in UAV funding, with emergency fund money and supplemental dollars being allocated towards UAV programs. The FY03 Supplemental recommended \$15.7 billion for the Iraq Freedom Fund, for procurement of items to meet anticipated requirements for weapons and equipment such as unmanned aerial vehicles.⁵³ It is anticipated that these funds would help replace UAVs lost during Operation Iraqi Freedom (OIF).

⁵⁰Andy Pasztor. "Boeing Aims For Slice Of Fighter-Jet Contract Awarded to Lockheed, But Blow Still Stings," *Wall Street Journal*, October 29, 2001.

⁵¹Amy Butler. "OSD Frowns On "Winner-Takes-All" As Companies Posture for UCAV," *Inside the Air Force*, March 28, 2003.

⁵²OSD. "Unmanned Aerial Vehicles Roadmap 2000-2025." April 2001, p.11.

⁵³U.S. Congress, 108th Congress, 1st Session, House of Representatives, Committee of Conference, *Making Emergency Wartime Supplemental Appropriations for the Fiscal Year 2003, and For Other Purposes*, H.Rept. 108-76, p.64.

DOD currently operates five major UAVs: the Air Force's Predator and Global Hawk, the Navy and Marine Corp's Pioneer, and the Army's Hunter and Shadow. Other key UAV developmental efforts include the Air Force and Navy's UCAV, the Navy's VTUAV Firescout and BAMS, and the Marine Corp's Dragon Eye and Dragon Warrior. The services continue to be innovative in their use of UAVs. Recent examples include arming UAVs (Predator, Hunter), using UAVs to extend the eyes of submarines, and teaming UAVs with strike aircraft and armed helicopters to decrease the time it takes to attack a target. DOD used one type of UAV, Pioneer, in the 1991 Persian Gulf War, three systems – Global Hawk, Pointer and Predator – in Afghanistan in 2001, and more than ten systems in Operation Iraqi Freedom in 2003. These systems include the Air Force's Global Hawk, Predator and Force Protection Surveillance System; the Army's Hunter, Pointer and Shadow; and the Marine Corps' Dragon Eye and Pioneer.⁵⁴

Operational UAVs

MQ-1 Predator.

The Air Force's MQ-1 Predator is a UAV with many "firsts" to its name. It is the first Department of Defense advanced concept technology demonstration (ACTD)⁵⁵ UAV to transition to active military duty. It is also the first UAV in history to fire offensive weapons against enemy combat forces.⁵⁶ Proving itself in recent conflicts such as Iraq, Kosovo, and Afghanistan, the Predator's production rate has been accelerated and funding has been increased through transfers from the Defense Emergency Response Fund (DERF) and Congressional plus-ups. Although featuring a high attrition rate, the Predator has enjoyed considerable success in the global war against terrorism, increasing the situational awareness of other aircraft such as the Air Force's AC-130 gunship, and employing its revolutionary armed strike capability against Al Qaeda and Taliban leadership.

⁵⁴Marc Selinger. "U.S. Using More Than 10 Types of UAVs in Iraq War, Official Says." *Aerospace Daily*, March 27, 2003.

⁵⁵ACTDs were initiated in 1994 to permit the early and inexpensive evaluation of mature advanced technologies. The ACTD program is structured and executed so that, when successful, technologies can transition rapidly into formal acquisition.

⁵⁶"Kudos for Predator." *Unmanned Systems*. Nov/Dec 2002.

Figure 7. Predator Flying in Support of OEF, Equipped with Hellfire Missile



Source: Air Force Magazine.

System Characteristics. Predator is a medium-altitude, long-endurance UAV, roughly half the size of an Air Force F-16 fighter. At 27 feet long and 7 feet high, it has long, thin wings and a tail like an inverted V. The Predator typically operates at 10,000 to 15,000 feet to get the best imagery from its video cameras, although it has the ability to reach a maximum altitude of 25,000 feet. The air vehicle launches and lands like a regular aircraft, but is controlled by a pilot on the ground using a joystick. Each vehicle can remain on station, over 400nm away from its base, for 24 hours before returning home. The 11th, 15th and 17th Reconnaissance Squadrons operate the Predator, all based at Indian Springs Auxiliary Field, Nevada. On February 1, 2002, the Air Force changed the Predator's military designation from RQ-1B (reconnaissance unmanned) to the MQ-1 (multi-mission unmanned) due to its added capabilities of laser designation and missile-firing.⁵⁷

Mission and Payload. The Predator's primary function is airborne reconnaissance and target acquisition. To accomplish this mission, the Predator is outfitted with a 450-lb surveillance payload, which includes two electro-optical (E-O) cameras and one infrared (IR) camera for use at night. These cameras are housed in a ball-shaped gimbal turret that can be easily seen underneath the vehicle's nose. New production Predators will have a Multi-Spectral Targeting System (MTS) sensor ball which will add a laser designator to the E-O/IR payload. The Predator's payload also includes a synthetic aperture radar (SAR), which allows the UAV to "see" through inclement weather. The Predator's satellite communications provide for beyond line-of-sight operations. New payloads are being tested on Predator, including launching smaller UAVS such as the Finder UAV, a 57-lb satellite guided system that can carry different sensors.⁵⁸

⁵⁷Glenn W. Goodman, JR. "UAVs Come of Age." *The ISR Journal*, July 2002, p.24.

⁵⁸Robert Wall. "Predator UAV Tested With New Payloads." *Aviation Week & Space Technology*, September 2, 2002, p.47.

Program Status. The Predator air vehicle is built by San Diego's General Atomics Aeronautical Systems, Inc. The UAV began as an ACTD in 1994 and then transitioned to the Air Force in 1997 after successfully flying missions over Bosnia the year before. In 2001, the Air Force purchased two Predator B (MQ-9) UAVs for testing. The B variant, also referred to as the "hunter-killer," is a larger version of the Predator,⁵⁹ with improvements in altitude, payload, speed and range. The MQ-9 can fly at altitudes of 45,000 to 52,000 feet, and carry eight Hellfire missiles (compared to two for the MQ-1). All Predators coming off the assembly line will be capable of carrying Hellfires, while older Predators are planned to be retrofitted to carry the missile.

Inventory. Due to production rates and current operational use causing high attrition, the inventory of Predators can change greatly from month to month. The Air Force currently has 48 air vehicles and eight ground control stations in its inventory. The service is purchasing replacement air vehicles based on an initial attrition study by the Air Force Studies Analysis Agency of seven air vehicles lost a year.⁶⁰ Some media reports have stated nearly 30 Predators out of 60 to 70 in the fleet have been lost since the plane entered service in 1994.⁶¹ A more accurate report could be the Air Force Safety Center analysis that stated 13 Predators have been lost since 1997.⁶² Reasons for the high attrition rates include Predator flying combat missions as a developmental ACTD, and the lack of redundant equipment in unmanned vehicles. In October 2001, the Secretary of the Air Force approved an option to accelerate production rate to two air vehicles per month. FY02 Supplemental and FY03 Appropriations included funds to support this acceleration. The Air Force contracted with General Atomics in December 2002 to build 12 more Predators, due out by April 2004.⁶³ The CIA reportedly also owns and operates an undisclosed number of Predators.⁶⁴

Cost. Each Predator air vehicle is estimated to cost \$4.5 million. An entire Predator UAV system costs \$30 million. Due to these costs, Predator is considered attritable rather than expendable.

Recent Operations.

Operation Allied Force (Kosovo). Although the Predator's first combat appearance occurred in Bosnia in 1995, it was during Operation Allied Force in 1999 that the Predator began to make a name for itself. Video feeds were downloaded from the UAV to the command center at Aviano Airbase, Italy. Information was then

⁵⁹The original version of the Predator, the RQ-1/MQ-1, is also referred to as the Predator A.

⁶⁰Air Force Background Paper, January 31, 2003.

⁶¹Mike Mount. "U.S. Loses Many Military Drones." CNN.com, January 2, 2003.

⁶²Air Force Safety Center. "Air Force Safety Analysis 1993-2002." January 2003, p.20.

⁶³Hampton Stephens. "Air Force Will Buy 12 More Predators From General Atomics." *Inside the Air Force*, December 6, 2002.

⁶⁴Bradley, Graham. "Pentagon Loses Two Unmanned Spy Planes Over Bosnia." *The Washington Post*, August 15, 1995, p.A10.

relayed to airborne forward air controllers (FACs), allowing the FACs to find targets that would have been difficult to locate otherwise. By the end of the war, Predator was being outfitted with laser designators to aid bombers with their target recognition. However, the Predator would have to wait until Operation Enduring Freedom to test out this new capability.

Operation Southern Watch (Iraq). Predators also started flying above Iraq to help monitor the no-fly zone in Operation Southern Watch. Prior to Operation Iraqi Freedom in 2003, Predators had expanded their surveillance mission in Iraq to include an offensive role. Predators successfully destroyed Iraqi mobile radar units using Hellfire air-to-ground missiles. The Predators' success meant that they were targeted by the Iraqis, who shot down as many as three of the UAVs over southern Iraq. One Predator was shot down by an Iraqi MIG on December 23, 2002, but not before shooting a missile of its own at the MIG.⁶⁵

Operation Enduring Freedom (Afghanistan). Operation Enduring Freedom (OEF) has provided the catalyst for the evolution of the Predator. While still carrying out its traditional mission of aerial reconnaissance, the Predator has moved into previously uncharted territory for UAVs with new capabilities such as close air support and armed strike.⁶⁶ A particularly significant aspect of the use of UAVs during OEF was that they were pivotal in the network-centric operations in Afghanistan. UAVs were a critical element in the chain that allowed targets to be struck within five minutes of their identification.⁶⁷ In Afghanistan, Predators have worked in tandem with both the Air Force's AC-130 gunship and the Navy's F/A-18 Hornet, locating targets for these strike aircraft and using its laser designator to aid in target acquisition.⁶⁸ Central Command outfitted the AC-130s with terminals that enabled the aircrews to get Predator feeds directly in the airplane — a major improvement on the 1999 Kosovo war, when Predator video was downloaded to the operations center and then passed piecemeal to pilots in the air.⁶⁹

War On Terrorism (Worldwide). In February 2001, the Predator added a lethal capability when weapons replaced cameras on some of the air vehicles. Prior to employing weapons on UAVs, the U.S. government performed a treaty-compliance review, and the weaponized Predator was deemed fully compliant with

⁶⁵60 Minutes II, CBSNEWS.Com, January 8, 2002. CBS reported Predator fired missile in dogfight. However, the Air Force has stated that the Predator will not be used in a dogfight, but rather will only fire air-to-air missiles in self-defense. No information was provided as to the fate of the MIG.

⁶⁶Capt. Russell Parker. "UAVs Take Center Stage In The War On Terrorism." *Airman*, December 2002.

⁶⁷Anil R. Pusta. "Unmanned Aerial Vehicles: Trends and Prospects." *Military Technology*, 2002.

⁶⁸Judith Miller and Eric Schmitt. "Ugly Duckling Turns Out To Be Formidable In The Air." *New York Times*, November 23, 2001.

⁶⁹Richard J. Newman. "The Little Predator That Could." *Air Force Magazine*, March 2002.

the Intermediate-range Nuclear Forces (INF) Treaty.⁷⁰ An armed Predator UAV belonging to the CIA, carrying Hellfire air-to-ground missiles, was credited with a hit on a senior Al Qaeda operative in Yemen in November 2002, as well as one against Al Qaeda fighters in Afghanistan. The Air Force has tested the Stinger air-to-air missile for use with the Predator, which would give the UAV a self-defense capability. The satellite-guided Joint Direct Attack Munition (JDAM) will also be carried by the Predator, making it the second attack weapon certified for use on the Predator B.⁷¹ General Franks, CENTCOM commander, stated in November 2001, “The Predator is my most capable sensor in hunting down and killing Al Qaeda and Taliban leadership and is proving absolutely critical to our fight.”⁷²

Operation Iraqi Freedom (Iraq). Although official DOD reports have not been released on Predator’s performance in Operation Iraqi Freedom (OIF), early press reporting suggests that the Predator has continued building on its success in previous conflicts. The Predator struck an Iraqi anti-aircraft vehicle using a Hellfire missile in March 2003. Predators have flown one-way decoy missions in Baghdad, in order to reveal the locations of Iraqi air defenses. Predator cameras also allowed U.S. commanders oversee the rescue of a U.S. Army prisoner-of-war in April 2003.⁷³

Predator Losses. Amongst all its successes, real world operations in Afghanistan have revealed some shortcomings of the Predator. Two UAVs crashed in Afghanistan due to wing icing caused by flying in clouds. Other losses might have been caused by the loss of its satellite communications link, which is often difficult to reestablish. The altitudes at which the Predator must fly to avoid bad weather or obtain imagery often put the UAV in the range of enemy air defense assets. Some of these vulnerabilities were mentioned in a 2001 report by the Pentagon’s operational test and evaluation office, which concluded, “As tested, the Predator UAV system is not operationally effective or suitable.”⁷⁴ Despite this finding, several Predator teams were among the first troops dispatched to central Asia after the September 11, 2001 terrorist attacks,⁷⁵ and have been singled out by operational commanders as vital to their mission. In OIF, at least one Predator has been reportedly lost, although its mission was to act as a decoy.

FY03/04 Developments.

Administration’s Request. In FY03, the administration began with a baseline request of \$23 million to procure seven Predator air vehicles. The anticipation of funds from the DERF increased this request to \$105 million for procurement of 22

⁷⁰U.S. Department of Defense. “Background Briefing on Unmanned Aerial Vehicles.” Defenselink.mil, October 31, 2001.

⁷¹Ron Laurenzo. “New Predator Will Carry New JDAM.” *Defense Week*, January 6, 2002.

⁷²Air Force Background Paper, January 31, 2003.

⁷³Jim Krane. “Iraqi Successes Have Air Force’s Pilotless Planes Stealing Pilots’ Jobs.” *The Associated Press*, April 24, 2003.

⁷⁴George C. Wilson. “Pilots! Unman Your Airplanes!” *National Journal*, December 1, 2001.

⁷⁵Richard J. Newman. “The Little Predator That Could.” *Air Force Magazine*, March 2002.

air vehicles and \$3.8 million for research and development. Additionally, \$37 million was requested in the DOD FY02 Supplemental Request, to accelerate production of Predator to two air vehicles a month, and \$8 million was requested to retrofit a ground station.⁷⁶ In 2004, the Administration's request was \$193.6 million for 16 air vehicles. The R&D request for endurance unmanned aerial vehicles (including Predator and Global Hawk) is \$398.6 million for 2004.

Authorization. The House Armed Services committee recommended an increase of \$26 million for six Predator B UAVs, noting, "the improved speed and payload capacity of turbo prop-powered Predator B UAV is critical to future combat operations."⁷⁷ The original budget request of \$23 million did not include funds for the Predator B. Additionally, the Armed Services Committee conferees transferred \$10 million from the DERF for research and development of the Predator B. The conferees authorized \$131 million for procurement of 28 Predator air vehicles and \$13.8 million for research and development.⁷⁸

Appropriation. Congress allocated a total of \$131 million for the purchase of 22 Predator air vehicles and \$13.8 million for research and development.⁷⁹ To the Administration's original request of \$23 million, they transferred \$68 million from the DERF to purchase the original variant of the Predator, \$14 million from the DERF for Predator equipment and added an additional \$26 million for procuring "not less than three" Predator Bs.⁸⁰ The \$93 million FY02 supplemental request for Predator was also approved.

RQ-2 Pioneer.

The Navy and Marine Corps' only operational UAV, the Pioneer was initially developed in Israel, then acquired by the U.S. Navy in 1986. The venerable Pioneer has played a critical role in generating U.S. interest in tactical UAVs. Originally flown from Navy battleships, the Pioneer is currently being launched from amphibious ships and land based facilities. The Pioneer was only intended to be an interim UAV pending the development of a joint tactical UAV. In fact, Congress ordered the Navy to halt future purchases in FY88 due to the decision to press ahead

⁷⁶See CRS Report RL31406, "Supplemental Appropriations for FY2002: Combating Terrorism and Other Issues," by Amy Belasco and Larry Nowels, updated August 30, 2002, p.70.

⁷⁷U.S. Congress, 107th Congress, 2d session, House of Representatives, Committee on Armed Services, National Defense Authorization Act for Fiscal Year 2003, H.Rept 107-436, May 3, 2002, p. 103.

⁷⁸U.S. Congress, 107th Congress, 2d Session, House of Representatives, Conference Report to Accompany H.R.4546, National Defense Authorization Act for Fiscal Year 2003, H.Rept. 107-772, November 12, 2002.

⁷⁹U.S. Congress, 107th Congress, 2d Session, House of Representatives, Conference Report to Accompany H.R.5010, Making Appropriations for the Department of Defense for the Fiscal Year Ending September 30, 2003, and for Other Purposes, H.Rept. 107-732, October 9, 2002.

⁸⁰Ibid.

with such a UAV.⁸¹ As the joint tactical UAV failed to materialize, the Navy used its Pioneer attrition replacements in such conflicts as the Persian Gulf War, which proved the worth of a tactical UAV. Lacking a new tactical UAV on the horizon, the Marine Corps instituted a Pioneer Improvement program in 2000, which should keep the Pioneer viable until the end of the decade. FY03 funding includes money for Pioneer upgrades, but only for use by the Marine Corps as the Navy no longer flies the Pioneer.

Figure 8. Pioneer Ready To Launch from Ship



Source: Navy UAV homepage, (<http://uav.navair.navy.mil>)

System Characteristics. At 14 feet long, the Pioneer is roughly half the size of the Air Force's Predator UAV. It can reach maximum altitudes of 15,000 feet, but flies an optimal altitude of 3-5,000 feet above its target. The Pioneer can stay aloft for five hours during the daytime, and has a range of 100nm. Since its inception in the 1980s, Pioneer has flown over 23,000 hours in direct support of Navy and Marine Corps operational commanders.

Mission and Payload. The mission of the Pioneer is to provide real time intelligence and a reconnaissance capability to the field commander. Pioneer can be used for over-the-horizon targeting, surveillance, Naval gunfire spotting, and battle damage assessment. Its 100 lb payload consists of an electro-optical and IR camera. Other payloads which have been demonstrated include a meteorological sensor, a mine detection sensor and a chemical detection sensor.

Program Status. The Navy had planned to retire the Pioneer, built by AAI, Hunt Valley, MD, in 2003 or 2004, and replace it with the VTUAV. However, when that program was curtailed, the decision was made to give all of its Pioneer systems to the Marine Corps and keep them flying another 10 years to meet that Service's requirements through a product improvement program.⁸²

⁸¹Steven Zaloga. RQ-2A Pioneer. *World Missiles Briefing October 2002*. Teal Group Corp.

⁸²Glenn W. Goodman Jr. "UAVs Come Of Age." *The ISR Journal*, July 2002. p.28.

Inventory. According to OSD, the Navy and Marine Corps have 47 Pioneer air vehicles. These air vehicles are organized into four Pioneer systems (two each for the Navy and Marine Corps), which are in a contingency status; meaning that they can be deployed rapidly.⁸³

Cost. Per unit cost estimates of the Pioneer range from \$250,000 to \$1 million, depending on payload and production rate.⁸⁴

Recent Operations.

Operation Desert Storm (Iraq). Flying a total of 533 sorties, the Pioneer rose to fame during Operation Desert Storm where it was used for surveillance and to define accuracy for the battleship's 16-inch guns; the Iraqi military learned to fear the sight of the Pioneer. During one widely reported incident, Iraqi soldiers actually surrendered to the Pioneer flying overhead, knowing that gunfire from the battleship was imminent.

Post Gulf War Operations. Since its success in Operation Desert Storm, the Pioneer has supported every major U.S. contingency operation to date. These contingencies include operations in Haiti, Somalia, the Balkans, Afghanistan and Iraq.

FY03/04 Developments.

Administration's Request. The Administration requested no procurement or research and development funds in 2003. In 2004, the Administration requested \$13.6 million for the Pioneer program.

Authorization. The Armed Services Committee Conferees (H.Report 107-772) authorized \$15 million for Pioneer upgrades and no funds for Pioneer R&D.

Appropriation. The Appropriations Committee Conferees (H.Report 107-732) agreed to provide a total of \$16 million for Pioneer upgrades in support of the Marine Corps. This incorporated \$7 million from Research, Development, Test and Evaluation, Navy Appropriation, and \$9 million from the Weapons Procurement, Navy appropriation. Furthermore, the conferees "direct that these funds, and any additional funds as required, shall be used only to upgrade the Pioneer UAV in support of the Marine Corps."⁸⁵

⁸³GlobalSecurity.org. *Pioneer Short Range (SR) UAV*.

⁸⁴*World Missile Briefing*. Teal Group Inc. RQ-2A Pioneer. October 2002.

⁸⁵U.S. Congress, 107th Congress, 2d session, House of Representatives, Committee of Conference, Conference Report to Accompany H.R. 5010, H.Rept 107-732, October 9, 2002, p. 280.

RQ-5 Hunter.

The Hunter UAV is currently one of the Army's two operational UAV systems. Manufactured by TRW (now owned by Northrop-Grumman) in San Diego, CA, and Israel Aircraft Industries, Hunter was originally planned to fulfill the Army's short-range UAV requirement. However, procurement was halted in 1996 before full-rate production had begun due to technical difficulties. Using the seven low rate initial production systems the service retained during the final stages of development, the Army has operated a Hunter company in Eastern Europe for reconnaissance missions in the Balkans since 1999. Considered a division and corps level asset, it has been fielded to units in Fort Hood, TX (III Corps), Fort Polk, LA (XVIII Airborne Corps), the Army's intelligence school at Fort Huachuca, AZ, and is expected to be operational with the US Army Europe's V Corps in Germany by January 2004.⁸⁶

Figure 9. A U.S. Army Hunter UAV Is Prepared For Launch



Source: Jane's Defense Weekly.

System Characteristics. Hunter can fly at altitudes up to 25,000 feet, reach speeds of 106 knots, and spend up to 12 hours in the air. Weighing 1,600 lbs, it has an operating radius of 144nm.

Mission and Payload. Possessing the standard UAV mission of reconnaissance and surveillance, Hunter is equipped with an E-O/IR sensor payload for day/night operations. However, it has recently conducted tests of other missions, to include a helicopter manned/unmanned teaming mission and an armed mission. The Army realized that it could use UAVs in concert with their armed reconnaissance and attack helicopters like the Apache and Comanche, to extend the helicopter's reach. During 2002, Hunter was involved in various experiments with the Apache helicopter controlling both the Hunter airframe and its sensor in flight. This linkage would increase the effectiveness and efficiency of the Apache crew. The Pentagon is now requiring the Army to develop a companion UAV for its Objective Force manned helicopters such as the RAH-66 Comanche.⁸⁷ Like the Predator, the Army

⁸⁶Kim Burger. "US Army Looks At Arming Hunter UAVs." *Jane's Defense Weekly*, January 8, 2003, p.8.

⁸⁷John R. Guardiano. "Manning and Unmanning Army Aviation." *Rotor & Wing*, (continued...)

has also been experimenting with UAV weaponization. Their weapon of choice for these tests was the Brilliant Anti-Armor submunition (BAT). On October 11, 2002, BATs were successfully dropped from a Hunter UAV at White Sands Missile Range, NM, striking their intended practice targets, a tank and an armored personnel carrier.⁸⁸

Inventory. The Army has approximately 43 operational Hunter air vehicles remaining.⁸⁹ Although originally organized into a Hunter system of eight vehicles, it is now deployed with six. The Army does not have an active Hunter air vehicle production line. However the Army does maintain a sustainment funding line to ensure required parts and contractor logistics support are maintained for the existing Hunter units.

Cost. The cost for an air vehicle with its payload is \$1.2 million. The approximate cost of a Hunter system is \$30 million.⁹⁰

Recent Operations. Hunter has proven itself as an intelligence and reconnaissance asset in the Balkans. The UAV was used extensively during Operation Allied Force in 1999, suffering seven losses attributed to either crashes or enemy fire. Hunter conducted 246 sorties during Allied Force totaling 1, 357 flight hours (highest flight hours of any NATO reconnaissance platform).⁹¹ U.S. Army Europe has requested the Hunter each year since 1999, to aid in peacekeeping operations in the Balkans region. One vulnerability of the Hunter UAV is that it cannot fly in bad weather. It is sent home each year from the Balkans once the winter weather season begins. In January 2003, the Hunter UAV system began a new phase of operations, when the UAV deployed to the CENTCOM area of operations to aid in the war on terrorism.⁹² The UAV was also sent to Iraq to participate in OIF.

Future Programs. Currently, the Army's Hunter UAV provides surveillance and reconnaissance for the corps commander, while the more tactical Shadow UAV is designed for the brigade commander. With the cancellation of the Hunter program, the Army is envisioning an Extended Range Multi-Purpose (ERMP) UAV which would fulfill Hunter's role. The Army has not decided what air vehicle to choose for its ERMP UAV. It could buy an updated version of Hunter, or go with an entirely different UAV platform, such as an unmanned helicopter. The Army wants to award

⁸⁷(...continued)

December 2002, p.8.

⁸⁸"Hunter UAV Successfully Drops BAT Munitions." *Defense Daily*, October 16, 2002.

⁸⁹Army Background Information, January 2003.

⁹⁰Ibid.

⁹¹Mark Hewish. "Pilotless Progress Report-UAVs Have Made Exceptional Strides Recently." *Janes.com*, October 2000, p.68.

⁹²Erin Q. Winograd. "Army UAVs Sent To CENTCOM Area Of Operations, May Soon Be Armed." *Inside The Army*, January 20, 2003.

a contract in fiscal year 2004 and achieve full-rate production by the second quarter of FY06.⁹³

FY03/04 Developments.

Administration's Request. In 2003, the Administration requested \$1.5 million from the DERF for procurement and \$12.1 million from the DERF for research and development funds. No funds were requested for FY04.

Authorization. The Armed Services Committee Conferees (H.Report 107-772, H.R.4546) matched the Administration's request for Hunter. They recommended \$1.5 million for Hunter upgrades and interoperability with the Shadow TUAV system to be transferred from the DERF. Under research and development, the Committee recommended \$12.1 million from the DERF to make the Hunter ground control system compatible with the Shadow UAV and develop an automated take-off and landing capability.

Appropriation. The Appropriations Committee Conferees (H.Rept. 107-732, H.R.5010) agreed to provide the \$1.5 million for Hunter upgrades and the \$12.1 million of research and development funds that the Armed Services Committee recommended.

RQ-7 Shadow 200.

The Army's Tactical UAV (TUAV) program was dormant for several years, as the Army worked with the Navy to develop a joint tactical UAV. It was revived in 1994 due to problems with the Hunter UAV program. When the Navy backed out of the program in favor of pursuing its own vertical takeoff and landing UAV, the Army was allowed to choose a new air vehicle with a shorter range in keeping with their own requirements. The vehicle they chose was the Shadow 200 TUAV, selected in December 1999. After 20 years, the Army is on its way to acquiring its own UAV. It had to give up its desire for a custom built design and opted instead for the low-cost, off-the-shelf solution it found in the Shadow 200.⁹⁴

⁹³Erin Q. Winograd. "Army Eyeing New UAV With More Endurance, Capabilities Than Shadow." *Inside The Army*, January 13, 2003, p.14.

⁹⁴Teal Group Corporation. World Missiles Briefing, RQ-7A Tactical UAV. January 2001, p.6.

Figure 10. U.S. Army Personnel Prepare To Launch An RQ-7A Shadow 200



Source: Jane's Defense Weekly.

System Characteristics. Built by AAI Corporation of Hunt Valley, MD, the Shadow is 11 feet long with a wingspan of 13 feet. It has a range of 30nm, a distance picked to match brigade operations, and an average flight duration of four hours. Although the Shadow can reach a maximum altitude of 14,000 feet, its optimum level is about 8,000 feet. The Shadow is catapulted from a rail on a launcher, and recovered with the aid of arresting gear. The UAV has an automatic takeoff and landing capability.

Mission and Payload. The Shadow provides real-time reconnaissance, surveillance and target acquisition information to Army brigades. A potential mission for the Shadow is the perilous job of medical resupply. The Army is considering expanding the UAV's traditional missions to include a medical role, where several crucial items such as blood, vaccines and fluid infusion systems could be delivered to troops via parachute.⁹⁵ The Shadow's 60-pound payload consists of an E-O/IR sensor turret which produces day or night video, and can relay its data to a ground station in real-time via a line-of-sight data link.

Program Status. The Shadow has moved into full-rate production as of FY03, making the TUAV the first Defense Department UAV officially to enter full-rate production. Although current funding allows the Army to finish fielding Shadow in 2009, Army programmatic efforts are focused at identifying funding for complete fielding by FY07.

⁹⁵Erin Q. Winograd. "Army Eyes Shadow UAVs Potential For Medical Resupply Missions." *InsideDefense.com*, December 20, 2002, p.14.

Inventory. The Army plans to field 41 Shadow systems⁹⁶; four will be used for institutional training and 37 will be assigned to deployable units.⁹⁷

Cost. The cost of a single Shadow air vehicle is \$350,000, while the Shadow system costs approximately \$10.7 million.⁹⁸

FY03/04 Developments.

Administration's Request. In 2003, the Administration requested \$109 million for the procurement of ten Shadow TUAV systems, to include \$9.5 million transferred from the DERF for support equipment and \$15 million for initial spares. \$46.6 million was requested for research and development, which was amended to \$57.9 million to include \$11.4 million for Crusader-TUAV target location error. In 2004, the Administration requested \$88.8 million for eight air vehicles and \$11.7 million for research and development.

Authorization. The Armed Services Committee Conferees (H.Rept. 107-772, 4546) matched the Administration's request and recommended a total of \$109 million for TUAV procurement and \$57.9 for research and development in 2003.

Appropriation. The Appropriations Committee Conferees (H.Rept. 107-732, H.R.5010) agreed to provide the \$115.5 million in procurement funds, transferring \$6.5 million for Shadow TUAV-Block II upgrades from the \$11.4 million that had been requested for Crusader. The Conferees agreed to provide \$56.5 million in research and development funds, adding \$10 million for one I-GNAT UAV system with sensors, spares, training, logistics and deployment support to develop tactics, techniques and procedures (TTPs) for Army medium range UAV employment.

FQM-151 Pointer.

All of the U.S. military forces have demonstrated and experimented with the hand-launched six foot Pointer over the last fifteen years, and it has been deployed in a number of U.S. operations, including the Gulf War and Operation Enduring Freedom (OEF). AeroVironment's Pointer UAV has a weight of ten pounds, and a wing span of nine feet. The Pointer can fly at an altitude of 100-300 ft, and can stay airborne for about ninety minutes at a range of three miles from its ground station. The U.S. Special Operations Command (USSOCOM) is buying the hand-launchable UAVs to meet urgent requirements identified in OEF.⁹⁹ Special Operations Command Europe (SOCEUR) has employed one system of three aircraft in Europe,

⁹⁶A Shadow system consists of four air vehicles, two ground control stations, a portable ground control station, a hydraulic launcher, a Tactical Automatic Landing System, and arresting gear.

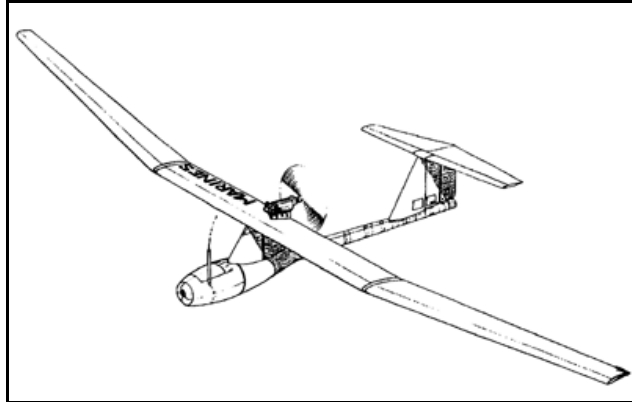
⁹⁷"Full-Rate Production of Shadow UAV Approved By Army Leadership." *Inside The Army*, September 30, 2002, p.1.

⁹⁸Army Background Paper, January 2003.

⁹⁹Kim Burger. "US Special Operations To Receive Pointer Unmanned Air Vehicles." *Jane's Defence Weekly*, May 15, 2002.

and the Army acquired six systems for use at its Military Operations in Urban Terrain facility at Ft. Benning, GA. In the past, the Navy used Pointer to keep the controversial Vieques training range in Puerto Rico free of protestors by using it to conduct reconnaissance of the range.¹⁰⁰ Pointers have served as testbeds for numerous miniaturized sensors and have performed demonstrations with the Drug Enforcement Agency, National Guard, and special operations forces.

Figure 11. FQM-151 Pointer



Source: [<http://www.uavforum.com>]

Developmental UAVs

RQ-4 Global Hawk.

The largest and most expensive UAV ever produced, the high altitude, long endurance Global Hawk provides near-real-time imagery of large geographic areas. Global Hawk claimed its place in history when it flew from California to Australia April 22-23, 2001, marking the first trans-Pacific flight by a UAV. It is also known for its use in Afghanistan, where as an experimental system, it was tested in an actual combat environment, flying more than 50 missions and 1,000 combat hours. Still in an ACTD status, despite its combat experience, the first production Global Hawk is not expected to be delivered until September 2003. Like the Predator, Global Hawk received a transfer of funds from the DERF in FY03, although no additional funds were appropriated for acceleration of the program. A signals intelligence capability is planned to be added to Global Hawk's existing imagery capabilities, making the Global Hawk the first multi-intelligence air vehicle. However, these added capabilities are causing many to be concerned about the rising costs of an already expensive UAV system.

¹⁰⁰Mike McCarthy. "Small Drone Sought Out Vieques Protestors." *Defense Week*, July 2, 2001, p.1.

Figure 12. RQ-4A Global Hawk

Source: Jane's Defense Weekly.

System Characteristics. At 44 feet long, 26,750 lbs, Global Hawk is about as large as a medium sized corporate jet. Global Hawk flies at nearly twice the altitude of commercial airliners and can stay aloft at 65,000 feet for as long as 35 hours without refueling. It can fly to a target area 5,400 nm away and loiter at 60,000 feet while monitoring an area the size of Illinois for 24 hours, then return. Besides the obvious size difference between the Predator UAV and Global Hawk, another significant difference between the two UAVs is that Global Hawk flies autonomously from takeoff to landing and in any weather.

Mission and Payload. The Global Hawk UAV has been called “the theater commander’s around-the-clock, low-hanging (surveillance) satellite.”¹⁰¹ The UAV provides a long-dwell presence over the battlespace, giving military commanders a persistent source of high quality imagery. As the result of a January 2002 Air Force requirements summit, the UAV will expand its payload to become a multi-intelligence air vehicle. The current imagery payload consists of a 2,000-lb integrated suite of sensors much larger than those found on the Predator. These sensors include an all-weather SAR with Moving Target Indicator (MTI) capability, an E-O digital camera and an IR sensor. A signals intelligence (SIGINT) sensor will be added to this payload to make Global Hawk a multi-intelligence air vehicle. A potential mission for the Global Hawk was supposed to be demonstrated in January 2003, when the Air Force planned to perform three missions to Ecuador to demonstrate the system’s ability to aid in drug interdiction. Congress asked for and funded the demonstration to support U.S. Southern Command, which has responsibility for the region.¹⁰² However, this exercise has been temporarily postponed due to operational commitments.

¹⁰¹Glenn W. Goodman, Jr. “UAVs Come Of Age.” *The ISR Journal*, July 2002.

¹⁰²“Global Hawk Missions.” *Aviation Week & Space Technology*, January 13, 2003.

Program Status. Developed by Northrop Grumman Ryan of Palmdale, CA, Global Hawk began life as an ACTD in 1994. The requirement for a high altitude long endurance UAV came about in response to ISR deficiencies highlighted during Operations Desert Shield and Desert Storm in Iraq. Prior to September 11, 2001, the Global Hawk program office concentrated on the UAV's acquisition and development. This focus changed following the terrorist attacks in 2001, and the UAV deployed to Afghanistan to support OEF as a developmental air vehicle in 2001. Global Hawk entered low-rate initial production in February 2002. Production plans call for the Air Force to buy 51 Global Hawks. Some Global Hawk advocates hoped the Pentagon would accelerate production of the system. Acceleration has long been a controversial subject, since many proposals for speeding Global Hawk development would entail taking money from the Air Force's U-2 program.¹⁰³ However, production will remain steady at 4-7 aircraft a year, until the final five aircraft are produced in FY11. The Air Force hopes to take delivery of its first production Global Hawk in September 2003. The Navy is also buying two Global Hawks in 2003 to evaluate them as part of a plan to buy a fleet of endurance UAVs to supplement its maritime patrol aircraft.¹⁰⁴ The Coast Guard was considering Global Hawk to fulfill its high altitude surveillance requirements, but now is reportedly leaning towards the less costly Predator.¹⁰⁵

Inventory. There are no operational Global Hawk air vehicles, as the first production Global Hawk does not deliver until September 2003 and the program does not achieve initial operational capability until 2006. There are four residual air vehicles from the ACTD Global Hawk developmental program.¹⁰⁶ ACTD assets were deployed previously in support of Operation Enduring Freedom. After two losses during missions supporting operations in Afghanistan, these assets are now being used for testing and training. While the crashes in Afghanistan have caused some skeptics to question the use of experimental technology on the battlefield, others point out that the kinds of things that caused the UAVs to crash would probably have happened in a test scenario as well. Additionally, the Global Hawks in operation were built to carry the program through the testing phase, and not with the demands of an operational deployment in mind.¹⁰⁷

Cost. The Air Force is still striving to meet its \$48 million goal for unit cost, with research and development costs increasing the price of the unit to as high as \$73 million. The average cost of a Global Hawk is \$57 million. This figure takes into account all air vehicles, sensors, mission control elements, launch and recovery

¹⁰³See Richard A. Best, Jr. and Christopher Bolkom. *Airborne Intelligence, Surveillance & Reconnaissance (ISR): The U-2 Aircraft and Global Hawk UAV Programs*, CRS Report RL30727, December 1, 2000.

¹⁰⁴Ron Laurenzo. "Northrop Grumman, Navy Get Ready For Global Hawk." *Defense Week*, April 8, 2002. More information also found in the developmental UAV section of this report, under "BAMS UAV."

¹⁰⁵Jefferson Morris. "Coast Guard Leaning Away From Global Hawk, Manager Says." *Aerospace Daily*, January 14, 2003, p.1.

¹⁰⁶Air Force Background Paper, January 2003.

¹⁰⁷*Ibid.*

elements, spares, and associated equipment. Concern among Air Force and DOD officials is that the constant addition of new features is making the aircraft unaffordable.¹⁰⁸ The House Appropriations Committee stated in the FY03 Defense Appropriations Bill that they are “very pleased that the Air Force is aggressively pursuing cost reduction initiatives in an effort to reduce the overall cost of this system.”¹⁰⁹ The Committee also “believes a major factor in the cost of this system is the development of short-term and longer-term sensor packages that would be integrated into the vehicle.”¹¹⁰

The Permanent Select Committee on Intelligence also mentioned their concerns about the management and cost growth of the Global Hawk program in the report accompanying the FY03 Intelligence Authorization Act. Stating that changes to the air vehicle have made the platform too expensive to risk losing, the Committee said the Global Hawk “must be considered, like the U-2, a standoff collection system that needs to be protected.” What was once a \$10 million air vehicle, “has become at least a \$30-40 million aircraft, and the cost will increase substantially further as additional and improved sensors, and corresponding power/payload upgrades, are added.” Moving on to other concerns, the Committee noted that there is “now an effort to flood the Global Hawk program with money, there are ad hoc plans for rapid, major upgrades before requirements have been established, and no sign of serious examination of where and how Global Hawk fits into an overall collection architecture.” To cite one example, “DoD has taken no serious steps to be able to relay and process the huge amounts of data from Global Hawk...The Committee understands the Department’s eagerness to address the shortage of airborne collection systems by investing heavily in Global Hawk, but it is concerned that it is engaged in this process in an ad hoc basis.”¹¹¹

Recent Operations.

Operation Enduring Freedom (Afghanistan). Called the imagery intelligence workhorse for OEF, Global Hawk has provided more than 15,000 images to support the conflict during 50 combat missions surpassing 1,000 flight hours.¹¹² Global Hawk was tasked to provide more than 50% of the OEF targets on the days it flew. Two Global Hawks have been lost since the UAV started flying missions in Afghanistan, one crash in December 2001 and the other in July 2002. Flight test operations were temporarily halted after each crash. The 2002 crash was attributed to engine failure, while the 2001 crash was due to an improperly installed bolt on the

¹⁰⁸Robert Wall. “Global Hawk Plan Gets Pentagon Nod.” *Aviation Week & Space Technology*, January 13, 2003.

¹⁰⁹H.Rept. 107-532, p.285.

¹¹⁰Ibid.

¹¹¹U.S. Congress, 107th Congress, 2d session, House of Representatives, Permanent Select Committee on Intelligence, *Intelligence Authorization Act for Fiscal Year 2003*, H.Rept. 107-592, p.21-22.

¹¹²Sue Baker. “UAVs Provide Warfighters A View.” *Aeronautical Systems Center Public Affairs*, December 10, 2002.

air vehicle.¹¹³ OEF has highlighted two of the limitations of the Global Hawk UAV - its high cost does not make the air vehicle readily expendable, and its altitude, although putting the vehicle out of range of enemy fire, prevents video cameras from being used.

Operation Iraqi Freedom (Iraq). Early press reports from OIF reveal some of the missions in which Global Hawk has contributed. During severe sandstorms March 24-27, Global Hawk's synthetic aperture radar and infrared cameras reportedly picked out Iraqi targets.¹¹⁴

FY03/04 Developments.

Administration's Request. In 2003, the Administration requested \$170 million for three Global Hawks, which included a baseline of \$105 million and \$65 million from the DERF. The baseline amount was for the procurement of two air vehicles and one launch and recovery element¹¹⁵, while the DERF dollars were for the procurement of an additional air vehicle. The request for research and development was \$306 million, which includes continuing the spiral development of the air vehicle and sensors. The Administration also requested \$48 million for one replacement air vehicle and two sensor packages in its FY02 Supplemental request.¹¹⁶ In 2004, the Administration requested \$253 million for four air vehicles. The R&D request for endurance unmanned aerial vehicles (including Predator and Global Hawk) is \$398.6 million for 2004.

Authorization. The Conference Committee (H.Rept. 107-772, H.R. 4546) matched the Administration's \$170 million request for procurement. The committee increased R&D to \$311 million by transferring \$5 million from DERF for a SIGINT capability.

Appropriation. The Conference Committee (H.Rept. 107-732, H.R. 5010) voted \$170 million for procurement, unchanged from the authorized funds. R&D appropriations totaled \$339 million, including \$35 million from the DERF for a defensive system and SIGINT. The \$48 million FY02 supplemental request was also approved.

¹¹³Jim Skeen. "Global Hawk Gets Mideast Order." *Los Angeles Daily News*, March 5, 2003.

¹¹⁴Jim Krane. "Iraqi Successes Have Air Force's Pilotless Planes Stealing Pilots' Jobs." *The Associated Press*, April 24, 2003.

¹¹⁵The Global Hawk program consists of the air vehicle, a ground segment and the support system. The ground segment includes the Mission Control Element (MCE) and the Launch and Recovery Element (LRE).

¹¹⁶See CRS Report RL31406, *Supplemental Appropriations for FY2002: Combating Terrorism and Other Issues*, by Amy Belasco and Larry Nowels, updated August 30, 2002, p.70.

UCAV.

The Unmanned Combat Air Vehicle (UCAV) is the first unmanned recoverable system designed from inception for combat. It is currently in varying stages of development, with the Air Force variant being more mature than the Navy version. UCAV development began when the Defense Advanced Research Projects Agency (DARPA) embarked on two ongoing demonstration projects, the UCAV Advanced Technology Demonstration (ATD) and the Naval UCAV (UCAV-N) ATD. These ATDs are considered high-risk, high-payoff programs, due to the number of critical technologies that must be developed before an operational UCAV would be viable. The UCAV ATD is a joint effort between DARPA and the Air Force, while the UCAV-N ATD is a joint project between DARPA and the Office of Naval Research. Boeing is working with DARPA to build the Air Force's UCAV (X-45), while the competing prime contractors for UCAV-N are Boeing (X-46) and Northrop Grumman (X-47). The Air Force conducted its first flight demonstration of the X-45A on May 22, 2002 and plans to fly an operational vehicle by 2008. The Navy plans to deploy its UCAV in 2015. In December 2002, the decision was made to combine Air Force and Navy UCAV efforts under a new joint office, similar to the Joint Strike Fighter effort.

Figure 13. Boeing X-45A Flight Demonstrator, Conducting First Flight Test at Edwards Air Force Base, California, on May 22, 2002



Source: Boeing.

Close in size to the Air Force's Predator at 27 feet long, with a 34-foot wing span, the demonstration UCAV air vehicle will be designed to have a flight radius of 500-1000nm and a deployment time of 24 hours. Smaller than manned fighters carrying comparable weapon payloads, the air vehicle has stealthiness and survivability advantages. The UCAV was highlighted in the fiscal 2001 defense authorization conference report, which set a goal for the military to have one-third of its operational deep strike aircraft be unmanned by 2010. Issues of potential congressional interest for UCAVs include acquisition strategy, affordability,

procurement quantity, arms control implications, manning implications, and suitability as a surveillance platform.¹¹⁷

Potential Missions and Payloads. The UCAV is envisioned to carry 1,000-3,000 lb of weapons payload. Its early combat application would likely be the Suppression of Enemy Air Defense (SEAD) mission, followed by precision strike. Low observable UCAVs could contribute to the success of an air campaign by providing a powerful “Day One” force enabler through the SEAD mission, supplementing deep penetration aircraft such as the B-2 and F-117, or providing a persistent presence to rapidly strike time critical targets such as mobile surface-to-surface missile systems.¹¹⁸ The Air Force and Navy have very different missions planned for the UCAV. The Air Force is focused on the SEAD mission, as well as an electronic attack role. The Navy wants a long-dwell air surveillance aircraft that could also perform strike missions.¹¹⁹ The two UCAVs would also be employed differently, with the Air Force keeping their vehicle in storage until needed, while the Navy plans on more frequent usage for its UCAV.¹²⁰

FY03/04 Developments.

Administration's Request. The Air Force requested \$40 million for UCAV R&D in 2003, which was agreed to by the Armed Services Committee Conferees. In 2004, \$275 million was requested for UCAV development; \$182 million for Air Force's UCAV, including a \$5 million request for a UCAV Joint Program Office, \$57 million for UCAV-N R&D, and \$36 million for DARPA R&D.

Vertical Takeoff and Landing Tactical UAV (VTUAV).

The VTUAV Firescout program was the culmination of Navy efforts to field a shipboard-capable UAV for reconnaissance and targeting. The helicopter-derived Fire Scout was intended to begin replacing Navy and Marine Corps Pioneers in 2003. However, stating “changed requirements,” the Navy cancelled the program in 2001 and will only be manufacturing low-rate initial production (LRIP) air vehicles for testing purposes. Critics of the VTUAV point out its slow speed, concerns about survivability and mobility, limited range and endurance and a small payload. The UAV is about 23 feet long and has an altitude ceiling of 20,000, with an endurance of more than six hours. It can remain on station 110 nm from the ship for three hours, and flies at a speed of 115 knots. Unlike the Pioneer, which is recovered aboard ship by flying into a net, the Firescout lands automatically using sensors. The

¹¹⁷See Robert E. Chapman II. “Unmanned Combat Air Vehicles: Issues and Outlook.” CRS Report RL31014, June 14, 2001, p. 23-31 for discussion of congressional items of interest.

¹¹⁸Ibid, p.4.

¹¹⁹For more information on the Naval UCAV, see CRS Report RS21294, *Unmanned Vehicles for U.S. Naval Forces: Background and Issues for Congress*, by Ronald O'Rourke, Updated October 22, 2002, p.2-3.

¹²⁰Robert Wall. “Uncertainty Engulfs Pentagon's Unmanned Aircraft Plans.” *Aviation Week & Space Technology*, September 16, 2002, p.27.

Fire Scout decision leaves the Navy with no shipboard UAV asset, as the one Navy squadron of Pioneers is being turned over to the Marine Corps.

Figure 14. VTUAV Firescout



Source: Jane's Defense Weekly.

Mission and Payload. Northrop Grumman's RQ-8A Fire Scout is an unmanned version of the commercial Schweizer helicopter. It carries an E-O/IR sensor payload that incorporates a laser designator. The air vehicle will have a primary training and experimentation mission. Boeing has contracted Northrop Grumman to look at the Fire Scout as a possible adjunct to the Army's Future Combat System, while the Marine Corps plans to demonstrate its Cobra coastal mine-detection system on the RQ-8A next year. Additionally, there are plans to fire a dummy Hellfire missile from the Fire Scout in the future. Northrop Grumman has also been marketing the UAV for a variety of other roles, including special operations support and homeland security monitoring.¹²¹

Inventory. The VTUAV inventory consists of five LRIP air vehicles, which are expected to go to Naval Air Station, Fallon, Nevada, in 2004 for experiments and to help train fighter pilots in UAV operations. Navy officials say these air vehicles, while not providing the Navy with a tactical UAV shipboard capability, will help develop pieces of the Navy's planned ISR system. These pieces include the tactical common datalink, the sensor payload and laser designator, and an automatic takeoff and landing helicopter.¹²²

FY03/04 Developments.

Administration's Request. In FY03, the administration requested \$43.6 million for VTUAV research and development. For 2004, \$56.5 million was requested for R&D for Navy tactical UAVs.

¹²¹Jefferson Morris. "Northrop Grumman To Fire Hellfire Missile From Fire Scout UAV." *Aerospace Daily*, October 23, 2002.

¹²²Hunter Keeter. "Uncertainty Continues for Naval Tactical UAV Capability." *Defense News*.

Authorization. Due to the Navy's termination of the Fire Scout program, the House Armed Services Committee recommended a decrease of \$43.6 million for VTUAV R&D (H.Rept. 107-772, H.R.4546). The committee expressed their concerns about the impact on the joint tactical control system (TCS),¹²³ noting that "though the Navy, which is the lead service for the joint tactical control system (TCS) development, no longer has a TUAV program, its responsibilities for program management for TCS remain."¹²⁴ The Committee went on to say the Shadow UAV program is critically dependent on successful Navy program management of TCS.

Appropriation. The Appropriation Committee conferees (H.Rept. 107-732, 5010) agreed to reduce by \$43.6 million the Navy's request for VTUAV R&D funding.

Broad Area Maritime Surveillance (BAMS).

The BAMS UAV will provide the Navy with global coverage through persistent long range surveillance. The Navy currently lacks a long-dwell standoff ISR capability. Initially using the Air Force's Global Hawk, the Navy will employ its first system for experimentation towards answering the BAMS UAV requirement. The BAMS UAV is being developed to meet Naval requirements such as persistent maritime/land ISR capability, the ability to send sensor data directly to the aircraft carrier, and a wide range of sensors to include E-O, IR and SIGINT. The Navy feels it needs to develop its own version of the Global Hawk, because the Air Force's model does not provide the following capabilities the Navy requires: the radar and sensors do not have 360-degrees point of view, no surface search radar, no communications intelligence, and no acoustic relay. BAMS concept of operations (CONOPS) development has explored using five world wide locations to forward base the UAV, including Hawaii, Florida, Italy, Diego Garcia and Japan. Navy planners would like the BAMS vehicle to operate alongside the multi-mission maritime aircraft, which is the planned follow-on to the P-3C Orion maritime surveillance aircraft.

Program Status. The BAMS program is being carried out in two phases. Phase I is known as the Global Hawk Maritime Demonstration (GHMD). In this phase, one system¹²⁵ will be procured in FY03 and delivered in FY05. The full system will be bought from the Air Force under the existing Global Hawk contract. Phase I will be used to develop CONOPS, experiment with alternate sensors, and study the integration of the tactical control system (TCS) into both land support centers and aircraft carriers/amphibious ships. Phase II, known as BAMS UAV, would have an initial operating capability in FY08. It has not been decided whether

¹²³The Navy-developed Tactical Control Station is designed to give users control over a number of different UAVs. Currently, the services possess unique ground stations for each of their UAVs.

¹²⁴U.S. Congress, 107th Congress, 2d Session, House of Representatives, Committee on Armed Services, Bob Stump National Defense Authorization Act for Fiscal Year 2003, H.Rept. 107-436, May 3, 2002, p.186.

¹²⁵One system consists of 2 air vehicles with a ground control station, 2 launch and recovery elements (LRE) and support equipment.

Phase II would continue using the Global Hawk air vehicle or evolve to a different UAV.

Citing concerns that the BAMS program has an unrealistic schedule, the Pentagon comptroller has instructed the Navy to hold back \$122 million in research and development earmarked for FY04, and split it between the FY06 and FY07 budgets for a more feasible timetable. One reason the BAMS program is in danger of running behind schedule is the Navy's desire for 360-degree radar coverage, which is technologically difficult and expensive. The alternate funding plan suggested would cause the prototype production to slip from FY04 to FY05.¹²⁶

FY03/04 Developments.

Administration's Request. In 2003, the administration requested \$180.3 million of research and development funds for the BAMS program. These funds include \$152 million for Global Hawk and \$28.3 million in the DERF, and will be used to acquire one marinized Global Hawk system, and start maritime payload development. In 2004, \$101 million was requested for BAMS R&D.

Authorization. The Armed Services Committee Conferees (H.Rept. 107-772, H.R. 4546) recommended \$180.3 million for BAMS, to include \$28.3 million from the DERF for sensor development. The House Armed Services Committee expressed their concerns about the BAMS program, noting that there is currently "no mission needs statement, no analysis of multiple concepts, and no specific exit criteria."¹²⁷ The Committee directed the Secretary of the Navy not to obligate more than 20 percent of the Navy's Global Hawk funding until these requirements have been met.

Appropriation. The Appropriations Committee conferees agreed to provide \$194 million for the Navy BAMS UAV (H.Rept. 107-732, H.R. 5010). Of the \$42.3 million additional funds over the Administration's baseline request of \$152 million, \$28.3 million is from the DERF; \$7 million is to determine the requirement for utilizing existing infrastructure at the Tactical Support Center's located at Navy P-3/EP-3 bases, for use with BAMS; and \$7 million is for producibility initiatives such as tooling enhancements and improvements and special test equipment, which the Navy should coordinate with the Air Force.¹²⁸ The House Appropriations Committee noted that, "despite its obvious support of the Navy's planned BAMS concept exploration and experimentation, the Committee is concerned about the lack of

¹²⁶Malina Brown. "Pentagon Comptroller Pushes Back Funding, IOC for Navy's BAMS UAV." *Inside the Navy*, December 9, 2002.

¹²⁷U.S. Congress, 107th Congress, 2d Session, House of Representatives, Armed Services Committee, *Bob Stump National Defense Authorization Act For Fiscal Year 2003*, H.Rept. 107-436, May 3, 2002, p. 208-209.

¹²⁸U.S. Congress, 107th Congress, 2d Session, House of Representatives, Appropriations Committee, *Making Appropriations for the Department of Defense for the Fiscal Year Ending September 30, 2003, and For Other Purposes*, H.Rept. 107-732, October 9, 2002, p. 279.

specificity and documentation provided thus far by the Navy.”¹²⁹ The Navy was thereby directed to submit a detailed BAMS UAV report by February 1, 2003. Additionally, the Committee commented that “the Navy has indicated that despite its plan to spend \$24 million on two air vehicles that would be delivered in 2005, the Air Force has not made a firm commitment to that delivery schedule.”¹³⁰ The Air Force was directed to ensure the air vehicles and equipment are provided as scheduled.

Dragon Eye.

On the other end of the spectrum from Global Hawk lies the Marine Corps’ five pound UAV, the Dragon Eye. Dragon Eye provides over-the-hill reconnaissance, surveillance, and target acquisition at the tactical level. With a wingspan of just 45 inches, the UAV can be stored in a backpack and launched by either hand or bungee cord. The reconnaissance UAV can fly 40 miles per hour, covering a combat radius of six miles and staying aloft for an hour. Its operating altitude is 300-500 feet. Developed by the Marine Corps Warfighting Laboratory and Navy Research Laboratory, the Dragon Eye system is being built by two competing contractors, AeroVironment and BAI Aerosystems. Current prototype systems, consisting of laptop-based ground control equipment and two air vehicles, run a total of \$60,000-70,000. The production system will include three air vehicles and could cost \$90,000.¹³¹ The Marine Corps plans to buy and field a total of 1,000 air vehicles and 200 control stations for about \$5 million.¹³² The first production systems are scheduled to be available in July 2003¹³³, with 10 prototype systems being given to three Marine Expeditionary Forces in late 2002.

Figure 15. Marine Holding Dragon Eye



Source: Janes.com

¹²⁹H.Rept. 107-532, p. 263.

¹³⁰H.Rept. 107-532, p. 264.

¹³¹Jefferson Morris. “Army Plans To Test And Evaluate Marine Corps Dragon Eye UAV.” *Aerospace Daily*, September 12, 2002.

¹³²Teal Group Corporation. “UAV-Very Low Cost.” *World Missiles Briefing*, October 2002, p.5.

¹³³“Small But Well Equipped.” *Jane’s International Defense Review*, October 2002, p.53.

Potential Missions and Payloads. Dragon Eye has been designed for over-the-hill reconnaissance, surveillance, and target acquisition for platoons, squads, and fire teams. This capability will make the small unit UAV very useful in an urban warfare environment. Other potential missions include infrastructure security and chemical and biological sensor. A pre-production version of the UAV was considered to support Marine Security forces protecting the American Embassy in Kabul, Afghanistan.¹³⁴ Operation Enduring Freedom has caused the Marine Corps Warfighting Lab to evaluate ways to speed up the development of Dragon Eye, so that the UAV could be outfitted to carry a chemical sensor capability.¹³⁵ Other services have also expressed an interest in Dragon Eye, with the Army's 1st Division in Germany receiving one system for testing and evaluation in 2002, and the Navy considering a version which would be called Sea-All. Interchangeable payloads for the Dragon Eye include a daytime camera, an infrared camera and a low-light black and white camera.

Dragon Warrior.

A vertical take-off and landing UAV, the Marine Corp's Dragon Warrior is being developed by the Marine Corps Warfighting Lab and the Naval Research Laboratory. Resembling a small helicopter, this UAV is envisioned to fill a middle ground between the Dragon Eye and a not-yet-named larger UAV system. The goal is to be able to transport the entire system in one Humvee. The initial system, at 105 inches long, will have a range of 50 nautical miles and an endurance of three hours. The Marine Corps plans to begin fielding Dragon Warrior in 2006. The air vehicles and ground control stations are estimated to cost around \$750,000 each, while the payloads cost from \$100,000-350,000.¹³⁶

Figure 16. Artist's Rendition of the Dragon Warrior



Source: Jane's Defense Weekly.

¹³⁴Marc Strass. "Marine Corps Plans To Deploy Dragon Eye UAV To Protect Kabul Embassy." *Defense Daily*, March 19, 2002, p.10.

¹³⁵Randy Woods. "Marine War Lab Hopes Airborne Sensor Can Help In War On Terrorism." *Inside the Navy*, February 4, 2002.

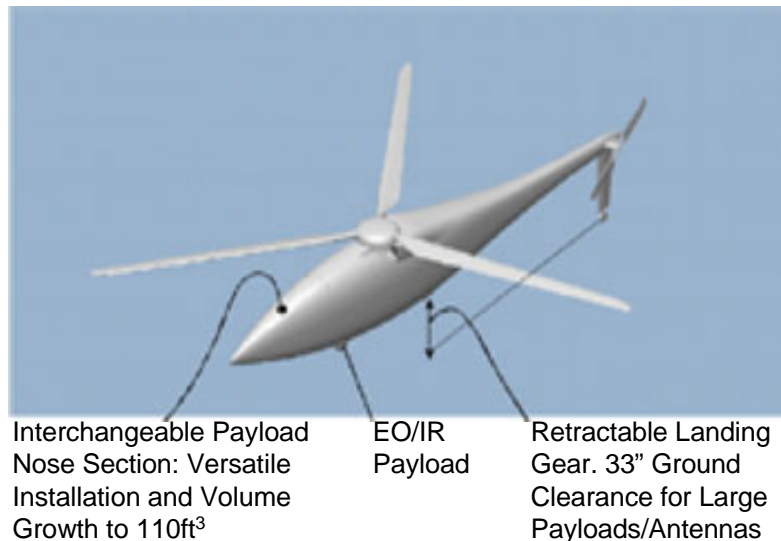
¹³⁶Jefferson Morris. "Marine Corps Dragon Warrior UAV To Fly By End Of This Month." *Aerospace Daily*, July 12, 2002.

Potential Missions and Payloads. Dragon Warrior will carry a communications payload and a target acquisition package, which consists of an E-O/IR sensor and laser designator. Like the Dragon Eye, the Dragon Warrior is envisioned to play a major role in urban reconnaissance.

A-160 Hummingbird.

A DARPA/Army joint program, the A-160 Hummingbird unmanned helicopter is being developed as a part of the Army's Future Combat System (FCS). Built to fly much longer and farther than conventional rotorcraft, the Hummingbird will probably operate at a range of 2,000 nm and an endurance of 24-48 hours. The project goal is to devise a 4,000-lb helicopter with a 2,500 nm range and 40 hours of endurance while carrying a 300 lb payload. Maximum altitude is planned to be 30,000 feet, with a speed of 130-140 kt. Potential missions include surveillance and targeting, communications and data relay, lethal and non-lethal weapons delivery, and special operations missions. DARPA and Frontier Systems logged their first flight of the Hummingbird in January 2002. The Army and U.S. Special Operations Command have expressed the greatest amount of interest in the UAV. The Army is considering buying the first two helicopters in 2006, while special operations forces are contemplating using the vehicle to extract personnel who have come under fire.¹³⁷

Figure 17. A-160 Hummingbird



Source: DARPA.

¹³⁷Robert Wall. "Hummingbird UAV Begins Flight Test Program." *Aviation Week & Space Technology*. February 4, 2002.

Scan Eagle.

Developed by Boeing, this UAV would be launched from ship, ashore or from a submarine. The Navy tested this new capability from January 17-27, 2003, during the Giant Shadow exercise in the Bahamas. During the exercise, the four foot long UAV was launched from land and acted as a reconnaissance and communications relay for the submarine. The concept of operations is to have a swarm of UAVs reporting back directly to the submarine. UAVs would also be launched directly from the submarine in the future. This experiment likely marked the first time the Navy has used a UAV to extend the range of submarine communications. Although the Scan Eagle demonstrated the potential value of UAVs to subs, the Navy could choose a smaller UAV to fulfill this new role.¹³⁸

Eagle Eye.

The Coast Guard plans to acquire Bell Helicopter Textron's Eagle Eye UAV as part of its Deepwater Modernization program. Deepwater will be run by a joint venture between Lockheed Martin and Northrop Grumman. The \$3 million Eagle Eye takes off like a helicopter, but then tilts up its rotor to fly like a plane. The Coast Guard will get up to 70 of these remote-controlled aircraft, which will extend the surveillance capability of their cutters. The Eagle Eye can fly up to 220 knots and has an operational radius of roughly 300 miles.¹³⁹ The UAV, which will be able to patrol the U.S. coastline for drug smugglers, refugees and ships in distress, can also transmit video and infrared images to the cutter and command centers ashore. The Eagle Eye is set to enter into service in 2006.

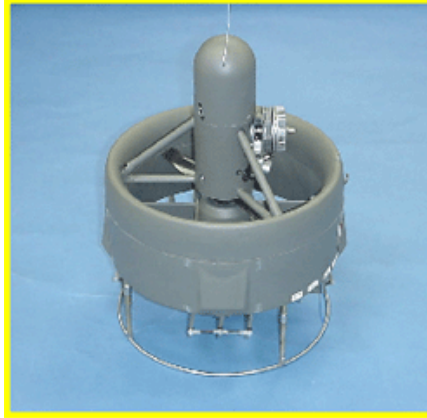
Figure 18. Eagle Eye



Source: Jane's Defense Weekly.

¹³⁸Jefferson Morris. "UAVs Prove Value To Submarines In "Giant Shadow" Experiment, Captain Says." *Aerospace Daily*, January 30, 2003.

¹³⁹Jefferson Morris. "No Plans To Use Fire Scout UAV, Deepwater Team Leader Says." *Aerospace Daily*, August 12, 2002, p.4.

Figure 19. Micro Air Vehicle

Source: DARPA.

Micro Air Vehicles (MAV).

The Defense Advanced Research Projects Agency (DARPA) is currently working on a \$30 million micro air vehicle (MAV) effort. Funded by DARPA, the Army and the Office of the Secretary of Defense, DARPA is producing 350 MAVs as part of an ACTD due to end in FY05. Unlike other UAVs, MAVs are measured in inches, not feet, and cost thousands of dollars instead of millions. A prototype nine-inch wide MAV, called the Organic Air Vehicle (OAV), is being delivered to the Army in February 2003 for testing as part of their future combat system (FCS). OAV, which employs a ducted-fan design vice a fixed wing, carries E-O sensors and could be upgraded to include infrared and acoustic sensors, according to its producer, Allied Aerospace.¹⁴⁰ One operational advantage of a MAV compared to a larger UAV, is the ability to conduct a “perch and stare” mission. Most UAVs perform their missions while they are flying; the MAV will be able to land and watch, using its camera to take pictures of any movements or other signs of enemy activity.¹⁴¹ MAVs are likely to increase in utility value as technology advances, and small, lightweight cameras become available.

UCAR.

Four industry teams, led by Northrop Grumman, Lockheed Martin, Boeing, and Sikorsky Aircraft, are under contract with DARPA to develop concepts for the unmanned combat armed rotorcraft (UCAR). In May 2003, DARPA will reportedly downselect to two teams.¹⁴² UCAR will be employed by the Army to perform armed reconnaissance and attack missions. It will be capable of collaborating with other manned and unmanned Army systems. The affordability goal for UCAR is 20-40%

¹⁴⁰Jefferson Morris. “Prototype MAVs To Be Delivered To Army For Testing Next Month.” *Aerospace Daily*, November 22, 2002.

¹⁴¹John G. Roos. “Organic Air Vehicle.” *The ISR Journal*, July 2002, p.45.

¹⁴²Jefferson Morris. “Northrop Grumman UCAR Team Meeting With DARPA Next Week.” *Aerospace Daily*, November 11, 2002.

of the Comanche helicopter's flyaway costs. UCAR would transition to the Army in FY09.

Force Protection Aerial Surveillance System (FPASS).

The Air Force is pursuing a variety of small UAVs such as Lockheed Martin's FPASS, also referred to as Desert Hawk. FPASS is a member of Lockheed Martin's SentryOwl family of mini air vehicles. The UAV is battery powered, and launched with a bungee cord. It has a length of 3 ft, can carry a payload of 1 lb, and has a radius of 5nm, with an endurance of 60-90 minutes. The system was developed to enhance security at overseas bases. It accomplishes this by conducting area surveillance and patrolling base perimeters and runway approach/departure paths. The system is currently being used in Operation Iraqi Freedom by the Air Force, as a force protection UAV to keep a camera out for ambushers.