Robotic craft called "Uninhabited Combat Air Vehicles" are on the way.

UCAVs Move Toward Feasibility

By John A. Tirpak, Senior Editor

IMPROVING the survivability of its military aircraft has been a top US technological priority for decades. In addition to backing the Air Force's planned acquisition of stealth aircraft, the Pentagon has promoted standoff weapons, seeing them as a way to reduce the exposure of combat airplanes to hostile fire. The idea is to put as much distance as possible between an American pilot and dense defenses encircling high-value targets.

This trend is certain to continue and, at some point, specific types of aircraft likely will be removed from the battle entirely, with a collection of robotic craft taking their places in combat over the target. Current terminology for these systems is "Uninhabited Combat Air Vehicles." They may not only help save the lives of pilots, but also provide more affordable and effective ways to attack certain targets.

Today, the Pentagon and the major US airframe houses are looking at UCAVs as a realistic military option—a kind of system that could serve as a complement to combat airplanes which exist now and likely will continue to serve for decades to come. Both industry and the Pentagon are investing significant amounts of money in UCAV concepts. They say that the technologies that make UCAVs feasible are, for the most part, already available. Success will hinge on whether someone can integrate these technologies into a reliable platform. That will take considerable effort.

In the principal program, the Air Force and the Defense Advanced Research Projects Agency have joined forces to explore use of UCAVs for Suppression of Enemy Air Defenses. This mission, historically one of the most hair-raising

UCAVs might operate as part of a strike package led by manned aircraft, as in this artist's rendition of a Lockheed concept.

Photo by Erik Simonsen

No one suggests UCAVs will supplant manned strike aircraft, but USAF has thought about modifying fighters, such as F-16s, for use as UCAVs. However, attention today focuses on pure UCAV models.

and perilous for airmen, often requires close-range attack of an enemy's fully functional surface-to-air missiles and targeting radar, well inside enemy lines.

Small and Stealthy

Officials believe the UCAV shows much potential for SEAD. Without the need to carry a pilot, the UCAV could be smaller and stealthier than a typical fighter, making it harder to detect and shoot down. Such an aircraft could also loiter in an area for extended periods—long beyond the duration of a human pilot—and wait for the enemy to turn on his radar. Being so close, the UCAV would be ready to launch a swift attack. Even if the enemy did get off a lucky missile shot, a UCAV could easily perform escape maneuvers so violent they might kill a human pilot.

Like a fighter aircraft, a UCAV would fly back to base, undergo rapid rearming, and depart to its next target. After the battle, it could be refurbished to be used again and again.

Larry Birckelbaw, DARPA's program manager for the UCAV, explained that the UCAV is an Advanced Technology Demonstration program. Its purpose is to evaluate the available technologies, combine them into an operational concept, and determine if the resulting system could "effectively and affordably address" the SEAD mission, he said.

Although the SEAD UCAV is not an acquisition program, it is geared to proceeding in such a way that, if the technology proves attainable, the Air Force would be able to acquire an operational vehicle in 2010. In the just-concluded first phase of the effort, various aerospace companies offered UCAV vehicle and operational concepts along with their views of what the key technological requirements are and ways in which the development effort should proceed.

The second phase, beginning now, will be a single-contractor, $116 million program. The aim is to build and fly air vehicles that are "not prototypes" but "representative" of the technologies and general layout of an operational UCAV, according to Birckelbaw's deputy, Air Force Lt. Col. Mike Leahy. The vehicles would fly before the end of 2002. If they prove to be successful, an engineering and manufacturing development program focused on an operational machine could get going by 2005.

Leahy asserted that "there are no technological miracles needed" to make a UCAV work. Rather, he said, "The challenge is integration" of diverse components such as the vehicle's command and control system and the "man–machine interface."

The program's goals are "aggressive" for an ATD, said Birckelbaw, and plans call for an aircraft that would come in at "one-third the cost of a JSF," the Joint Strike Fighter now under development for the Air Force, Navy, and Marine Corps. The JSF itself is intended to come in at very low cost by comparison to the cost of earlier fighters—thanks to a large production run, commonality of service variants, modular design, and scrupulous avoidance of unnecessary capabilities.

At one-third the cost of a JSF, the UCAV could have an $11 million price tag, as measured in 1999 dollars.

Even more dramatic would be the reduction in operating and support costs. Unlike fighter airplanes, in which pilots must fly frequently to remain proficient, UCAVs are expected to remain in cold storage for most of their service lives, awaiting the call to action. UCAV operators would maintain proficiency by practicing in a "virtual environment," according to Northrop Grumman UCAV program manager Greg Zwernemann.

"They will train exactly as they would operate in a real conflict," Zwernemann said. He noted that the operator would be using exactly the same software and flight consoles and experience the same visual and aural cues as he would on a real mission. In this way, "we don't accrue operating costs"—such as fuel, spare parts, and depot maintenance.

Dormant Storage

"We are working hard on the issue of dormant storage," to make sure that concept will work, he added. "We are attacking cost on all fronts." It is an example of how the UCAV will mark a profound break with traditional combat aircraft.

Boeing, Northrop Grumman, and Raytheon vied for the UCAV project; Lockheed Martin withdrew from the competition but still maintains a UCAV development team for other anticipated projects, both in the US and overseas.

Armand Chaput, head of Lockheed Martin's UCAV integrated product team, explained that UCAV cost will be pushed down further by a total change in crew ratios. Today, the Air Force maintains a pilot-to-fighter aircraft ratio of about 1.3-to-1. In UCAVs, the ratio will be reversed: one operator will control—"manage" is the preferred term—many UCAVs at once.

"We've simulated up to six UCAVs" being operated simultaneously by a single person, Chaput said. "For certain missions, that's very manageable." This is accomplished because

the operator doesn't "hand-fly them," Chaput said. Instead, thanks to a degree of onboard autonomy, and automatic cues taken by the UCAV from various sensor platforms and other sources, it will be "like flying a highly intelligent autopilot."

Where a "higher degree of involvement" by the operator would be required is during the actual weapons-release phase of the mission. On its own, the UCAV will likely be able to take off, fly the approach to target, and return to base, much as today's reconnaissance Unmanned Aerial Vehicles can.

"Man in the loop" would be retained for weapons release at a minimum, and maybe for more of the mission, "depending on the rules of engagement," Birckelbaw said. At this point, no one sees a machine deciding to launch weapons on its own, he added. There will have to be a human involved "to authorize the use of lethal force."

Technologies needed to make UCAVs a reality "have almost nothing to do with airplanes," Chaput said. How to create a low-observable air vehicle is by now well understood; to make UCAVs acceptable to the military will require "robust communication," which is "very jam resistant," Chaput said.

Unlike manned fighters, UCAVs would remain in cold storage for most of their service lives, awaiting a call to action. Pictured here is a Northrop Grumman UAV concept, resembling a small B-2.

The man–machine interface will require an unprecedented degree of situational awareness, with a highly realistic virtual-reality presentation for the operator, and it will be necessary to sharply reduce the operator's workload so that managing multiple vehicles at once is feasible.

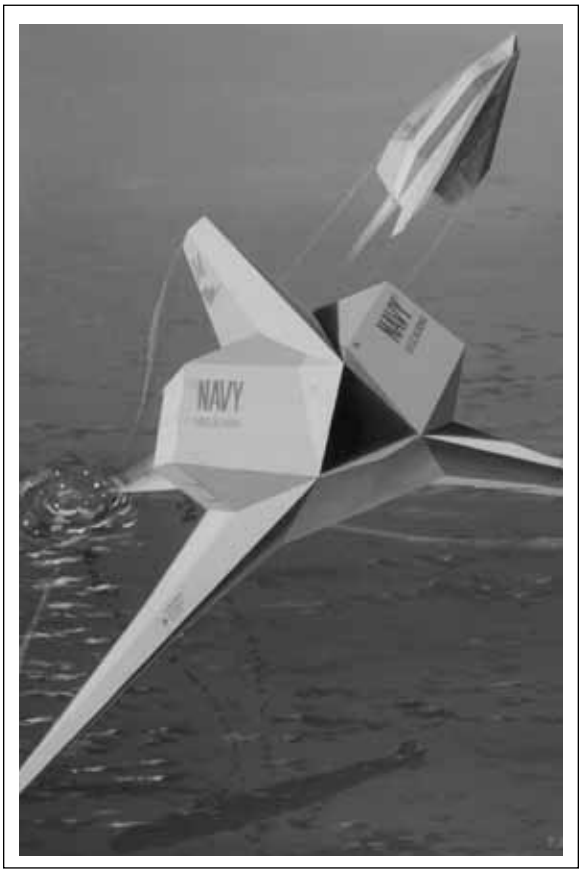
"Operators" would maintain proficiency by practicing in a virtual environment. One operator could control and direct many UCAVs.

Who Will Control Them?

Right now, "the technology exists for one or two" unmanned aircraft to be operated by an individual, he noted. The operator station will probably look little like a cockpit and more like an elaborate home computer setup. Moreover, it will not require an extensive ground trailer or base station but will be small enough that UCAVs could be operated from an E-3 AWACS or E-8 Joint STARS console or perhaps even by a pilot or backseater in another combat airplane.

Boeing examined more than 40 configurations to prepare its entry in the DARPA–USAF program, according to company UCAV program manager Rich Alldredge. The shape of the final version was driven by "the weapons available and the laws of physics," he said. All the contractors assumed that, even in 2010, a considerable number of present-day munitions will still be in the USAF inventory, and, as a result, their vehicles were sized to accommodate them; Birckelbaw said the typical UCAV will be about 40 percent the size of today's F-16 or F/A-18. For reasons of stealth, weapons carriage will be internal.

The competitors also anticipated, however, that USAF research into smaller munitions will bear fruit



***From the Sea.** Thinkers are churning out inventive concepts, such as a UCAV that can be launched from a submerged submarine.*

within 10 years, leading to much smaller weapons with just as much explosive power as today's big 1000- to 2000-pound bombs. That will simply make their designs "that much more effective," Alldredge said. For missions where stealth is not as critical, external hard points will also be installed, "just like on the JSF and F-22," he added.

He doesn't believe that there will be much cultural opposition to the idea of robotic warplanes after the technology has a chance to prove itself. The Air Force and other services, he said, "are ready to be shown that UCAVs can operate with a high degree of safety and reliability, as part of a strike package." While there may be some who resist the idea of a mission being taken away from pilots and handed over to robots, demonstrations of the technology should allay fears, and Alldredge believes the US military has "an open mind" about any concept "that can be a force multiplier."

No one, he said, is suggesting that UCAVs will supplant the manned strike fleet even within 20 years, though Boeing envisions the use of UCAVs for a variety of missions, including combat air patrol and other missions involving long loiter times.

Acting Air Force Secretary F. Whitten Peters is leery of getting too excited about UCAVs at this stage and maintains that the concept may prove a tougher nut to crack than anyone now expects.

Go Slow

There has been "substantial ... cost growth" on the reconnaissance UAVs—Global Hawk and the recently canceled DarkStar—Peters noted, and "it is proving very difficult to fly these [vehicles] outside of military airspace [through commercial airways with their civilian controllers]. [Global Hawk and DarkStar] have taught us a lot, but there is still a lot more to learn before we go to having UCAVs." The idea of combat robot airplanes is one "where we really ought to go slow."

Birckelbaw acknowledges the problems with DarkStar and Global Hawk, but he maintains that his program is being allowed to watch closely over their shoulder "and those 'lessons learned' are being directly applied" in the SEAD program. "I appreciate the skepticism," he said. "There have been problems with UAVs."

He's most interested in "how to transition" rapidly from a technology demonstrator with proven operational merit to an operational system, Birckelbaw said. The Predator UAV and others have suffered somewhat from their own success in that, once the demonstration concluded, and it was agreed they should be swiftly fielded, there was no organizational apparatus in place for assessing the requirements for, or supplying, spare parts, organic maintenance, or an ongoing training syllabus.

"The airspace issues are genuine," Birckelbaw said, but it's a problem which is also getting attention from the UAV Battlelab, which is "working through that."

"We've worked a lot with the Global Hawk and DarkStar folks to make sure that we understand what's good and bad about those programs," Birckelbaw noted. "We especially are paying attention to ... where the challenges were underestimated."

Leahy said the senior leadership is "starting to realize there's merit here" in taking on a tough problem and fixing it in a new and affordable way. Air Combat Command, which would be the user of any future SEAD UCAV, is "internally skeptical" about the project, because "they don't want to give away a capability" until its replacement is in hand, Leahy said.

Still, ACC is "willing to push and explore it," if the UCAV offers good potential, but the command "definitely has adopted a 'show me' attitude" about UCAVs, he added.

"The hurdles we've had to overcome have been monumental," Leahy went on. Leahy also praised ACC's "willingness to debate" the concept and its refusal to "jump to a conclusion."

Alldredge said he thinks the SEAD project has skipped years of potential dead ends because it is "the best example so far of a technology demonstration program working with the ultimate user." ACC, he said, has offered "invaluable insights" in the concept development studies and steered the project

toward what would be most useful. In other projects where the coordination has not been as tight, "we've missed the mark," Alldredge said.

Birckelbaw also reported that the Navy is keeping an eye on the DARPA–Air Force SEAD project, and there is the expectation that if it proceeds to a full-fledged developmental effort, "before full production, there is an interest in making it a joint program."

An artist's conception of the Raytheon craft. UCAVs show much potential for SEAD, being smaller, sleeker, and stealthier than a typical fighter and with a loiter time well beyond the duration of a human pilot.

Cooling Off

A successful SEAD UCAV project would take lots of heat off the Air Force, which has had no dedicated SEAD platform for seven years. The service was hit with withering criticism from Congress and its own veterans when it phased out the F-4G Wild Weasel dedicated SEAD airplane after the 1991 Gulf War, with no direct successor in mind. Since the F-4G's retirement, the mission has been performed in the Air Force by F-16s employing the High-speed Anti-Radiation Missile with an associated pod. Many have argued that the pod, called the HARM Targeting System, is a valuable asset, but still not as comprehensive as the F-4G's avionics suite, and that USAF should give this critical mission the attention it deserves and a platform of its own.

"I'm absolutely convinced there's a market for UCAVs," Chaput asserted. "It depends on the concept of operations" which the military services settle on, "but we're keeping our options open."

Lockheed's withdrawal from the SEAD UCAV project stemmed in part from the company's belief that the UCAV eventually acquired will have to be more "multimission" than it is envisioned in the DARPA–USAF project. Combat aircraft are so expensive and budgets so tight that "the days of a single-purpose anything have gone away," Chaput asserted. The UCAV of tomorrow, he predicted, will find a niche "somewhere between a manned aircraft and cruise missiles."

He also noted that Operation Desert Fox, the combined US and British action against Iraq in December 1998, involved use of hundreds of cruise missiles—what he surmised is the trend for future such actions—to limit the chance of Iraq downing an American airman.

One industry official speculated that the Navy might more rapidly embrace UCAVs than the Air Force because the Navy "is already comfortable with" the massive use of a non-piloted attack platform—the Tomahawk land attack missile. "The Navy already has a UCAV," the official said of the Tomahawk. "It just doesn't come home."

Ultimately, said Zwernemann, UCAVs "will have to buy their way into the force." As with "anything that's new, there's a period of acceptance," he said, during which judgment is withheld until a new idea proves its merit. "I think UCAVs [will become] an important part of the force structure," he said. ■

The Navy is keeping an eye on the DARPA–Air Force SEAD project and might want to acquire such systems for use aboard warships.