The Air Force’s concept for an unmanned combat aircraft is trending larger and larger. This full-size mock-up of Boeing’s X-45C is shown alongside the company’s F-15E (on ramp outside) and F/A-18F.
The future of unmanned combat air vehicles is getting intense scrutiny this summer as the Air Force and Navy negotiate the merger of separate UCAV efforts into a joint program led by the Air Force. The plan, set for completion by August, will shape UCAV development for years—perhaps in startling ways.

The two services need to make sure they get what they want from these systems. The Navy has a long-standing requirement for a pilotless reconnaissance vehicle that can take off from and land on a carrier deck and hover for long periods over an area of interest. Ideally, it would be able to strike targets, too.

Air Force needs, however, continue to evolve. The service’s original vision of a light, semidisposable craft used to suppress enemy air defenses has given way to a more ambitious concept. Now, USAF seeks an airplane that can loiter deep inside enemy airspace and strike targets, either autonomously or in conjunction with manned and unmanned strike aircraft. Other possible missions include electronic attack and close air support.

Such an aircraft would have to be large and expensive. As such, it could turn out to be in direct competition with some manned aircraft on which USAF today places a higher priority.

Leadership of this Joint Unmanned Combat Air System (J-UCAS) effort fell to the Air Force as a result of Program Budget Decision 753, the late-2004 DOD document that signaled profound changes in many programs. (See “Washington Watch: QDR 2005 and Tactical Airlift,” February, p. 8.) PBD 753 directed the Air Force to take over the program from the Defense Advanced Research Projects Agency, which ran J-UCAS for two years. Presumably, the move indicated Pentagon approval of USAF’s evolving approach to unmanned aircraft.

The PBD ordered that the Air Force and Navy realign the program “with emphasis on the development of air vehicles that will contribute to ... future joint warfighting concepts of operations” approved by the Joint Requirements Oversight Council. It also ordered a $1.1 billion program cut through 2011.

Serving to complicate the task is the fact that the Quadrennial Defense Review—which is to take a comprehensive look at systems needed for air dominance—is to wrap up at the same time the new J-UCAS program plan is to be completed. Decisions on many other projects—including the F/A-22 and F-35 fighters, airborne electronic attack aircraft, and even aerial tankers—will directly affect the mission and numbers of UCAVs.

DARPA’s Demos

DARPA had aimed at a series of demonstrations. These ranged from basic autonomous flying to a series of experiments showing how UCAVs could, with stealth, new sensors, and a certain degree of artificial intelligence, search for, identify, track, and strike targets with minimum human involvement. It’s not clear yet whether the restructuring program will continue to focus on demonstrations or shift to a more deliberate effort to produce an operational system.

The Air Force initially wanted a relatively small 8,000-pound machine equipped with light weapons. It was to have enough “persistence” to be able to loiter in a given area. When enemy radars were turned on, the UCAV was to attack with onboard weapons ranging from electronic devices to bombs.

In the intervening years, changing circumstances have produced a different UCAV concept. Plans call for a much larger machine—36,000 pounds or more—that can penetrate deep into enemy airspace, survive, and loiter in the vicinity of deeply inserted friendly ground troops. It would allow
these ground forces to call down a variety of airborne weapons, as the situation dictated.

As a result, the Air Force’s UCAV is gaining in weight, range, and payload. It may, in fact, be growing into the world’s first unmanned bomber.

Gen. John P. Jumper, Air Force Chief of Staff, described the current thinking about the UCAV in an interview with Air Force Magazine earlier this year. He called it a “very stealthy thing that is able to go and loiter over maneuver units on the ground, in direct contact with battlefield airmen, [who] can directly order up a weapon that can be delivered within seconds.”

The mission needs will define the shape and size of the machine, Jumper said.

“If you make it with long endurance, it’s going to be fairly big,” he noted. Once over enemy territory, it would be able to persist by simply going back and forth to an aerial tanker “as long as it’s got weapons.”

The Air Force would benefit from such a machine because it “gives us great leverage to be able to do [the attack mission] with fewer airplanes [and with] fewer people to take care of the airplanes.”

Power Overhead

More importantly, though, the airplane would be directly or nearly above ground forces, so that, if a need arose, they would not have to summon close air support from aircraft flying orbits perhaps hundreds of miles away. A weapon would be just “time of flight” away from the target on the ground, Jumper said.

What the UCAV should not be, he added, is an aircraft that is loaded up with enough processors, agility, sensors, and other necessary gear to make it into a dogfighter that could defend itself against enemy airplanes. Such a machine would be too expensive. Someday, “there may be some breakthrough that gives us that combination, but I don’t see that right now,” he said. Protecting the UCAVs, as well as offering other kinds of support to deeply inserted ground forces and suppressing enemy defenses, is a mission better left to the F/A-22.

Jumper added, “I want to get on with this” and create an asset that “gets beyond being a novelty and gets to what is truly ... responsive to real requirements.” He pointed out that the Air Force is asking whether the UCAV could become a tool for long-range strike. “I think it is,” he said, “but there’s more work to be done.”

DARPA’s Michael S. Francis, who has directed the J-UCAS program, said that substantial effort has been applied to keeping the system affordable and ensuring that it doesn’t duplicate or replace anything else.

He is frequently asked if the J-UCAS competes with the F/A-22 and the Joint Strike Fighter, and his answer is, “Only for money.”

“The mission niche is unique enough,” said Francis, “but, fundamentally, there’s only so much money out there, and people will evaluate you for your ability to do your piece of the mission space affordably, in comparison to those other things doing their job, and that’s how decisions get made. So, we’re very cognizant of the need to be competitive at what we do.”

Moreover, the F/A-22 program is likely to be concluded before the first operational J-UCAS flies, and even the F-35 will be well into production when a possible J-UCAS production line starts ramping up.

The focus has stayed on conducting demonstrations, and not trying to anticipate the exact needs of the services, which tend to fluctuate. DARPA has also worked with the services to steer them toward the possible.

“In some cases, what are high-priority [capabilities] may not be obtainable with technology,” Francis went on. “They may be too expensive. So, we’ve tried to blend things in a way that makes an ‘executable’ program.”

He noted that the existing effort has been structured so that if the services decided at some point to pursue a formal weapon program, they can do so with confidence.

DARPA set up the program to allow a continuing series of demonstrations from Fiscal 2007 through 2012. Francis said, “At any point during that time, a service could say, ‘Now I know enough to do something’ and spin off an acquisition program. We’ve left the opportunity for multiple ‘off-ramps.’”

The services would not have to pursue an identical solution. One could conduct demonstrations while the other could go directly to a development project. “The intent was to put [the UCAV] in the hands of the warfighting community, to figure out what its real potential is, and let them decide what the real system was going to be,” Francis said.

Two Platforms

The demonstrations feature two basic types of UCAVs. Both are being redesigned with advanced applications in mind.

The Air Force had selected Boeing to build conceptual airplanes for the defense-suppression mission. It built two X-45A aircraft to demonstrate some UCAV capabilities. It has flown two X-45As—including both at the same time, under the guidance of one human operator. It has explored much of the
flight envelope and released ordnance from the X-45A’s weapons bays.

Northrop Grumman was picked by the Navy to build and fly the X-47. This craft has flown and has also “recovered” on a simulated carrier flight deck (on land), touching down on the spot where it would catch an arresting wire.

Both companies have modified their designs to keep up with the services’ evolving requirements. Boeing has canceled a planned X-45B; it has gone directly to an X-45C, which will be much larger and feature a flying wing shape. Northrop Grumman’s new X-47B will be vaguely similar, with larger wings to carry greater payload and provide longer range and loiter time.

When DARPA was directed to run the two UCAV efforts as a joint program, it decided to realign the development effort in the most logical way possible so the maximum amount of effort on the project could support whatever the Air Force and Navy eventually decided to do.

To that end, the J-UCAS program has focused not on the airframes themselves but on the system, Francis said. The airframe is simply one aspect—and a fungible one at that, he said.

The J-UCAS will be run by an “operating system,” which Francis likened to the one that allows a computer to function. The airframe, communication system, weapons, data links, electronic attack functions, ground stations, sensors, etc., will all be like applications or peripherals running off the common operating system.

There is a great advantage in doing it that way, Francis explained. If new requirements force a change in one component—the size and shape of the airframe, for instance—a service can simply exchange that element for another, without the need to go back and complete a new labor-intensive software effort.

“When you decide you don’t like the platform you have, you can swap it out for something bigger or smaller—or just simply different,” explained Francis.

That will come in handy, he believes, because J-UCAS will not be a single, one-size-fits-all airplane for all missions. Some will be designed with heavy emphasis on stealth, while others may emphasize range or payload or persistence.

“You can leave off some of the bells and whistles,” he said. While “first day of the war” aircraft will need stealth and other survivability measures, those expensive attributes aren’t needed after an enemy’s air defenses have been beaten down.

**Cadillacs and Chevys**

This approach will save money because, Francis predicted, “we’re going to build a few of those Cadillacs, but we’re going to use the same chassis to build a whole lot of Chevys.”

The approach being pursued would also allow the interchangeability of a “navalized” UCAV and one that meets the Air Force’s desires for differing missions within the operating system, without the need to develop different support systems.

Boeing and Northrop Grumman are working together on a common operating system. To make sure optimum solutions are selected, the program has hired Johns Hopkins University to act as “integrator/broker” between the two companies.

Rick Ludwig, Northrop Grumman’s X-47 business development manager, said, “If we [Boeing and Northrop Grumman] don’t get along, Johns Hopkins’ position grows, and they will subsume more of the budget. If we get along very well with Boeing, then [Johns Hopkins’] position and their footprint doesn’t grow.”

Ludwig said this approach is unprecedented.

The X-45 program has been marching toward a series of demonstrations, beginning around 2007, that will involve three X-45 machines flying long distances and seeking out targets, according to Darryl W. Davis of Boeing, who until April was general manager of the company’s X-45 program.

He said that two of the machines in these operational demonstrations would be “fully representative of a weapon system configuration,” from a survivability and communications suite perspective, including electronic warfare systems. The aircraft, before a combat demonstration, would exercise capabilities such as use of a sensor suite to map areas of interest and locate targets.

Beginning in 2009, the X-45 program would demonstrate advanced tactical targeting technology. In this demonstration, three UCAVs, working together, would locate and target a fixed surface-to-air missile system, using synthetic aperture radar and possibly electro-optical systems. Then the airplanes, “talking” among themselves, would together “decide” which is best suited to carry out the attack.

“That is the network-centric approach and capability that we are maturing for the Air Force and the ... Navy,” Davis said.

The three aircraft would triangulate the position of the radar emitter and, after receiving consent and possibly specific aim points from a human operator, release weapons. By cooperating, the three could also improve their survivability.

“The key to all this is the ability to integrate multiple platforms ... to
communicate with each other,” Davis added.

The Achilles’ Heel

Francis said much work is going into development of this communication capability. It could be the Achilles’ heel of the entire UCAV concept, so developers are assuming that communications will be intermittent and occasionally broken.

Nevertheless, plans say that release of weapons will always require human consent, even though “it’s the intelligent system software” that finds and picks out the target, Davis noted.

Boeing’s idea throughout the program has been to build aircraft with which military operators can experiment and use aggressively without concern for fragility.

An earlier concept, in which the X-45 would spend most of its time in a climate-controlled container and be brought out and used only at need, has not been discarded but merely “tabled,” Davis said. It’s become apparent that the UCAV can “self-deploy” around the world, meaning it wouldn’t be necessary to tie up airlift hauling the crated aircraft around.

The company has also worked with the Air Force to define an aircraft whose stealthy surfaces need not be protected in a climate-controlled facility, Davis said.

“They want to park it on the ramp overnight, be in the rain, be in the sun, and not have to do lots of restoration to the survivability attributes.”

These self-deployment and loitering concepts will gain further credibility when the Air Force demonstrates the aerial refueling of a UCAV. The demonstration is not part of the UCAV program per se, but is being undertaken with the X-45 under contract to the Air Force Research Laboratory. Boeing is developing the aerial refueling capability using differential Global Positioning System signals. Northrop Grumman is working on a complementary capability.

With air refueling, UCAV airborne time will be limited only by the failure of subsystems. A key requirement will simply be to keep an adequate supply of oil in the engine.

Under the AFRL contract, an aerial refueling demo is scheduled to take place in the period 2008-09.

Another challenge in the program has little to do with technology and everything to do with politics, Francis said. The world is still uncomfortable with the idea of an armed machine flying around without a human controller on board.

“It’s a cultural issue,” he said. For example, despite its proven track record, “filing a flight plan for Global Hawk is not a simple administrative act; it’s a negotiation.” And Global Hawks aren’t even armed.

There is high confidence that the public eventually will accept unmanned aircraft. Francis cites the Boeing 777 and the Lockheed Martin F-117 as two examples of aircraft so automated that they could be said to have “optional pilots.” Another confidence builder will be commercial use of unmanned aircraft technology. Francis sees long-duration cargo flights as one area where the technology could be a big cost-saver, “flying UPS from Memphis to downtown Beijing ... [with] a single safety pilot on board, just in case something goes awry.”

In fact, Francis believes there will have to be commercial applications for unmanned aerial vehicles to become truly competitive and therefore affordable.

For the time being, Boeing and Northrop Grumman are technically collaborating on the J-UCAS project, but each has its own system and its own approach. It’s not clear yet if there will be a competition down the road, with one contractor selected to build UCAVs for both the Navy and the Air Force.

Francis said the hardest part of UCAV development is not aerial refueling, sensor integration, low observability, or flight autonomy. It is, he said, the operating system, which will require intensive amounts of software. However, once the initial code is written, “updates come fairly rapidly,” he noted.

Ludwig said contractors are aware of the Air Force’s changing requirements and are happy to try to meet them. However, given the competition between programs, there is concern that J-UCAS might dry up.

“We do know that both services are supportive of the program and want it to move forward, and that’s one of the biggest concerns for us,” Ludwig noted, “that it does move forward, and it does stay a joint program. All indications are, that’s going to happen.”

Francis said, “We’ve tried not to get too big, and there are a variety of reasons for that. We want representative X-planes ... which are capable of demonstrating all the functionality that the real thing would have, whether it be bigger or smaller.”

Davis voiced a common concern about UCAV growth.

“If you want to drive these things larger and larger in size, they tend to cost you more and more,” he said. If the Air Force wants a bigger airplane, “we’re all for it, we want to help them do it, but we’re also sensitive to affordability, so ... we’ve been trying to help them understand, it’s a trade that they will make.”

He concluded, “I fear someday, someone will say, ‘For this much money, why don’t I build an airplane with a man in it?’”