For UAVs, though, the basic challenges are being overcome. Between now and 2025, vehicle technology is likely to remain quite stable while sensors, systems architecture and doctrinal issues are dealt with — at a pace that will depend on finances.

Northrop Grumman Fire Scout VTOL UAV.

In fact, it is not inconceivable that some successful UAV platforms will emulate the longevity of the most successful manned military aircraft designs like the Boeing B-52, Lockheed Martin C-130 and Lockheed U-2 — all of which were designed before "Rock Around the Clock" hit the record charts. One lesson that is already emerging from the development of Global Hawk and the General Atomics Predator is that a good UAV design is highly scalable. If the user wants to increase the payload of Global Hawk, for instance, it is not a major task to place a plug in the wing center section, stretch the fuselage, add more fuel and install a more powerful commercial engine. Even an all-new vehicle is no more costly to develop than a corporate jet. The more expensive and trickier parts of the system — control and communications hardware — work across a wide range of vehicle sizes. In 2025, it would not be at all surprising to see variants of Global Hawk and Predator still in service and constantly adapted to carry new devices.

A key issue in UAV planning is that of size, range and deployment. One clear lesson from UAV history is that big UAVs are, in some ways, easier to develop than small UAVs. Since many losses occur during launch and recovery, a long-endurance UAV that makes fewer flight cycles is less likely to suffer an accident. Its systems undergo fewer operating cycles and are less likely to fail, and the larger vehicle is easier to outfit with back-up systems. A long-range vehicle can operate from a rear-area, semi-permanent base where operations are likely to go more smoothly.

One of the obstacles to making full use of a medium- or high-altitude long-endurance UAV is cultural. Ground and naval commanders tend not to believe that they "own" a UAV, even though it is overhead and linked directly to a ground control station (GCS) a few feet away, if they have to rely on an Air Force crew hundreds of miles away to place the vehicle overhead. But the fact remains that a small number of long-endurance vehicles can provide 24-hour overhead presence at stand-off ranges.

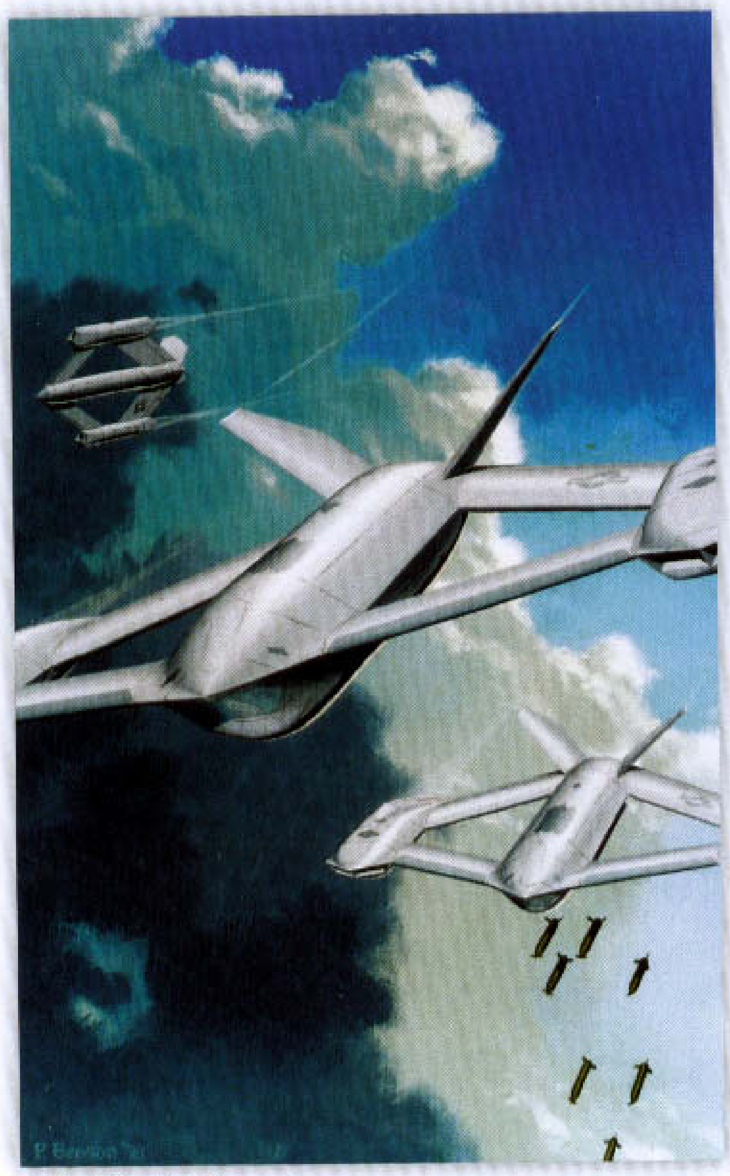
Navies and armies will continue to develop their own "organic" UAVs such as the Northrop Grumman Fire Scout VTOL Tactical UAV (VTUAV), which will be compatible with all air-capable Navy ships. Significantly, Northrop Grumman's winning strategy was based on the use of a commercially certificated manned helicopter, providing a solid base of reliability for the specially developed autonomous control system. At the same time, the Army has relaunched its own TUAV program with the AAI Shadow 200.

UAVs are likely to carry an expanding range of sensors. There is a revolution in radar development under way, building on the active electronically scanned array (AESA) technology first developed for the Lockheed Martin/Boeing F-22. Meanwhile, the USAF and Boeing have studied a radical diamond-winged UAV, called the Sensor Craft, which is designed specifically as a platform for large-aperture passive, bistatic and active AESAs that can be used for air

On the previous page: AeroVironment's Pathfinder, the predecessor to the company's Helios.

and surface surveillance. Another example of a new class of payload for a UAV is DARPA's Airborne Communications Node comprised of an array of communications antennas and processors.

Will UAVs be armed? Eventually, the answer is probably that they will be. Predator is already being equipped with a laser designator. In doctrinal terms, there is no real difference between launching a weapon from a UAV and using the UAV to designate a target for a weapon released from another aircraft. In both cases, the weapon is released and aimed by the remote UAV operator and no human sees the target except through a camera and datalink. Adding a Hellfire missile to the UAV — as the USAF has done in preparation for tests which were planned this year — is a matter of eliminating the middleman.



Lockheed Martin UCAV concept.

However, the Predator demonstration has already encountered one obstacle: is an armed UAV a ground-launched cruise missile, outlawed under current treaties? This question will have to be resolved before uninhabited combat air vehicles (UCAVs) are deployed operationally, or even tested with live weapons. Boeing's X-45 UCAV demonstrator, now being prepared for flight tests, will be very important to the development of UCAVs.

High-altitude, long-endurance UAVs are likely to be the first to make the transition into non-military use. Several companies and consortia, some of them backed by major industry players, have proposed the use of high-altitude aircraft, carrying antennas, as the basis for high-data-rate wireless communications systems. Several UAVs have been proposed for this role, including AeroVironment's solar-powered, 200-foot-span Helios. SkyStation, a company which includes major aerospace companies among its backers, is proposing a solar-powered airship with a flight endurance measured in years. Burt Rutan's Proteus was developed for Angel Technologies, which plans an airborne network. Although the Proteus is a manned aircraft, the clear intention is to migrate to a UAV when the technology is mature.

Less exotic UAVs could be invaluable for other missions, such as monitoring forest fires — a Predator is to be evaluated in this role. A key development is the demonstration of reliable technology and operational procedures which will allow UAVs to operate in commercial airspace. One of three Predator B aircraft being built by General Atomics is primarily intended for tests and demonstrations in this area.

UAVs always take up a lot of space in any discussion of UVS but teleoperated UUVs are already in service or under development worldwide for tasks such as mine neutralization. The Navy plans to develop autonomous UUVs for long-distance mine detection and other missions, such as surveillance in shallow water and information gathering. UUVs could also be used to gather tactical oceanographic data in hostile waters, and to identify surface and subsurface targets. Navy special operations forces have defined a requirement for a mini-UAV, 52 inches long and 6 inches in diameter, which would scout shallow waters before a landing.

Space aboard a ship is always at a premium, and the navy's UUV designs are mostly intended to fit in a torpedo tube. Providing useful speed, range and endurance in such a small vehicle is difficult, so breakthroughs in stored energy will have an important impact on the usefulness of the UUV. The Office of Naval Research (ONR) has demonstrated a semi-fuel cell — combining the characteristics of a fuel cell

Predator being readied for a mission.

and a battery, with hydrogen peroxide as an on-board oxygen source — to provide both high power and long endurance for UUVs.

An indication of the importance which the Navy places on the UUV in the long term is the fact that the third Seawolf-class submarine, USS Jimmy Carter (SSN-23), is being redesigned with a new hull form which provides more space for tethered or autonomous vehicles, and the same hull form will be used on the all-new Virginia-class. An important goal is to allow the submarine to launch and recover vehicles much larger than present-day torpedoes. The future submarine, operating in noisy littoral waters, may operate routinely with a formation of robotic pickets around it.

Unmanned ground vehicles (UGVs) today are in much the same position as UUVs. After many years of work, the Pentagon and its contractors are still evaluating technologies to solve the basic problem: how to create an autonomous vehicle that can make its way from point A to point B without either falling into a ditch or running over a non-combatant. Several current initiatives under the Pentagon's Joint Robotics Program (JRP) are aimed at solving exactly that problem.

If the most basic challenges of autonomous ground navigation and obstacle avoidance can be solved, the UGVs will follow the same route as UUVs: they will first be used as replacements for remotely-controlled mine detection and neutralization vehicles of the type used today. Next, UGVs are likely to be used for reconnaissance: such vehicles could be extremely useful in urban operations, allowing ground troops to explore buildings without the risk of ambush.

As short-range reconnaissance vehicles for tomorrow's infantry, though, UGVs have a rival — the Micro Air Vehicle (MAV). UGVs have a lower practical size limit set by terrain, but the minimum size of a flyer is determined only by technology and mission performance. The MAV effort, coordinated by DARPA with the support of innovative contractors, includes the development of miniature propulsion systems — tiny jet engines, for example, measuring no more than two inches in diameter — as well as MAV prototypes with wingspans of six inches or less.

MAVs, planners believe, could be flown within buildings. Their flight range and endurance would be limited, but they would extend their mission times by alighting on any convenient vantage point. A MAV or even a larger (but still portable) vehicle could combine the advantages of a UGV and a UAV, landing to take advantage of concealment and to save fuel, and popping up to view distant terrain, to clear obstacles, move rapidly over the ground or to gain line-of-sight communication with its controller.

Consider, for example, a 50-pound platform with a single turbine engine, large enough to lift it vertically. In the not-too-distant future, such a platform could carry both optical and radar sensors as well as a communications system. Mobile and portable, it would move faster cross country than any UGV (and would be smaller and lighter) and would be able to land vertically in a small space either to conceal itself or to perform extended surveillance. Such vehicles could be among the most important surveillance assets for the armies of the 21st century.

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