The military drafts

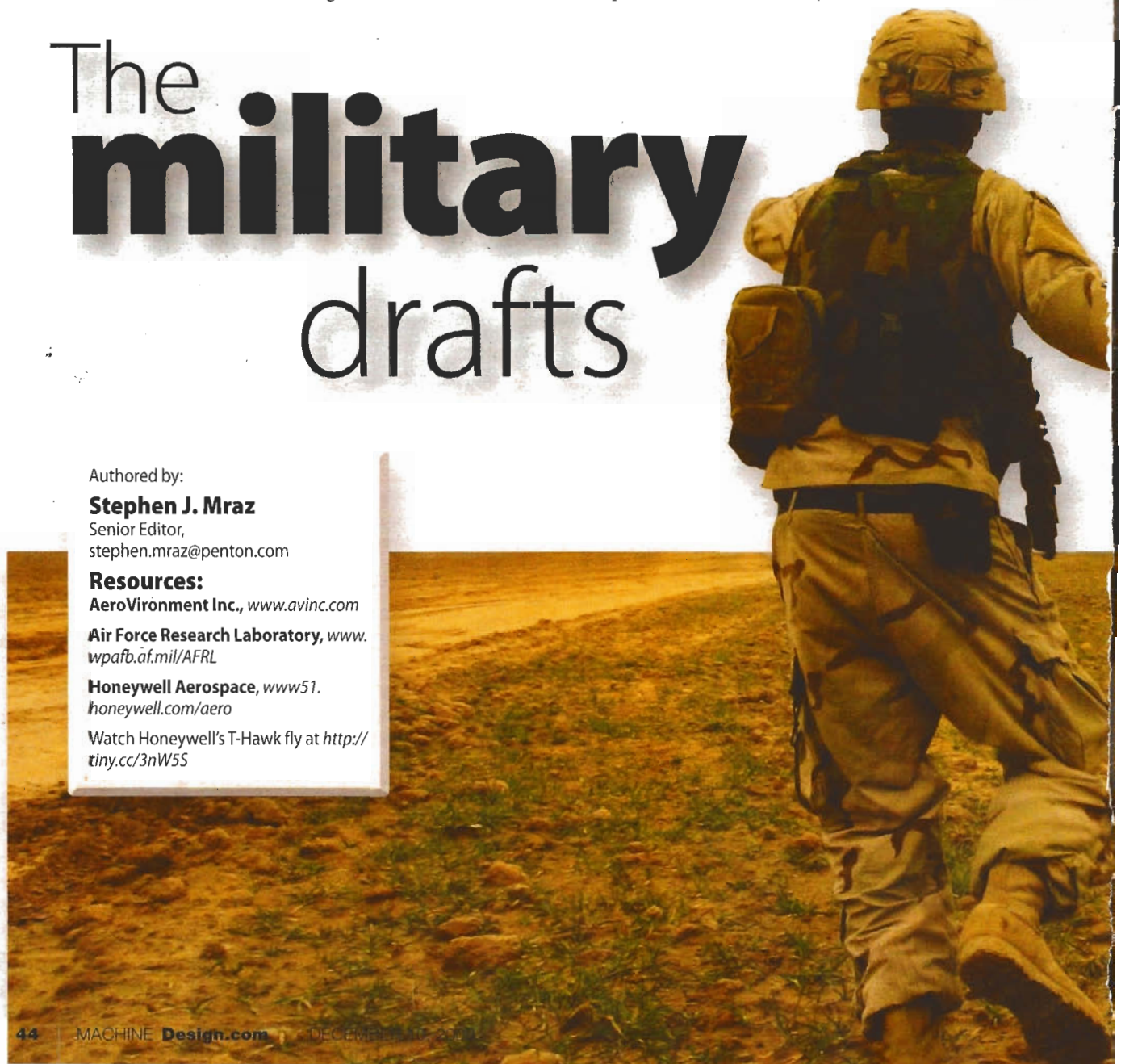
Every military leader facing hostile forces wants to know what's over the horizon, the location of enemy forces, and what they're up to. In the past, a trooper or two would venture out as scouts on an incredibly dangerous mission in the hopes of returning with useful information. These days, well-equipped armies no longer rely on humans scouts. Instead, they send up small unmanned aircraft, micro-air vehicles (MAVs), that can remain almost invisible to the enemy, stay on station for a few hours monitoring enemy forces or specific areas, and send back video images with GPS precision about where the action is — all without risking a life.

One of the most-successful companies designing and building MAVs highly sought after by the world's militaries is **AeroVironment** in Monrovia, Calif. Here are some of the aircraft in its arsenal.

Wasp III

With a 2.4-ft wingspan, the Wasp III is one of AeroVironment's smallest UAVs on the market. It is powered by lithium-ion batteries running an electrical motor. The motor and battery details and output are classified, as are many of the technical specs behind the company's offerings.

The company has a history of using electric power dating back to the Pointer, a relatively small UAV developed in the late 80s when every other small drone relied on gasoline engines. "But gas engines are finicky and require a lot of tuning," says Gabriel Torres, an AeroVironment aerospace engineer. "They are also unreliable and



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Resources:

AeroVironment Inc., *www.avinc.com*

Air Force Research Laboratory, *www.wpafb.af.mil/AFRL*

Honeywell Aerospace, *www51.honeywell.com/aero*

Watch Honeywell's T-Hawk fly at *http://tiny.cc/3nW5S*

extremely loud, even if you muffle the heck out of them, And finally, they entail transporting flammable liquids, a task our customers are not fond of. So from an operational standpoint, we made the move to electric power."

Today, batteries and electric motors dominate the MAV market as gas power shrinks. "And the move to electric power will likely spread to general aviation and eventually to airliners," says Torres.

The nearly 1-lb Wasp III carries all the sensors found on high-end airplanes, including an altimeter, GPS-based navigation, accelerometers, and magnetometer. The most important onboard component, the payload, consists of either a pod with forward and side looking electro-optical color cameras, or a pod with forward and side-looking IR cameras, both with high resolution. These pods are interchangeable and can be switched out in the field in less than 15 sec. All of these cameras have a limited amount of electronic pan, tilt, and zoom, and enough digital stabilization to let the plane keep a target in sight as it flies in a nearby circular or loiter pattern.

The Wasp fits in a backpack and soldiers can launch it by hand. Once safely airborne, the aircraft follows a predetermined flight profile (path and altitude). A soldier can change the flight profile using a portable and ruggedized handheld ground station to make it circle as it checks out a target. The station and Wasp remain in two-way communication, meaning the MAV must remain within line-

Micro-air vehicles are taking over some of the more dangerous missions for the U.S. military.

the DRONES

A soldier launches a Raven RQ-11B MAV on a surveillance mission to see what is over the horizon. Currently, the cost of three MAVs, two ground stations, and some spare parts can cost $150,000.

of-sight of the ground station as it beams back video signals. The Wasp and other AeroVironment MAVs have fail-safe procedures set up by operators prior to flight in case the link between station and craft goes down. Usually the MAV flies at an assigned altitude to a specific GPS waypoint and lands unless an operator takes over.

A display on the station lets the operator see what the MAV is seeing, and other soldiers equipped with remote video terminals can also see the same images in real time. The Wasp uses onboard processors to triangulate a target position based on its own GPS coordinates, altitude, and pitch, yaw, and roll angles. The data gets displayed along with the target.

The MAV is small and quiet with a radar signature similar to that of a turkey vulture. So it is unlikely to be detected by radar or by people at a target site, characteristics AeroVironment's customers appreciate.

When it comes time to land, the operator specifies a landing spot and, on its own, the aircraft establishes a proper glide path and landing approach. When the Wasp III calculates it is close enough to the ground and the right spot, it cuts the engine, glides down, and slides across the dirt. There are no landing gear.

Currently, both the Air Force and Marine Corps use the Wasp. The Air Force, for example, uses it as its Battlefield Air Targeting MAV (which makes the handy acronym BAT-MAV). It contracted with AeroVironment for 30 systems, which could include three aircraft, for $45 million. Meanwhile the company is developing a version that can land on water. The challenge, according to Torres, is to make it waterproof and add as little weight as possible so as not to degrade its range or endurance.

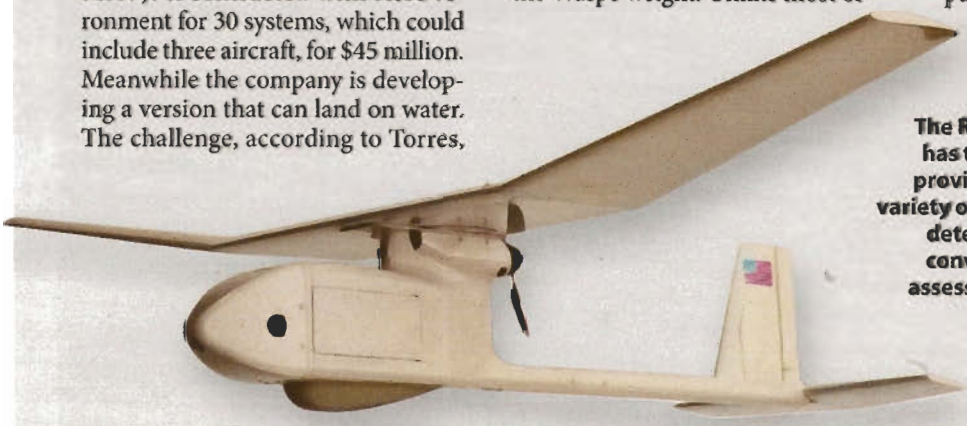
Technical specifications

AIRCRAFT	WASP III	RAVEN RQ-11B	PUMA AE
WING SPAN (ft)	2.375	4.5	9.2
LENGTH (ft)	1.245	3	4.6
WEIGHT (lb)	0.95	4.2	13
SPEED (mph)	25 to 40	20 to 50	23-52
RANGE (miles)	3	6	9
ENDURANCE (min)	45	60 to 90 (rechargeable battery)/80 to 110 (Single-use battery)	120
OPERATING ALTITUDE (ft AGL)	50 to 1,000	100 to 500 (14,000 MSL maximum)	300-1,000

With its small size and limited range, the Wasp III flies missions such as reconnaissance and surveillance in urban areas and out over the countryside for smaller military units such as squads and platoons. Its size lets it be carried in a backpack, along with a ground-station controller.

Raven RQ-11B

The Raven has a 4.5-ft wingspan, almost twice that of Wasp III and it weighs in at more than four times the Wasp's weight. Unlike most of the company's MAVs, this one uses a pusher prop mounted in back of the main fuselage. This was done because the customer wanted the payloads — forward and side-looking color cameras or a forward and side-looking IR imager — mounted on the nose so they could look down the aircraft's flight path. Each payload weighs about



The Raven RQ-11B, a 4.2-lb MAV, has the range and endurance to provide military intelligence in a variety of missions, including target detection, force protection and convoy security, battle damage assessment, and tactical updates during urban battles.

6.5 oz. "The pusher prop stays out of the way of the cameras and out of the way of soldiers when they hand launch the Raven," says Torres. With Wasp, the prop is much smaller so it is less dangerous, and with larger MAVs such as the Puma, the operator's hands don't go near the prop during launch.

Like most MAVs, the Raven flies in VFR (visual-flight rules) weather, which means no low-lying clouds or fog, high winds, heavy rain or icing. As Torres says, "There's no reason to fly if you cannot see the target, which is the sole purpose of the flight. And you cannot fly when winds are greater than a MAV's top speed, as it just won't make headway unless it's

The all-weather T-Hawk can fly day or night through rain falling at 0.5 in./hr, a 23-mph wind, saltwater spray, fog, sand, or dust. It can also take off or land in 17-mph winds. Soldiers carry it in a backpack and can get it aloft in under 5 min.

The T-Hawk, a different kind of MAV

The RQ-16A Tarantula Hawk (or T-Hawk), the brainchild of engineers at **Honeywell Aerospace,** is neither sleek nor streamlined. And it doesn't look at all like a conventional aircraft or helicopter that's been scaled down. But it's one of the first backpackable aircraft to be deployed in field tests with the U.S. Navy and Army. One of its major advantages is its vertical take-off and landing, making it suitable for deserts, jungles, and even shipborne applications.

The 17-lb MAV (19.5 with fuel) uses a modified 4-hp, two-stroke gas engine running a fixed-pitch ducted fan. With the fan buried in a duct, there is little risk to soldiers while deploying it, and the fan is protected from hitting anything while in flight or landing.

The spinning fan sends air through a tubular duct to generate thrust. The moving air also creates lift as it passes over the airfoil lip of the duct. Movable flaps at the bottom of the duct directs thrust for steering and stabilization. The craft climbs or descends by increasing or decreasing its engine rpm. (At 7,000 rpm, the T-Hawk hovers.) One current drawback of the powerplant is that it runs on gasoline, a volatile fuel the military would prefer soldiers not carry into combat. The military is working on a 3 to 4-hp diesel or heavy-fuel engine that will be safer and be under the Army's One Fuel initiative (the move to burn a single fuel in all Army vehicles and generators).

The engine is relatively quiet, putting out 60 dBA at 400 ft, making it inaudible in urban environments.

The MAV is not flown remotely by a pilot. Instead, soldiers construct a flight path with up to 100 waypoints using a portable, ruggedized ground station. The ground station maintains two-way communications with the T-hawk for up to 5 miles using common military UAV frequencies. And the craft can store up to 10 flight paths. The ground station also stores several hover, surveillance, and landing maneuvers that can be activated at any time. The current vehicle can download video signals at 1.7 GHz and stores up to 10 min of imagery onboard.

The payload of the T-Hawk includes an electro-optical sensor or an IR sensor, both pointing forward and canted forward. Soldiers in the field can switch one sensor for another in less than 15 sec. It is said the vehicle can detect a man-sized target at 820 ft during the day, 320 ft at night. Honeywell is developing a zoom capability for the cameras, as well as vibration isolation.

RQ-16A T-Hawk

TECH SPECS	
HEIGHT	22.5 in.
DIAMETER	13 in.
WEIGHT	17 lb
ENGINE	56-cc Bower twin-piston engine (4 hp)
AIR SPEED	46 mph
ENDURANCE	50 min, or 38 miles
CLIMB RATE	25 fps
CEILING	10,000 ft
GUIDANCE	GPS

The Puma AE, an all-weather MAV, is relatively large with a 9.2-ft wingspan, giving it the range and endurance needed for practically any unarmed mission, including search and rescue and drug interdiction.

The Puma AE was designed from the outset to be waterproof, letting it land on water.

flying with the wind."

As with most AeroVironment MAVs, Ravens are built out of totally custom parts or heavily modified off-the-shelf components. The components could be built by vendors, but the company's stable of engineers do much of the development and design. The motors, for example are customized commercialized products, as are some of the flight-surface actuators. "But some of the actuators are totally our design," says Torres. "And we usually size them not based on flight loads but by handling and landing loads."

Although the Raven will not fit in a backpack, it is controlled by the same ground station used by almost all AeroVironment's MAVs. The control system, its hardware and software, has become somewhat of a de facto standard for military MAVs. "There have been four DoD competitions for small UAVs and we've won each," says Steve Gitlin, AeroVironment director of marketing and strategy. "So all of the volume-production MAVs are ours and we've trained thousands of users in how to use our control system."

Puma AE

The largest MAV in this group is Puma AE, which was designed from the beginning to be waterproof, so it can land in water without damaging itself. "We've even filled the Puma with mud, hosed it off, then flown it," says Torres.

The Puma's waterproofing, together with its larger size and higher flight speeds lets it fly in heavier winds and rain than the smaller Raven and Wasp III. And unlike those two MAVs, the 13-lb Puma has a mechanically gimballed payload, which is a combined optical and IR camera and IR illuminator. The gimbal mechanism lets operators pan the cameras or illuminator through 360° and tilt it from looking straight down to looking at the horizon. The illuminator is not a target designator, cautions Torres. "It is boresighted with the cameras and lets the Puma put a spot on the actual target it looks at, much like a laser pointer," says Torres. "Anyone on the ground wearing night-vision goggles can see this spot. It lets soldiers identify which targets are being discussed."

Currently no MAV carries a weapon, though AeroVironment is working on a new UAV, the Switchblade, that could carry one on some of its possible missions. The plane collapses so it fits into a tube, which serves as a shipping container and launching mechanism. Once it shoots out of the tube, the wings spring open and the prop starts spinning. The company is also converting its two-way data links between controller and MAVs from analog to digital, which will let MAVs serve as relays or airborne repeaters for video and voice communications. **MD**