Unmanned *Military* Vehicles

Autonomous robots will soon be patrolling land, sea and air.

In just a few years, one-third of the U.S. military will consist of unmanned vehicles. Robotic aircraft, helicopters, ships, submarines, tanks, tractors and trucks will perform autonomous missions and work alongside humans.

Many unmanned vehicles are already deployed at home and abroad, especially for surveillance and reconnaissance operations. According to the Brookings Institution, the U.S. military currently operates more than 12,000 unmanned ground vehicles (UGVs) and more than 7,000 unmanned air vehicles (UAVs). In addition, more than 40 countries are actively buying or building military robots.

This 6.5-ton unmanned military vehicle uses six electric motors embedded in each wheel. ***Photo courtesy Carnegie Mellon University***

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Last year, the U.S. Air Force trained more UAV pilots than traditional manned aircraft pilots. That trend is expected to continue in the future, as manned, fixed-wing aircraft become less important.

The Pentagon plans to spend billions of dollars over the next decade to create a new generation of unmanned vehicles for various land, sea and air applications that are "dangerous, dirty or dull." Those devices will require a wide variety of state-of-the-art robotics, sensors, electronics, vision systems, grippers, controls, batteries and other components.

Unmanned systems offer numerous benefits to the military. Officials estimate that robotic aircraft cost less than half as much as piloted fighters, largely because they lack humans. For instance, Boeing claims that its unmanned X-45A fighter could be built and operated at one-third the cost of the current Joint Strike Fighter.

"Unmanned systems don't need to worry about life support, and that helps alleviate some of the complexity," says Patrick Egan, director of special programs at the Remote Control Aerial Photography Association and a leading expert on UAV technology. "Most of the components are constantly evolving, and are outpacing the limitations of manned systems."

"Remotely controlled aerial, surface and underwater unmanned vehicles reduce risk to sailors and other operators," adds Admiral Robert Willard, commander of the U.S. Navy's Pacific Fleet. "We see environments where unmanned vehicles have a great advantage over a manned vehicle. There are times when unmanned vehicles may be more affordable and simpler, and still meet our needs, and therefore obviate a necessity for manned platforms."

Willard's colleagues at the Air Force fully agree. In fact, they recently unveiled a long-range strategic plan that calls for the development of unmanned combat fighters, bombers, cargo transports and aerial refueling tankers.

Unmanned military vehicles come in all shapes and sizes, ranging from tiny flying insects that weigh only a few ounces, such as the Dragonfly from BAE Systems, to the Global Hawk from Northrop Grumman, which is the size of a small passenger jet and weighs 10,000 pounds. Currently, most vehicles are remotely monitored and controlled by soldiers. "All systems have a human in or on the loop," Egan points out.

Composite materials are used to assemble UAVs such as the Global Hawk aircraft (left) and the Fire Scout helicopter (right). ***Photos courtesy Northrop Grumman Corp.***

But, in the future, many military robots will operate autonomously. "Right now, the big stumbling block is sense and avoid [technology]," says Egan. The Federal Aviation Administration's Unmanned Aircraft Program Office is currently working on new regulations covering small unmanned aircraft systems (SUAS). The regulations will be released in 2012.

"The [regulations] will enable the commercial use of SUAS," notes Egan. It will also allow military UAVs to fly in national airspace. That will open up the market for new, nonmilitary applications, such as unmanned cargo aircraft, crop dusters and advertising blimps.

Diverse Applications

The unmanned military vehicle industry is currently dominated by aerospace applications. Most UAVs are fixed-wing aircraft, but several rotorcraft and hovercraft variants are in production.

"Some unmanned aircraft systems (UAS) are as simple as remote-control model aircraft," says Egan. "On the other end of the spectrum are aircraft that have autopilots and are remotely piloted via satellite."

According to the Teal Group, UAVs represent the most dynamic growth sector of the global aerospace industry. Steve Zaloga, a senior analyst who recently completed a study on the topic, claims that UAV spending will more than double over the next decade, from $4.9 billion to $11.5 billion annually.

"Most of that activity will be in manufacturing sensors and control systems," says Zaloga. "The airframe itself typically is less than one-quarter the cost of the whole system. The value is in the electronics, not the airframe.

"Most UAV activity in the past focused on reconnaissance and surveillance applications," Zaloga points out. "During the next decade, the focus will be on developing strike capabilities. Tactical UAVs will offer some of the best opportunities [for electronics manufacturers] over the next decade."

Future development efforts will attempt to bring large-aircraft capabilities to smaller and smaller UAVs. "There will be more demand for small, unmanned helicopters," predicts Daniel Harrison, defense industry analyst manager at visiongain. "There also is a trend to smaller and lighter UAVs that can be launched from a soldier's backpack."

Specifically, interest in mini and micro air vehicles is increasing. Mini air vehicles feature wingspans that range anywhere from 6 inches to 10 feet. Micro aircraft have wingspans less than 6 inches and often resemble insects.

No matter the size or scope of future UAVs, advanced electronics will continue to be in great demand. "The UAV electronics market will grow steadily, with especially fast growth and opportunities in synthetic aperture radars, signals intelligence and electronic warfare systems," says Zaloga.

"When third-generation UAVs start to emerge in a few years, there will be more plug-and-play platforms that can perform different types of missions," says Lindsay Voss, a research analyst at the Association for Unmanned Vehicle Systems International. "For instance, there will be more platforms based on open architecture software and sensors. That will help simplify things and keep the cost down."

To speed up deployment and hold down costs, UAV manufacturers are eager to adapt and integrate existing commercial products, such as GPS sys-

Unmanned underwater vehicles are a growing market. ***Photo courtesy BAE Systems***

Many unmanned aerial vehicles resemble model airplanes. ***Photo courtesy AeroVironment Inc.***

tems whenever possible. "Moore's Law is in play here, as these everyday items become cheaper to manufacture and easier to integrate," says Peter Singer, director of the 21st Century Defense Initiative at the Brookings Institution and author of a recently published book entitled *Wired for War*.

However, when unmanned military vehicles rely on the same technology that's widely used in cameras, cell phones, laptops and other consumer electronics, there's a higher risk of security breaches. As the military uses more off-the-shelf hardware, Singer believes it needs to do a better job with data encryption and sensitive component shielding.

Until recently, most unmanned military activity focused on aerial systems. But, ground robotics represents a fast-growing market.

"The success of UGV systems in Iraq is leading to growing investment in the technology," says Harrison. "Because 52 percent of casualties are in first contact with the enemy, robots are a clear solution to that problem.

"There's a trend toward smaller, lighter, portable UGVs," adds Harrison. "Semiautonomous operation will become more important. That will allow unmanned vehicles to achieve mission objectives with reduced input from operators and to function by themselves if the communications link is lost."

WinterGreen Research Inc. predicts the military robot market will skyrocket from $831 million in 2009 to $9.7 billion in 2016. "Military ground robots protect soldiers via sensors, cameras and arms [that assist with missions and keep soldiers out of harms way while they are on patrol]," says Susan Eustis, president of WinterGreen Research.

Applications for UGVs include transporting troops and carrying heavy loads over rough terrain, in addition to chemical and biological weapon detection, explosive ordnance disposal (EOD), and remote-controlled armed combat.

One of the most widely deployed UGVs is the PackBot, which is manufactured by iRobot Corp. The company recently delivered its 3,000th tactical mobile robot to the U.S. Army. The tracked devices can easily climb stairs, rubble and rough terrain or navigate through narrow, twisting passages. It has several modular configurations for a broad range of infantry support and EOD missions.

"The robot uses commercial off-the-shelf cameras and sensors that stream video, audio and data back to the operator," says Bill Ames, director of manufacturing at iRobot. "The PackBot also features a game-style hand controller for faster training and easier operation in the field."

The Defense Advanced Research Projects Agency (DARPA) is working on a wide variety of new UGV initiatives, such as the Legged Squad Support System (LS3). The quadruped robotic vehicle is significantly different from traditional wheeled or tracked vehicles.

Engineers are developing the device for the U.S. Marine Corps and expect to have a prototype in operation by late 2012. "Prior efforts have researched walking robots, but not at the system level," says Mark Peterson, a DARPA spokesman. "The key challenges in terms of performance are to carry 400 pounds of payload over a 20-mile squad mission profile, including walking, running and resting within a 24-hour period without a need to service the platform. [In addition], the entire system, including payload and fuel, cannot weigh more than 1,250 pounds."

Unlike UGVs and UAVs, the

Unmanned helicopters are popular for surveillance applications. ***Photo courtesy Schiebel Corp.***

unmanned maritime vehicle (UMV) market is still in its infancy. "Technologically, it's the least mature of the three unmanned military vehicle markets," says Harrison. "It is currently only an $85 million market, but it's the fastest-growing segment.

"Growth is strong due to increased demand for intelligence, surveillance and reconnaissance, antisubmarine warfare and force protection," Harrison points out. "Also, there's increasing homeland security spending for port and harbor security, border security and maritime security."

Key UMV categories include unmanned surface vessels (USV) and unmanned underwater vehicles (UUVs). "Many of the simplest merely entail taking sensors and a remote control unit and plugging them into a boat, [submarine or torpedo]," explains Singer. "However, many think the sea is actually a far more difficult environment than land." For example, waves and currents can be unpredictable, while salt water can be extremely corrosive to sensitive USV electronics.

"Limitations in range, endurance and communications can limit mission capabilities," adds Harrison. "Battery technology will play an important role, because increased demand for range and duration is leading to larger UUV designs. [Naval engineers are experimenting with] advanced lithium-ion battery technologies and fuel cells to extend speed and range."

These UAVs are assembled on a dedicated pull production line.
Photo courtesy AAI Corp./Textron Systems

Assembly Challenges

Traditionally, most unmanned military vehicles are built by hand. That's because production volumes have been relatively small.

For instance, approximately 800 PackBots were assembled by iRobot Corp. last year. "PackBots are assembled manually on a balanced line made up of subassembly cells that flow to the final integration and test station," says Ames. "Robots are not used to assemble the PackBot.

"All PackBots are built on the same assembly line," adds Ames. "The line is rebalanced as needed to allow for variations in product configuration. The subassemblies are moderately complex. There are several subassemblies, including the chassis, arm, head and radio. Each of these has multiple components."

As unmanned vehicles become more important to the military, production volumes have been growing annually. Manufacturers that traditionally built manned systems are applying many of the same assembly principles to their unmanned product lines.

"In almost all cases, UAVs are built on multi-model mix assembly lines," notes Don Gaw, director of unmanned military system production at Northrop Grumman Aerospace Systems, which produces the Global Hawk fixed wing aircraft and the Fire Scout helicopter. "These lines are separate from the manned vehicles, just as the different manned vehicles are separated.

"However, one of the challenges the UAV presents are infinite variables to the mission, thus a UAV platform can undergo many changes," Gaw points out. "In the past, planes were often built in blocks and as improvements or mission changes were identified, they were scheduled to be 'cut' in at a certain block.

"UAVs by their nature are more fluid and, as such, 'spiral' changes dictate custom configurations of payloads," explains Gaw. "Sometimes, a platform lends itself to multiple missions, but may require airframe changes such as airfoils, gear, deicing or other changes. When these are specific and require different tooling, especially if they are for a specific customer, a separate line will be considered."

As UAV demand ramps up in the future, many manufacturers will be eager to use automation to streamline production. "This is always a consideration," claims Jim Glowacki, director of manufacturing at AAI Corp., an operating unit of Textron Systems. "But, in order to move toward more automation to reap the production efficiencies, the ROI requires a significant volume."

Glowacki's company currently builds about 100 UAVs annually. Its most popular model is the RQ-7B Shadow, a tactical aircraft with a 14-foot wingspan that's used by both the U.S. Army and the Marine Corps.

"There [has been a] considerable increase in automation, especially in composites and this has been evaluated," adds Glowacki. "[However], the volumes haven't been high enough to justify the initial investment costs. As the setup costs or capital costs decline and the technology becomes more stable, and in parallel the volumes increase, it [will be] an absolute alternative." **A**