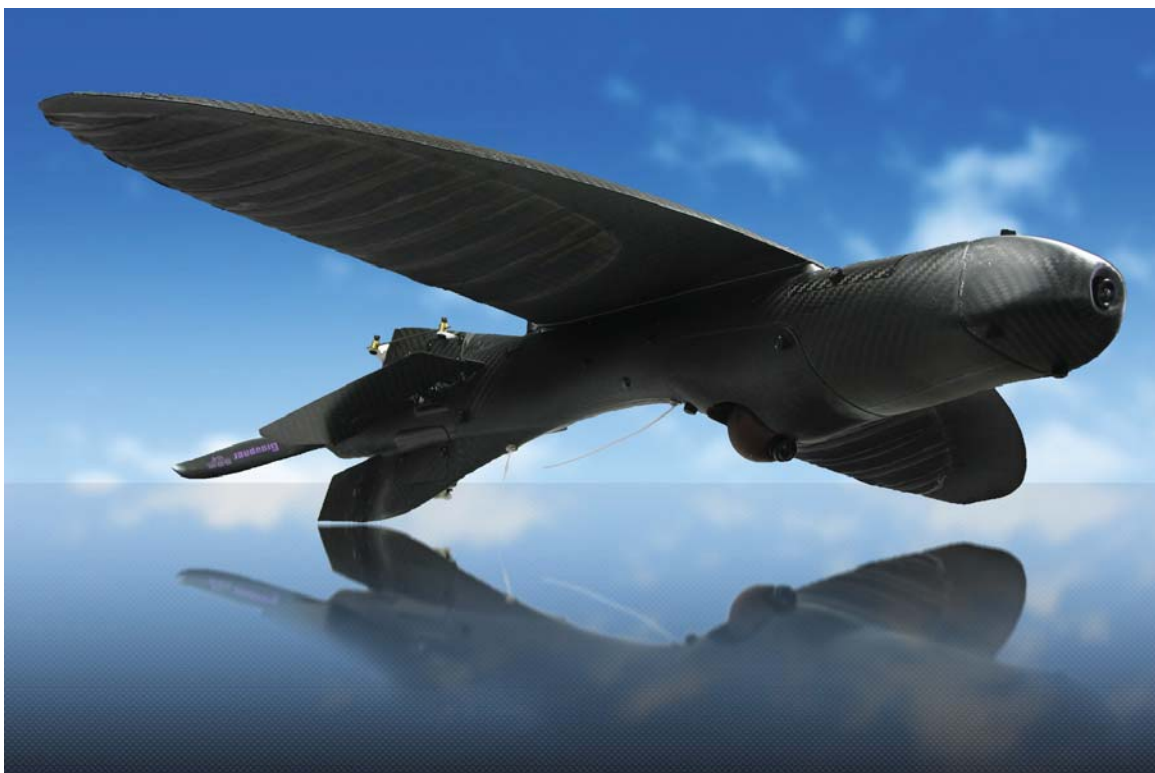

A New World of Unmanned Systems



Maveric Unmanned Aircraft System.
Source: Prioria Robotics, Inc.

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It's been a couple years since Secretary of Defense Robert Gates called for a greater emphasis on improved intelligence, surveillance and reconnaissance (ISR) capabilities, and industry, academia and the military have responded with a variety of new platforms, sensors and capabilities for unmanned aircraft systems (UAS).

Operating in parallel are efforts to develop improved command and control of unmanned systems that will permit unmanned aerial vehicles (UAVs) operated by the military, government agencies and local law enforcement to fly in airspace reserved for manned aircraft.

Unmanned aircraft systems are also playing an important role in homeland security by monitoring borders between the U.S. and Mexico and in coastal waters off Florida. The Coast Guard, for example, is now training ground controllers to fly the Guardian UAV (a naval version of the Predator) out of Cape Canaveral, FL.

"The role of unmanned systems is evolving to the point where we are now surveying our country's harbors, both our inner harbors and just outside our harbors, as well," said Vice Chief of Naval Operations Adm. Jonathan Greenert, speaking recently at a conference sponsored by the Navy's Naval Surface Warfare Center in Panama City, FL. "When you look at expeditionary warfare and mine warfare, in that regard, that is where unmanned systems can play an extremely significant role.

The following sections examine some recent developments in the UAS field from the perspective of adding new capabilities for the warfighter and helping to secure national borders.

UAS Collaboration Between Academia & Industry

Partnerships between the private sector and academic institutions are increasingly seen as vital to the development of new unmanned aerial systems, particularly the sensors and capabilities flown on UAS platforms. In numerous instances, the money spent on research and development into new unmanned systems has led directly to partnerships on winning teams with the private sector.

For example, Florida A&M University (FAMU) received \$12.4 million in funding from Congress, virtually all of it going to the development of sensors for unmanned systems.

The funding will go to a number of projects that are expected to have near-term impacts on the wars in Iraq and Afghanistan. The largest portion of funding, \$6.4 million, is part of the Future Affordable Multi-Utility Materials program, and will facilitate development of advanced process sensors for unmanned systems operated by the Army.

Another \$4.8 million went to FAMU for the Standoff Improvised Explosive Device Detection Program, which is designed to develop advanced sensors and imaging systems for the detection of improvised explosive devices (IEDs). Some of these sensors are expected to be installed on unmanned aerial systems for standoff detection. A final \$1.2 million is for the Advance Standoff Technologies for National Security program, which will lead to sensor systems capable of detecting nuclear, chemical and biological agents, which can also be modified for carriage on unmanned systems.

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FAMU development efforts for these types of sensors helped lead to its participation in a General Dynamics Robotics Systems-led consortium of eight academic and corporate leaders in robotic technologies. In June, the consortium, which also includes the University of Central Florida, was awarded a \$63 million five-year research agreement by the U.S. Army Research Laboratory to create the technical foundation supporting development of autonomous unmanned air and ground systems.

The contract has a second five-year option worth \$67 million, and a parallel technology-transition contract valued at up to \$90 million to facilitate transition of technology to other government programs. Taken together, the entire effort has a potential value of \$220 million.

"This award paves a path for transitioning the seminal work of our alliance's researchers into robotic products and systems that will transform the battlefield and save soldiers' lives," said Phil Cory, vice president, General Dynamics Robotic Systems. "The alliance will pursue four technology areas critical to the development of future autonomous air and ground systems of multiple scales. These key technologies are perception, intelligence, human-robot interaction, and dexterous manipulation and unique mobility. In addition, the alliance will focus on the interplay between these four areas to form the foundations of cohesive, integrated robotic systems."

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Developing the Armed UAS

The success of unmanned systems such as the Reaper—an armed Predator UAV that has been employed to substantial success attacking Al Qaeda leadership hiding in the mountains on the Afghanistan-Pakistan border—has led to development of additional weapons that can be carried on small UAVs. Lockheed Martin Missiles & Fire Control in Orlando, FL, for example, is working to customize existing weapon systems and develop new ones that can be carried aloft by unmanned aircraft.

In late June, for example, Lockheed Martin for the first time flight tested its Scorpion munition, which is an unpowered, lightweight, compact munition that is adaptable to multiple launch platforms, including unmanned systems. Targets for the weapon are typically those surveilled by UAVs, including structures, personnel, lightly armored vehicles, trucks, cars, missile launchers, and artillery or gun positions. It has a maximum range of about 10 nautical miles.

"Scorpion provides the warfighter with a much-needed affordable solution against targets in areas requiring low collateral damage, such as urban environments," said Randy Bigum, vice president of strike weapons for Lockheed Martin Missiles and Fire Control. "This precision attack munition features a small, lethal warhead that can be launched from a wide variety of platforms to take out time-critical fixed or moving targets."

The precision provided by Scorpion ensures accuracy to less than one meter and dramatically reduces the possibility of collateral damage.

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A reduction in collateral damage is also the strategy behind development of the Hellfire II. Also managed out of Lockheed Martin's Orlando headquarters for its Missiles & Fire Control division, the R model, or "Romeo" missile, recently completed its second proof-of-principle flight test at Eglin Air Force Base, FL.

"It's an important milestone for the Hellfire program, bringing us one step closer to providing the warfighter with one missile that can defeat hard, soft and enclosed targets," said Ken Musculus, director of Air-to-Ground Missile System programs at Lockheed Martin Missiles and Fire Control. "In this case, we tested the Romeo's ability to penetrate and then detonate within a target vehicle or structure, a critical capability against today's threats. Both the multi-purpose warhead and ESAF module are new to the Hellfire." The multi-purpose HELLFIRE II missile can be carried on both rotary-wing and UAV platforms.

Besides Scorpion and Hellfire, a number of other Lockheed Missile programs with key connections to unmanned aircraft systems are managed out of central Florida. One is ALERT (Advanced Low Observable Embedded Reconnaissance and Targeting Sensor), which had its origins in the Joint Strike Fighter electro-optical targeting system. It combines a traditional targeting forward looking infrared radar with a true IR search and track capability. Lockheed Martin and General Atomics, manufacturer of the Predator, plan to fly ALERT on the Avenger UAV (a jet-powered version of Predator).

Another is DAGR (Direct Attack Guide Rocket), a 2.75-inch (70mm) precision-strike munition designed to neutralize lightly armored vehicles or fly into specific rooms within a building. Designed to fill the gap between unguided missiles and Hellfire, DAGR can integrate onto Predator, Reaper, Warrior and Fire Scout UAVs.



Scorpion Munition.
Source: Lockheed Martin

UAS Sensor Development

Similarly, Northrop Grumman is working to take sensor systems developed for other aerial platforms and modify them for use on unmanned aircraft. One such program is COBRA (Coastal Battlefield Reconnaissance and Analysis), a fiber-optic system that detects mines on the beach, which was tested on a manned platform and which will ultimately be flown by the Navy on the vertical takeoff and landing unmanned aerial vehicle (VTUAV) known as MQ-8B Fire Scout. That UAS is manufactured by Northrop Grumman.



MQ-8B Fire Scout UAV
Source: Northrop Grumman

Another program is ASTAMIDS (Airborne Standoff Mine Detection System), which is designed to detect mines on land and be flown on a Class III UAV (a battalion-level UAV, as defined by the Army).

Northrop Grumman faces a number of technical and engineering challenges associated with developed sensor systems for UAS programs.

"The two biggest challenges we face are the weight limitations and the thermal limitations," said Dan Chang, vice president of Maritime and Tactical Systems at Northrop Grumman in Melbourne, FL, where these sensors are developed. "We

have to build sensors that will go to extreme low temperatures, as well as operate in a harsh, desert environment with blowing sand.

"In addition, we have to meet all the Mil-Spec requirements while also using lightweight materials because UAVs don't have a tremendous lift capacity. In fact, some of the real challenges come with the materials we use, some of which require special handling and machining in order to assemble these units.

"Another problem is trying to create low power units because UAVs typically don't have big generators. So we've developed strategies where we can bounce the power loads across the mission capabilities, so if you're using the sensor for one application and then transition it to a detector mode you can shut down other parts of the sensor in order to optimize power availability."

Northrop Grumman also takes advantage of the expertise of nearby universities to help hone its sensor designs for UAVs. For work done by Maritime and Tactical Systems in Melbourne, Northrop Grumman works with both the Center for Research and Education in Optics and Lasers (CREOL) at the University of Central Florida, and the Florida Institute of Technology, which has specialized oceanographic facilities that let Northrop Grumman test sensor capabilities in a marine environment.

"Another advantage of being based in Florida is that we can test all year 'round because of the good weather," said Scott Hoffman, chief engineer for Northrop Grumman's Maritime and Tactical Systems. "That is important when you deal with electric optic sensors. We have prototype systems that fly on both manned and unmanned aircraft and we do our own testing in addition to what the government does."

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Man-Portable UAVs for the Squad Level

Much of the media in the UAS world goes to well-known air vehicles like Predator or Global Hawk, which have performed admirably in Iraq and Afghanistan. Arguably more valuable to soldiers and marines on the ground, however, are small, portable UAVs—some of which are man portable and can be carried in backpacks—that can be flown and operated by squads. For them, knowing what's on the other side of the hill or who's walking around inside a compound is what's most important, and they don't have time to wait for a Predator, for example, to get into position.

Developing and manufacturing such systems are a variety of companies that specialize in inexpensive but capable UAS solutions. Some of them include: the Redtide Defense Group, Dunedin, FL, which builds UAVs with wingspans ranging from 48-110 inches; Applied Research Associates (ARA), which has facilities in Northwest Florida that helped design and test their 1.6 pound Micro Air Vehicle called the Nighthawk; and Prioria Robotics, Gainesville, FL, which has built and flies a man-portable system known as Maveric.

Prioria, for example, is typical of the entrepreneurial-type companies that have sprung up to meet the immediate needs of the warfighter.

"The Maveric UAV is a truly backpack-portable, lightweight solutions that's a squad level asset," said Derek Lyons, Prioria marketing manager. "They have bigger systems that have to be assembled. For example,

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the Raven UAV has had the most success in our class, but the Army considers it a company level asset, which means it supports 200 people. We are a squad level asset that supports a 12-15 person team. That is part of the hole we fill now.”

“The gimballed camera is another hole we fill. The Raven, for example, has a fixed side-looking camera. Our camera is gimballed, which gives the operator a greater ability to track targets.”

Maveric capitalizes on advanced composite materials and other patented technology that Prioria’s founders developed at the University of Florida. The UAV’s bendable-wings allow its fully-assembled airframe to be stored in a six inch tube. Designed as a smart, customizable UAV, Maveric utilizes Prioria’s proprietary processing platform called Merlin to enable image processing and vision-based control to be performed onboard, and, in general, aims to reduce reliance on ground station communication.

“Our technologies were born in a lab in the University of Florida, our founders were all University of Florida grads, and 80 percent of our employees are University of Florida grads,” said Lyons. “The reason Florida is important to us is because we have access to a top-notch university and a very educated workforce. It’s easy to attract the right talent here.”

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Flying UAS in NAS

The development of UAS technology is driven partially to provide offensive firepower and to offer ISR capabilities to battlefield commanders for improved situational awareness. Paralleling those efforts is research and testing of sense-and-avoid technologies and other capabilities that will permit unmanned aircraft to fly in the same space as other manned aircraft, including those flown by the military, commercial airlines, business aviation and general aviation.

Bringing UAS into the NAS (National Air Space), which is how the FAA refers to the initiative, is a major goal of many organizations, including Embry-Riddle Aeronautical University, Daytona Beach, FL, which was part of the team that won the prestigious Collier Award two years ago for its work related to ADS-B and NextGen.

“We believe at Embry-Riddle that a large part of future aviation will be unmanned, and we need to address those issues now and try to integrate and determine what kind of technological studies need to be done to integrate unmanned systems into the national airspace,” said Christina Frederick-Recascino, vice president of research at Embry-Riddle and assistant to the president. “I think a lot of the growth in this area will be in smaller unmanned aircraft that don’t get up to above a few hundred feet, but can be useful in many ways.”

Embry-Riddle is playing an important role in helping to bring UAS into the NAS by working with the FAA and the agency’s William Hughes Technical Center to collect the data necessary to develop the certificates of authorization that will be necessary for this type of flight. The studies touch on many of the important disciplines in the UAS world, including propulsion, detection, sense and avoid, communications, command and control, and emergency recovery and flight termination.

For example, a UAV powered by a turboprop will act differently in a variety of flight situations compared to a UAV powered by a reciprocating engine, or a turboprop engine, or one that takes off and lands vertically (like Fire Scout). The industry is studying more electrified aircraft, as well, adding another engine type to the mix. The FAA wants to understand the differences between those types of powerplants before approving UAVs in the NAS. And that's where Embry-Riddle comes in.

"The gap comes because the technology has evolved beyond the regulations or the regulations just don't quite fit," explained Tim Wilson, chairman of Embry-Riddle's Department of Electrical, Computer, Software and Systems Engineering.

Gaps also exist in other areas, which must be filled to the FAA's satisfaction. One would be crashworthiness.

"Manned aircraft have to be engineered to help facilitate the survival of people in a crash," said Wilson. "A UAS doesn't have that constraint as long as there aren't people onboard. The FAA is very careful not to have an unpowered aircraft with people onboard. Some people think it could go that way some day. And you could also see how the technology could evolve over time that the airlines would like to get one less person in the cockpit as an element of automation."

Another gap is redundancy and recovery for unmanned systems that go out of control.

"The issue of ditching the aircraft has implications for training, for the technology onboard the aircraft and the degree of autonomy on board," he said. "People are very concerned about what happens if an airplane comes down. That is certainly what the FAA is concerned about and why they are moving slowly on this. I think that is an area of technology development that hasn't received enough attention yet."

Because of its expertise in flight training, education and R&D, Embry-Riddle is especially qualified to handle this job for the FAA.

"People in the engineering world are familiar with the regulatory world," said Wilson. "If you went to an engineering school somewhere else that didn't have these types of aerospace or aviation programs then you would have a much steeper start up to do this work. So what we bring to the table is not just the ability to understand the engineering that goes into aircraft, but an existence in the aviation culture that lets us cut across all aerospace disciplines."

A Proving Ground for Unmanned Systems Flight Testing

In 2012, the skies over Florida, specifically the Florida Keys, will also be the locale for flight testing of a new Defense Advanced Research Projects Agency (DARPA) ISR (intelligence, surveillance, reconnaissance) program.

Known as the Integrated Sensor is Structure (ISIS) program, it will provide a detailed, real-time picture of all movement on or above the battlefield via a giant, unmanned aircraft capable of hovering at about 70,000 feet. As envisioned, the ISIS airship will be able to track troop movements—friendly as well as enemy—up to 180 miles away, and also track the most advanced cruise missiles from about 370 miles away.

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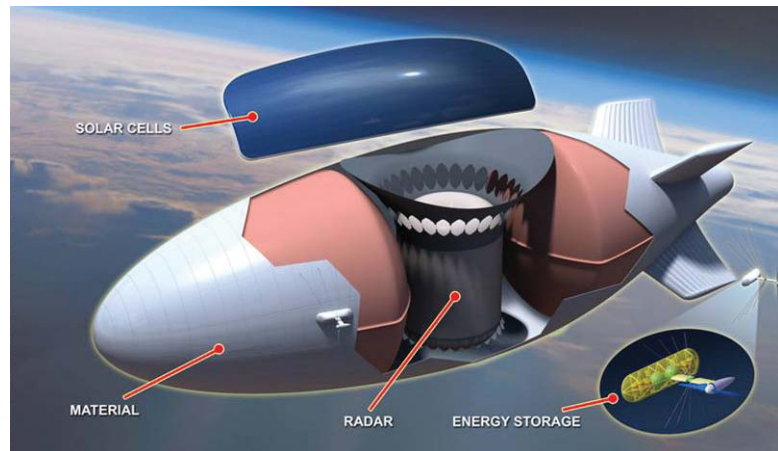
—Christina Frederick-Recascino, vice president of research at Embry-Riddle and assistant to the president.

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Earlier this year, DARPA selected Lockheed Martin as the systems integrator and Raytheon as the radar developer for Phase 3 of the ISIS program. Raytheon's Network Centric Systems division in St. Petersburg/Largo, FL, specializes in battle management systems and joint sensor networking, and will participate in the program.

Under the contract valued at just under \$400 million, Lockheed Martin will lead an industry team in the design, build, test and flight-demonstration of a one-third scale airship. Onboard will be Raytheon's under-development, low-power density radar. The autonomous flight test system will operate on station for 90 days, proving several key technologies with an anticipated total demonstration of one year.

"The development of high energy density power systems, an extremely lightweight radar solution and an advanced flexible composite material were necessary to make a stratospheric airship like ISIS possible," said Eric Hofstatter, Lockheed Martin ISIS program manager. "This is an extremely advanced machine that represents a dramatically different approach to persistent real-time intelligence gathering and to the overarching utility of airships."



DARPA ISIS Airship
Source: Lockheed Martin

The Right Environment for UAS Development

Because of their unique capabilities in the areas of intelligence, surveillance and reconnaissance, unmanned aircraft systems will play increasingly important roles in prosecuting the wars in Iraq and Afghanistan, protecting the borders of the continental U.S., and in aiding local law enforcement agencies in protecting the citizenry.

Enhancements to existing UAS technology and development of next-generation systems will depend on close cooperation between industry, the military and academia. The environment for such cooperation presently exists in Florida, as evidenced by some of the examples cited in this white paper.

The future of UAS development is on a continual climb upward, and Florida will continue to play an important role in this area.

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