VOLUME 35 NO.5 | MAY 2017

# UNMANNED SYSTEMS

#### **UAS Go Commercial**

The market for commercial uses of unmanned aircraft is growing, with some analysts saying it will rival the IT boom of the 1980s.

#### **Integrating Drones** 26 into UK Airspace

The United Kingdom was ahead of the United States when it came to integrating UAS, but in the wake of the FAA's small UAS rule, is that still true?

### **Off the Shelf**

38

The military has been studying commercial unmanned aircraft, and is figuring out ways to make greater use of them.





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Brian Wynne President And CEO, AUVSI

As businesses continue to incorporate UAS into their operations, we need government's guidance, expertise and participation to further unlock the tremendous potential of this technology.

#### Waivers Provide Window into Future of Unmanned Aircraft Systems

It is a particularly exciting time to be working in the field of unmanned aircraft systems, as we are hearing from members of our new Remote Pilots Council. Invaluable information has been exchanged and great connections forged during town hall-type meetings in six cities to date. These meetings, coupled with discussions at the recently held FAA UAS Symposium, cosponsored by AUVSI, have given us a real-time look at flying under the new Part 107 rules.

Needless to say, remote pilots are experiencing challenges. We knew there would be gaps in information, gray areas to clarify, procedural headaches to address. As with everything in AUVSI, we are tackling these as a community and with the enthusiastic collaboration of the FAA.

A very hot topic of discussion has been waivers. AUVSI has been paying close attention to the rollout of the waiver process and recently reviewed the more than 300 waivers the FAA has granted for extended operations since Part 107 was implemented last August. The data provide a window into how UAS could mature over the next few years. Ninety-four percent of the waivers were issued to allow UAS operators to fly at night, demonstrating the great interest in nighttime operations. There is also eagerness among waiver applicants to operate multiple small UAS at one time, and to explore the use of UAS for beyond-lineof-sight operations and flights over people.

Small businesses are the primary recipients of the waivers. Around 89 percent of these companies have fewer than 10 employees and make less than \$1 million a year in revenue. Small businesses are using UAS under the waiver program for a variety of applications, including real estate, aerial inspection, construction and filmmaking.

All of this adds up to paint an increasingly vibrant picture of a robust commercial UAS marketplace waiting to take shape.

While regulations may not be popular in Washington these days — or ever — they are vital for the safe and secure evolution of emerging technology like UAS. Establishing regulations for expanded UAS operations will enhance the safety and security of the national airspace. The development and implementation of Part 107 was the result of industry and government working together. We hope to see similar collaboration on issues like flights over people, remote identification and UAS traffic management to integrate UAS of all sizes into the airspace.

As businesses continue to incorporate UAS into their operations, we need government's guidance, expertise and participation to further unlock the tremendous potential of this technology.

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May 8 - 11, 2017 Dallas Texas Kay Bailey Hutchison Convention Center

#### AUVSI Israel Annual Symposium

May 25, 2017, 9:00 AM - 5:00 PM (UTC+2:00) Beer Sheba, Israel AUVSI Chapter Event

**Automated Vehicles Symposium** July 11 - 13, 2017 San Francisco, California

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# INDUSTRYNEWS

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#### Intel Acquires Mobileye to Strengthen Positioning in Driverless Vehicle Development

On March 13, tech giant Intel announced its intention to acquire the Israeli company Mobileye for \$15.3 billion, strengthening its hand in the emerging self-driving car market.

Intel wants to combine its high-performance computing and connectivity technologies expertise with Mobileye's experience in computer vision, machine learning, localization and mapping technologies to improve driver assistance systems and autonomous driving systems.

"Intel provides critical foundational technologies for autonomous driving, including plotting the car's path and making real-time driving decisions," says Intel's CEO Brian Krzanich. "Mobileye brings the industry's best automotive-grade computer vision and strong momentum with automakers and suppliers. Together, we can accelerate the future of autonomous driving with improved performance in a cloudto-car solution at a lower cost for automakers."

The two companies will have a combined global autonomous driving organization headquartered in Israel, and the organization will be led by Mobileye's cofounder, chairman and CTO, Prof. Amnon Shashua. The organization, which will include the two companies' Automated Driving Group, will offer support for existing production programs from each company.

The transaction has been approved by the board of directors of both companies, and is expected to close within the next nine months.

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powerlines in Canada. Photo: Canadian UAVs

#### Canadian UAVs, Lockheed Martin Conduct BVLOS Inspections of Pipelines, Powerlines

Canadian UAVs and Lockheed Martin CDL Systems have conducted the first beyond visual line of sight (BVLOS) inspections using unmanned aircraft in Canada, at Alberta's Foremost Centre for Unmanned Systems.

Using Lockheed Martin's Indago 2 UAS, which was compliant with Transport Canada, several pipelines, well sites and power lines were inspected during the flights.

"Canadian UAVs has been focused on creating an end-to-end paradigm in coordination with Transport Canada to conduct these operations outside of Restricted Military Airspace, where our customers have a substantial regulatory and logistical needs to acquire actionable data," says Sean Greenwood, the company's president.

"Due to our in-house combined military and commercial, manned and unmanned aviation backgrounds, the most advanced Lockheed Martin unmanned aircraft systems and a constant drive to evolve our aerial solutions, we have been able to demonstrate today the most logical operating structure for BVLOS on the market."

![](_page_10_Picture_7.jpeg)

The flightpath of the Day and Nighttime BVLOS flights conducted by V-TOL Aerospace and RelmaTech. Photo: RelmaTech

#### V-TOL Aerospace, RelmaTech Complete Daytime and Nighttime BVLOS Flights

On March 1, Australian commercial UAS maker V-TOL Aerospace and U.K.-based RelmaTech completed daytime and nighttime beyond visual line of sight flights, using V-TOL's fixed-wing and multi-rotor UAS.

V-TOL used unique flight permissions granted by the Australian Civil Aviation Safety Authority and Royal Australian Air Force to conduct the landmark flights. A UAS traffic management system monitored the UAS throughout the flights, which took place at the Brisbane flight centre.

"V-TOL has successfully commenced its BVLOS flight program designed to develop and test appropriate operational procedures, minimum technical platform requirements and pilot training competencies," says Mark Xavier, company CEO and chief remote pilot.

![](_page_10_Picture_13.jpeg)

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An artist's rendition of the Knifefish UUV. Photo: General Dynamics.

#### General Dynamics Mission Systems, US Navy Complete Evaluation of Knifefish UUV

General Dynamics Mission Systems and the U.S. Navy have completed a full-scale evaluation of the Knifefish autonomous surface mine countermeasure (SMCM) UUV, designed to be deployed from surface vessels of the U.S. Navy.

Using mine test targets on the seafloor and at various depths in the water, the evaluation confirmed the UUV's ability to detect and classify potential mines at different depths that could potentially threaten naval vessels operating in a mission area.

"The system performed well against a variety of surrogate targets and we are confident we will refine its performance to support the planned schedule in 2017," says Capt. Jon Rucker, the US Navy Unmanned Maritime Systems Program Office (PMS406) program manager. The UUV, which was tested off the coast of Boston, is built to protect personnel and take them out of harm's way, as it operates as an off-board sensor in the minefield, taking the host vessel outside of the minefield boundaries.

The UUV will go through more at-sea testing later in 2017 to continue improving the performance of the system. This extra testing will take place before the U.S. Navy conducts formal System Acceptance Testing.

#### Leidos Develops UAS Notification Service to Enhance Safety of UAS Operations

In an effort to provide more safety in the airspace, Leidos announced that it has developed the Leidos UAS Notification Service, which sends automatic notifications about UAS operations to relevant groups to provide deconfliction services. UAS operators will be able to file flight plans for the operating areas of their UAS, which are usually a section of a bridge or a rail that is being inspected. The service then sends all pertinent notifications to pilots, including applicable military personnel and a Notice to Airmen, to alert them. General aviation pilots also receive alerts if they will be flying in the same vicinity when the UAS is operating.

The service is being tested with BNSF Railways to research concepts for beyond visual line of sight flights of small UAS, as part of a Pathfinder Program under the Federal Aviation Administration.

The service began in September 2016 and is being offered in New Mexico for UAS operations over sections of railroads.

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#### DARPA Awards Phase 2 Contracts for Gremlins UAS Program

To develop reusable unmanned aircraft that can be launched and later recovered in midair, DARPA has awarded Phase 2 contracts of its Gremlins program to two teams, one led by Dynetics and the other by General Atomics Aeronautical Systems.

The goal of the Gremlins program — named after the good luck charms of British pilots during World War II — is to develop UAS that can be launched in groups from different types of military aircraft, while they are out of range of adversary defenses. The groups of UAS would be launched from military aircraft such as small fixed-wing UAS, bombers and fighters.

Once the UAS complete their mission, a C-130 transport aircraft would recover them in the air and take them home, where ground crews would prep them for reuse in the next 24 hours.

"The Phase 1 program showed the feasibility of airborne UAS launch and recovery systems that would require minimal modification to the host aircraft," says DARPA's program manager Scott Wierzbanowski.

"We're aiming in Phase 2 to mature two system concepts to enable 'aircraft carriers in the sky' using air-recoverable UASs that could carry various payloads — advances that would greatly extend the range, flexibility, and affordability of UAS operations for the U.S. military."

Gremlins are expected to have 20 uses during their lifetime. Some of the advantages of these UAS will be a reduction of payload and airframe costs compared to expendable UAS, and they will also lower mission and maintenance costs in comparison to conventional manned aircraft.

#### Boaty McBoatface AUV Embarks on Its First Research Mission

An autonomous underwater vehicle named Boaty McBoatface has embarked on its first research mission to Antarctica.

During its mission, the AUV will be tasked with researching water flow and turbulence in the depths of the Orkney Passage, which is a 3.5km deep region of the Southern Ocean, and is known for having some of the coldest and deepest abyssal ocean waters on Earth.

The data collected during the AUV's exploration will be transmitted to researchers via a radio link, and will help scientists get an understanding of how the ocean is reacting to global warming.

Boaty McBoatface, so dubbed by an Internet poll, is a name shared by three AUVs that are part of the expedition. They belong to the Autosub Long Range class of underwater vehicles, which were developed at Southampton's National Oceanography Centre.

![](_page_12_Picture_13.jpeg)

The Boaty McBoatface UUV. Photo: National Oceanography Centre

### SHOW SCAN:

# FAA UAS Symposium

#### Industry Involvement Key To Integration, FAA Officials Say

Industry involvement with the integration process for unmanned aircraft will be the key to getting it done in a timely way, Federal Aviation Administration officials said in late March at the 2017 FAA UAS Symposium.

FAA Administrator Michael P. Huerta said often there is a combative atmosphere between government and the industries it regulates, "but I don't think we have that here."

The symposium, which focused on a wide range of technological issues that went beyond even aviation, was the second one the FAA has held. This one, in Reston, Virginia, was held in partnership with AUVSI.

New Secretary of Transportation Elaine Chao kicked off the conference, saying via a video recording that the potential of unmanned systems is "attracting some of the best minds in technology and manufacturing. The devices they are creating have practically limitless uses."

Huerta noted the progress made thus far in allowing the safe, commercial use of small unmanned systems, but said, "this was the easy stuff. As we move toward integration, the questions we need to answer are getting more and more complicated," such as flying drones over people and beyond visual line of sight."

There are valid concerns about safety with these areas, and others, but "FAA can't and shouldn't solve these on their own," he said. "As we tackle these new safety and security challenges, we're coming to you [industry] again."

#### **Remote ID**

For example, he said FAA is setting up a new rulemaking committee to create standards for remotely identifying and tracking unmanned aircraft, "one of the law enforcement community's top concerns."

Interested parties can apply by sending an email to UAS-ID@faa.gov. AUVSI has also been collecting feedback on that topic for the FAA, which garnered one public response from DJI, the China-based drone maker that is the world's

largest producer of commercial drones.

Brendan Schulman, DJI's vice president of policy and legal affairs, described the proposed process as working like automotive tags do now: they can help the police locate a car's owner, but don't broadcast to the public who owns the car. DJI's proposal would use radio equipment aboard many of today's UAS to transmit the location of the drone, as well as its registration number or similar identification code.

Law enforcement officials or aviation regulators would be the only people that could use the registration number to identify a UAS user.

It actually goes beyond safety and includes privacy protections for users, Schulman said.

"In years past, some companies said aircraft flights should be confidential for businesses, so it does not give their plans away. The same thing should be available to consumers," he said. "As we work on remote ID and counter-UAS technology, we have to keep in mind the needs of the operators."

At a panel discussion with top FAA officials, the speakers gave other examples of industry involvement in rulemaking.

Terry Bristol, chief operating officer of the FAA's air traffic organization, said the agency is seeking to automate the LLANC, or Low Altitude Authorization Notification Capability

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process, to allow UAS to notify air traffic control of flights within five miles of an airport, or to get authorization to fly in certain airspace classes.

The existing notification process is manual, which worked fine before unmanned aircraft, but now the demand is too high "so it's not unusual to have thousands of authorizations waiting to be processed," she said.

The solution is to partner with industry, she said.

"The agency has developed maps for all of our airports with the important info that needs to be on them, and the industry will manage through that," she said. "So if you want to operate your UAS in a controlled airspace near an airport ... it could be a very rapid authorization."

The FAA expects to have this capability "online before the end of this year," she said. "We're going as quickly as we can."

Testifying before Congress on March 15, Earl Lawrence, director of the FAA's Unmanned Systems Integration Office, said automating LLANC is "the first step" toward an unmanned traffic control system.

Jim Eck, the assistant administrator in the FAA NextGen Office, said eventually a UTM system and automated LLANC will go a long way toward helping counter problems from rogue UAS operators.

Once "things like LLANC and UTM move into the community," air traffic control will know that most vehicles are where they are supposed to be. If there's an aberration, it's either "a blunder or something nefarious," he said.

"The more the industry can do as part of the development of operational capability and the service, the more that FAA can rely on a third party to be capable of producing that service and running that service, the faster we can

![](_page_14_Picture_9.jpeg)

integrate things," he said. "So the sooner we can get to these automated systems, where everyone is filing, the better off we will be as a community."

#### **Ride Sharing in the Sky**

One lunch panel considered the question, have we reached the future promised by the old cartoon "The Jetsons," which featured individual flying cars? The answer: Not yet, but we may be on the way to something like it.

Intel, Uber and Airbus are all working on concepts that would essentially be very large drones that could carry passengers but be as easy to fly as their smaller counterparts. Intel's Volocopter has had its first flights in Germany, and Dubai recently announced it will soon start passenger flights using a multi-rotor vehicle built by the Chinese company Ehang.

Mark Moore, engineering director of Uber, said going up instead of along the roads could turn a two-hour commute into a 15-minute trip, and do so for the same cost as a trip on the ground.

"All the technology jigsaw puzzle pieces are there, we just need to put the whole jigsaw puzzle together," he said. "And that's very complex ... but we can do it, and the time really to do it is now."

There are still challenges ahead, from fast-charging batteries to public acceptance. People fear that such systems might lose their command links as easily as cell phones lose connections, but that's not the case, said Charles Bergan, vice president of engineering for Qualcomm Technologies.

People take their experience on the ground "and project it up in the air," he said. "People think I'm going to get the same performance as I get here, [but] up in the air the signal is 10,000 times more powerful than down on the ground. You lose a lot when you go through buildings."

![](_page_14_Picture_18.jpeg)

FAA Administrator Michael Huerta talks with Peggy Gilligan, associate administrator, FAA Safety Organization, during an executive panel at the symposium. Photo: AUVSI To recap the symposium on Facebook, scan the QR code with your smart device.

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## TESTING, TESTING

## INDIANA DRONES: UAS Are Important Tools in the Field of Archaeology by Gaea HoneyCutt

A drone's-eye view of an archaeological site. Photo: J

In the olden days, just five years ago, few in archaeology were using unmanned aerial vehicles in field projects.

Archaeologists were beholden to the unpredictability of three methods to gain useful data for discovery and mapping kites and balloons, conventional manned aircraft and orbiting satellites.

Kites and balloons couldn't be controlled and often fell victim to wind and other weather hazards. Planes and helicopters, while able to get fairly close to the ground, often flew too quickly to shoot clear photos. Although not subject to shifts in the weather or the drawbacks of moving too fast, satellites usually produced low quality reconnaissance photos.

#### **Emerging from the Dark Ages**

Around 2013 all that began to change as archaeologists started introducing

unmanned aircraft into the field and testing applications.

"That was the Stone Age. Back in 2013, we used a custom-built drone that had the tendency to cut out and fall to the ground or lose power," says John Kantner, associate vice president for research and dean of the graduate school at the University of North Florida.

He partnered with Jesse Casana, associate professor of archaeology at Dartmouth College in New Hampshire, to test the efficacy of UAS thermal cameras to discover evidence of archaeological remains in the southwestern United States. After experimenting with the camera at different times of day, the team was able to complete the work in hours instead of weeks.

"Thermal cameras have existed forever, but anything flying on an aircraft just couldn't move slow enough or close enough to the ground. [The drone] provided the advantage to do quite a bit of work in a short amount of time," explains Kantner. "We were able to find things I knew existed below the ground and things I didn't know were there."

Today, unmanned aircraft are common in the field. "It's rare now that you meet a project that isn't using a UAV ... If the country allows them, people are using UAVs," says Morag Kersel, associate professor of Anthropology at DePaul University.

In fact, the Society for American Archaeology published a special edition of The SAA Archaeological Record (March 2016) dedicated entirely to UAS use in the field. Nine papers ranged in topics from how to use UAS to topography to generating 3-D models to Federal Aviation Administration regulations and legal uncertainty. Much of the conclusions supported other articles on fieldwork with drones — they are ideal passive tools that reduce time and expense.

But, not only do UAS — combined with georeferencing — allow faster mapping of archaeological sites, which reduces costs, but the tools also aid in avoiding unnecessary damage to the sites themselves. Archaeology, by its nature, requires disturbing and destroying the environment around artifacts. UAS allow archaeologists to more precisely identify areas of interest at a site, decreasing the chances of excavating the wrong items or causing damage by trekking across the less relevant parts of the site.

Off-the-shelf applications such as thermal cameras, photogrammetry software, lidar and mapping programs provide high-quality data and analysis capacity that allow the newly initiated to get up to speed quickly and reduce the number of steps necessary to produce data. Kantner describes detecting heat signatures in photos that they'd thought might be subterranean tunnels, only to find they'd discovered "a ton of ant hills."

Kersel encountered a similar situation when she teamed up with Austin "Chad" Hill, research associate and lecturer at Dartmouth College, in 2013 to map a site in Israel to determine the impact of looting.

"From one day to the next we processed the images. We kept seeing this red point on the pictures," she says. Kersel and Hill were surprised by what they discovered when they went out into the field the next day.

"It was a watermelon rind from looters who had been there the day before. It's amazing what we can see from the air that we may miss when we're walking on the ground."

However, there are drawbacks to using UAS. With the variety of vehicles and payloads available, it can be difficult to know how a specific unmanned vehicle will handle the rough environment of an archaeological site until it's out in the field. Most of the tools aren't effective with vegetation and overgrowth, or in wetland environments, as they're unable to penetrate water and aren't usually waterproof. In addition, sensing technology has difficulty sorting out ancient roadways from modern dirt roads, which means approaching it the oldfashioned way — by hand.

Field sites are typically isolated, requiring carrying drone cases, extra batteries and equipment, as well as camping supplies to locations where one won't find a UAS repair person. Also, while local populations are usually friendly, there may be opposition to strangers and UAS that could disrupt livestock or encroach on personal privacy.

And, although the learning curve for operating off-the-shelf UAS isn't steep, archaeologists in remote locations may not be able to fix problems onsite. "All technology fails. So, we have had fantastic crashes. Luckily, Chad is a wiz at all of this, so we've usually been up and running the next day," Kersel says. Most researchers in the field aren't FAA-certified UAS pilots or longtime hobbyists like Hill, who prefers building his own vehicles.

But before getting out in the field, other issues may impact the project.

"Usually, the flight company is aware [that you're carrying LiPo batteries] and has rules that you have to follow," says Jan Driessen, professor of Philosophy at the Catholic University of Louvain in Belgium, who works with pilot Nicolas Kress. "But sometimes, the people in the airport don't know what to do, and you can waste time at the airport waiting for a positive or negative outcome."

Not to mention what researchers describe as the changing laws and arbitrarily applied rules in each country.

For now, drones won't replace the heart and sole of archaeology, uncovering and studying artifacts.

"I don't think there's ever going to be a situation where you don't have to get down on the ground and look," Kantner says. "There's no way to determine the chronology of things without digging things up. There's a limit to [a drone's] utility."

A do-it-yourself quadcopter built by Austin "Chad" Hill. Photo: Austin H

# Company highlight by Rich Tuttle

## Triton Maritime UAS Headed to Guam to Mark Debut of Operational Service

The U.S. Navy Triton takes its 100th flight, soaring over the newly commissioned USS Zumwalt near Naval Air Station Patuxent River, Maryland, in October, 2016. Photo: Northrop Grumman

Two U.S. Navy MQ-4C Triton unmanned aircraft are slated to deploy to Guam early next year to mark the beginning of the type's operational service, according to Northrop Grumman's Mike Mackey, the program's deputy manager.

The two big eye-in-the-sky jets are now in the final stages of production at Northrop Grumman. When they are completed, they will move to a series of tests that will wind up in August. They will be handed over to the Navy in the fall, Mackey says.

He says the service will take them to the Naval Air Warfare Center at Point Mugu, California, for workups with VUP-19, the Navy's first dedicated unmanned aircraft squadron, commissioned last October. Once the squadron passes all its tests at Point Mugu, the jets will fly to Guam, the first of five planned Triton bases around the world.

Sixty-eight Tritons will ultimately be procured, with 20 assigned to each of the

bases. Powered by a single Rolls-Royce turbofan engine and with a wingspan of 131 feet, they will fly 24 hours at a time at about 60,000 feet at ranges of 8,200 nautical miles. Their mission will be to patrol oceans and littorals to provide "persistent 360-degree maritime domain awareness through vessel detection, classification and tracking," according to Northrop Grumman.

The Triton "will provide surveillance when no other naval forces are present and will support operations in the littorals" and "respond to theater level operational or national strategic taskings," according to the Pentagon's latest Selected Acquisition Report (SAR). All parties will see the same picture to ease the decision-making process.

Triton will be teamed with manned counterparts, like the EP-3E Aries II signals intelligence aircraft that Triton will someday replace. If Triton finds a hostile target, manned attack aircraft would be called in to hit it. Mackey said there are no plans to arm Triton itself.

Each Triton will have a service life of 20 years, flying some 3,000 hours per year. Attrition rate is projected to be four per 100,000 flying hours. The program would be phased out in 2045. Total cost will be about \$14 billion.

#### **No Antecedents**

Triton has no antecedent, according to the SAR. It "is projected to fly significantly more hours than the closest analogous airframe and has different missions, different concept of operations, and different payloads resulting in substantially different projected avionics repair costs" which, in fact, will be "the next major 0&S [operations and support] cost driver after the number of flight hours."

Triton is related to the RQ-4B Global Hawk, operated by the U.S. Air Force, and the NATO Alliance Ground Surveillance unmanned aircraft, both of which are also built by Northrop Grumman.

The Triton program notched several goals in recent months, according to the Navy and Northrop Grumman.

In February 2016, the operational assessment phase was completed. It consisted of six flights totaling about 60 hours, as well as ground and simulator events at Naval Air Station Patuxent River, Maryland. Operational assessment paved the way for Milestone C, the first part of the production and deployment phase.

In late August, the Department of Defense gave the program the green light to proceed to Milestone C.

On Oct. 17, a Triton flying from Naval Air Station Patuxent River made the program's 100th flight. Later in 2016, wings of new models were attached at Northrop Grumman's Palmdale, California, facility, and company engineers completed a key endurance flight.

"So we're on plan," Mackey says. "We did have some delay early in the program for first flight [in 2013] for some technical reasons which we easily resolved, and since then we're on our mark."

This includes progress on the Integrated Functional Capability software suite. Work on IFC-2 was completed in the December timeframe, and formal testing of final mods for IFC-3 was wrapped up in Northrop Grumman labs. IFC-3 is "basically our last software delivery before we go operational and deploy," Mackey says. Northrop Grumman has also "brought in some additional mission capabilities" for the Triton's Multi-Function Active Sensor radar, Mackey says.

It's the first radar system "to provide full 360-degree persistent coverage of both open oceans and littoral regions from extremely long ranges," Northrop Grumman says.

The radar and the electro-optical infrared system working together will provide clear identification of ships, according to Mackey. Testing "has gone very well for us," having brought in some of the final capabilities required for operational missions.

"We're meeting all of our requirements in terms of what we expected from the system operations, and we've added some additional communications activities," Mackey says, including Link 16, which allows Triton to talk to other aircraft.

The first IFC-3 flight was conducted at Pax River on March 24, 2017. "We hit it within three days of [the schedule] we had planned 18 months ago, so the team's done an outstanding job. That's an integrated test team, so it's us and the Navy," Mackey tells Unmanned Systems.

The IFC-3 flight was "very successful," he says. "Two days later we did a second flight" and a third was slated for the first of April . Two Tritons are being used for these activities.

By late March 2017, the team had completed about 80 percent of the Triton flight-test program, with some 175 flights logged and about 30 to go, mostly for the next-in-line IFC-4 software suite. Mackey says there are no big outstanding issues as the Guam deployment date approaches.

"Our focus, as we're delivering these last pieces of software, is on mission capability and functionalities and, quite honestly, it's going well and we're seeing the product that we expected. We're learning every day and we're also learning how to use the system in ways that maybe we didn't think about before. "

Australia and Germany are among countries that could become Triton customers, Mackey says. Other interested countries include Canada, Japan, Norway and the United Kingdom, according to the SAR.

Northrop Grumman and the Navy continue to work on a sense-and-avoid radar for Triton that would allow it to climb and descend safely near other aircraft.

"We're going through the phases to understand what is going to be the best product for Triton," Mackey says.

A cyber vulnerability assessment is now underway.

"I won't say too much more about it, other than that we absolutely have an eye on that," Mackey says. "We have a very stable system. We interrogate ourselves and we know that we're going to be protected."

![](_page_18_Picture_21.jpeg)

# **FASTER DATA ACQUISITION** Drones Could Help Feed The Planet

by Jennifer Redmond

While the term "agriculture" calls to mind images of farmers and livestock, one of Earth's most age-old pursuits is being revolutionized by the use of unmanned systems, ones that are simultaneously reducing manpower and increasing the speed and quality of data acquisition.

These advances are coming none too soon, according to lead researchers at the University of Georgia.

Prof. Changying "Charlie" Li's research is largely motivated by what he calls "one of the greatest challenges facing humanity," the growth of our population to 9.1 billion people, estimated to occur by 2050. In an interview published by UGA, Li explains, "This is a 30 percent increase in a little more than 30 years

... [it] will demand that we nearly double our current food production. That's a tall order but one solution is to use genomic tools to develop high-quality, high-yield, adaptable plants." Li is one of three principle investigators for a current project dedicated to "developing robot-assisted high throughput phenotyping technologies for plant improvement." Essentially, Li and his co-researchers will be working to collect close to 600 terabytes of data that will inform and improve crop production in real time. Not only will their data be collected in a rapid and repeatable fashion, it will also allow them new insights.

"In principle, these data could contribute to crop management on the same day they are collected," says Andrew H. Paterson, a co-principle investigator. "For example, indicating the need for irrigation."

Such insights allow for gains at a much faster rate than historical advances in agriculture. They expect to "unmask plant responses that will inform a new level and quality of decision making" in crop selection, Li says. Gone are the days of manual measurement, a labor-intensive and haltingly slow method to study plants. Li and his researchers will be analyzing numerous traits concurrently throughout the growing season, from the physical characteristics of plants to the internal structures.

They will accomplish this through the use of ground robotic systems, equipped with lidar and thermal cameras, and unmanned aircraft systems, equipped with color, multispectral and thermal cameras to collect traits in high temporal resolution.

Li says they plan to use two to three unmanned aerial systems, DJI S1000+ models, outfitted with on board battery and monitored via a DJI app. In the past, UAS were limited by the need for satellite and large payload vehicles to support the imaging equipment. Now, Li and his researchers in the Bio-Sensing and Instrumentation Lab have developed an aerial imaging platform that monitors crop growth with smaller, more lightweight drones. Moving forward, Li explains, "we have to select lightweight sensors and design a data acquisition system that can minimize the power consumption."

They will also monitor the UAS closely for flight time, payload and weather conditions.

Two or three ground robotic systems will also be used, which will measure distance through the use of a pulsed laser, or lidar; this remote sensing method will allow them to build the 3-D structure of plants.

These systems not only allow for "the means to more efficiently do what we already do, but also the means to gain information that is presently beyond our reach," Paterson says.

Part of that efficiency is coming from the speed and type of data acquired. Li explains that the UAS is designed to acquire multiple traits including plant architecture, canopy temperature, flowering, canopy coverage, plant biotic and abiotic stresses.

The focal plant for this study is cotton due to its unique "architecture" and reasonable height, which make it a good match for the systems' current capabilities. Prior to high-throughput phenotyping systems, measuring the height of a cotton plant had to be calculated manually, understandably leading to what researchers call a "bottleneck" of data collection. Now, with the UAS developed by this UGA team, plant height can be measured rapidly, at a processing time of .01 second, and accurately, with an average reading of over 92 percent when compared to the control. While plant height is measured by part of the ground robotics system, the UAS can quickly scan an entire field to obtain physiological measurements on many plants at one time. Paterson explains that this speed allows them to continually measure various plant traits throughout a single growing season. Being able to do so means researchers can effectively interact with various cultivars in real time, having "new insight into responses ... to specific events such as rainfall, irrigation, fertilization and other variables."

Paterson adds that the researchers will hopefully identify the "superior new cultivars" faster since they'll have a "more rapid detection of stresses that might be mitigated by crop management and more accurate forecasts of yield and quality."

Of course, improved efficiency in data collection means they also need continually advancing data analytics tools so they can effectively sort the data and use it.

As Li explains, the system they are employing allows them to "acquire data on an unprecedented scale."

During last year's six-month growing season, the preliminary testing period, approximately 20 terabytes of data was collected, according to Li's estimates. This year, he is anticipating close to 30 times that amount of data collection with one to three data collections per week throughout the growing season.

The sheer amount of factors involved in such a project is staggering, but in light of estimated population growth for the next few decades, such efforts are on par.

![](_page_20_Picture_12.jpeg)

A tractor equipped with the imaging cameras getting ready for a test run before installing the cameras to rovers. Photo: Kyle Johnsen, University of Georgia College of Engineering.

"It's realistic to envision that genetics will need to account for about half of the doubling of agricultural output that's needed by 2050," Paterson said in a February article published by UGA. "This will require roughly doubling historical rates of progress in crop improvement and more detailed and efficient phenotyping will be essential to accomplishing this."

The UGA research team plans to continue toward that goal, harnessing their unmanned ground and aerial vehicles to continually collect more information at faster and more reliable rates. After the promise of their preliminary testing in 2016, the group was recognized as a National Robotics Initiative Project, a designation that yields nearly \$1 million in funding for the next three years of research.

UGA Prof. Charlie Li working with a prototype rover while a UAS waits nearby. Photo: Kyle Johnsen, University of Georgia College of Engineering.

# with Matt Pickett

Matt Pickett is president and CEO of M4 Consulting, which provides planning and operational support for the use of small unmanned aircraft for research and development in Marine Protected Areas. Before that, he spent two decades providing operational support for the National Oceanic and Atmospheric Administration aboard ships, small boats, aircraft and by diving. He will be speaking on his research at AUVSI XPONENTIAL in Dallas on Tuesday, May 9.

### **Q: You've been using unmanned aircraft to try to find seabirds?**

A: Yes, we've done a couple of projects with seabirds. Recently we were working with Oregon State University and Oceans Unmanned, a nonprofit, to try to find these marbled murrelets that nest in old growth forest up there.

### Q: Why is it important to find these seabirds?

A: Well, the marble murrelet are a protected species. They've been relatively unknown, their habitat. The first nest wasn't even really discovered until 1974, which is extremely recent for a species that prominent. The main reason they're kind of important both politically and financially is because they do nest in the old growth forest and the logging pressure, as you know well, in Oregon and Washington is a huge industry, so if researchers can identify the habitat, the forest stands that they use to nest, it can allow the logging to not impact those areas and allow that to still continue in an environmentally safe manner.

#### Q: What sort of systems are you using? I understand you're using commercial off the shelf products?

A: For our original field survey we took four different systems up there. We took a [DJI] Phantom 2, DJI Inspire, a [DJI] Phantom 4 and a Microdrones md4-1000, which is a quadcopter system. We evaluated all four of those platforms and the Phantom 4, the DJI Phantom 4, became our go-to tool during that evaluation period. It's small enough and nimble enough to fly under the canopy. We had some ideas originally that it could fly above the canopy, and use infrared to see where the nests were, and kind of focus that way, but the canopy above the nests is too thick to do that so we ended up having it fly under the canopy.

#### Q: What sort of performance do you require from a UAV to be useful?

A: Small and nimble and relatively stable. The Phantom 4, once you get GPS lock, it's just rock solid and it's small and nimble enough that you could fly among the branches and within the tree relatively easily, and feel confident that you would maintain control of the platform during the entire flight.

## Q: What sort of sensors are you using on these?

A: We were using the stock Phantom 4 camera for visual orientation for the pilot, and also to compare that data with a FLIR unit. We attached a FLIR Vue Pro to the Phantom 4 so we could collect simultaneously IR and visual imagery, and so the FLIR Vue Pro is small, but we use a higher-resolution version to get the resolution we need to spot birds.

### **Q:** Is that the easiest way to spot them, using the infrared?

A: Yes, if you come to our presentation at AUVSI in Dallas you'll see some pretty amazing slides where we put up side by side ... what you see, or really don't see visually, and with the infrared overall how easy it is to see those birds hidden in the trees.

![](_page_21_Picture_15.jpeg)

#### Q: So how are you enabling this precision flying into the canopy, is it a skilled pilot, or programming things in?

A: I don't want to give my pilot too big of a head, but yes, he was very skilled, he was actually a NOAA pilot of years and years and has a lot of experience. One of the challenges in the canopy was to be sure we got GPS lock before we launched, and occasionally we couldn't do that. We would have to launch, kind of fly above the canopy or find a gap and stay airborne until we got GPS lock, and then begin the survey of the tree. We wouldn't fly unless we had that GPS lock. We had two observers helping the pilot at all times because you're basically flying a three-dimensional "Frogger" where it's like, 'OK, you can go up 10 feet, move over, three feet, all right, I think you can continue up.' Between two observers, using that camera as a visual reference point to fly through, we were able to fly safely the whole time and never had any incidents.

#### Q: What kind of potential have you seen for being able to use these systems to find and understand these birds a little better?

A: We've had two kind of interim steps so far. The first time we went up there we actually flew at Newport Aquarium where they have an aviary and there's a net. So we flew outside, above the aviary, just to make sure we could image seabirds with an IR sensor on a UAS. The next time we went up there, we used quail as a stand-in for the marble murrelets, where the researchers would go in ahead of the UAS team, hide the quail in the trees in cages, and then we had to go in and try to find those hidden quail, and we were able to successfully find 10 out of 10 without knowing where they were. So we proved the concept.

We're going back in up June, late May and early June, and actually work during the nesting season with marble murrelets. We had to prove the concepts so we could actually work in the forest during nesting season. When we go up there, we're either going to succeed or the marble murrelets are going to be different enough from the quail that we'll have to go back to the drawing board. The potential is there, I mean the infrared on the UAS is an amazing combination that's really working out well, not just for birds, for other species that we've been researching as well.

#### Q: Tell me more about these birds, where they are typically located and now they behave?

A; What's interesting about the murrelets is they spend most of their life out to sea, feeding at sea, and then when they come in to nest they nest in old arowth forest. 200 feet off of the forest floor in these 300-foot-tall trees, so they are way up there, well hidden from predators. They can nest anywhere from old-growth forests just a few miles off the coast to 100 miles inland, so it's a huge area that they have to survey to try to find these birds and they [researchers] work all summer long and find only perhaps 10 nests because it's such an effort to try to track these birds and find out where they are. So if we can use UAS to find even a few each season, we've dramatically increased the efficiency of their tagging and tracking operation.

#### Q: based on what you've done so far, what improvements would you like to see in these unmanned aircraft that you're going to be using?

A: I think taking some of the stress off of the operator and going to fully autonomous, and we actually have a partnership with UC Santa Barba, the University of California Santa Barbara, where some of their engineering students are trying to adapt a fully autonomous scanning system, where you can launch the UAS, it can scan 365 [degrees] in its environment, and then you just target a tree and it will automatically do kind of that back-andforth scanning of that tree and take that stress and pressure off the pilot trying to fly visually and manually.

![](_page_22_Picture_10.jpeg)

![](_page_22_Picture_12.jpeg)

# VIEWFINDER

This photo was taken in December 2016 in Tucson, Arizona, by Airscope LLC's Chief Pilot, Chris Volkman. It was taken using a DJI Matrice 600 with an X5 camera.

Have a great photo you've taken with an unmanned system? Send it to **Brett Davis at bdavis@auvsi.org** 

![](_page_24_Picture_0.jpeg)

## membership PROFILE

A few questions for industry movers and shakers:

## Deb Norris

Senior VP, Workforce Development & Corporate Services, Sinclair Community College, Dayton, Ohio The technology I'm most excited about is ...

Live Virtual Constructive Simulation (LVC) — It has great potential to advance the UAS industry

When I was a kid, I wanted to grow up to be ... An interior designer

> The strangest thing in my office is ... A pink cowgirl hat with rhinestones

**For fun, I like to ...** Go "junkin" for antiques/ treasures

> My favorite robot movie is ... Short Circuit. Robot movies don't have to be scary

SINCLAIR CC

The best part of my job is ... The ability to be a connector

![](_page_26_Picture_0.jpeg)

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# MIND THE GAP

#### by Beth Stevenson

## In the Wake of Part 107, US May Pull Ahead of UK Integration Efforts

![](_page_27_Picture_3.jpeg)

Until the Federal Aviation Administration's 2016 release of its Part 107 ruling governing the use of small UAS in national airspace, the United Kingdom was arguably strides ahead of the United States in allowing commercial operations of this kind.

As a result of a more lenient approach to airspace integration — albeit not a truly open one — the U.K. saw companies such as Amazon set up shop in country to carry out UAS testing, in that case for the online retailer's delivery UAS prototypes.

This gap between progress the two nations are making is now closing following the FAA's Part 107 release that provides a blanket exemption for commercial operations using drones that meet certain criteria, and the U.K. is starting to lag behind.

At the government level, the approach to airspace integration is mixed, with the U.K.'s Civil Aviation

Authority (CAA) continuing to promote the message that the U.K.'s skies are open for business should the right safety case be submitted, but still requiring permissions to be granted for this work.

One example of this was the flight of a Thales WK450 Watchkeeper UAS in controlled airspace in 2015, which saw it fly under air traffic control.

The one-hour sortie was the result of efforts being made under the Single European Sky ATM Research project, which is looking to modernize air traffic control to allow for integration of unmanned operations.

However, while the flight was the first of its kind, and was a feat for all parties involved, it was an isolated event and testing of this kind has not been replicated since.

The same year, the U.K. government decided to pull the plug on funding for the Autonomous Systems Technology Related Airborne Evaluation & Assessment (ASTRAEA) project, which it had provided 50 percent of financing for up until that point.

Drawn by a lenient approach to airspace issues, Amazon began testing in the United Kingdom last year. Photo: Amazon.

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![](_page_28_Picture_14.jpeg)

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![](_page_29_Picture_0.jpeg)

The Thales Watchkeeper, which flew under air traffic control direction in 2015. Photo: Thales. Citing its new position in supporting small and medium enterprise efforts, the cancellation of the project was a disappointment to the industry involved, which included Airbus Defence & Space, AOS, BAE Systems, Cobham, QinetiQ, Rolls-Royce and Thales all working to develop technology and procedures to support full airspace integration of unmanned systems.

The government continued to support the development of underlying technologies through the Defence Science and Technology Laboratory's (DSTL) Autonomous Systems Underpinning Research (ASUR) program that ran from 2013 to 2017, which did involve small companies that were exploring unmanned technology, but also involved some of the same large players involved with ASTRAEA, namely BAE Systems, Thales, Rolls-Royce and QinetiQ.

ASUR is now complete, so the next government-supported effort is yet to be determined.

#### **Restarting the Test Bed**

In the meantime, BAE Systems has taken it upon itself to leverage the work carried out under ASTRAEA by restarting flight testing of a Jetstream 31 test bed it had previously used for the project.

Announced in December 2016, BAE selffunded the £400,000 (\$495,000) effort, which saw it carry out 17 flights to test a number of parameters including a satellite communication (SATCOM) link.

This essentially replicated beyond-line-ofsight UAS flight, as the aircraft was remotely operated via the SATCOM link once it was airborne. Each flight was expected to last an hour and a half and involved the Jetstream flying from BAE's Warton, Lancashire site to Inverness in Scotland at around 15,000 feet.

The company could not provide much detail on the effort, but confirms to *Unmanned Systems* that the testing had been completed, and it will be analyzing the results over the next few months with the potential of more flying towards the end of the year.

The CAA says it supports efforts being made by industry such as this, and will continue to

work alongside companies such as BAE to support their testing.

"Together with other organizations like NATS we actively support a number of projects such as the BAE work that is looking to advance UAV technology," a CAA spokesperson tells *Unmanned Systems*. "They all have the capacity to influence future developments for us and others, such as EASA, which holds the responsibility for large UAV certification."

Another government initiative that garnered interest was the execution of a public dialogue on the approach to UAS use by the Department for Transport, which was carried out from 2015 to 2016.

It was partly funded by DSTL and the business division of the government, and included members of the Ministry of Defence, CAA, British Airline Pilots Association and privacy organization Big Brother Watch.

The project involved the group of UAS experts entering a dialogue with the general public to determine the attitude it has toward civil unmanned systems being used in national airspace, which is ultimately expected to help inform the government's policy making in this area.

The results of the dialogue were released in December 2016, and concluded that an initial lack of knowledge of the breadth of potential UAS uses resulted in negative attitudes towards them, but as this awareness increased, attitudes then changed.

"As the dialogue progressed and participants learned more about drones, they tended overall to become more positive," the paper says. "This was prompted by a number of factors. Firstly, discovering the range of commercial and state uses for drones. Participants were surprised at what they perceived as the wide-ranging scope and scale of drone technology, and the potential for positive uses that could benefit citizens.

"Secondly, seeing drones in person and interacting with their operators reassured participants about the safety features, the quality of materials used, and the nature of the commercial permissions process." Four areas were highlighted as being of importance to UAS integration, namely aircraft registration, mandatory training, technical restrictions such as geofencing and blade coverings, and an increase in awareness and education.

Notably, the U.S. has enforced the first two suggestions in recent changes to its rulemaking, with Part 107 requiring that commercial operators have a remote pilot airman certificate or for the operator to be supervised by somebody who has, and registration of systems weighing over 0.55 pounds having been mandatory since 2015.

Furthermore, the public also concluded that because the industry is already growing at such a pace, regulations need to catch up with this, and be more "future-orientated."

"They reported that there are many more drones in the U.K. already than they were aware of, leading some to feel that policy and regulation is already 'behind the curve,'" the paper says. "Participants — associating drones with 'the future' suggested policy needs to be future-oriented and future-proofed to keep pace with the sector as it continues to evolve."

However, the CAA says that other work is more important to this progress than the public dialogue: "This [the CAA's] work is influenced by many initiatives. While the public dialogue was useful, [an] ongoing national government consultation on drones may have more impact on our future drone work," the spokesperson says.

The CAA continues to stress that the regulations allow for UAS use, so long as a safety case backs the proposal.

"We absolutely want to ensure the U.K. takes advantage of the benefits drones can deliver both economically and for the benefit of citizens," the CAA spokesperson says. "The U.K. regulations and guidance material enable all size/mass of UAS to be operated, provided adequate safety can be demonstrated."

They added that the speed of large UAS integration will primarily be led by the industry and technical advances, again so long as they meet the safety criteria of the CAA.

As it currently stands under European law, each nation is responsible for UAS weighing less than 150 kilograms, (330.7 pounds) and the U.K. allows

![](_page_30_Picture_9.jpeg)

![](_page_31_Picture_0.jpeg)

commercial operations for small systems weighing 20 kilograms (44 pounds) or less so long as permission is granted beforehand. Anything above this category is subject to the same regulations as manned aircraft, so further permissions would be required, and large UAS are currently only routinely flown in segregated airspace in the U.K.

#### **A New Proposal**

Under a new proposal by EASA, the agency wants to start controlling the regulation of drones below the 150-kilogram threshold, passing more responsibility to Europe and harmonizing rulings across the continent further. It has also proposed a more proportionate approach to UAS laws, which would consider the risk each system takes in its operations and make allowances based on that, rather than just weight.

This is still under consultation, and it is expected that a notice of proposed amendments on this be published around April 2017. "We responded to the earlier EASA consultation and will consider the NPA once it's published," the CAA spokesperson says.

The testing of Amazon's UAVs in U.K. airspace — which resulted in the first 13-minute delivery sortie being carried out in Cambridgeshire in December 2016 — is an example of the U.K.'s appeal for companies to carry out testing. The retailer had become frustrated with the lack of progress for this type of testing in the U.S., albeit notably before Part 107 came into force. "Safety will always be our first priority and the Amazon project is an example of where we have worked with numerous parties, including government, to be able to allow trials to be carried out in a safe and controlled manner that will hopefully deliver benefits to the U.K. and UAS industry," the CAA spokesperson adds.

While the U.K. claims to be open for business when it comes to UAS operations, there is a clear lack of progress in the commercial use of these systems, or for beyond-line-of-sight work.

Until EASA enforces its new ruling, which the U.K. will ultimately be at the mercy of, the future is unclear, but a once pioneering approach to UAS use is in danger of being overtaken by the U.S. that is exploring BLOS operations now that Part 107 is enforced.

"We stand by to support any project or work that meets our safety requirements and falls under our remit," the CAA spokesperson adds. "If, when and how anything is brought to us for consideration will be for the drone industry and community to decide."

Until then, applications for permissions for aerial work are ever on the rise, but the U.K. is in need of the next leap in progress that will take airspace integration that one much-needed step further.

Editor's note: The United Kingdom has a pavilion at Xponential 2017 in Dallas, Booth #1917.

![](_page_32_Picture_0.jpeg)

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# FROM DEFENSE TO CONSUMERS TO COMMERCIAL

by Rich Tuttle

PLUS

Drone Market Seen Topping \$10 Billion In The Next Decade

> The commercial aerial drone market is booming. Estimates vary, but several research firms say the worldwide market value will balloon from about \$2 billion today to more than \$10 billion within the next 10 years.

> "Like the internet and GPS before them, drones are evolving beyond their military origin to become powerful business tools," says Goldman Sachs Research. "They've already made the leap to the consumer market, and now they're being put to work in commercial and civil government applications from firefighting to farming."

Goldman expects businesses and civil governments to spend \$13 billion on drones between now and 2020.

PricewaterhouseCoopers says the effect of drone technologies on business models is like that of the information technology revolution of the 1980s. Then, companies re-engineered their operations to transform the modern economy.

"Today we are witnessing a comparable disruption on a similar scale" as drones come onto the commercial scene, PWC says. "In the very future, clients in all areas of the economy will begin to see the impact of drones on their operational processes — from the way they receive deliveries to how they interact with their insurers."

Teal Group says production of non-military drones will jump from \$2.6 billion today to \$10.9 billion in 2025.

"The commercial segment of the worldwide market will lead growth in civil" unmanned aerial systems, says Philip Finnegan, director of Teal's corporate analysis. "Eased airspace regulations, an influx of venture capital investment, the development of a service industry and involvement of major technology companies all are creating the foundations for solid growth."

Idaho-based xCraft made a splash on "Shark Tank" with its VTOL drone. Photo: xCraft.

![](_page_34_Picture_0.jpeg)

ABI Research says suppliers of small drones to the military like AeroVironment, Aeryon Labs and Elbit Technologies, as well as consumer drone companies like 3D Robotics, DJI, Parrot, Yuneec and others are "aggressively targeting the commercial sector through acquisitions, internal development, partnership and investment."

It's because the commercial sector "is where the greatest long term growth opportunity lies," says Philip Solis, ABI's research director. He sees the market growing from \$1.3 billion in 2016 to \$11.2 billion in 2021.

He ranks the world's top seven drone companies this way: China's DJI; Sensefly, owned by Parrot Group of France; Hexagon of Germany; Aeryon of Canada; 3D Robotics of the U.S., and Delair-Tech of France.

Drones in commercial use face some hurdles, including safety, privacy, and availability of insurance coverage, according to PWC. But assuming such hurdles can be cleared, analysts say flying drones will see ready application in agriculture and construction. Solis says film and media applications are surpassing those of agriculture. Other hot areas include insurance, energy, infrastructure inspection, security, mining, turnkey services, telecommunications, real estate and delivery. (More use cases will be discussed at AUVSI's Xponential 2017 conference and exhibition in Dallas.)

In fact, scores, possibly hundreds, of industries may be revolutionized by drones. They are attractive because they promise to do jobs faster, safer and less expensively.

#### **Mergers and Acquisitions**

One indication of the strength of the commercial drone market is the fact that big companies have acquired drone businesses. Google, Facebook and Intel fall into this category. Intel, for instance, has acquired two German companies, MAVinci and Ascending Technologies, and has invested in China's Yuneec.

Disruption in several forms is evident among the drone companies themselves. For one thing, there's a shakeout in the personal market, which has begun to overlap with the professional market, largely because the financial opportunities are more attractive. Mota Group, headquartered in San Jose, Calif., is one of a number of drone-makers that started in the personal market and is shifting to commercial. "Now you can fly business class," its website says.

China's DJI, the unquestioned leader of the global nonmilitary drone market with some 70 percent of the pie, is seeing one aspect of this shakeout with its popular Mavic personal drone. Mavic folds up to fit in a deep pocket or backpack, and was designed for fun stuff — shooting videos of rock-climbing adventures, for instance.

But another company is turning it into a professional tool for collecting crop health data. Sentera, a Minneapolis developer of remote sensing technologies, says that with its mods, the Mavic can simultaneously capture visualband RGB color, near-infrared, and normalized difference vegetation index (NDVI) data, and interpret it in the field, which "ensures precision while saving time." DJI's view is that the potential for Mavic to shift from personal to professional wouldn't have been there if quality hadn't been designed in from the start.

"Unless you want a toy of a couple of hundred bucks, it's going to be fairly hard to build a drone that is solid and strong and stable," says DJI spokesman Adam Lisberg. He declines to speak about specific competitors, but says that, in general, they've had trouble matching DJI's products.

One such competitor is Yuneec. DJI has sued it for patent infringement. GoPro, another DJI competitor, aimed to boost its camera business with the Karma drone. The Karma was recalled after instances of losing power in flight, and in the market itself, but is back again — and again going up against DJI. 3D Robotics, once the biggest maker of consumer drones in the U.S., wanted its Solo drone to compete with DJI's Phantom. But a series of troubles, including production difficulties, crushing competition from DJI and a faulty GPS system, ended the plan, according to Forbes.

Do difficulties like GoPro's Karma losing power and GPS troubles with 3D Robotics' Solo mean that, while hardware may be fine, better software is a route to market dominance?

"I think it's both," says Lisberg. Refinements in both areas are "moving up the chain," he says. Things like obstacle avoidance systems, for instance, depend on new hardware and software. "They're going hand in hand, but you'll really see an explosion on the software side of things."

One reason for that, he says, is the demand for autonomy, which will require "a big software advance," which in turn will require hardware advances like "a more precise maneuverability handler and more precise reporting of data and positioning and aircraft interaction."

Lisberg makes it clear that DJI aims to stay on top of the personal and professional drone markets. He says the company was "started by four guys in a dorm room who were willing to work all night on some great ideas."

But, he says, "we've never lost the feeling that we continually are vulnerable to four guys in a dorm room somewhere coming up with their own great ideas."

This is why "we constantly push ourselves to do more and do better," and "can't assume that we'll be the next ones coming up with the next great market-leading advance. That keeps us going and keeps some of our engineers staying up all night too."

#### Lots of Competition

As well they should, because there's no lack of competitors. Idahobased xCraft, for instance, believes it has a market-beater with its patented design that takes off and lands vertically but transitions to high-speed forward flight.

"We started in the consumer market to build interest and build our brand, and we are now branching into the commercial space" with the X2, a tricopter VTOL, says xCraft CEO JD Claridge. "Our niche is primarily the hybrid VTOL capability, and that's something that isn't offered by DJI, at least currently, or by any of the major market players."

XCraft's potential so impressed the business whizzes of ABC's "Shark Tank" show that they jumped in with an unprecedented fiveway investment of \$1.5 million.

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XCraft's potential so impressed the business whizzes of ABC's "Shark Tank" show that they jumped in with an unprecedented five-way investment of \$1.5 million.

Another "Shark Tank" winner is DARTdrones of Scranton, Pennsylvania, which teaches the finer points of flying drones. When CEO Abby Speicher appeared on the show to pitch her company, she had 22 flight instructors. Now she has 45 instructors in over 40 cities and 4.000 students.

"We're also doing a lot of corporate and government training. We've trained the FBI, we've trained people from the Arizona Cardinals, CBS — a ton of really cool, big organizations." She said such clients expect training on autonomy.

On "Shark Tank," she talked only about her flight training classes but now she's offering several other courses, including preparation for the Federal Aviation Administration's drone pilot test. Once this Part 107 test is passed, you can fly drones for business purposes.

The venerable King Schools aviation educators are also offering Part 107 training, in partnership with AUVSI.

At last check, in mid-March, the FAA had granted 318 waivers to the Part 107 small drone regulation, which says drones can only be flown under certain conditions, including within visual line of sight. Only three companies are currently allowed to fly farther than that, but it's one of the keys to future wide-spread commercial drone operations.

"Where [the commercial drone business] goes in the future is related to the transition from line of sight applications to beyond line of sight," says ABI Research's Solis. "To move towards things like delivery, you need beyond line of sight, and to do that you need to be tracked for regulatory compliance, for safety reasons and for integration" into the National Airspace System.

And that's where the planned Unmanned Aircraft System Traffic Management network, being developed by NASA and numerous industry partners, is needed, Solis says.

Meanwhile, xCraft's Claridge expresses the sentiment of most companies in the commercial drone business when he says that "people are starting to figure out how to use these things to make money, and we want to be there."

The xCraft X2 competes in a competitive market that includes the likes of DJI and Yuneec. Photo: XCraft.

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# OFF THE SHELF AND IN THE FIGHT

Military Operators Eye COTS Systems for Unmanned Needs

by Michael Fabey

One commercial system the U.S. Marine Corps is considering, the InstantEye drone made by PSI Tactical Robotics. Photo: U.S. Marine Corps

As the U.S. Marines prepare for the Talisman Saber exercise in July, the Corps hopes to pick up right where it left off with the last set of amphibious drills off the Australian coast two years ago, especially when it comes to unmanned operations.

Fringing the country's Northern Territory near Darwin, Fog Bay turned into a combat zone during the 2015 drills as Australian, American and Japanese forces assaulted the shore in MV-22 Ospreys, landing crafts and amphibious assault vehicles — with a DJI Phantom 2 quadcopter buzzing overhead and then zipping and zooming along the shoreline to capture images and intelligence from vantage points the Marines had never seen before. They would use the film for training and a whole new set of lessons-learned. It was the first time the Marines had deployed such an unmanned aircraft in the exercise and they touted their ability to take an off-the-shelf quadrotor and use it as an indispensable tool. Now, the Marines hope to expand those unmanned operations at Talisman Saber and beyond. As the other services are learning, commercially developed equipment can help jump-start such efforts, but advancements are still needed to make them military-grade.

"At the battalion level, Talisman Saber is going to be the next major event," says Lt. Col. Noah "Spool" Spataro, the UAS capabilities integration/requirements officer for the Fires and Maneuver Integration Division in the Capabilities Development Directorate (CDD) at Marine Corps Combat Development Command. "We're exploring in all domains, exploring across all the different approaches robotics, how to integrate all of these things."

The Phantom 2 was a good start in the last Talisman Saber. But to expand, the Marines will need more. The system would work poorly at night and likely would never survive the saltwater, marine environment and other rigors of an amphibious assault. Communications would most certainly fail in a contested environment.

But, yet, it is readily available, easily controllable and most definitely affordable. This is the conundrum facing the Marines and every other service trying to increase its unmanned footprint: the need to find the right mix of operational flexibility with affordable costs. So far, the services have found that the best way to do this is to reap the harvests sewn in the commercial world – in all domains.

Consider the subsea realm. The most famous, or infamous, underwater unmanned vehicle right now is the U.S. Navy's ocean glider that was seized and released recently by the Chinese, the Slocum G2, developed by Teledyne Webb for such work as water column monitoring for the oil and gas industries. The Navy uses the autonomous underwater vehicles to collect oceanographic data to better understand the ocean. "We have approximately 130 of these gliders and they are relatively inexpensive," Rear Adm. Tim Gallaudet, Oceanographer of the Navy and commander, Naval Meteorology and Oceanography Command, says in a blog released soon after the Chinese seizure. The Navy plans to expand glider operations, he says, to explore more of the ocean depth much more affordably than the cost of doing so with a submarine or another manned ship.

Measuring a mere five feet long and sleek as a torpedo, the Slocum UUVs are surprisingly complex, featuring the following components: acoustic modem; altimeter; bathyphotometer (for bioluminescence); beam attenuation meter echo sounder; optical backscatter optical attenuation; oxygen conductivity; depth fish tracking; fluorometer; hydrocarbon hydrophones; radiometer; scattering attenuation meter; spectrophotometer (for red tide detection); and a turbulence sensor.

According to the company, the UUV propels itself forward by varying buoyancy. The glider's wings and control surfaces convert vertical velocity into forward velocity, diving or surfacing depending on the water density.

The Navy's first gliders, though, were developed in part through the efforts of academic institutions or small closely associated businesses working with the Office of Naval Research (ONR).

#### **Future Opportunities**

It is through ONR and other specialty labs that services see some of the best opportunity for future unmanned systems. The Army recently created a Rapid Capabilities Office to fast-track the development and deployment of critical technologies to deal with new and future threats. The office will focus on building prototypes to better handle key operations such as cyber, electronic warfare, survivability and positioning, navigation and timing, particularly in contested environments.

The Pentagon also recently established the Defense Innovation Unit. Officially called the Experimental (DIUx), and unofficially referred to by former Defense Secretary Ashton Carter as his "new startup," the military's fast-track tech team will include experts from the civilian and defense segments and operate with future annual budgets of about \$5 million under the directorship of George Duchak, a retired Navy officer, former government consultant and DARPA program manager.

Admittedly, the group's annual funding will not itself set unmanned systems development soaring, but what the team hopes to foster is a setting for a "crosspollination of concepts" that help incubate visions for the future. As Duchak explained during a recent AUVSI's Unmanned Systems Defense Conference, his group will be searching for "cool, nascent and emerging technologies."

Inspiration for those ideas will come from a variety of other sources. In the same way that the Marines found a way to

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deploy the off-the-shelf quadcopters to surveil an amphibious assault or the Navy acquired scores of commercial gliders to recon the ocean depths, the military may be able to order fleets of ground robots able to navigate urban grids and other terrain or even other advanced drones based on vehicles being developed today to deliver mail, packages and other items.

United Parcel Service has designed a specially equipped diesel-electric delivery van to launch a swarm of UAS through a retractable roof to deliver parcels to someone's front door and then return to the road vehicle. UPS and partner Workhorse Group recently tested a lithium-powered, 9.5-pound carbon-fiber HorseFly UAV Delivery system recently in a suburb just outside Tampa, Florida. Workhorse reckons its HorseFly drone can fly at a top speed of 45 miles per hour for about half an hour, carrying up to 10 pounds.

Other companies are looking at autonomous technologies the military has shown interest in developing.

Mercedes Benz has teamed with delivery drone developer Matternet, and American auto stalwart Ford recently revealed an "autodelivery" concept that relies on self-driving vans and drones. Toyota Material Handling Europe recently unveiled automated vehicles equipped with Natural Navigation, a tool that maps out recognizable warehouse reference points or landmarks, including walls, racking and fixed objects, to pinpoint the truck's location and map out a path.

Amazon recently patented a concept that calls for a drone to hover near a drop-off point, painting a target with a camera and

other sensors that would help navigate a package as it parachuted toward the surface. Another company, Starship, has designed ground-bots that look like wheeled coolers to deliver packages and other goods. The company alerts recipients with their smartphones to go to their front door and use their phones to open the cooler-cargo drone.

It's a 24/7 service that could be partnered with the Mercedes-Benz drone-van concept. Traveling about 4 miles per hour, the ground-bots' sensors identify pedestrians as well as other obstacles and the drones take appropriate action.

#### Go Tough or Go Home

Such technology could form the kind of backbone the military services need for robotic logistic operations, but many military operators regard commercial products more with cautious minds than open arms.

"I ask everyone I see at trade shows when they're harking their wares to the defense industry — is that marinized?" says U.S. Marine Corps Brig. Gen. Francis L. Donovan, commander, 5th Marine Expeditionary Brigade.

"Can it sit out in salt spray for six months and still operate?" Donovan wants to know. "Is that really man-portable? What is its battery life? I'm always suspect of things out in the market. They may work in certain civilian environments, but at any time, we can be operating in the Arctic — or in 100 degrees and 100 percent humidity here in Bahrain."

In "Spool" Spataro's experience, "Most of the commercially available or off-the-

shelf nonmilitarized systems, such as the DJI Phantom, are not militarized at all. Those of commercial grade are basically for hobbyists. They break easily. They're not very durable. If a Marine throws it in his pack and a leg or a propeller breaks, it's now useless. If a UAS can't make it to contact, it's useless in a fight. To package them and to protect them, oftentimes it becomes too much."

Also, he says, the commercial unmanned systems cannot be integrated easily with one another, and especially with existing military systems. Many cannot operate well in moisture or fly in high winds.

"Stability in high winds is kind of big deal when the primary purpose is to fly the camera," he says.

But the promise of the technology keeps the Marines and other services hunting and hoping for breakthrough unmanned systems that, combined, provide true game-changing potential.

"It's the Lego blocks coming together," Spataro says. "They are much more than the sum of their parts, especially with these unmanned systems. You take disparate technologies and pair them together — software components, a new camera or a way of data being produced from full-motion video. Oftentimes, you get a leap in capability. When you integrate items in a shareable network, the information becomes viable for anybody to analyze when you pair those things together. The sum of all of that together is much more than the individual parts especially in UAS." ■

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# CHAPTER NEWS

### 👫 New England

The New England Chapter held its first Autonomous Vehicle Summit in early March at the Draper Laboratory in Boston. The event featured speakers from government, industry and academia to discuss the state of self-driving vehicles in Massachusetts and around the world.

Speakers included Kathrine Ficther, assistant secretary for policy coordination at the Massachusetts Department of Transportation; Robin Chase, cofounder of Zipcar, Buzzcar and other companies; Jane Lappin, chair of TRB's Intelligent Transportation Systems Committee; and Gina Fiandaca, transportation commissioner for the city of Boston.

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A self-driving car from Swedish-American company Autoliv was on display outside the New England Chapter's Autonomous Vehicle Summit. Photo: AUVSI

## 📔 Spain

On Feb. 9-10, AUVSI's Spain chapter organized Diálogo 2017, the first congress about the integral automation of transport. The event included experts from all over the world, leading companies such as Qualcomm, authorities from our government, leadership from AUVSI and AUVSI's Israel chapter. The head of the Telematics Department for Mobility in the Spanish government's Directorate General for Traffic, made news when he announced that the agency is working on regulation in Spain for driverless cars. The heads of transport from Castilla and León, our regional government, announced the creation of an Integral Automation of Transport commission and asked AUVSI Spain to be part of it. AUVSI Spain proposed the use of automated vehicles to eliminate road deaths and congestion.

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### ⊡ Nevada

The Nevada AUVSI Chapter is ramping up activities for 2017. The newly elected officers are rolling out a new series of unmanned system focused networking events, with the first planned for April 19. The majority of these events will be open to the public, but presenter/panelist roles are limited to active AUVSI members. As part of the preparation for Xponential 2017, we are also trying to recruit more corporate, academic and individual members as we discovered a large proportion of exhibitors and attendees from Nevada who are not aligned with the Chapter or AUVSI.

## 😵 Pathfinder

One of the original AUVSI student chapters, the AUVSI Pathfinder Student Chapter at the University of Alabama in Huntsville, recently participated in their Week of Welcome (WoW) during the 2017 Spring semester. WoW is intended for new students to become familiar with the wide assortment of extracurricular organizations on campus. The student chapter members set up a booth which included various student projects and displays. A total of 22 new students signed up and many more were curious and excited to learn more. Overall, the engagement was another great opportunity to interact with the next generation of unmanned systems professionals.

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Pathfinder student chapter members participate in the Week of Welcome at the University of Alabama in Huntsville. Photo: AUVSI Pathfinder Chapter.

#### Emerald Coast, Florida Peninsula

AUVSI's Emerald Coast and Florida Peninsula chapters hosted a State Capitol Advocacy Day, featuring a meeting of the Remote Pilots Council. The meeting kicked off in Tallahassee, Florida, with a legislative luncheon. The luncheon featured speakers such as AUVSI's Brian Wynne and Tom McMahon, Emerald Coast Chapter President Anil Raj and Florida Peninsula Chapter President Brent Klavon, and state Sen. Jeff Brandes. After the luncheon, a meeting of the Remote Pilots Council took place, following a reception at a nearby capital venue.

The goals of the event were to share the industry's priorities for a safe and robust market in Florida, and hear from legislators regarding their support and concerns for the technology.

#### **Our Chapters:**

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# JOIN AUVSI

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#### For information on joining a chapter, contact:

Amanda Bernhardt, Chapter Relations Manager abernhardt@auvsi.org

To visit local chapter websites, scan this QR code or visit auvsi.org/MembershipandChapters/Chapters

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# **FORD** Ford's 'Autolivery' Concept Looks to Combine

## Driverless, Drone Technologies for Future Deliveries

by Brian Sprowl

Driverless vehicles and UAS are being developed to make deliveries independently, but one day, those two technologies could be combined to create one seamless delivery platform. Ford is looking to corner the market on combining those technologies to make future deliveries, as three Shanghai-based Ford designers, Euishik Bang, James Kuo and Chelsia Lau, have developed a concept that would solve the issue of delivering packages the last 15 meters, or from curb to door.

This concept, known as Autolivery, would play an integral role in the heart of what Ford envisions as the City of Tomorrow, which is an urban area that overcomes mobility challenges by lowering gridlock and air pollution in an effort to help people move around easier and more efficiently. The concept was developed in response to Ford's Last Mile Mobility Challenge, which seeks to find mobility technologies that could be used in urban areas.

During the Mobile World Congress in Barcelona, Spain from Feb. 27 to March 2, visitors were given the opportunity to experience the concept through virtual reality headsets. Through the headsets, people experienced a scenario where a person was preparing for a

dinner party at their apartment, but were missing an ingredient for a meal they were getting ready to cook.

Typically, in this situation, one would have to leave their apartment and head to the grocery store to make a last-minute purchase, but the Autolivery rendered that process null and void. Using Autolivery, the person simply ordered what they needed, and an autonomous vehicle drove the ingredients to their residence, where a drone delivered the package directly to the person's balcony, saving time and reducing the danger of having hungry guests.

Obviously, the scene experienced through the virtual reality headsets is not possible in real life just yet, but the Autolivery concept could one day make life a lot simpler and more efficient, according to one of the concept's designers, Euishik Bang.

"It's all about making life in the city easier," Bang says. "The possibility of harnessing autonomous and electric vehicle technology with drones to quickly and easily send and deliver parcels could help to make life better for everyone."

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# SOCIAL UPDATE

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![](_page_52_Picture_11.jpeg)

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![](_page_53_Picture_2.jpeg)

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