



**Calhoun: The NPS Institutional Archive**  
**DSpace Repository**

---

CRUSER (Consortium for Robotics and Unmanned Systems Education and Research) / CRUSER and Research Systems Sentinel (publication), 2015-2016

---

2016-03-06

# Unmanned Systems Sentinel / 6 March 2016

Monterey, California: Naval Postgraduate School

---

<https://hdl.handle.net/10945/48896>

---

*Downloaded from NPS Archive: Calhoun*



Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

**Dudley Knox Library / Naval Postgraduate School**  
**411 Dyer Road / 1 University Circle**  
**Monterey, California USA 93943**

<http://www.nps.edu/library>



## **Unmanned Systems Sentinel**

Thanks to Robin Alexander and Mark Rindler for providing several of the below articles. 6 MAR 2016

Please keep in mind that in most instances the below summaries are excerpts from the original article. The full articles can be viewed at the accompanying hyper-links. The inclusion of these links does not represent an endorsement of the organization, service, or product. All opinions expressed are those of the respective author or authors and do not represent the official policy or positions of the Naval Postgraduate School, the United States Navy, or any other government entity. Immediately below are this edition's highlights with links to the respective articles:

### **NAVY/USMC:**

[Navy Will Not Buy More RMMVs, Will Compete 3 Unmanned Vehicles For Future Use](#)

[Navy's Ice Exercise Kicks Off in the Arctic - UAS](#)

### **ARMY:**

[Army wants lightweight weapons for UAS](#)

### **NATIONAL AIR SPACE:**

[Arizona Senate Working on Bill to Permit Commercial Drone Use](#)

[Utah Bills Would Allow Law Enforcement to Shoot Down UAVs](#)

[Passenger jet forced to make evasive maneuver to avoid smashing into drone](#)

[Dueling drones detect, avoid](#)

[NextGen Trail with Conflict Detection Service](#)

[FAA Convenes Aviation Rulemaking Committee to Consider Performance Standards, Requirements for Certain Unmanned Aircraft Systems](#)

### **PUBLIC SAFETY:**

[NDSU Breaks Ground with Drones in Ag Research](#)

[Federal Aviation Authority \(FAA\) funds research for creating cities that repair themselves](#)

[Industrial Networks Launches Rail Automation Drone](#)

[UAV can track humans and animals, fly home to base](#)

[Offshore ROAV Inspection in N. America](#)

[U.S. Geological Survey plans to use drone to map Cape Cod National Seashore](#)

[Lightweight Drone Sees in Infrared to Find Lost Hikers](#)

[3D Crime-Accident Scene Drone System](#)

[Autonomous cloud seeding aircraft successfully tested in Nevada](#)

### **SENSORS/APPLICATIONS:**

[DroneBox is a Nest for Drones](#)

[Drones detect threats such as chemical weapons, volcanic eruptions](#)

[Google Earth builds textured area maps](#)

[Next-Generation Operational Intelligence \(OI\) Application, Delivering Real-time UAS Situational Awareness](#)

[The time is now for battlefield 3D printing - UAS ISR](#)

[New UAV cameras smaller, lighter and more capable](#)

[DARPA's sensor-laden quadcopter zooms around indoors at 45 mph](#)

### **COUNTER UAS:**

[Startup pitches anti-drone launcher as answer to rogue UAVs](#)

## [The Rise of Counter-Drone Technology](#)

### **COMMENTARY:**

## [Manned/Unmanned Teaming to Transform the MAGTF](#)

## [How a Robotic Octopus Could Help Us Control Autonomous Drone Swarms](#)

## [DARPA Announces VTOL X-Plane Phase 2 Design](#)

---

---

### **NAVY/USMC:**

#### **Navy Will Not Buy More RMMVs, Will Compete 3 Unmanned Vehicles For Future Use**

The Navy will halt procurement of the Remote Multi-Mission Vehicle included in the Littoral Combat Ship's mine countermeasures (MCM) mission package and will instead compete several unmanned vehicles over the next three fiscal years, officials decided this week.

According to a Friday evening statement from Navy spokeswoman Capt. Thurraya Kent, the Navy will halt production of the Lockheed Martin-built RMMV, 10 of which the Navy owns but have long struggled to meet reliability requirements. The Navy will upgrade the vehicles it already owns and then compete the upgraded RMMVs against the Textron Common Unmanned Surface Vehicle (CUSV), which is already slated to join the LCS mine countermeasures package as a mine-sweeping vehicle, and the General Dynamics Knifefish unmanned underwater vehicle, which will join the mission package for buried and high-clutter mine-hunting.

In the short term, the Navy will continue to operate the MCM mission package from two Independence-variant LCSs – both locally and in deployments abroad in Fiscal Year 2018 – to gain operational experience and lessons learned, Kent said. In the longer term, the Navy will select an unmanned vehicle to move forward with by FY 2019, and in FY 2019 or 2020 the Navy will use the updated mission package to complete developmental and operational tests in support of initial operational capability for the mission package. The full text of Kent's statement is included at the end of this post.

Navy Secretary Ray Mabus said at a Brookings Institution event on Friday that this approach lines up with the Navy's recent emphasis on rapid prototyping and experimentation, and in seeking the eventual solution for filling the remote mine-hunting requirement the service should push multiple solutions out to the sailors and let them discover what works.

"The hard part, the sensor part, is working great," and the Navy now needs to find the right vehicle to tow those sensors.

"This kind of open architecture approach will make that mission able to be shared with other nations in the region, and I think overall we'll get a much more comprehensive approach to a really difficult

mission, which is finding some small objects and potentially crazy environments. We're on the right track right now."

The Navy also has a head start on upgrading its RMMVs. Four of the 10 have already been upgraded to the 6.0 configuration, which replaced worn-out parts from the 10-year-old vehicles. Two more are undergoing the upgrade now, Kent said in her statement, and two more will be upgraded later. USNI News understands the final two have been used for testing and training and may not be upgraded.

"Joint U.S. Navy and Lockheed Martin assessment teams largely attributed the RMMV reliability issues experienced during testing to mission package integration issues, vehicle configuration and maintenance shortcomings. Lockheed Martin recognizes the challenging role the Navy has as systems integrator for the mission packages and will continue to provide support including upgrading vehicles, establishing a class maintenance plan, resolving integration challenges, and training proficient operators and technicians to deliver a reliable RMMV system to the fleet."

The full statement from Navy spokeswoman Capt. Thurraya Kent:

On February 24, 2016, the Assistant Secretary of the Navy for Research, Development and Acquisition and the Chief of Naval Operations concurred with the Independent Review Team's (IRT) recommendations. The IRT recommended an approach which:

- . Halts procurement of the follow-on RMMV (Low Rate Initial Production (LRIP)-2).
- . Addresses existing RMMV V6.0 LRIP-1 and RMS support system deficiencies.
- . Pursues the most promising near term technologies to accomplish the MCM mission and enhance current legacy mine countermeasures (MCM) capability, leveraging knowledge gained from Urgent Operational Need Systems currently being operated within Fifth Fleet.
- . Exercises MCM capability from LCS and other platforms to refine concepts of operation and systems.
- . Integrates improved RMMV V6.0 vehicles and supporting systems on the LCS-2 variant.
- . Deploys the MCM MP Increment I (2 packages) on LCS-2 variants to gain operational experience and lessons learned (similar to the approach used for CVN Anti-Torpedo Torpedo Defense System).
- . Evaluates and competes through FY19 Unmanned Surface Vehicle (USV), RMMV and Unmanned Underwater Vehicle (UUV) technology for long term incorporation within the MCM MP program of record.
- . Executes Developmental Testing (DT) and Operational Testing (OT) to support MCM MP Initial Operational Capability (IOC) (FY19/20).
- . Establishes within the Office of the Chief of Naval Operations (OPNAV) an Integrated Product Team (IPT) for mine warfare capability, led by OPNAV N95.

- . Evaluates reorganization options within PEO LCS to provide sufficient management focus on mine-hunting.

The CNO and ASN(RD&A) have directed the Deputy Chief of Naval Operations (OPNAV N9) and the Program Executive Officer, Littoral Combat Ship to develop an implementation plan that executes the IRT recommendations. The plan will coordinate experimentation, technology maturation, concept of operations and concept of employment development, and industry and Fleet engagement leading to a supportable MCM capability, tested and delivered to the Fleet before legacy systems reach end of life.

The Navy will evaluate and compete three capabilities to perform the volume and bottom mine-hunting function for the MCM MP:

- . RMS with improved RMMV V6.0 vehicles (LRIP-1)
- . Common Unmanned Surface Vehicle (CUSV) with the AQS-20 or AQS-25 towed sensor
- . Knifefish Unmanned Underwater Vehicle

In the meantime, the Navy will use the existing RMMVs as a transition capability. The Navy will complete planned upgrades of the existing (LRIP-1) RMMVs to the current configuration (four are upgraded; two are in progress; two more will commence, for a total of eight). This will provide four MCM MPs which will be available to support MCM MP deployments on LCS-2 variants in FY 2018. These RMMVs will include correction of deficiencies identified by the IRT to improve reliability.

The other MCM MP systems evaluated during TECHEVAL, the helicopter-borne Airborne Laser Mine Detection System (ALMDS) and the Airborne Mine Neutralization System (AMNS), both performed well and will continue. The plan for fielding the remainder of the MCM MP systems, including COBRA for Beach Zone Mine Detection, CUSV + mine sweeping (Unmanned Influence Sweep System- UISS) for Influence Mine-sweeping, and Knifefish for buried/high clutter Mine-hunting remains on schedule, with an acceleration of Knifefish being considered. These systems add capability in other portions of the water column or other portions of the MCM detect-to-engage sequence and are not dependent on RMMV to continue their efforts.

<http://news.usni.org/2016/02/26/navy-will-not-buy-more-rmmvs-will-pursue-system-of-systems-approach-to-mine-countermeasures>

[Return to Top](#)

## **Navy's Ice Exercise Kicks Off in the Arctic - UAS**

The Navy's biennial Ice Exercise — also known as ICEX — began this week with more than 200 participants expected to travel to the Arctic over a five-week period, service officials said March 1.

The exercise will “help the Navy access our overall readiness to operate in the Arctic, increase our operational experience in that area and develop international and interagency partnerships,” said Capt. David Kirk, head of the Navy’s undersea influence branch.

The exercise is taking place 200 miles north of Prudhoe Bay, Alaska, in the Beaufort Sea. Construction of an ice camp known as Sargo — which could house a maximum of 80 people at one time — began Feb. 29.

The entire exercise will take place over five weeks, with about four weeks of scientific experimentation, Kirk told reporters at the Pentagon.

The Navy — alongside partner nations such as the United Kingdom, Canada and Norway — plans to participate in more than 20 tests over the exercise. More than 30 organizations are involved, including the Army, Coast Guard, Alaska Air National Guard, the Department of the Interior and the Department of State.

The Arctic region presents unique challenges to the military, Kirk said. Differences in acoustics, salinity and temperature in the Arctic Ocean greatly affect submarines and their equipment, he said.

“The overhead ice canopy alters the way we ... operate and communicate and navigate,” he said. “The simple fact that the water temperature is about 28 degrees and we have fresh water systems throughout the ship is just a challenge in and of itself to keep things from freezing.”

Experiments will include the use of unmanned vehicles, said Scott Harper, head of Arctic research at the Office of Naval Research. Underwater drones used during the exercise will collect environmental data in the region. The harsh conditions in the region could pose a challenge for many of the systems, he noted.

Additionally, many unmanned underwater vehicles use GPS to navigate. Ice cover will degrade that, requiring a higher level of autonomy, he said.

Small unmanned aerial vehicles will also be used during the exercise, Kirk said. They will be used for perimeter searches and situational awareness. Additionally, they’ll help spot polar bears that might attempt to enter the ice camp.

The Navy’s goal is “not to militarize the Arctic,” said Jerry Barker, deputy branch head for policy within the office of the chief of naval operations. “The president has clearly stated that, our national objectives clearly state that.”

<http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=2107>

## **ARMY:**

### **Army wants lightweight weapons for UAS**

The Army could be looking to expand the lethality of its drone fleet, recently issuing a request for information for small guided munitions that can be outfitted to rotary wing and unmanned aerial

systems. Specifically, the Army said its primary interest is in weapons of 60 pounds or less—and preferably in the 25-pounds range.

Additionally, these weapon systems should be able to engage both moving and stationary targets that include lightly armored vehicles, fleeting light vehicles and dismounted combatants in day and night conditions, with low collateral damage.

The Army already operates UASs with lethal payloads such as the medium-altitude, long-range MQ-1C Gray Eagle that can carry four Hellfire missiles weighing roughly 100 pounds each.

Hellfire missiles – the primary munition outfitted on unmanned aircraft associated with the controversial targeted killing program run by the CIA using the dual surveillance and strike capability of drones – have been described by many, such as former CIA director Michael Hayden, as one the most accurate and humane forms of targeting, given their precision and small warheads that limit collateral damage.

The Army is not releasing details regarding the platforms, regions or units the armaments being requested would be applied to, saying that information is too sensitive, a contracting employee told Defense Systems.

As such, it is not clear if the Army wishes to arm smaller UAS platforms such as the MQ-5B or the RQ-7B Shadow, or if it wishes to apply the desired technology to the Gray Eagle, potentially freeing coveted size, weight and power requirements for additional payloads.

Army officials have indicated in the past that they are interested in taking weight off of certain UAS platforms to increase payload capacity. Additionally, they have discussed potentially weaponizing the Shadow, an aircraft with a 14-foot wingspan that has been used for surveillance, target acquisition and battle damage assessment.

"Weaponizing Shadow comes at a cost to the commander who now has to maybe trade station time and fuel for a payload," Col. Thomas Von Eschenbach, the director of the capabilities integration center at TRADOC, told reporters last fall. "It depends on what it weighs and what it can do. So at what cost would it take, and what munition would that do? We're not ruling it out [but] on the current Shadow system, that's a challenge."

There has also been talk of changing the armament of the Gray Eagle to include other weapons than just Hellfire missiles.

Responses are due by March 10, 2016.

<https://defensesystems.com/articles/2016/02/29/army-small-weapons-for-uas.aspx>

[Return to Top](#)

**NATIONAL AIR SPACE:**

## **Arizona Senate Working on Bill to Permit Commercial Drone Use**

KSWT-TV Yuma, AZ (2/25, 10:02 p.m. MST) reported in continuing coverage that the growth of drones in Arizona has led to cities and towns passing strict regulations due to fears over safety and privacy. These local laws can prevent commercial drone use, but the Arizona Senate is working on legislation that would allow commercial drone use in the state. KWST mentioned Amazon is testing the use of drones to deliver packages within 30 minutes, and Arizona Sen. John Kavanagh, who proposed the drone bill, said drone deliveries “would be a phenomenal revolution in the way we do business, just like the Internet has revolutionized business.”

[Return to Top](#)

## **Utah Bills Would Allow Law Enforcement to Shoot Down UAVs**

SALT LAKE CITY (AP) — Utah lawmakers' proposed solution to getting recreational drones out of the way of emergency response units?

Shoot them out of the sky.

Legislators throughout the U.S. are working to figure out the best way to regulate drones as they become increasingly prevalent, particularly when it comes to interfering with emergency response work. Other states have proposed shooting down drones, but it hasn't become law, according to the National Center for State Legislatures.

Law enforcement already has some tools to control airspace.

In cases such as wildfires, law enforcement can ask the Federal Aviation Administration to restrict air travel. That could apply to planes and unmanned aircraft, more popularly known as drones.

Drones keep coming, though.

The flying devices interfered with aircraft fighting during more than a dozen wildfires last year, according to the U.S. Forest Service. In 2014, they interfered during just a handful of fires.

State Sen. Wayne Harper, a Republican from Taylorsville, proposed a bill that would allow law enforcement to "neutralize" drones, which could include shooting them, jamming their signals or convincing their operators to move them.

Whether Harper's bill will gain traction remains to be seen. Sen. Alvin Jackson, who chairs the technology committee, said most of Harper's proposal is already covered by state or federal law.

The sponsor of the other Utah bill, Rep. David Lifferth, a Republican from Eagle Mountain, said he came up with the idea after hearing of numerous incidents in which law enforcement had to stop fighting fires because drones flew too close. His bill hasn't been debated yet.

Lifferth said shooting down a drone is the least desirable option for getting rid of an aircraft, as it could be dangerous.

Abby Speicher of DARTdrones Flight Academy, a school that teaches individuals in Utah and across the country about drones, said shooting down these aircrafts could be appropriate in certain dangerous situations

The National Center for State Legislatures doesn't have records of any state that allows agencies to shoot down drones.

A few have tried, though.

Last year, the governor of California vetoed a bill that would have protected emergency personnel from certain repercussions should they damage a drone interfering with their work.

Oklahoma considered a proposal last year that would have allowed property owners to shoot down drones that fly over their property, but it also failed.

A tiny Colorado town let the public vote in 2014 on whether to issue hunting licenses to shoot at drones. It failed nearly 3-to-1.

<http://www.chron.com/business/technology/article/Utah-bills-would-allow-law-enforcement-to-shoot-6855026.php>

[Return to Top](#)

### **Passenger jet forced to make evasive maneuver to avoid smashing into drone**

Passenger jet forced to make evasive manoeuvre to avoid smashing into drone that came within five metres of the plane as it comes in to land in Paris

Air France jet narrowly avoid colliding with a drone flying 5,500ft in the air

The plane was descending to land when the drone was spotted by its wing

A co-pilot was forced to take evasive measures to avoid colliding with it

An Air France Airbus A320 jet narrowly avoided colliding with a drone while descending for an approach to Paris Charles de Gaulle airport last month, it has emerged.

The aircraft had been operating a service from Barcelona on February 19 and was flying at 5,500ft when the co-pilot saw the drone.

He immediately disengaged the autopilot and carried out an evasive maneuver while informing the captain of the drone's presence, the French aviation investigation agency BEA said.

The drone passed just five metres below the aircraft's left wing, the agency said, classifying the incident as 'serious'.

An investigation has now been launched with a focus on how the drone managed to fly unnoticed 5,500ft in the air when French law prohibits them from travelling above 500ft.

Charles de Gaulle airport, located just outside Paris, is also a no-fly zone for the hobby aircraft.

The minimum distance they can be flown near an airfield is three miles, with this extending to nine miles for major airfields.

Flying restrictions also extend to sites of 'strategic' significance - these include nuclear power plants, military installations, historic monuments, or nature reserves and national parks.

Aviation industry group IATA warned last month that civilian drones are increasingly becoming a 'real and growing threat' to the safety of commercial aviation.

In late 2014, France was hit by a spate of mystery drones flying over French nuclear plants.

<http://www.dailymail.co.uk/news/article-3476195/Passenger-jet-forced-make-evasive-manoevre-avoid-smashing-drone-came-five-metres-plane-comes-land-Paris.html>

[Return to Top](#)

## **Dueling drones detect, avoid**

With registered drone hobbyists now outnumbering certificated pilots, it may comfort some that two major manufacturers (including the market leader) have developed consumer drones that can detect and avoid. The initial offerings have limitations—it does not appear that either system is robust enough to detect an oncoming aircraft at a range sufficient to prompt a timely evasive maneuver by the unmanned aircraft—but they do give these small systems some “smarts.”

Market leader DJI (which sells roughly seven of every 10 consumer drones, by some estimates) announced its latest model, the Phantom 4 camera quad-copter, on March 1, hailing a “new era of intelligent flying cameras” in a media release; the \$1,399 quadcopter is equipped with a pair of tiny, forward-facing cameras connected to an obstacle sensing system. If the stereoscopic sensors spot trouble, such as a tree or a wall, the Phantom 4 will steer around the obstacle or hover and await further pilot input.

“Obstacle avoidance also engages if the user triggers the drone’s ‘Return to Home’ function to reduce the risk of collision when automatically flying back to its take off point,” DJI noted. A video posted on YouTube illustrated the Phantom 4’s capabilities, highlighting ease of use.

Yuneec actually beat DJI to the market with a hexacopter introduced in January at the Consumer Electronics Show, where the Typhoon H flew through an obstacle course of fake trees, following a slow-moving mountain biker and adroitly sidestepping a falling (fake) tree. Yuneec’s pitch video shows

Typhoon H navigating around obstacles, and even flying ahead of a moving car, a maneuver the FAA has specifically prohibited commercial UAS operators from attempting. The \$1,799 system uses a similar obstacle avoidance approach to the Phantom 4, with a pair of forward-facing cameras linked to an autopilot powered by Intel.

“A central part of our mission is to bring new and advanced creative possibilities within the reach of everyone,” said Yuneec International CEO Yu Tian, in a January news release. “We’ve engineered the Typhoon H to redefine what customers should expect to pay for a drone with such an array of professional features. At this price point, no other drone comes close to the Typhoon H in terms [of] capability and value.”

DJI and Yuneec are far from alone developing detect-and-avoid technology for small unmanned aircraft. Research and development in similar systems is ongoing. Yuneec has also added another safety feature to the Typhoon: the ability to remain stable and land if one of its six electric motors fails, an ability that quadcopters (by any manufacturer) do not share.

Safe operation of consumer drones is about more than avoiding trees, of course. The FAA, AOPA, and other organizations support the Know Before You Fly education campaign, which gives consumers a quick overview of rules for hobbyists including the need to fly below 400 feet agl, and other restrictions. The FAA also requires registration by new drone owners (including those of us now suffering pangs of buyer remorse, having just bought a Phantom 3). Drones flown for fun must carry a legible number that allows authorities to track down the owner if need be; the registration process also includes a briefing on applicable regulations.

<http://www.aopa.org/News-and-Video/All-News/2016/March/02/Dueling-drones-detect-and-avoid>

[Return to Top](#)

### **NextGen Trail with Conflict Detection Service**

MONTREAL, March 2, 2016 -- Adacel, an industry leader in air traffic automation, announced today it has successfully participated in a Trajectory Based Operation (TBO) and Unmanned Aircraft Systems (UAS) Integration Demonstration Project conducted recently at the Florida NextGen Test Bed at Embry-Riddle Aeronautical University in Daytona, Florida.

The project, sponsored by the Federal Aviation Administration (FAA), serves to further mature TBO concepts through research and development efforts aimed to identify the functional capabilities for integrating Four-Dimensional Trajectory (4DT) operations in the National Airspace System (NAS) using UAS as a platform within Class A airspace. The outcome of the project will include recommendations on updates to concepts, standards and benefits of the future integration of UAS into the NAS, which can be provided to key stakeholders.

One of the objectives of this segment of the project was to investigate trajectory negotiation processes/concepts to resolve conflicts focusing on the En-route phase of flight. Working as part of a team of industry partners, Adacel adapted its Aurora ATM system conflict probe software to work in a Flight Information Exchange Model (FIXM) environment. FIXM is a data interchange format for sharing flight information.

Adacel's Aurora ATM automation system is a global system that manages all types of airspace and is scalable and configurable to meet present and future requirements while incorporating the latest in CNS/ATM technologies. Aurora automation technology is currently in operational use in airspaces controlled by Fiji, France, Iceland, New Zealand, Norway, Portugal and the United States.

<https://globenewswire.com/news-release/2016/03/02/816247/10160633/en/Adacel-Supports-NextGen-Trail-with-Conflict-Detection-Service.html>

[Return to Top](#)

### **FAA Convenes Aviation Rulemaking Committee to Consider Performance Standards, Requirements for Certain Unmanned Aircraft Systems**

The Federal Aviation Administration (FAA) has convened an Aviation Rulemaking Committee to consider and provide recommendations on a regulatory plan to allow certain unmanned aircraft systems (UAS) to operate and fly over people who are not involved in a particular UAS flight mission.

The committee, which is comprised of members of the aviation community, industry representatives, manufacturers, researchers, and academics, is meeting throughout the month of March to develop performance-based standards for classifying certain UAS (previously described as micro UAS weighing less than 4.4 pounds) to allow for such flights to occur throughout regulated airspace in the United States. The committee has been tasked to consider issues such as “current and past research on human injury thresholds, hazard and risk assessment methodologies, and acceptable levels of risk to persons not directly participating in the operation.”

In addition to developing performance-based standards (rather than focusing solely on weight and speed) for classification and operation of certain UAS, in connection with flying over people not affiliated with the UAS operator, the committee is considering manufacturer compliance with any new regulations that are promulgated as well as proposing specific operational provisions to be followed by certain UAS operators. As soon as the FAA receives the committee’s report and recommendations, which are due by April 1, it will proceed with drafting a rulemaking proposal.

In commenting on the establishment of the new committee, U.S. Transportation Secretary Anthony Foxx said “the Department continues to be bullish on new technology...We recognize the significant industry interest in expanding commercial access to the National Airspace System. The short deadline reinforces our commitment to a flexible regulatory approach that can accommodate innovation while maintaining today’s high levels of safety.”

<http://www.natlawreview.com/article/faa-convenes-aviation-rulemaking-committee-to-consider-performance-standards#sthash.r0OT7RVq.dpuf>

[Return to Top](#)

## **PUBLIC SAFETY:**

### **NDSU Breaks Ground with Drones in Ag Research**

North Dakota State's unmanned aerial vehicle program has been and continues to do ground-breaking research since it began in 2014.

The program, led through the NDSU extension service of the Agricultural and Biosystems Engineering department, has conducted research at the Carrington and Williston research centers. It now will be conducting research out of the Hillsboro airport.

Currently, NDSU has four UAVs, two small roto-copters and two small fixed wing aircraft.

In 2014 and 2015, research with UAVs has been mainly on crops. The aims of the research was to collect aerial data of corn and soybean fields and compare it to ground data.

Then, anomalies such as weeds that needed spraying could be spotted and aerial data could become more accurate and practical.

The new UAV, named the Hermes 450, will have a 35-foot wingspan and will have a flight time for around 18 hours at a time, John Nowatzki, an agriculture machine systems specialist and the head researcher of NDSU's UAV program, said.

The goal of the Hermes 450 project will first be to obtain more data for a longer duration, as the roto-copters NDSU has can only fly for about 15 minutes and the fixed wing aircraft can only fly for about an hour.

Secondly, the Hermes 450 can take imagery of about 50,000 acres per hour with a one inch pixel size on the ground, Nowatzki said.

The Hermes 450 will be flown over a 40-mile by 4-mile rectangular area just west of Hillsboro at altitudes of 3,000 feet, 5,000 feet and 8,000 feet collecting ground data.

Nowatzki said the purpose of flying the Hermes 450 at different altitudes is to find out what the most economical way to gather data for farmers is.

#### Problems With UAVs

"It's very difficult to fly these legally," Nowatzki said.

NDSU has to work in conjunction with the Northern Plains Unmanned Aircraft Test Site, which is operated by the North Dakota Department of Commerce and is one of six Federal Aviation Administration approved test sites for UAVs in the country.

The NPUATS has to grant approval for NDSU to fly drones so that NDSU is not in violation of federal law.

The Hermes 450 will also have to be flown with in formation by a manned aircraft, as current FAA rulings dictate that unmanned aircraft are currently not allowed to fly beyond the line of sight.

Another concern is the issue of who would own all of the images that NDSU researchers take with UAVs.

Ultimately, all of the imagery collected will belong to NDSU, in which it will be stored at the Center for Computationally Assisted Science and Technology and will be analyzed by big data researchers.

The imagery will be public record and thus subject to open record laws.

Looking ahead

“As we look to the future, I think lots of farmers will have these, for sure,” Nowatzki said.

Nowatzki added that companies like Elbit will most likely establish business here where they will fly fields and sell farmers the information regarding their fields. Nowatzki also added that in the future, the FAA will also probably loosen flight restrictions, allowing drone operators to fly beyond the line of sight, which is what the current policy is.

<http://ndsuspectrum.com/large-ndsu-drone-take-flight/>

[Return to Top](#)

### **Federal Aviation Authority (FAA) funds research for creating cities that repair themselves**

It was interesting to see that Chris Tuan has received funding from the U.S. Federal Aviation Authority (FAA) to pursue research in his conductive concrete.

Tuan, a professor of civil engineering at the University of Nebraska-Lincoln, devised his concrete almost 15 years ago, but not a lot has happened since then.

His idea is simple. He added either carbon or steel fibers to his concrete to make it conductive. Steel rods were embedded in it and attached to electrodes that connected to a 120-volt AC power source. The concrete warms enough to melt the snow on it.

Demonstration projects — one of them the patio in Tuan's backyard — proved the concept, but nothing much happened until the FAA became interested. They see a possible use for it on airport tarmacs, where snow removal vehicles have to compete with luggage carriers, refueling trucks and other service vehicles. But they're not interested in using it for runways where there is lots of room for plows to work.

The knock on Tuan's original concrete was that it was too expensive. So he's eliminated the carbon or steel fibers and substituted "coke breeze," which is a carbon byproduct of the manufacturing of blast-furnace coke and steel shavings that are considered industrial waste.

Of course, once one turns one's imagination loose, there's no end to the ideas.

Dutch scientists have developed a bio-concrete that uses bacteria and a healing agent to repair its own cracks. Could that concrete be used in buildings in areas that are prone to earthquakes? Or bridges?

What about self-healing surfaces for our roadways? Or imagine small robots flying along, sealing cracks in the road's running surface.

We're well on the way to having drones inspecting bridges, using sophisticated technology to build precise, three-dimensional maps of the underside of bridge decks.

Why not use robotics elsewhere? How about robots swimming endlessly through sewer systems looking for blockages or potential blockages, and taking remedial action when they find them?

After all, we've made great strides in the field of Artificial Intelligence (AI), why not give it to robots?

Robotic inspectors could patrol a city's streets, finding and fixing potholes. They could patrol skies over cities, skimming low over rooftops looking for storm damage, for example, and repairing it on the spot.

They could also weave small-scale suspension bridges for people stranded by floods — or use slings to ferry lightweight materials to replace bridge decks that have washed away.

With urbanization accelerating, with the risk of floods, wildfires, droughts and storms like Superstorm Sandy a few years ago, creating resilient infrastructure is at the front of many municipal engineers' minds.

Resilience can take many forms. It can be as simple as not building on floodplains, or engineered solutions to storm water like rain gardens and storm water retention ponds in parks.

New materials, like the self-healing concrete, are being developed every week somewhere in the world. But we can't leave them to languish in the laboratory or in Tuan's backyard.

We have the technology to develop maintenance bots with the "intelligence" to make repairs, whether it's to a water-main that needs to be relined, or a roof with a storm-damaged membrane.

What we're headed for — or could be, if we have the imagination — is cities that repair themselves.

<http://dailycommercialnews.com/Technology/News/2016/2/CONSTRUCTION-CORNER-Creating-cities-that-repair-themselves-1013752W/>

[Return to Top](#)

**Industrial Networks Launches Rail Automation Drone**

SPRING, Texas

-- Since 2005, Industrial Networks (INet) has transformed the rail industry for shippers and provided tools to automate the complete process of rail and truck shipping. INet's stationary and mobile Automated Equipment Identification (AEI) readers provide pivotal rail and truck shipment management for control over in-plant operations. This automation reduces the occurrence of errors and improves overall productivity for shippers across North America.

In late 2015, INet applied for exemption to Section 333 of the FFA Reform Act in the rail-car inspection and inventory market space and began testing a new drone AEI reader, the INet Rail Automation Drone (IRAD1), which will change the face of rail-yard automation once again. It's a bold plan that requires safety testing and FAA approvals, but will give rail shippers a greater amount of flexibility in their rail-yards. The IRAD1 will be capable of fully autonomous scanning of the rail-yard for inventory and inspection of a rail-car. Built into the drone is an elaborate collision detection and avoidance system to help avoid objects in the flight path and reinforce safety. Research shows these sophisticated systems are highly effective. This tool gives the IRAD1 the ability to be a completely autonomous AEI scanner. This will lead to faster data collection and help the business reduce workforce requirements.

INet's current collection of AEI-scanning tools includes stationary and handheld readers and automates data collection in the field. This is critical in alleviating manual data entry errors and expediting the turnaround of rail-cars within a facility. The addition of the IRAD1 to INet's arsenal of AEI-scanning tools helps the customer create a work environment that is specific for their business.

"Advancement in drone technology has allowed Industrial Networks to explore what we feel is the future of rail automation," said Jimmy Finster, president of Industrial Networks. "We are continuously researching new and innovative ways to help our customers improve their operations and streamline their daily processes."

<http://www.prnewswire.com/news-releases/industrial-networks-launches-rail-automation-drone-300225752.html>

[Return to Top](#)

### **UAV can track humans and animals, fly home to base**

SAN FRANCISCO – The world's largest drone maker is releasing a new consumer drone with camera that can lock onto a person or animal and follow them, avoid objects in its path and fly back to its base on its own.

"It is a pretty big deal," said Colin Snow, an analyst with Skylogic Research, a Redwood, Calif.-based drone analysis company.

The Phantom 4 is available for pre-order beginning March 1. It can run for 28 minutes on a single battery charge and fly up to 45 miles per hour in sports mode. Most of the upgrades to the three pound quad-

copter are incremental, but together they make a compelling buy for hobbyists and semi-professionals, said Snow.

While “you wouldn’t use it to inspect a bridge,” the drone hits a sweet spot among photographers and filmmakers, he said.

The drone features two forward-facing optical sensors that scan for obstacles and automatically direct the aircraft around them.

While a price tag of \$1,399 might seem high for what many consider a toy, it’s actually around what many people pay for cameras at the professional/consumer border, said Snow.

The consumer drone market is projected to reach \$4.6 billion by 2025, according to ABI Research, a technology market intelligence company. They predict more than 90 million consumer drones will ship during 2025, up from 4.9 million in 2014.

Hovers, won't crash

During a demonstration on San Francisco’s Treasure Island, a DJI employee showed how the Phantom 4 wouldn’t throw itself at a group of banners flapping in the wind. Instead, it gently lifted up and flew over them.

When the drone’s pilot tried to get it to crash into the flags, the drone instead hovered in place, waiting to be redirected.

The Phantom 4 also features a “return to home” button that tells the unmanned aerial vehicle to come back to a set landing place, avoiding obstacles along the way.

Useful to filmmakers is a feature that allows users to set it to follow and keep the camera centered on a subject even as it moves.

The software also allows the Phantom 4 to “learn” a person or object that’s pointed out to it. It will then follow the subject, keeping them in the shot even if they change shape or turn.

Beginning March 1 the drone is available for pre-order from DJI online or Apple.com. At the end of the month it will be available from other authorized dealers.

DJI’s main competition in this portion of the drone market is Shanghai-based Yuneec, which Intel invested \$60 million in last year.

GoPro is also moving into the market and there are rumors that Samsung is looking at the drone market, said Brian Blau, a drone analyst with the Gartner Group.

Growing, if somewhat amorphous, market

Personal drones are a growing consumer market, with significant advancements in usability expected in 2016, said Blau.

He expects to see “a whole bunch of new entrants into the market, some of them big name brands. That will likely change the landscape.”

GoPro has already announced it’s moving into the drone market. There are also rumors that Samsung may be working on a drone as well, Blau said.

For now, consumer drones are mostly used for photography and videography. While a niche market, it's one with a large and passionate following.

“That’s a great thing for drones because it can leverage people’s never ending fascination with taking pictures and sharing what’s going on around them in the world with images,” Blau said.

Consumer drones are also popular with hobbyists who do drone racing and obstacle course running. Other uses will come over time "as people figure out all that can be done with them," Blau said.

<http://www.usatoday.com/story/tech/news/2016/03/01/phantom-4-aimed-filmmakers-and-other-amateurs-who-want-ease--flight-features/81131620/>

[Return to Top](#)

### **Offshore ROAV Inspection in N. America**

The multiple work-scope project was completed over the course of two weeks in Newfoundland, Canada.

Cyberhawk used ROAVs to inspect the live flare, the platform under-deck and the roof of the giant concrete gravity base, and conduct numerous thermal surveys in order to maximize the mobilization. A back log of complex inspection and survey work was completed whilst the Cyberhawk team was on the platform.

ROAVs were opted as the preferred method of inspection for this project, primarily to reduce safety risks posed to personnel in the notoriously hazardous, foggy conditions present off the east coast of Canada.

Stringent HSE regulations imposed mean that frequent inspection of offshore assets is required, in order to verify the integrity of the asset and maintain an operating license. Due to the short weather windows available, the speed of ROAV inspection and the ability to capture large amounts of data in a short time presented a significant advantage.

“Carrying out the under-deck inspection work-scope alone would have taken weeks of complex over-side work for a rope access team, or months for scaffolding to be erected. Add to that the challenging weather conditions on the Grand Banks and this would realistically have resulted in an inspection campaign spanning over the whole summer.

“The main advantage that the ROAV had over other access techniques in this instance was its speed and its ability to capture large amounts of inspection information in short periods. Although the ROAV is able

to operate safely in 30kts of wind, during this project we were only able to fly on five out of 15 days due to either fog or gale force winds. The number of areas that were inspected in five productive days proves the speed and efficiency of ROAV inspection.

Headquartered in Livingston, Scotland, and with bases in the Middle East and SE Asia, Cyberhawk carried out the very first ROAV industrial inspection in 2009 and since then, has completed more than 25 world firsts to date, with blue-chip customers in more than 20 countries on four continents.

<http://www.marinetechologynews.com/news/cyberhawk-completes-offshore-inspection-529077>

[Return to Top](#)

### **U.S. Geological Survey plans to use drone to map Cape Cod National Seashore**

EASTHAM — A federal effort to produce better maps more quickly and cheaply with drone technology will get a test run today at Coast Guard Beach.

A small unmanned drone that looks like a model plane will be flown across the beach and over Nauset Marsh to produce three-dimensional, high-resolution maps similar to images you might see with Google Earth software, U.S. Geological Survey research oceanographer Chris Sherwood said.

The National Park Service approved a permit for the use of the drone from Monday through March 20, Cape Cod National Seashore Superintendent George Price said in an announcement Friday. The USGS project is the first authorized use of drone technology for a research project in the Seashore, Price said.

The Seashore spans 44,000 acres of private and public land, crossing the six easternmost towns on Cape Cod, including Eastham.

The USGS also received written permission from the town of Eastham, Mass Audubon and a land trust to fly over and map their parcels within the Seashore, Sherwood said.

The test planned for Tuesday is with a relatively inexpensive drone, costing about \$2,000, with a good camera, and using a careful flight pattern executed by the USGS staff and drone contractor Raptor Maps, Sherwood said. The test run should take less than an hour, he said.

“This is really a proof-of-concept map,” he said.

A drone-produced map could capture images of a beach just before and just after a winter storm to document coastal erosion and better tie changes in the landscapes to wind and wave activity, Sherwood said. The USGS has recently completed a test at Town Neck Beach in Sandwich, under a permit from the town, Sherwood said. Images at the Sandwich beach were taken on Jan. 22 and then on Jan. 25, the day after a nor’easter, and also on Feb. 11, and a “difference map” was produced that showed where sand was lost and gained, he said.

The Raptor isn't the first drone to be used locally in the name of science.

National Oceanic and Atmospheric Administration seal researchers used a hexacopter, a type of drone, in January on Muskeget Island off Nantucket to help count gray seals. In July, Woods Hole Oceanographic Institution scientists used a hexacopter to take photographs of humpback whales in the Stellwagen Bank National Marine Sanctuary, north of Cape Cod. The team also flew the hexacopter, with a sterilized surface, through whale spouts to collect breath samples.

The use of drones has been under strict control in national parks since 2014 because of incidents of drones being used in ways that harass wildlife, bother park visitors and interfere with firefighting aircraft, according to Price. Drones are permitted when the proposed use supports the mission of the Seashore and the National Park Service overall, he said.

Among the reasons for the USGS test is to work through the permitting process and deal with weather and other logistical challenges, Sherwood said.

<http://www.capecodtimes.com/news/20160229/usgs-plans-to-use-unmanned-drone-to-map-cape-cod-national-seashore>

[Return to Top](#)

### **Lightweight Drone Sees in Infrared to Find Lost Hikers**

Woods are good at hiding people. That's great for those who don't want to be found, but for hikers that fall off the beaten path or otherwise find themselves lost, the impenetrability of forests hinders rescue efforts. A new drone, created by Canadian engineer Stefan Weissenberg, wants to help rescue workers find people lost in the woods quickly.

The pilot tosses the cylindrical Sentry drone into the air and then takes control. Video from the drone's HD camera is fed live to screens for a second person to watch. The drone can optionally carry an infrared camera, which is good for finding warm bodies hidden amidst cold nature. The drone folds up into a compact cylinder, thought not in a way as aesthetically pleasing as some other foldaway quad-copter designs. It weighs just barely more than two pounds. With a flight time of 15 minutes, it's useful for scanning an area, but not the kind of drone that can conduct day-long searches on its own.

Built by Weissenberg's Riderless Technologies, the Sentry with infrared camera is priced at about \$5,000 Canadian. Buyers can also pay in Bitcoin. There are other drones in a similar price range that offer infrared capability, though they tend to be less rugged or compact.

Recently, Riderless Technologies teamed with Kaslo Search and Rescue to test the drone in a search for a dummy. The video is delightfully Canadian, from accents to diligently following safety best practices at the end. Watch below:

<https://www.youtube.com/watch?v=MDeGmKh12EE#action=share>

<http://www.popsci.com/lightweight-infrared-drone-wants-to-find-lost-hikers>

[Return to Top](#)

### **3D Crime-Accident Scene Drone System**

With this combination of advanced imaging software and the latest in unmanned aerial vehicles, agencies can rapidly map crime-accident scenes, and simultaneously gather more information than other traditional technologies. Conservatively, even large scenes can be documented in less than 30 minutes and because the system easily fits in the trunk of a car, there is no need to wait for ladder trucks, or manned aviation.

On scene operation is made simple with app based software to which basic details are set, and the software automatically develops the finer details. When ready, the user taps the GO button, the drone automatically flies the mission capturing all necessary photos, returns home, and lands.

After the scene has been captured, the included software will render the high resolution photos into a complete 3 dimensional map. With the map, the scene can be viewed from any position, any angle, and measured from any position or angle. Because the map is based upon actual photos, the scene is true-to-life, and is accurate within an incredible 5mm.

The 3D crime-accident scene drone system comes field ready with the latest in powerful, easy-to-use, off-the-shelf drones that require minimal training and can be used for a host of other applications. The included software operates locally for chain-of-custody preservation, and is compatible with any Windows based computer.

MAXSUR is provider of law enforcement technologies to include unmanned aerial vehicles, surveillance and tactical awareness. For all equipment offered, MAXSUR provides a full complement of training resources.

<http://www.officer.com/product/12167667/uav-direct-3d-crime-accident-scene-drone-system>

[Return to Top](#)

### **Autonomous cloud seeding aircraft successfully tested in Nevada**

A team of Nevada scientists and unmanned aircraft systems (UAS) engineers have successfully flight tested the first-ever autonomous cloud seeding aircraft platform.

Cloud seeding flare tests were deployed from Drone America's DAX8 UAS aircraft flown at a remote desert location outside of Reno, Nevada in early February.

As the first phase in a new industry-academic research partnership between the Desert Research Institute (DRI), Drone America, and AviSight, the test flight of a DAX8 multi-rotor aircraft with attached cloud seeding cargo validates the potential for UAS to significantly enhance airborne seeding operations, explained Adam Watts, Ph.D, the project's lead and an assistant research professor at DRI.

"This is a major milestone," said Watts. "Utilizing our state's FAA test site designation, we were able to fly this advanced aircraft right here in Northern Nevada and verify that UAS are fully capable of carrying active cloud seeding payloads."

The DAX8 is a robust multi-rotor aircraft for commercial and industrial applications. The unique eight-rotor design allows for the DAX8 to carry large payloads, while the advanced software and GPS guidance provide the aircraft with self-stabilizing capability and multi-way-point navigation.

"We are extremely excited to have completed yet another step in reaching our goal of autonomous cloud seeding application," said Mike Richards, President and CEO of Drone America. "Our joint research program with DRI is well on its way to revolutionizing the cloud seeding industry by providing safe airborne seeding with significant potential of providing relief to people in drought-stricken areas."

The next phase of the project will be to conduct flight planning and test airborne flare deployment with Drone America's Savant fixed-wing aircraft, said Watts.

This project is supported through Nevada's Knowledge Fund.

<https://globenewswire.com/news-release/2016/02/24/813794/10160412/en/Autonomous-cloud-seeding-aircraft-successfully-tested-in-Nevada.html>

[Return to Top](#)

## **SENSORS/APPLICATIONS:**

### **DroneBox is a Nest for Drones**

Drones are a set of limitations that fly. Batteries limit how far drones can go, memory limits how much a drone can record, signal strength (and the lack thereof) limits how far drones can fly. The DroneBox, presented by H3 Dynamics at last week's Singapore Air Show, is a way around those limitations: a home for drones, connected to a network of drones, that are together an Internet of Drones.

With DroneBox, a quad-copter lives most of its life inside a landing pad. The top of the box has solar panels to charge the drone, and it can be connected to the grid too. When the drone wants to fly, the roof retracts and the platform elevates, letting the quad-copter fly free. Or not free, if instead the quad-copter is tethered to its home like a dog leashed in the hard, an alert sentry over a very small area. These Droneboxes will connect to other drone boxes, and eventually back to a central control system. This means they can be networked, short-flying drones communicating with other stations in an "internet of drones."

To really work, though, a customer needs to buy a lot of DroneBoxes and set them up over an area. This could be a military that wants to place scouts along a front line, a conservation group that wants to monitor wildlife in remote areas, or an oil company trying to check on the far flung parts of a pipeline. With external power stations and weather monitoring units, as well as wireless data download and

transfer to server, Droneboxes could be a surrogate network of watchers, watched by a relatively small staff of people.

Watch below:

[https://www.youtube.com/watch?v=Y8NJLtcJy\\_Q#action=share](https://www.youtube.com/watch?v=Y8NJLtcJy_Q#action=share)

<http://www.popsci.com/dronebox-is-nest-for-drones>

[Return to Top](#)

## **Drones detect threats such as chemical weapons, volcanic eruptions**

Dow uses drones at its propylene production facility in Freeport, Texas.

Before Dow Chemical got federal approval in 2015 to fly drones through its chemical plants, the company had to hire a helicopter, set up telescopes, or spend days erecting scaffolding to check on potential problems in hard-to-reach places.

“Now within hours we can get high-resolution photos and videos,” says John Flanagan, director of corporate aviation at Dow. “When we get that image, we can zoom in and really make assessments on nuts, bolts, wiring, tie-offs—you name it. It’s like having a human eye a couple of feet away, when really we’re standing off by 100 feet.”

The company has also been flying the drones inside enormous 12-meter-high chemical storage tanks to check for cracks or seal problems. Unlike most aerial photos taken with drones, “the images inside a tank are actually very boring and very dark,” he says. But this is a good thing because any unusual textures in a dark, monochromatic image could be signs of a crack, he says.

After Dow got Federal Aviation Administration approval to fly its small unmanned aerial vehicles, it quickly put three drones to work at plants in Texas and Louisiana—although the firm had already been using the devices for airborne inspections at several sites abroad for the past several years. The company is currently putting only cameras on board the drones, but there are “hot and heavy discussions” about sending other kinds of analytical equipment up to monitor the chemical plants, Flanagan says, for example, to sniff out gas leaks.

As one of the first—if not the first—chemical companies to use drones in this way, Flanagan says Dow has been fielding phone calls from others in the chemical industry who are curious about getting in on the game.

Erupting volcanoes are not exactly the most compliant experimental subjects. Volcanologists often have to study them from afar, using satellite imaging technology to follow the trajectory of ash and sulfur dioxide being spewed into the atmosphere.

Sometimes they even embark on risky missions to collect samples, approaching belching craters on foot or using piloted aircraft. Despite these courageous endeavors, researchers have a patchy understanding

about the chemical composition and atmospheric trajectory of poisonous plumes, says David Pieri, a volcanologist at the National Aeronautics & Space Administration.

Although unmanned aerial vehicles (UAVs) have been used heavily to take impressive video high above erupting volcanoes, this team is the first to systematically penetrate plumes with a variety of gas and environmental sensors.

Over the past two-and-a-half years, they've been flying a squad of U.S. military hand-me-down Dragon Eye drones and other UAVs through the plumes of Costa Rica's Turrialba Volcano.

Turrialba's steady but diffuse belching of poisonous gas has given the researchers a chance to refine their data acquisition techniques at a relatively mellow volcano. "Ultimately we want to fly into larger eruptions," Bland says. "If we transect some more violent eruptions, we could look at plume gradients, velocity, temperature, chemistry—and then map where those emissions go." Mapping those emissions is not just of academic interest—it's essential for post-eruption air safety.

Scientists haven't yet reached a consensus about what levels of volcanic ash are safe to fly in, Pieri says. This has led to some close calls with commercial planes, such as the KLM flight that passed through a volcanic ash plume near Alaska in 1989. The plane plunged more than 3.5 km before the pilot managed to restart its four ash-choked engines.

The work on Turrialba has also given the team a chance to study the volcano's unique chemical fingerprint as it emerges from the crater, before the gases mix with nearby air. In a typical eruption, volcanoes spew large quantities of carbon dioxide, water vapor, and sulfur dioxide, Pieri says. But it's the total suite of gases—including hydrogen sulfide, nitrous oxide, carbon monoxide, and carbonyl sulfide—that reveal characteristics of an individual volcano's underlying magma geochemistry.

The small Dragon Eye drones used to study Turrialba are light, weighing just 3 kg. Their 1-meter wingspan can carry 500 g of miniature analytical instrumentation, which can include cameras; thermal infrared cameras; and sensors for temperature, pressure, humidity, sulfur dioxide gas, carbon dioxide gas, and more.

"What we really want to do is fly a mass spectrometer through a plume," Pieri says, but at 20 kg in weight, even their miniature mass spectrometer is an order of magnitude too heavy for a Dragon Eye. So the team has now outfitted another military hand-me-down, a large Sensor Integrated Environmental Remote Research Aircraft (SIERRA) drone weighing 225 kg, so that it can accommodate the instrument.

Developing drone technology to study active earthbound volcanoes could eventually lay the groundwork for a mission to Venus, Bland says, a planet whose surface is composed almost entirely of volcanoes.

Although researchers have developed gas masks and antidotes to mitigate exposure to chemical weapons, it's best to avoid contact with the toxic agents in the first place. Victims exposed to substances such as sarin or tabun experience headaches, vomiting, and convulsions, not to mention the fact that these nerve agents can rewire neural pathways and cause long-term changes to personality and behavior. Exposure to biological or radioactive threats isn't any better.

Back in 1998, researchers at the U.S. Army's Edgewood Chemical Biological Center were recruited by the Defense Threat Reduction Agency (DTRA) to figure out ways to put chemical weapon sensors on drones.

"Unmanned aerial vehicles are suited for dull, dirty, and dangerous missions," says Britt K. Kelley, unmanned systems integration manager at DTRA. "Our focus is on anything that is a threat. We look holistically at chemical weapon threats as well as other biological and nuclear threats. Our goal is to keep our people out of harm's way the best we can." If the military could use drones to detect chemical weapons before an attack, it would limit troops' exposure.

One of the biggest challenges to developing monitoring systems for drones is that most sensors "are designed to be stationary or hand-carried," Kelley says. "So when you take it and put it at 40, 60, or 100 miles an hour, it's a whole different problem set."

Another challenge is integrating sensor software with drone navigation electronics, so that when a suspicious compound is detected, the drone can be maneuvered into a cloud for optimal detection and collection, says Vince McHugh, a research chemist at Edgewood.

To start with, the Edgewood team has outfitted drones with ion-mobility spectrometers for real-time detection of chemical weapons. According to Kelley, the drones are also equipped with sample collectors that store substances for later forensic analysis and are part of a system of checks and balances.

[Return to Top](#)

## **Google Earth builds textured area maps**

At some point, you've probably used Google Maps to figure out how to get somewhere. If you went to menu and clicked "Satellite," you were able to see physically what your surroundings look like, so you could look for key landmarks. In fact, the concept of satellite imaging was so popular that Google created a whole new application dedicated to it: Google Earth.

Google Earth emerged from Earth Viewer 3-D, a program created by Keyhole Corp., a digital mapping company based in Mountain View, California. Keyhole Corp. was also funded in part by the Central Intelligence Agency. According to a Google press release, Google acquired Keyhole Corp. back in 2004, and thereafter released Google Earth in 2005.

The present application highlights 3-D images that allow the user to explore cities, buildings, bridges, monuments — you name it. Distant galaxies can be explored using Google Sky, a feature introduced in Google Earth 4.2 in August 2007, and the ocean can be explored using Google Ocean, a feature introduced in Google Earth 5.0 in February 2009.

Google Earth images are so detailed that you can clearly see your house, objects in your yard, all pretty accurately. But how does Google Earth get all of these high-resolution graphics? The answer lies in satellite and aerial imaging. We'll focus on satellite imaging here.

Satellite imaging is a process that uses satellites to scan the Earth and gain information about it. Satellites use different sensors to collect electromagnetic radiation reflected from objects on the Earth — passive sensors collect radiation from the Sun reflected on the Earth, while active sensors send out radiation themselves and analyze it after it has been reflected off of the Earth. The difference in reflectivity allows us to identify objects using remote sensing.

Water, for example, reflects little infrared or visible light, while vegetation absorbs visible light, but strongly reflects infrared light.

Satellite images are the result of thousands of pixels that the satellite scanned into rows and columns. The satellite gathers these pixels into a computer file, and the area the file covers is called a scene. Scene sizes vary depending on the type and size of the sensor.

Satellite imaging has many applications — personal, environmental, militaristic. It can be used for weather predictions; it can also help map out enemy terrain.

Google Earth gets their images from satellites like TeleAtlas and EarthSat, which compile photographs and maps into digital form for commercial use. Google Earth images differ from images collected by major satellites in many ways.

With Google Earth images, the image is sharpest in the center and becomes increasingly blurry towards the edges. There is also no time-stamp on Google Earth images, so although they are one to three years old, it is impossible to tell the exact time and date the images were taken, which is essential with images from major satellites.

While compiling images is a major feature of Google Earth, the most challenging thing is transferring those images to your computer quickly and efficiently. One way Google Earth cuts down transfer time is by using your computer's disk cache to store images for places you've already looked at so that when you look at them again, Google Earth doesn't need to re-download the images.

Mipmaps are collections of bitmap images that create the illusion of depth by working within a texture in an inverted pyramid structure. These images stack onto one another in layers, with each layer having twice the resolution of the layer below it. Clip stacks are portions of giant mipmaps that are clipped to a specified maximum size, which speeds up the process since Google Earth relies on the fact that a user only wants to see a portion of the mipmap at a time.

Since the data comes from different sources, it is provided at different resolutions, which is why your town may appear really crisp, while a town in, say, Mexico, is blurry. Google Earth has several countries including the United States, Canada, and the United Kingdom mapped out clearly to the street level, and there is a good amount of information on other regions like Western Europe, India, and Japan, but everything else is hit or miss. While you can zoom in to look at the Egyptian Pyramids in great detail, for example, you can't see where the local grocery is.

There is also controversy that it may provide unwanted information, whether in regard to personal privacy or national and international security. Google has blocked Google Earth in Iran and Sudan since

2007 due to U.S. government export restrictions, and Maroc Telecom, a major service provider in Morocco, has also blocked the application since 2006 for unknown reasons. Other countries such as India, South Korea, and Israel have expressed concern that Google Earth made highly classified locations visible to terrorist organizations, some of which have since been censored and pixelated by Google.

Regardless of how you use it, the images were brought to you through the use of satellite imaging.

[Return to Top](#)

## **Next-Generation Operational Intelligence (OI) Application, Delivering Real-time UAS Situational Awareness**

Simulyze, Inc., a leading provider of operational intelligence (OI) technology and applications that empower both federal and commercial organizations, today announced the launch of Mission Insight™, its next-generation OI application that makes complete situational awareness easy to attain and easy to deploy. A packaged, commercial off-the-shelf (COTS) application, Mission Insight provides unprecedented situational awareness in real-time to unmanned aircraft systems (UAS) management and complex mission planning.

Built on Simulyze's proprietary OI platform, Mission Insight processes and analyzes large streams of data from disparate sources in real-time to provide UAS operators with a common operating picture (COP) in a customized graphical interface. It builds on the success of Simulyze's Flight Control application, which was released in 2000 and was one of the first, comprehensive air, land and sea visualization tools for operators, commanders, mission planners and analysts. Over the last 15 years, Flight Control has been deployed across numerous organizations, including the U.S. military/Department of Defense, the U.S. intelligence community and homeland security.

"As the commercial UAS industry is poised to take flight in the U.S., ensuring the safety of unmanned operations requires integration of vast amounts of disparate data that need to be displayed in a standardized, graphical format," said Kevin Gallagher, president and CEO of Simulyze. "As a packaged, proven COTS application, Mission Insight enables UAS commanders, mission planners and analysts to make better, more strategic decisions in real-time by providing a single, complete operational view of workflow data, from pre-operational planning to post-event analysis."

With the launch of Mission Insight, Simulyze extends its product offerings to commercial, non-military UAS operations. These can include: aerial photography and surveying, agriculture, construction, infrastructure and utilities inspection, emergency management, search and rescue, disaster recovery, and oil and gas exploration.

Mission Insight offers a number of advanced technical benefits, including:

- Highly scalable: Can be deployed in a variety of operational environments, ranging from enterprise server systems to a low-bandwidth single user

Low-bandwidth environments: Complex data filtering, advanced processing and timing techniques enable Mission Insight to prioritize data and allow transmission as low as 2400 baud, even in remote areas

Real-time processing: Built on a sophisticated OI platform, Mission Insight processes and presents data in real-time

Analytics: Delivers a range of analytics, from simple calculations like distance and proximity, to complex terrain analysis including line of sight and intervisibility

Command and control: Contains a tool suite designed for the command and control of remote sensors within the common operating COP architecture

Seamless data integration: Integrates data from a wide variety of sources, including sensory data, weather, Global Positioning System (GPS) tracking, social media data, video metadata, radar intelligence (RADINT), Unmanned Aerial Vehicle (UAV) data, databases, imagery, and signals intelligence (SIGINT)

Alerting: Multiple customizable alerting functions including geo-fences, relative movement, position reports, and keywords

Trusted security: Trusted to process, analyze and safeguard data vital to U.S. national security, including data residing on classified networks

Operational intelligence (OI) is gaining critical mass in multiple industries as companies seek to gain greater insight and visibility into data, streaming events and business operations. The commercial UAS industry is primed for massive growth as the U.S. Federal Aviation Administration (FAA) nears its decision on the use of commercial drones in U.S. air space. According to Teal Group's 2015 market study, the UAS industry is the most dynamic growth sector of the world's aerospace industry during this decade. Its analysts estimate that, once regulations are announced, commercial drones will become a billion dollar industry in the U.S. In fact, by 2025, the industry could total more than \$80 billion, according to the Association for Unmanned Vehicle Systems International.

<http://www.pressreleaserocket.net/simulyze-launches-mission-insight-its-next-generation-operational-intelligence-oi-application-delivering-real-time-uas-situational-awareness/409975/>

[Return to Top](#)

### **The time is now for battlefield 3D printing - UAS ISR**

Military officials see a lot of potential for on-demand 3D printing – or as it's also known, additive manufacturing – on the battlefield. And while there's still a lot to be hashed out, commanders and decision-makers want to get it into the hands of troops sooner rather than later.

“We can use AM now in the short term,” said Scot Seitz of the Army Logistics Innovation Agency, referring to operational opportunities. Specifically, he thinks this technology could be utilized in swarming concepts. “I don’t need any metals production capability...I can produce using plastics and I can impact the operational maneuver space by swarming technologies...so that’s a simple example for near-term operational impact,” he said at an event on Feb 29 hosted by Deloitte.

“We don’t need to wait, in my opinion, to do 3D printing,” Marine Lt. Col. Howard Marotto said. “We want to get the machines out in the hands of the operator right now. Because the thing about ISIS and China and Russia and Iran and you name the country out there, they aren’t waiting. This technology isn’t that expensive on the low end. Anyone can afford it...Maybe [adversaries] make a decoy, maybe they make a bomb, maybe they make an IED – our Marines can do that too.”

Marotto noted that additive manufacturing is at the core of the Pentagon’s Third Offset Strategy. The problem for the Defense Department now and looking ahead, he said, is how to operate in an anti-access/area denial environment. The Third Offset Strategy aims to keep the U.S. military on top of near-peer competitors by leveraging technological advancements and utilizing concepts such as man-machine teaming.

“I will tell you, frankly...AM is the foundation for the Third Offset,” Marotto said. “Levering the technology as agnostic as it is...is really the key if you’re going to operate as a Marine Corps in a distributed ops environment. Everything from being able to print your own parts in stream...to printing your own UAVs for ISR, for weaponization, on site, custom made, with sensors to do that exact mission that you need at that exact moment.”

This concept could offer unprecedented tactical advantages for deployed soldiers. In fact, Army researchers are currently working on 3D printing small unmanned aircraft in the field for ISR.

Other military officials also have talked recently about 3D printing’s potential. “On our event horizon, the 2030 year time frame is we’re looking at 3D printing where the engineering analysis is done for a problem – the part is printed down range and I don’t have to have spares. That’s where we want to go,” Rex Curry, chief of the Logistics Chief Information Office Support Division in the Air Force, said at a January mobile summit hosted by AFCEA.

Officials also note that adversaries also could take advantage of 3D printing’s inexpensiveness, printing what could be used as improvised explosive devices either in the air – by way of small drones – or on the ground. 3D printing enables one to mask the true nature of an object, especially one a small scale.

<https://defensesystems.com/articles/2016/03/02/3d-printing-on-the-battlefield.aspx?m=1>

[Return to Top](#)

**New UAV cameras smaller, lighter and more capable**

GIS solutions have been around for decades, but low cost, high tech drones have increased the market potential so dramatically that what we're seeing now is almost a new industry. Established businesses are being revolutionized, while new opportunities are evolving daily.

But when we speak about these revolutionary drones, what we're really talking about is the payload they carry, i.e. the camera and/or sensing device, and the software that processes the resulting data. Without cameras, sensors and software, drones are just radio-controlled aircraft, like those that hobbyists have been flying for decades. Sure, they now come fully assembled, are less expensive and easier to fly, but the real differentiators — and what matters to the geospatial industry — are the instruments and software sUAVs now carry and use. There's a critical symbiotic relationship between the UAV, its payload and geospatial applications.

In this article, we'll take a look at some of the new cameras and sensing devices that have been specifically designed to serve the industry's emerging and evolving markets.

Parrot, the French-based drone and robot manufacturer, has just announced development of a lightweight multispectral camera called Sequoia. In addition to a 16MP RGB sensor, Sequoia has four 1.2MP sensors that gather near-infrared, red-edge, red and green data. Users can specify high or low-resolution imagery. The device weighs less than 4 ounces and contains 64GB of internal storage plus an SD card.

Sequoia will first be used on-board the fixed-wing eBee UAV to monitor and respond to crop health. Once data are collected from eBee flights, the information can be processed and analyzed by MicaSense's ATLAS software platform. The eBee drone is manufactured by senseFly, a Swiss UAV company, also owned by Parrot. Sequoia is expected to ship in March at a price point of \$3500.

MicaSense, a Seattle-based startup, developed the RedEdge multispectral camera for UAV operations. Parrot backed MicaSense by investing almost \$10 million in the company. This relationship enabled Parrot to use RedEdge technology to build Sequoia, a more affordable and smaller camera. Both the RedEdge and Sequoia drones now use MicaSense's ATLAS software platform to analyze and measure plant reflectance.

RedEdge is priced at \$5900 and has been shipping for about a year. Both Parrot and MicaSense intend to license these cameras to other drone companies.

Flir is a large, established, publicly traded company that has been making thermal imaging cameras for almost 40 years. They have recently introduced three new lightweight cameras specifically designed for UAV operations.

DJI's gimbal technology and knowledge of image transmissions was combined with Flir's thermal imaging expertise to build the Zenmuse XT Thermal Camera. The device provides aerial infrared scanning at 640/30 fps or 336/60 fps when used with DJI's Inspire1 or M100 drones. Both cameras are available with four different lens options. Cost and delivery have not yet been announced.

The DJI Go app provides real time camera controls for color palette selection isotherms, zoom levels and the selection of either video recording or still image capture. Applications include fire fighting, cell tower and substation inspections, and precision agriculture.

Flir also offers two additional thermal devices, the Flir Vue and the Flir Vue Pro. The Flir Vue offers either 336 or 640 pixel resolution and is priced at \$1500 and \$3000, respectively. Both versions have optional GoPro mounting holes but neither is hardware integrated like the Zenmuse XT. In other words, users will need to independently mount the Flir Vue on their UAV.

Like the Flir Vue, the Flir Vue Pro is not an end-to-end hardware solution, but it does have thermal video recording capability. Users have access to in-flight camera controls and output is compatible with applications like Pix4D. Cost is \$2000.

San Diego-based Peau Productions, Inc. has developed a 12-megapixel UAV camera that captures images every 3 seconds. Images taken at 400 feet produce an accuracy of 6.83cm/pixel. The MAPIR camera is about the size and weight of a GoPro Hero camera, at just 2.3 ounces.

Peau Productions has actually created not one camera with these specifications, but a series of six devices. A different lens type distinguishes each camera.

Camera one has a standard lens that sees visible RGB light.

Camera two sees blue and infrared light.

Cameras three through six see infrared, red, green and blue light.

Multiple devices can be mounted on a UAV and, depending on the combination of the cameras, captured images can be used for crop scouting, assessing plant health (ENDVI), identifying different areas of vegetation, surveying and creating photo-mosaic maps.

The most interesting camera is the one you can't buy. Light, a Palo Alto startup, has developed the L16, a point and shoot-sized camera that houses 16 different lenses. It is billed as a \$1700 DSLR replacement. Unfortunately, it's not being delivered because the first production run has sold out. We expect shipments to begin again this summer.

Light describes the L16 as the world's first multi-aperture computational camera. Firmware on the camera merges images from the lenses to form a 52-megapixel image. Depth of field, focus and optical zoom (35 to 150mm) can be adjusted after the photo is taken.

The L16 is not currently being promoted as a drone camera, but considering the image resolution and optical zoom capabilities, it's hard to believe this device won't also be used as an aerial mapping and surveying tool.

Seek Thermal, a startup out of Santa Barbara, has developed several consumer thermal cameras designed to operate with both iOS and Android devices. Their Reveal camera is a stand-alone hand-held version of the Seek Pro. It has a 26-degree field of view and works up to a distance of 500 feet.

Like the Light L16, the Reveal is not currently being used in drone operations. It is however, worth mentioning because a modified version of this lightweight device could be marketed as a low cost alternative to other pricier thermal cameras.

It's interesting to note that none of the cameras and sensing devices in this article were developed by what one might call traditional camera companies, and it's not surprising — disruptive forces almost always come from outside the industry they disrupt. And these cameras are just the first wave. No doubt, lighter, less expensive, more feature-rich devices will be developed by those companies that see the market potential and are nimble and creative enough to build winning products.

<http://www.directionsmag.com/entry/new-uav-cameras-smaller-lighter-and-more-capable/463778>

[Return to Top](#)

### **DARPA's sensor-laden quadcopter zooms around indoors at 45 mph**

A Pentagon research program to develop small, fast, agile unmanned vehicles that could operate in tight spaces indoors recently tested sensor-laden quadcopters that managed to avoid obstacles while hitting their target speed on 20 meters per second (about 45 miles per hour).

The specially equipped quadcopters, developed by three teams of researchers under the Defense Advanced Research Projects Agency's Fast Lightweight Autonomy (FLA) program, were equipped with high-definition onboard cameras and sensors such as LIDAR (the laser-based Light Detection And Ranging technology), sonar and inertial measurement units. The quadcopters were able to navigate a cluttered hangar in Massachusetts without the intervention of operators, outside sensors or GPS, DARPA said in a release.

The goal behind FLA is to give dismounted soldiers a view inside buildings, especially in urban areas, and do it with a minimum of involvement by drone operators. Units such as expeditionary military teams and rescue teams already have UAVs that can provide an eye in the sky to help with situational awareness, but they can't see inside a building that could be unstable or threatening. FLA is working to develop algorithms that will allow small drones to operate independently, gathering images and data inside a building without an operator, who might have other things to do, having to control their every movement.

For the tests, researchers used quadcopters with a commercial DJI Flamewheel 450 airframe, E600 motors with 12-inch propellers and 3DR Pixhawk autopilot, DARPA said. And while showing their speed, the quadcopters also demonstrated a degree of autonomy, although DARPA said it is still looking to improve on that.

On the project, DARPA is working with teams of Draper with the Massachusetts Institute of Technology; the University of Pennsylvania; and Scientific Systems Co. with AeroVironment.

A key to the FLA program is managing to equip small UAVs with the sensors that will allow them to sense their environment and operate autonomously (one future possibility could be replacing lenses, mirrors and other components with light-emitting and -detecting semiconductor dots on wafer-thin discs, an idea DARPA issued a solicitation for in December.)

“Very lightweight UAVs exist today that are agile and can fly faster than 20 meters per second, but they can’t carry the sensors and computation to fly autonomously in cluttered environments,” Micire said. “And large UAVs exist that can fly high and fast with heavy computing payloads and sensors on board. What makes the FLA program so challenging is finding the sweetspot of a small size, weight and power air vehicle with limited onboard computing power to perform a complex mission completely autonomously.”

In future tests, DARPA plans to add more obstacles to the hangar to make the environment more realistic. And although the program is working with quadcopters, the agency said its technology could also be applied to ground, sea surface and underwater vehicles, particularly in areas where GPS signals are contested or denied.

[https://defensesystems.com/articles/2016/02/23/darpa-fla-autonomous-quadcopter.aspx?s=ds\\_240216](https://defensesystems.com/articles/2016/02/23/darpa-fla-autonomous-quadcopter.aspx?s=ds_240216)

[Return to Top](#)

## **COUNTER UAS:**

### **Startup pitches anti-drone launcher as answer to rogue UAVs**

What’s the answer to a drone that has gone rogue and is flying where it shouldn’t? According to Northumberland-based startup OpenWorks Engineering, it’s an air-powered net launcher that fires small anti-drone projectiles.

The SkyWall is a new shoulder-mounted compressed-air launcher that fires shells containing a net and parachute to capture and bring a drone back to the ground without damaging it.

The Northumberland firm’s launcher looks like something out of a computer game, complete with a targeting computer and holographic scope to predict a drone’s flight, which the company says will help law enforcement take out potentially dangerous targets.

<https://www.youtube.com/watch?v=6uu4yoi0TqY#action=share>

The launcher weighs 10kg, uses compressed air and can fire almost silently at drones up to 100m away, reloading in 8 seconds, according to the company.

The efficacy of the SkyWall will rely on the accuracy of the human controlling the launcher, as well as the drone not changing direction after the projectile has been launched.

The managing director of OpenWorks Engineering, Chris Down, said: “OpenWorks Engineering believes that security enforcement authorities need a cost-effective and proportionate way of protecting the public and high-profile individuals and we wanted to put a system on the market that offered just that.”

Drones are becoming an increasingly difficult problem. The small, versatile machines, which can be bought for less than £100, can fly virtually unrestricted over and within sensitive areas. Recent events at airports, the White House, around German chancellor Angela Merkel, and sporting events – where a camera drone narrowly missed downhill skiing champion Marcel Hirscher on a slope in Italy – have highlighted the need for drone control and safety.

The SkyWall is among other technology-based solutions dubbed drone falconry, where a drone fires a net at another drone. Other solutions use radio-frequency jammers to block the control of drones, however, these can interfere with other nearby devices such as radios and mobile phones.

Meanwhile, Dutch police have been training eagles to attack and capture drones, described as “a low-tech solution to a high-tech problem”.

<http://www.theguardian.com/technology/2016/mar/03/british-startup-drone-openworks-engineering-skywall-net>

### **The Rise of Counter-Drone Technology**

Commercially available unmanned aerial vehicles (UAVs), popularly known as drones, appear to be changing the game in regards to aviation. The market for drones has been expanding rapidly, the applications of drones are growing more diverse, and the cost of the machines themselves is dropping. There are plans to try and use drones to revolutionize everything from shipping to border control, and the trend towards greater use of UAVs shows no sign of slowing. However, the growing number of UAVs flying in American airspace is beginning to create a problem for law enforcement and security organizations, due to concerns about drones being used as weapons.

As UAV technology has become more ubiquitous, the fear of drones being used for nefarious purposes has grown as well. For example, it would not be inordinately difficult to strap explosives to a commercial UAV and convert it into a flying bomb. Given that a UAV was able to land on the White House lawn in January 2015, the potential damage that could result from such an attack is a serious national security concern. Additionally, there are fears that drones could be used to intentionally cause passenger planes to crash by flying into their engines. As a result, the growing number of UAVs seen loitering near airports is a persistent cause for concern.

Such fears have given rise to a number of systems meant to counter-UAVs, but these systems are not without their own downsides. Dr. Robert Griffin, Deputy Undersecretary for Science and Technology at the Department of Homeland Security, told The Cipher Brief that, “when you consider the possible consequences of the use of countermeasures in and around critical infrastructure including mass gatherings like sporting events, concerts, or civic events there are considerable technological, legal, and policy challenges.”

This can clearly be seen in the trade-offs that are intrinsic to each type of anti-UAV technology. The most basic type of anti-UAV system simply shoots them out of the sky. While this is both direct and efficient, the falling drone can be a hazard depending on where it crashes.

Other systems use radio frequency (RF) jamming technology to disable or seize control of the UAV's control systems. This capability removes the danger of a falling drone, but that type of jamming technology is legally problematic and can interfere with important civilian technologies – such as medical implants.

By far the most novel approach to disabling UAVs involves training birds of prey to attack them, but this can sometimes harm the birds. These represent just a sample of the systems currently being developed to disable drones, and the anti-UAV industry is likely to be just as robust as the UAV industry itself.

Part of the problem with anti-UAV technology is that those legal and regulatory challenges are proving to be both complex and enduring. Tyler Black and Sean McGowan, of Thompson Coburn LLP, described both UAVs and anti-UAV technology as being in the middle of the “fascinating nexus between aircraft safety and communications regulations, civil tort law, local ordinances, and criminal laws.” The inconsistent patchwork of laws and regulations, which can vary from state to state, has created an environment that is difficult to understand, and even more difficult to navigate. Additionally, the problem is exacerbated by the fact that the technology is changing faster than the law. And the commercial interest in UAVs is likely to continue to promote innovation and rapid change for the foreseeable future.

Drones are not weapons in and of themselves. As Griffin said, “UAVs are not a threat any more than a car, plane or cell phone camera.” Like most technologies, the nature of the UAV threat is entirely dependent upon the people using them. The UAV genie cannot be put back into the bottle, so law enforcement and regulatory agencies will need to learn to adjust to the reality of their existence more nimbly than has been the case thus far.

<http://thecipherbrief.com/article/techcyber/rise-counter-drone-technology>

## **COMMENTARY:**

### **Manned/Unmanned Teaming to Transform the MAGTF**

US. strategic guidance addresses the challenges of a future operating environment categorized by diverse and uncertain threats, distributed across the global commons. Violent extremism, transnational crime, failed and failing states, and emerging near-peer competitors are just a few of these challenges. Add to that the increasing proliferation of anti access/area denial (A2/AD) tools and the explosion of new and emerging technologies on the open market, those “other duties as the President may direct” become more complicated to execute.<sup>1</sup> The MAGTF must possess the capability and capacity to meet that challenge.<sup>2</sup>

The Threat Has Evolved

Existing and emerging technologies are fueling an explosion in commercially available robotics and autonomous systems (RAS). This has created an environment in which states and non-state actors alike have gained access to tools which provide potential adversaries the ability to offset both current and future MAGTF capabilities and disrupt our operational concepts.<sup>3</sup> Many of the advertised capabilities envisioned in EF 21 are either delayed or aspirational, exposing a gap that has provided a sanctuary for prospective enemies. Left uncorrected, this poses a severe threat to MAGTF operations.<sup>4</sup>

Rand senior analyst, David Ochmanek, said this regarding the growing capabilities of the near-peer threat:

Of particular concern for future U.S. power projection operations is the accelerating proliferation of systems and concepts aimed at impeding U.S. forces' access to key regions in Eurasia and dramatically raising the risks and suppressing the operating tempo of those forces that do deploy forward. Key elements of these anti-access/area denial (A2/AD) strategies are: accurate ballistic and cruise missiles; dense, integrated surface-to air defenses; large numbers of modern 4th generation fighter aircraft and capable air-to-air missiles; near-real time surveillance and reconnaissance systems; hardened, redundant command and control networks; electronic warfare (jamming) systems; anti-satellite weapons; and cyber weapons.<sup>5</sup>

The rise of advanced capabilities designed to negate our current operational concepts is disconcerting but well known. More troubling is the threat of extremely inexpensive, commercially available communications tools and RAS. These types of systems create parity for state and non-state actors alike, and provide the means to affect the battlespace over large distances with little chance of detection and interdiction<sup>6</sup>—one only has to look at ISIL's (Islamic State of Syria and the Levant) rapid spread and many tactical successes across the Middle East to see how commercial off-the-shelf (COTS) technology is changing the modern battlefield.<sup>7</sup>

The time has come to re-envision our MAGTF concepts of operation and to adjust to the threats as the threats have adjusted to us. Once again, adaptation and innovation must become the hallmarks of the Marine Corps as we leverage technology at the tactical edge and enable our Marines to be successful on the modern battlefield. The currency of warfare is the O311 rifleman, and we must focus on innovative ways to team RAS with the individual Marine rifleman in an integrated fashion that takes the best of man and machine to create a more effective asset. Ultimately, this seamless manned-unmanned teaming (MUM-T) will provide our MAGTF the means to obtain and maintain a new competitive advantage.

#### Evolution vs. Revolution

A study of modern warfare suggests that whoever is first to combine new technologies with disruptive doctrine can gain a decisive advantage. Conversely, a military that is slow to adapt new ways of fighting to technological advance opens itself to catastrophic defeat.<sup>8</sup>

Many contend that innovative platforms, like unmanned aircraft systems (UAS), the MV-22 Osprey, and the F-35 Lightning II, are "revolutionary." In truth, they are merely evolutionary advances in existing

technology, as doctrine has yet to change dramatically because of the introduction of these capabilities. The “drone” was invented in order to more effectively conduct persistent surveillance and reconnaissance than existing platforms, yet does so in much the same fashion as manned aircraft. Indeed, the Marine Corps focus on small tactical UASs—at the expense of more capable platforms<sup>9</sup>—has left an enormous gap in ability to provide persistent battlespace awareness, long-range command and control, and precision fires to the MAGTF commander. The MV-22 was created as a means to project forces farther and faster than the conventional helicopter, with little regard to other aspects of MAGTF operations, outstripping the capabilities of the majority of the ACE to provide escort. Even the F-35, with its superior sensor fusion and situational awareness, will be operationally employed in much the same manner as its fourth predecessors, providing little improvements in speed, range, or persistence. Further, if a MAGTF commander seeks to employ the F-35 to execute distributed STOVL operations, he will be extremely challenged by the capability gaps described above. Thus, while these systems have all been significant steps forward in capability, they have not lead to a dramatic revolution in military technology on par with the development of the tank or the aircraft carrier.<sup>10</sup>

In the meantime, the DOD has spent billions in research and development on programs that were touted as “revolutionary,” but fallen well short of desired results and/or resulted in dramatic cost overruns.<sup>11</sup> Senator John McCain stated the following regarding our current acquisition methodology:

[Let me] ...describe root causes of why big programs fail: aggressive promises for “revolutionary” capability; poorly understood or fluid requirements; unrealistic initial cost estimates; overly optimistic schedules and assumptions; unreliable manufacturing and integration risk assessments; starting major production with an immature design or unproven critical technologies; and poorly performing government and industry teams.<sup>12</sup>

The DOD has a terrible track record when it comes to acquiring viable, cost-effective, military capabilities in a timely manner. And, when a new capability is fielded, it is rarely revolutionary. Worse, with the rate of advancing technology and long time lag for fielding new programs of record, any advantage gained is often negated by time, during which potential adversaries can develop countermeasures.<sup>13</sup>

To counter this trend, future Marine Corps acquisition strategy should augment established programs of record with readily available, rapidly fielded RAS solutions to increase the individual capabilities of our advanced, but limited, manned systems. The inclusion of RAS, as a series of “stepping stones,” will compensate for gaps in manned systems’ capabilities and capacity. The Marine Corps should look to field and integrate affordable, high technology readiness level RAS while simultaneously developing an effective MUM-T concept of employment. Acknowledging existing gaps within our manned systems capacity and capability legitimizes an increased investment of science and technology dollars toward the integration of RAS capabilities to fill these shortfalls. By adopting this strategy, the Marine Corps could expedite an increase in fleet capabilities in a timelier manner than the legacy method of spiral upgrades—that take years to materialize—while also increasing capacity for global engagement.

Significant changes in the military and political capabilities of naval forces have come when long-existing technologies were eventually refined and integrated. It is the final integration of several technologies that came quickly in some cases. In other cases an essential component was lacking from the ensemble, but by itself would have been useless. Certainly, no single technological “breakthrough” has brought immediate change in naval capability.<sup>14</sup>

To be clear, a deliberate and workable integration of RAS into our scheme of maneuver is required to achieve the vision laid out in our capstone concept. Applied properly, an effective MUM-T concept of operations would prove disruptive to the point of initiating a revolution in military affairs. However, to jump to this conclusion without looking at the situation as an evolutionary process would be to ignore years of historical experience in introducing other technologies, such as the tank, helicopter, and aircraft carrier. As before, the innovative application of technological advancements must strengthen our currency—that O311 rifleman—and provide better ways to accomplish the mission. An accelerated development and integration of RAS can not only mitigate identified capability gaps of some of our manned platforms but also ultimately enhance the effectiveness of our Marines.

Should the Marine Corps attempt to abruptly supplant existing capabilities with RAS, as a standalone innovation, we are likely to fail.<sup>15</sup> At the same time, we cannot continue to pursue programs that take a decade-plus to field—with the guarantee that the technology will change every five to ten years—and with ever increasing costs. A logical compromise is a measured integration of RAS, through rapid acquisition programs, and an aggressive embrace of MUM-T. Only then, will the MAGTF truly derive a set of capabilities to effectively meet the complete spectrum of future conflict.

#### Envisioning Employment: MUM-T in Practice

As previously highlighted, introducing RAS into Marine Corps concept of operations is not the panacea to address the diversity of threats across the operating environment. Just as no one will argue that victory against a counterinsurgency can be achieved solely through employment of stealth fighters and bombers, it is equally unreasonable to propose that a fleet of UAS alone is the answer to the A2/AD threat. However, the Marine Corps could quickly invest in multimission UAS that could—through effective MUM-T—greatly complement stealth fighters and bombers,<sup>16</sup> allowing manned assets to become significantly more survivable in an A2/AD environment. In the same vein, long-range, long-persistence UAS, configured with appropriate sensors and digital datalink interfaces, could increase situational awareness in an asymmetric operating environment and act as battlespace manager for any number of manned platforms. This increased awareness would effectively minimize the amount of time manned assets would be required in the objective area, reducing risk to aircrew, while increasing efficiency by minimizing the amount of flight hours required. The second order effect becomes an overall reduction in the need for additional airborne refueling capacity. In total, this would result in significant cost reduction and an increase in efficiency for the entire MAGTF.

The Marine Corps must shed the preconception that RAS are (a) purely intelligence assets and (b) tools limited to the three “D” missions—dull, dirty, and dangerous; and (c) a threat to existing programs of record and manned aviation writ large. Those are artificial assumptions. They limit any potential for

innovative applications in the context of MUM-T and retard the growth of what could be a cornerstone of future Marine Corps operational concepts.

If the F-35 are conducting distributed STOVL operations, the unmanned assets could provide mission essential aerial reconnaissance of the 3,000-foot mobile forward aerial refueling and rearming points, provide critical digital command and control, and serve in an on-call fire support role—while also, if necessary, leveraging these same 3,000 foot runways to rapidly refuel and rearm before lifting again for another 24 hour or longer, multithousand nautical mile mission. Ultimately, combining the persistence and battlespace awareness of UAS, with the deliberate, focused efficiency and lethality of the F-35, increases the survivability and effectiveness of precious resources and, most importantly, gives that 0311 the protective blanket of situational awareness and responsive fires.

MV-22 Osprey. Without question, the advent of the MV-22 has increased the reach of the MAGTF by a factor of 10. This has facilitated an expansion of the MAGTF commander's area of responsibility, and combatant commanders recognize this. Senior Marine Corps leadership has found creative ways to keep Marines engaged with the resources available.<sup>17</sup> However, our special purpose MAGTFs, and MEUs alike, are lacking an accessible and responsive asset that can penetrate threat airspace ahead of the MV-22, and provide greater awareness of the operating environment.<sup>18</sup> The need for critical intelligence preparation of the operating environment and the battlespace awareness necessary to provide critical information necessary to make informed decisions is more acute than ever.<sup>19</sup> Presently, emergent and crisis response missions are reliant on joint assets for support. Aside from the critical shortage of such assets, our reliance on Joint and theater resources is a complicated endeavor, as they are rarely integrated into the MAGTF scheme of maneuver and lack adequate levels of interoperability (many times due to Marine Corps shortfalls) to be effective. The teaming of the MV-22—and the raid force in the back—with a long-range, long-persistence, electronic warfare equipped UAS would enable a greater awareness, while also introducing the ability to deny and degrade the threat's ability to detect our forces. Without this integration, our commanders incur unnecessary risks in making assumptions about the threat environment, the landing zones, and the nature of the enemy itself.

Maritime domain awareness. Within an A2/AD environment, the ARG-MEU team is also extremely vulnerable to the latest generation of cruise missiles.<sup>20</sup> The defense of the ARG-MEU from this threat is missing a critical persistent airborne detection system to provide ample advance warning of inbound missiles. However, a long endurance UAS, with the appropriate size, weight, and power, could digitally link with other surface assets of the ARG to act as that over the horizon detect and track system, much in the same manner as an E-2D works with the carrier strike group. If the UAS were to be equipped with an effective kinetic kill system, such as General Atomics' 150 kW laser system designed for the Predator C Avenger UAS, then the UAS could become the persistent, over the horizon, protector of the ARG-MEU team.<sup>21</sup> This frees up the F-35 to focus on the more traditional DCA missions—as previously highlighted—as well as close air support and electronic warfare support for long-range raids or assaults.

Distributed operations. While examples of the benefits of MUM-T with respect to aviation functions are sufficiently compelling, there are also efficiencies that can be gained from incorporation within the land domain, specifically distributed operations.

At the squad level, robotic followers can carry provisions, ammunition, and provide detection to protect and inform the individual Marine. Our Corps' explosive ordnance disposal (EOD) community has extensive experience with MUM-T. Armored unmanned ground vehicle (UGV) scouts can be networked and controlled to provide increased fire support.<sup>22</sup> Further incorporation of UGVs will enable mission accomplishment and save lives, as any EOD Marine with Iraq or Afghanistan experience will state without hesitation. Unlike current engagements where a Marine is required to physically breach a door or clear a building, the robotic system would incur the risk, allowing the infantry Marine increased situational awareness and a safer position from which to act. The same could be stated for our reconnaissance units, who would benefit greatly from a mix of locally employed and networked small tactical UASs and UGVs, employed around the perimeter of vulnerable, small unit positions. These systems could provide early warning of an attack to inform leaders as to the nature and intent of the enemy, while also providing a critical, real-time network bridge between ground forces and higher headquarters. Depending on the system, they could also absorb the attack prior to effects on friendly forces.

The benefits of MUM-T extend to the artillery as well. Currently, our supporting artillery and mortar forces lack precision situational awareness in the impact area and have an inability to strike moving targets. Efforts by the Office of Naval Research (ONR) have demonstrated "swarms" of small, tube launched UAS, called "LOCUST," which could enhance current 155 millimeter howitzer and 81 millimeter mortar fires significantly by launching persistent small tactical UASs over the target area and then using that real-time imagery to conduct precision corrections without the need of a traditional forward observer.<sup>23</sup> Conceptually, artillery launched LOCUST will mitigate the challenges of operations in an urban environment, as swarms of small kinetic UASs could loiter in the objective area for several hours, providing immediate responsive fires to the MAGTF.<sup>24</sup>

Command and control. Any discussion that leads to the creation of a more effective MAGTF through the integration of RAS would not be complete without discussing the benefits in terms of revolutionizing the Marine Corps command and control system, which is yet another gap in the current vision. This is the greatest vulnerability within the MAGTF and requires the most amount of attention. Future engagements will forever necessitate a continuation of the Marine Corps' hallmark close integration of air, ground, and logistics, but will also require integration with cyber and electronic warfare in order to truly employ 21st century combined arms. Our aging, legacy command and control architecture is vulnerable to modern threats that exist within the A2/AD environment. The reliance upon single channel UHF and VHF communications is a shortfall easily exploited by a modern adversary, as demonstrated by the Russians in eastern Ukraine.<sup>27</sup> Additionally, the large infrastructure required to enable a MAGTF's command and control network is susceptible to individual failures, which cascade to disable the greater network as whole.

Integrating digitally networked RAS would reduce these complicated—and at times cumbersome—systems to manageable, agile networks that provide seamless and survivable connectivity across the MAGTF, leading to higher levels of shared awareness. As an example, existing plans call for less than 10 percent of the MAGTF's MV-22s to have "tactical satellite" and "tactical gateway" capabilities beginning in 2018 and will steadily increase across the MV-22 fleet by 2031.<sup>28</sup> We can bridge this gap, as early as

2018, incorporating a cloud of highly-persistent, low-cost, long-endurance UAS as network relay nodes, in conjunction with individual UASs and UGVs that provide network connectivity down to the squad level. Leveraging this digitally interoperable, extended range network would transform the GCE in much the same way as sensor fusion has transformed the ACE from a fourth generation to a fifth generation level of awareness. This “balancing” of awareness is the critical lynch-pin in the evolution of the MAGTF and is ultimately the capability that will transform our foundational operational construct from merely a cooperative air, ground, and sea capability, into to a fully integrated and efficient 21st century combined arms force.

Significant enhancements will be found within the sea as well. Today, there are efforts by the ONR to develop unmanned surface vehicles (USVs), which defend larger manned assets, such as destroyers and carriers.<sup>29</sup> This benefits the Marine Corps, as part of an integrated naval force. USV arsenal ships, sailing in formation with their manned counterparts in the ARG, would increase its overall lethality and effectiveness and provide a critical defensive edge against advanced enemy missile systems. These arsenal USVs would also provide enhanced, long-range call-for-fire capabilities for expeditionary forces with ship-to-shore fires the likes of which have not been seen since the days of the Iowa class battleship. Meanwhile, unmanned undersea vehicles (UUVs) would be capable of autonomously tracking enemy submarines and ships, creating “hunter-killer” teams between the ARG and an unmanned subsurface force. They could also be used as a means to deliver reconnaissance and Marine special operations teams to the shore, undetected. This cumulative capability equates to exponential increases in lethality and survivability of the ARG-MEU and enhances the ability to maneuver within the littorals to deliver forces ashore more efficiently.

## Conclusion

Ultimately, the rapid introduction and eventual evolution of MUM-T will dramatically enhance the Marine Corps ability to influence and engage on the world stage. With the growing, multi-axis threats that face our Nation today, it is imperative that we find the means to be present in more places than ever before, with capabilities that far outmatch our enemies. It is equally important, given the reduction in defense spending, that our Corps find a more economical approach to the sustained conflict against global extremism, while preventing the overuse of capabilities designed to deter and defeat a near-peer threat. The effective integration of RAS with manned platforms, through MUM-T, and the development of concepts of operations, which supports and embraces RAS as a critical enabler, will create the conditions for our future success, and will ultimately prove essential to realizing both EF 21 and The Cooperative Strategy for 21st Century Seapower.<sup>30</sup>

[https://www.mca-marines.org/gazette/2016/02/mannedunmanned-teaming-transform-magtf?utm\\_source=Vocus&utm\\_medium=email&utm\\_campaign=promotions%40mca-marines.org&utm\\_content=Final+MUMT&vsmaid=8413&vcid=17359](https://www.mca-marines.org/gazette/2016/02/mannedunmanned-teaming-transform-magtf?utm_source=Vocus&utm_medium=email&utm_campaign=promotions%40mca-marines.org&utm_content=Final+MUMT&vsmaid=8413&vcid=17359)

[Return to Top](#)

**How a Robotic Octopus Could Help Us Control Autonomous Drone Swarms**

Evolution goes like this: cockroach, octopus, robot swarm. At least, that's the rough impression I got after talking to James Crowder, a Raytheon engineer who's working on solving the problems of artificial intelligence.

Crowder's focus is on systems that reason and learn on their own. For a decade, this meant building a robotic cockroach that's afraid of light. Now, it means an octopus-inspired robot with a central brain that filters responses from smaller sub-brains. In the future, lessons from this octo-bot could power autonomous swarms of drones.

"My thought is that if I can't build self-evolving lifeforms at the cockroach level, I'll never build C-3PO," Crowder told Popular Science. "Can I build something that will self-adapt at a lower brain level, because if I can't do it at that level, I'll never do it at an adult human level."

His robo-roach is a success: it can detect light, and moves away from the light either by turning or, if it can't turn, by backing up.

So why the leap from roach to octopus?

"A biologist suggested I try a distributed brain model like an octopus," Crowder said, "because an octopus has like mini-brains in each leg and then a central mediator that mediates how they interact with each other and how they work. The mediator carries the objectives and goals but each of the other distributed neuro pieces does what it needs to to accomplish those."

This is cool science, but Raytheon isn't into research just because it's interesting. Going from a roach to an octopus (or, currently, a two-limbed robotic dipus) will teach the defense giant how to make better, smarter drones.

"Right now it takes multiple people to run one UAV," said Crowder. "We'd like to get to where one person can run multiple UAVs, but that requires them to have some degree of autonomy."

So if drone swarms are going to be a thing, with humans controlling multiple robots all at once, then robots are going to have to handle the basic tasks themselves. And to do that, they're going to need to learn from a robotic octopus.

<http://www.popsci.com/raytheon-engineer-is-learning-for-octopi-to-build-autonomous-robots>

[Return to Top](#)

## **DARPA Announces VTOL X-Plane Phase 2 Design**

Unorthodox unmanned aircraft would push the limits of technology to combine plane-like speed and helicopter-like agility into one breakthrough vehicle

DARPA's Vertical Takeoff and Landing Experimental Plane (VTOL X-Plane) program seeks to provide innovative cross-pollination between fixed-wing and rotary-wing technologies and by developing and

integrating novel subsystems to enable radical improvements in vertical and cruising flight capabilities. In an important step toward that goal, DARPA has awarded the Phase 2 contract for VTOL X-Plane to Aurora Flight Sciences. Click below for high-resolution images.

For decades, aircraft designers seeking to improve vertical takeoff and landing (VTOL) capabilities have endured a substantial set of interrelated challenges. Dozens of attempts have been made to increase top speed without sacrificing range, efficiency or the ability to do useful work, with each effort struggling or failing in one way or another.

DARPA's VTOL Experimental Plane (VTOL X-Plane) program aims to overcome these challenges through innovative cross-pollination between fixed-wing and rotary-wing technologies and by developing and integrating novel subsystems to enable radical improvements in vertical and cruising flight capabilities. In an important step toward that goal, DARPA has awarded the Phase 2 contract for VTOL X-Plane to Aurora Flight Sciences.

[https://www.youtube.com/watch?v=3b\\_YQgfa7OA#action=share](https://www.youtube.com/watch?v=3b_YQgfa7OA#action=share)

"Just when we thought it had all been done before, the Aurora team found room for invention—truly new elements of engineering and technology that show enormous promise for demonstration on actual flight vehicles," said Ashish Bagai, DARPA program manager. "This is an extremely novel approach," Bagai said of the selected design. "It will be very challenging to demonstrate, but it has the potential to move the technology needle the farthest and provide some of the greatest spinoff opportunities for other vertical flight and aviation products."

VTOL X-Plane seeks to develop a technology demonstrator that could:

Achieve a top sustained flight speed of 300 kt to 400 kt

Raise aircraft hover efficiency from 60 percent to at least 75 percent

Present a more favorable cruise lift-to-drag ratio of at least 10, up from 5-6

Carry a useful load of at least 40 percent of the vehicle's projected gross weight of 10,000-12,000 pounds

Aurora's Phase 2 design for VTOL X-Plane envisions an unmanned aircraft with two large rear wings and two smaller front canards—short winglets mounted near the nose of the aircraft. A turbo-shaft engine—one used in V-22 Osprey tiltrotor aircraft—mounted in the fuselage would provide 3 megawatts (4,000 horsepower) of electrical power, the equivalent of an average commercial wind turbine. The engine would drive 24 ducted fans, nine integrated into each wing and three inside each canard. Both the wings and the canards would rotate to direct fan thrust as needed: rearward for forward flight, downward for hovering and at angles during transition between the two.

The design envisions an aircraft that could fly fast and far, hover when needed and accomplish diverse missions without the need for prepared landing areas. While the technology demonstrator would be

unmanned, the technologies that VTOL X-Plane intends to develop could apply equally well to manned aircraft. The program has the goal of performing flight tests in the 2018 time-frame.

Aurora's unique design is only possible through advances in technology over the past 60 years, in fields such as air vehicle and aeromechanics design and testing, adaptive and reconfigurable control systems, and highly integrated designs. It would also be impossible with the classical mechanical drive systems used in today's vertical lift aircraft, Bagai said.

The Phase 2 design addresses in innovative ways many longstanding technical obstacles, the biggest of which is that the design characteristics that enable good hovering capabilities are completely different from those that enable fast forward flight. Among the revolutionary design advances to be incorporated in the technology demonstrator:

Electric power generation and distribution systems to enable multiple fans and transmission-agnostic air vehicle designs

Modularized, cellular aerodynamic wing design with integrated propulsion to enable the wings to perform efficiently in forward flight, hover and when transitioning between them

Over-actuated flight control systems that could change the thrust of each fan to increase maneuverability and efficiency

"This VTOL X-plane won't be in volume production in the next few years but is important for the future capabilities it could enable," Bagai said. "Imagine electric aircraft that are more quiet, fuel-efficient and adaptable and are capable of runway-independent operations. We want to open up whole new design and mission spaces freed from prior constraints, and enable new VTOL aircraft systems and subsystems."

Image Caption: DARPA's Vertical Takeoff and Landing Experimental Plane (VTOL X-Plane) program seeks to provide innovative cross-pollination between fixed-wing and rotary-wing technologies and develop and integrate novel subsystems to enable radical improvements in vertical and cruising flight capabilities. In an important step toward that goal, DARPA has awarded the Phase 2 contract for VTOL X-Plane to Aurora Flight Sciences. Click below for high-resolution images.

<http://www.darpa.mil/news-events/2016-03-03>

[Return to Top](#)