UNMANNED
SYSTEMS

SENSE
AND
AVOID
SYSTEMS
ADVANCE

Progress in development of sense and avoid technologies for unmanned aerial vehicles is bringing them closer to integration into the National Airspace System.

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SPECIAL REPORT:
UNMANNED
SYSTEMS
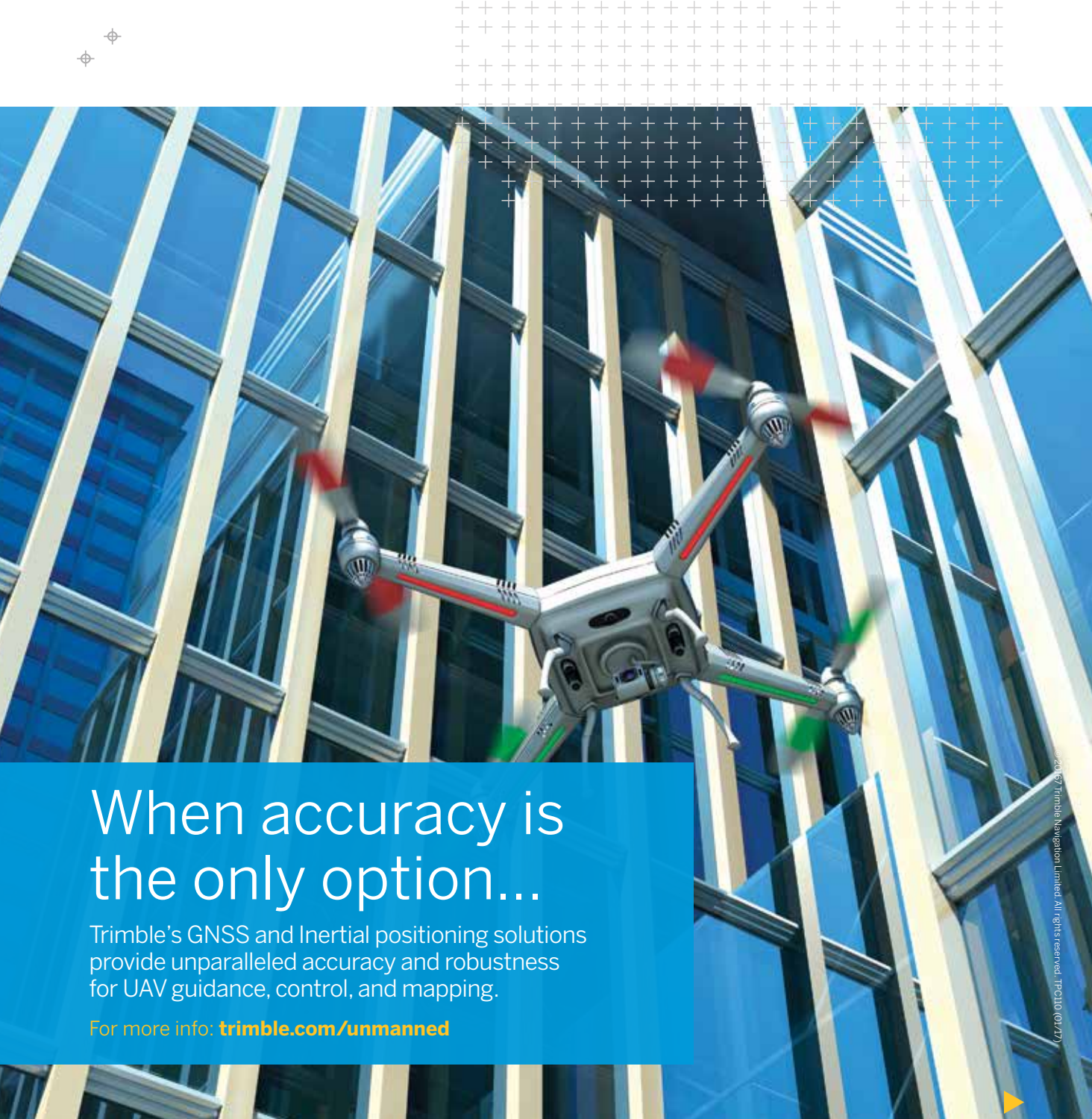### *IN THE*
OIL & GAS
INDUSTRY

More and more industries are using the technology, including the oil and gas industry.

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Brian Wynne
**PRESIDENT AND CEO,
AUVSI**

The Remote Pilots Council's immediate goals are to bring AUVSI members together to provide feedback on real-world UAS operatioans.

That includes clarifying and offering suggestions for greater efficiency in the FAA's UAS waiver process.

AUVSI's Remote Pilots Council
gives commercial operators a voice

By the end of this year more than 600,000 commercial unmanned aircraft systems will take to the skies operated by FAA-certified remote pilots. To meet the unique needs of this new and growing community of professional aviators, AUVSI has established the Remote Pilots Council.

As you will read in this issue of *Unmanned Systems*, the council, which is comprised of AUVSI members throughout the United States, will discuss how to ensure the safe and responsible integration of UAS into the nation's airspace.

The RPC's immediate goals are to bring AUVSI members together to provide feedback on real-world UAS operations. That includes clarifying and offering suggestions for greater efficiency in the FAA's UAS waiver process. Going forward, the RPC will identify and review operational challenges and potential solutions that can be addressed through FAA rulemaking.

Already, the RPC has held meetings with local AUVSI chapters in San Francisco, Denver, Washington and Chicago, with more planned in other cities throughout the year. These meetings provide a forum for council members to meet with their peers and FAA officials as they set an initial agenda.

When the small UAS rule, also known as Part 107, was implemented last August, it established a clear regulatory framework, which has helped reduce many barriers to commercial and civil operations. Additionally, the FAA has set up an online process for UAS operators to request a waiver and/or airspace authorization to fly outside the requirements of the rule. In the past several months, the FAA has approved hundreds of waivers, permitting UAS operations such as flying at night, over people, from a moving vehicle or aircraft and beyond visual line of sight. The RPC will play an important role for the UAS industry by providing feedback to the FAA on the current set of waivers, as well as recommending new waivers for other types of operations in advance of further regulations.

Another aspect of AUVSI's Remote Pilots Council, and perhaps the most important, is helping to increase airspace safety. The implementation of the small UAS rule has provided a guide for developing the necessary tools and training to create a culture of safety around the use of UAS.

As the FAA certifies more remote pilots, they will become part of the aviation community, which I have been a member of for more than 24 years as a commercial pilot and, recently, a Part 107 remote pilot. They will foster aviation's long-standing principles of airmanship and self-policing to promote safety and discourage careless and reckless operations.

The small UAS rule did not come about overnight. It took industry and government working together to embrace and accelerate innovation. These efforts continue today as we look for ways for UAS to fly higher and farther. AUVSI's Remote Pilots Council, working collaboratively with the FAA, will help pave the way for a true, holistic plan for full UAS integration into the airspace.

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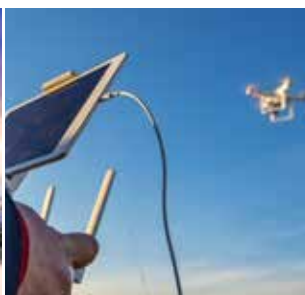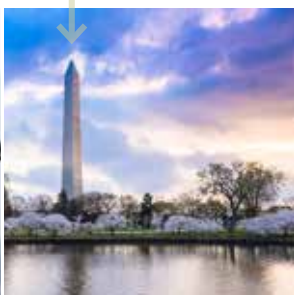1800 Presidents Street
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CONTENT

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ASSOCIATION**EVENTS**

FEATURED EVENT

Rocky Mountain Unmanned Symposium

March 7 - 8, 2017
Denver, Colorado
AUVSI Chapter Event

Increasing Endurance:
How Increasing Power Sources Can Improve Your Bottom Line
March 15, 2017, 11:00 AM - 12:00 PM EST
AUVSI Webinar

Imagery Payloads:
Strengthening Your Business with Images Captured from
Unmanned Vehicles April 5, 2017, 3:00 PM - 4:00 PM EST
AUVSI Webinar

AUVSI XPONENTIAL 2017
May 8 - 11, 2017
Dallas, Texas

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

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

INDUSTRY**NEWS**

Intel Acquires Stake in HERE
Will Work on Mapping Technology for Driverless Vehicles

Computing giant Intel, automotive company BMW and tech firm Mobileye say they plan to have 40 self-driving test vehicles on the road by the second half of this year.

"Making autonomous driving a reality for our customers is the shared ambition behind our cooperation with Intel and Mobileye. This partnership has all of the skills and talent necessary to overcome the enormous technological challenges ahead and commercialize self-driving vehicles," says BMW board member Klaus Fröhlich.

Intel also announced it will acquire a 15 percent ownership stake in HERE, a company that produces digital maps and location-based services.

Intel and HERE have also agreed to work together in the research and development process of creating a "highly scalable proof-of-concept architecture that supports real-time updates of high definition maps for highly and fully automated driving," the companies said.

Intel will acquire the stake from HERE's current indirect shareholders, which include Audi, BMW and Daimler. Intel will work with these shareholders to test the proof-of-concept architecture.

RE2's medical module, LIFELINE.
Photo: RE2

RE2 to Develop Robotics Tech for Combat Medics

The U.S. Army Small Business Innovation Research (SBIR) office and the U.S. Army Telemedicine and Advanced Technology Research Center (TATRC) have awarded a Phase II SBIR grant worth approximately $1 million to Pennsylvania's RE2 Robotics, which will help advance the development of RE2's medical module payload LIFELINE.

LIFELINE is designed to help combat medics treat wounded and injured soldiers in the battlefield.

"Our team is honored that the Army has selected RE2 once again to further develop technology to help improve the safety of our brave military personnel while in hazardous combat situations," says RE2 president and CEO Jorgen Pedersen. "The LIFELINE technology, in addition to our Patient Assist Robotic Arm and the ARIBO Assistive Arm programs, further extends our reach into the healthcare market."

Originally developed during Phase I of this SBIR program, LIFELINE is meant to make the process of maneuvering and evacuating wounded soldiers easier for combat medics. LIFELINE is designed for military ground vehicles, and will allow one combat medic to evacuate a combat casualty, as opposed to two combat medics.

The main emphasis of Phase II will be to reduce the weight of the payload to help take the burden off a soldier during installation. The final prototype of the payload is expected to be complete by the end of Phase II.

Agribotix, senseFly Team on Data Collection

Colorado-based Agribotix, an agricultural intelligence company, has teamed with France's senseFly to combine its data and analysis software with senseFly's fixed-wing drone, which they say enables users to collect information faster than with a quadcopter.

"This partnership creates a professional end-to-end solution that is uniquely easy to use," says Jean-Christophe Zufferey, senseFly's CEO.

Agribotix's products include the FarmLens, a cloud-based data analysis and reporting system for those using drones in the agriculture field.

The new partnership is based on senseFly's new fixed-wing UAS, the eBee SQ. This model was built using parent company Parrot's Sequoia sensor, which allows data to come in as RGB along with four other ways, including near-infrared, red-edge, red and green.

The technology allows farmers and other users to make better choices regarding their business due to the rapid imaging of current crop conditions.

"[It's] a great fit for people who are looking for a simple, yet powerful, 100 percent agricultural solution," says Agribotix CEO Lou Faust.

"After evaluating the fixed-wing options available today, there was no question that the eBee SQ is the easiest to use long-range drone on the market. It also has the best-in-class agricultural sensor, while FarmLens does the heavy lifting in the background, returning superb quality data presentation via the Agribotix Digital Scouting Report and enabling farmers to make time-critical adjustments," Faust says.

ESSENTIAL
COMPONENTS

Clearpath's UGV Collects IEEE Innovation Award

The 2017 IEEE Robotics and Automation Award for Product Innovation from the IEEE Robotics and Automation Society (RAS) has been won by Clearpath Robotics.

Julian Ware, General Manager for Research Solutions at Clearpath Robotics, says, "we are honored to receive this award and to be recognized for our ongoing contributions to the global robotics research community."

Clearpath Robotics won this award for its Jackal unmanned ground vehicle. Clearpath's UGV is a small, durable, weather-proof mobile robotic designed for application development and rapid prototyping. Jackal has an easy-to-use mounting platform for sensors and payloads.

The company says Jackal is a UGV that other industries, such as, mining, military, agriculture, and environmental monitoring have adopted.

"The versatility of the Jackal UGV has encouraged wide adoption in applications that we did not envision. Customers are continuing to dream up new uses for our robot," says Ware.

UAS Standards Body Seeks New Members

UL standards are set to create a balance between product manufacturers, standard users and other general interests, and UL's Standards Technical Panel 3030, which has the responsibility for unmanned aerial vehicles, is seeking members.

Currently under development, the Proposed First Edition of UL 3030 will be based on the current Outline of Investigation for Unmanned Aerial Vehicles. It will also cover the electrical system of unmanned aerial vehicles used in flight for commercial applications or flight incidental to business applications in accordance with the U.S. Federal Regulation 14 CFR 107. Organizations or individuals with interest or experience may apply for membership on the STP.

If you are interested, please contact:

Barbara Davis
STP Project Manager, Standards
Barbara.j.davis@ul.com

Vigilant Aerospace tests its FlightHorizon detect-and-avoid system in California. Photo: Vigilant Aerospace

Vigilant Aerospace Completes BLOS Test at NASA's Armstrong Flight Research Center

Vigilant Aerospace has announced that its new FlightHorizon detect-and-avoid (DAA) collision avoidance system for UAS has undergone successful beyond line of sight (BLOS) flight testing.

During the test, the system was used to detect and track intruder aircraft, as well as provide traffic alerts and collision warnings on all air traffic during the encounters.

The flights, conducted at NASA's Armstrong Flight Research Center in Edwards, California, showcased FlightHorizon's ability to provide BLOS flight safety for small and midsized UAS, which help to not only meet FAA regulations, but also integrate UAS into the national airspace.

To demonstrate the system's BLOS capabilities, a variety of flights were conducted, including ones where ground based unmanned pilots were possibly unable to see approaching aircraft due to a variety of factors such as distance, weather, altitude and speed.

In total, almost 100 scripted encounters between UAS under different realistic flight conditions were flown to test several of the system's primary functionalities, including its DAA algorithms, user interface performance and hardware integration.

Two DJI Phantom 4 UAS were used to fly 18 different scenarios multiple times, in which one Phantom acted as the primary ownship, while the other Phantom played the part of an intruding aircraft. These testing scenarios triggered FlightHorizon's traffic alerts, threat alerts and collision warnings, which allowed the pilots to make the proper adjustments so that they could avoid collisions with other aircraft.

Unifly Gets EU's Best Emerging Drone Company Award

The first annual EU Drone Awards were held in January at the European Parliament in Brussels. The EU Drone Awards is an organization of the European Young Innovators Forum (EYIF).

"The EU Drone Awards are a great way to put innovations and new developments in the drone industry in the spotlight and give your entrepreneurs a well-deserved boost," says Marc Kegelaers, CEO of Unifly, which was named Best Emerging Drone Company.

In total, there were 50 candidates from 14 countries. The nine finalists were then selected out of the categories, Best Drone Manufacturer, Best Drone-based Application and Best Emerging Drone Company. Microdrones won Best Drone Manufacturer and the best drone-based application was awarded to Clear Flight Solutions.

Transportation Secretary Anthony Foxx, shown here at the AUVSI-TRB Automated Vehicles Summit in 2016, has announced 10 sites for driverless car technology testing. Photo: AUVSI.

U.S. DOT Picks 10 Sites for Driverless Vehicle Testing

The U.S. Department of Transportation (DOT) has announced 10 sites from across the United States that it has designated as proving grounds for the testing and development of autonomous and driverless technology.

Among many goals, the sites will be used to provide helpful insights into big data usage through automated vehicle testing.

They will also be used to encourage collaboration and innovation in the world of autonomous vehicle development, to find new concepts for personal and commercial mobility, and foster new ideas that could possibly help the lives of disadvantaged communities and people.

The sites that have been picked include the City of Pittsburgh and the Thomas D. Larson Pennsylvania Transportation Institute; the Texas AV Proving Grounds Partnership; the U.S. Army Aberdeen Test Center; the American Center for Mobility (ACM) at

Willow Run; the Contra Costa Transportation Authority (CCTA) & GoMentum Station; the San Diego Association of Governments; the Iowa City Area Development Group; the University of Wisconsin-Madison; Central Florida Automated Vehicle Partners; and the North Carolina Turnpike Authority.

"The designated proving grounds will collectively form a community of practice around safe testing and deployment," says U.S. Transportation Secretary Anthony Foxx. "This group will openly share best practices for the safe conduct of testing and operations as they are developed, enablingthe participants and the general public to learn at a faster rate and accelerating the pace of safe deployment."

FAA Approves More Than 300 Part 107 Waivers, More On The Way

WAIVER
TO FLY

by Laken Vita

An Intel drone, one of hundreds, prepares to fly in a light show over Disney. Photo: Intel

When the small UAS rule, also known as Part 107, was introduced, the Federal Aviation Administration said companies could go beyond the various flight limitations by applying for waivers from specific rules. Companies could see waivers to the bar on operating UAS from moving vehicles, flying at night, flying beyond visual line of sight, operating multiple aircraft systems at once, flying over people, among others.

By the time the rule was announced in August, dozens of companies had already applied for waivers, most of them seeking to operate at night, which was otherwise prohibited under the rule.

AUVSI analyzed the waivers approved to date, and as of the middle of January, the preference for night flight exemptions still held true, as 318 total waivers had been approved, and of those, 312 called for flights beyond civil twilight.

Lagging a distant second in demand was to fly multiple UAS at once, granted by nine waivers, and operation beyond line of sight, granted by three. Some companies sought and received waivers for more than one

category, such as Walt Disney, which wanted to fly multiple UAS and fly them at night. The company did that in the skies over its Disney Springs shopping and entertainment complex in Orlando, using tiny, lighted drones as stand-ins for conventional fireworks.

The event, dubbed "Starbright Holidays — an Intel Collaboration," saw 300 small Intel drones flying in formation accompanied by recordings of classic holiday songs recorded by a full orchestra.

"The sparkling experience invites guests to look up to the sky and wish upon a holiday star. This is the first time a drone show of this scale has ever been performed in the U.S.," Disney said in its Disney Parks blog. Disney had submitted a patent to use drones as fireworks as far back as 2014, but it took the passage of the small UAS rule to make it possible.

Of course, Intel also made a splash with its drones at the Super Bowl, in a pre-recorded performance that accompanied Lady Gaga during the halftime show.

Intel, not surprisingly, also got waivers for nighttime operation of more than one small UAS at a time. Of the nine companies seeking waivers for multiple UAS, six also sought to fly at night, including Disney and Intel. Among the others are the former Google X's Project Wing; CyPhy Works, founded by iRobot cofounder Helen Greiner; and Nightingale Intelligent Systems, a Silicon Valley company that provides automated drone-based security systems.

In January, the company became the first "robotic aerial security" company to be granted an exemption for multiple UAS use, the company notes on its company website blog.

"This is a valuable benefit for our clients as they can take full advantage of this exemption and deploy a multi-drone operation."

Another dual-waiver company, Full Spectrum, of Stone Mountain, Georgia, is likely to follow more in the Disney-Intel mode, as it produces laser and light shows for events and theme parks.

Pathfinder Programs

In May 2015, at AUVSI's Xponential annual conference and exhibition, the FAA announced it was creating Pathfinder programs to push the boundaries of what unmanned flight then allowed, similar to what the waiver program is doing now.

Drone manufacturer and service provider PrecisionHawk would test UAS flights beyond line of visual sight for agriculture, and BNSF Railway would do the same for railway inspections. CNN would prepare for the use of small unmanned aircraft for flights over people.

Not surprisingly, PrecisionHawk and BNSF were among the first companies granted waivers for beyond-line-of-sight flights, although they were later joined by Astraeus Aerial, a Los Angeles-based aerial cinematography company that has been working with the FAA for years on using drones for closed-set filmmaking.

CNN, so far, is the only company having been granted a waiver to fly over people.

Disney and Intel sought an FAA waiver to fly 300 Intel Shooting Star drones in a nighttime aerial light show. Photo: Intel

RAYTHEON IIS

Company highlight

by Brett Davis

Command and Control Challenges Changing, Raytheon Says

The USS Coronado, which carries Raytheon control software for the Fire Scout unmanned helicopter. Photo: U.S. Navy/Keith DeVinney.

U.S. military leaders have made no secret of their desire to have a common controller for as many unmanned systems as possible, a topic that was a big part of the conversation at AUVSI's Unmanned Systems Defense conference last fall.

Automation is another key factor in the future of unmanned systems, so they require less human brainpower and manpower to control.

Defense contractor Raytheon has been working in the unmanned system command and control space for decades, and recently a company official described to *Unmanned Systems* some of the strides the company has made in fusing those technological paths together, and how to guard them against the ever-present threat of cyber attack.

"The proliferation of various types of UAVs has been significant and with that the command and control architectures that go with them," says Todd Probert, vice president of mission support and modernization at

Raytheon intelligence, Information and Services, which provides automation analytics to a number of UAS platforms.

"You can imagine that that causes a challenge for our warfighters. Specifically, a challenge because they have to deploy any number of command and control systems to command each of these UAVs and then, maybe more importantly, the logistics and the training and detail that comes with that."

The Navy "probably leads the pack" in terms of developing a common control system, and Probert says Raytheon has been working to help the service build an open architecture system, the Navy Common Control System, that could be used for all of its UAS, everything from the high-flying, fixed-wing Triton to the small helicopter-based Fire Scout.

Navy commanders think, "I've got a ship at sea that ship has a fixed footprint, it has fixed power, fixed, you know, swap size weight

and power type of limitations," Probert says. "I want one command environment. I want that command environment to control all of my unmanned systems and the benefits are clearly significant on the logistics side and the footprint side. But then on the training side as well. So, you could train each soldier once in a basic interface and then he or she with that basic interface just has to learn the derivatives on the unmanned system, that's specific to their unmanned system."

Raytheon has been working on Global Hawk guidance systems since the early 1990s, so flying the Triton variant is an evolution, but Probert says the NCCS has demonstrated that it could control Predator and Reaper vehicles, although the company hasn't done so in the field.

"… We're leveraging a high degree of autonomy that's resident on the platform," Probert says.

"It's really about the data, and that military

that can go work the data-to-decision [chain] and then decision-to-action sequence the fastest, is going to have edge in that future war," he says.

Analytics, automation and the need for cyber defenses are going to drive command and control systems in the near future, he says.

The previous "kill chain" has now turned into a "kill web" where multiple sensors are monitoring a potential target, and machines are tasking other machines to perform functions such as take pictures to collect data.

"More information's going to get comingled into this, the analytics are going to get more sophisticated to make best use of that information, that automation's going to allow you to do it faster. And then again the cyber overlay is critical to make sure that first and foremost you know that nobody's coming in and upsetting it and then sometime in the very near future cyber will become an effector in and of itself in that kill web as well," Probert says.

With autonomous systems comes the fear of hacking, and defending against that has to be considered alongside increasing performance. Probert says both the command and control systems and the vehicles themselves have to be considered.

"Both sides are vulnerable, both sides we're spending considerable amount of time working with our customers to figure out smart ways to go harden them," he says. "Simple things done on the platform can take the platform out of service. Simple things done on the network can take a network out of service, so both are our concern."

Raytheon was awarded a contract worth up to $104 million in the summer of 2016 to upgrade the Global Hawk command and control segment to a more open architecture systems, something that was not a concern in the early days of UAS fielding.

"From a cyber standpoint, if you build the architecture well, you build in a development operation construct that allows you to constantly go back in and reassess your architecture and the components of the architecture as you're moving through time," he says.

The new way of doing things is "very modular, very thoughtful in terms of protected core. Very thoughtful in terms of an application layer and then most importantly the regression testing and cyber resiliency within that type of architecture before you deploy something that allows you to protect it from a cyber standpoint."

Cyber threats are coming these days not just from the traditional rival nation states, but from third parties as well. Where they are coming from isn't as important as how they change, Probert says.

"If you find a particular cyber issue and you fix it, that's great, tomorrow there's going to be a new one … so you have an ever-increasing number of threat factors or bad guys trying to get in, with an ever-increasing number of systems that they're trying to go get into. … It's an exponentially increasing threat situation not just because a number of bad actors but because of the number of things that those bad actors are doing across a continuum of networks that are tethered out there today."

Probert compared drone maintenance to modern car maintenance, where mechanics plug cars into a diagnostic machine to see if anything is wrong. However, that's another avenue for cyber mischief that must be guarded against.

"So folks that are plugging things into these systems while in a maintenance state introduce opportunities for other things to get in," Probert says. "What we do is work with our customers on the platform side to go do a threat assessment of everything that's happening that could potentially get in to that platform, and then design protection paths to go block those vectors from getting in and then design assessment paths that allow us to potentially monitor what's happening with that platform as its actually in service."

Raytheon won a $104 million contract to modernize ground controls for the U.S. Air Force's Global Hawk. Photo: Northrop Grumman

NEW YEAR, NEW
XPONENTIAL

This year marks the 44th year for AUVSI's annual conference and exhibition, but only the second year of Xponential, a complete rethinking of the previous Unmanned Systems conferences and exhibitions. The theme of this year's show is "Shaping the Future," and AUVSI is focusing on how unmanned systems and robotic technology is transforming business and society.

Xponential kicks off May 8 in Dallas with a new Startup Showdown competition, an expanded Women in Robotics forum and a new host, the Weather Channel's energetic Jim Cantore.

Brian Krzanich, the CEO of tech giant Intel, will be the first keynote speaker and address how his company's technology is helping push the industry forward.

Krzanich, a general aviation pilot, joined Intel in 1982 and became chief executive officer in 2013. He oversees the company's innovations in unmanned aircraft systems, including tests to fly multiple UAS per pilot and its own UAS platforms. Prior to becoming CEO, he served as the company's chief operating officer, leading more than 50,000 employees from

Intel's Technology and Manufacturing Group, supply chain operations, information technology, and other sectors.

"Unmanned vehicles, including drones, are some of the most dynamic technologies of the future, and well beyond recreation, they have the potential to improve people's lives, create new jobs and industries, and find solutions to real-world problems," said Krzanich.

Two new sessions were added at last year's Xponential: Startup Showdown, where companies described their business plan to a panel of judges to compete for funding, and the Women in Robotics forum. Due to the positive feedback from attendees, these will also be added to this year's Xponential schedule.

The Women in Robotics forum turned out to be wildly successful last year, with around 150 women participating. This year, the event will include more time for discussion and networking.

Big-name players will also have booths on the exhibit floor, including market-leading companies like DJI, Airware, NVIDIA, senseFly and Stampede. Companies will showcase their latest hardware, software, components, guidance systems, payloads, services and more.

Another feature the show offers is pavilions, with both technology and international pavilions featured on the floor. The international pavilions showcase the talent and technologies from China, France, Spain and the United Kingdom. The technology pavilions provide information about different services and technology, including pavilions on air systems, a business services zone, a software pavilion and a startup pavilion.

Theaters on the show floor will focus on business information that is new to the industry, including the solutions theater, which will be a chance for show exhibitors to focus on their new products.

The conference program is divided into three tracks:

- **Policy**: Airspace, local, state and federal government cooperation, international trade affecting unmanned systems, and regulation of unmanned maritime systems.
- **Technology**: Defense technology innovation, drone delivery technology, protecting intellectual property, software development powering unmanned systems and automated vehicle technology development.
- **Business Solutions**: Remote sensing, drones in the wireless industry, mapping and imaging, maritime applications for oil and gas, aviation risk management, and managing and protecting data.

"UNMANNED SYSTEMS ARE TRANSFORMING THE ENTERPRISE,"

-Brian Wynne, President and CEO of AUVSI

"From energy and agriculture to broadcasting and security, unmanned systems, robotic and drone technology is enabling applications that were previously impossible. The educational program at Xponential is designed not only to showcase these advancements, but to provide attendees with real-world examples, best practices and smart strategies to leverage the power of unmanned systems in their own organizations," said Brian Wynne.

Xponential is structured to make sure it meets the needs of every attendee. By visiting the event's website, visitors can pre-plan to make sure they don't miss out on any viable information. Visitors can also take advantage of event maps that custom tailor the show to their needs.

AUVSI "recognizes that our community encompasses a really broad range of experts with different needs," says Lindsay Voss, AUVSI's Director of Education.

With an expected turnout of more than 7,000 people, Xponential will bring the entire unmanned systems community together, from commercial to academic leaders to military officials, all under one roof to learn and network.

Voss says first-time Xponential goers should arrive with an open mind and engage with people who are outside their usual circles. "We have a lot to learn from each other," she says.
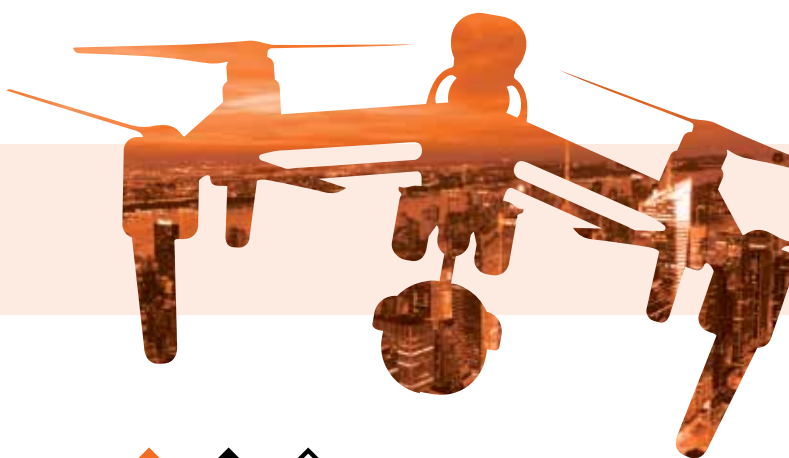
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KAY BAILEY HUTCHISON CONVENTION CENTER

The JPL's methane-sniffing UAS makes a test flight. Photo: NASA

FROM MARS ROVER TO EARTH UAS

NASA ADAPTS EMISSION DETECTION TECHNOLOGY FOR THE HOME PLANET

by Jessica Reyes Sondgeroth

Methane sensor technology developed by NASA and used by the rovers Opportunity and Spirit to detect life on Mars has become the prototype for methane-monitoring unmanned aerial systems used to detect emissions here on Earth.

With funding from the Pipeline Research Council International (PRCI), NASA's Jet Propulsion Laboratory in Pasadena, California, is developing UAS equipped with emissions-detecting technology used in the Mars Rovers to enhance safety and improve the location accuracy of methane leaks from pipelines, and potentially for wider use in public and private spaces.

"NASA developed small instruments and rovers to go investigate if there is life, and conduct other scientific investigations, on Mars and so in the course of developing these instruments, we had to make them very small, we had to make them really robust, precise and accurate. So over the last decade, NASA invested heavily in making these instruments and making the core technologies, such as the lasers themselves to detect methane on Mars," says Lance Christensen, the NASA Jet Propulsion Laboratory open path laser spectrometer (OPLS) principle investigator.

About four years ago, Christensen was approached by PRCI and Chevron to see if NASA could harness that technology for leakage and emission detection along pipelines. The boom in natural gas production and transportation in the United States increases the risk of leakage and exposure. The NASA laboratory began the project in 2014.

The laboratory claims that its technology enables detection of methane with much higher sensitivity than previously available for the industry in hand-carried or small UAS-deployable instruments.

But pipelines stretch across vast distances, and the lighter the UAS, the longer the flight time. That presents a challenge for everybody, which is why NASA engineers worked even harder to lighten the load.

"Every gram you cut adds more flight time to the [vertical take-off and landing] or fixed-wing UAS, and that equals dollars," Christensen says.

NASA's vertical take-off and landing UAS, or quadcopter, a small UAS equipped with a miniature methane gas sensor, is ready for commercialization. Flight times range from 20-50 minutes.

The lab is also testing fixed-wing UAS, which should maintain a longer flight time, and a hybrid of both VTOL and fixed-wing. "The hybrid can take advantage of wing lift to travel long distances and increase time in the air but also be agile enough to take-off and land precisely as well as hover at points of interest," Christensen says.

Excluding UAS, the detection technology cost is six to seven times less than existing available emission detection technology, Christensen says, in large part because the technology does not use complicated optics, to put it simply.

The cost of the UAS varies depending on the end-user's need and, as Christensen suggests, will depend on the market. But current prices range from a few hundred dollars to $10,000.

Phase one of the NASA laboratory project involved developing the technology to detect emissions from large stretches of pipeline. Researchers from the NASA laboratory in Pasadena and the Mechatronics, Embedded Systems and Automation (MESA) Lab at the University of California, Merced, conducted the flight tests though last year. They flew the UAS, equipped with the OPLS sensor, at various distances from methane-emitting gas sources.

Tests were done in a controlled setting to test the accuracy and robustness of the system. NASA could not release test results for that phase of the project at this time and participating companies, including Statoil and PG&E, did not respond to requests for comment.

While PCRI works to help transition the technology from development to commercialization, Christensen says NASA hopes to take the project a step further and apply the methane monitoring system to other types of emissions for wider use, at refiners, in cities and other industrial uses to combat climate change.

"Now it's transitioned to the next, larger vision, which is to use many of these sensors in networks to provide public safety, reduce pollution," Christensen says. "The technology can detect other gases, like water, carbon monoxide, carbon dioxide." The NASA laboratory has developed ancillary software to enable the technology to operate more like an autonomous, large-scale network. It is also equipped with collision avoidance and is prepared to locate and land at charging stations.

"It's not inconceivable in the future that some private entity or federal agency may want to monitor a city-scale area, and they have an autonomous platform that takes off at a certain time every morning and just sniffs the air and after it does that survey, it comes back," Christensen says.

The technology harnesses a sensor, similar to one NASA developed for use on the Mars Rover, that utilizes "stabilized cells and mid-infrared red laser technology," or the OPLS sensor, which detects methane in parts per billion by volume.

There is currently no federal rule that accounts for UAS emission detection technology. But for older pipelines, the cost of this kind of emission detection technology could outweigh the potential safety hazard.

And companies that wish to be proactive in their approach to pipeline safety or general emissions monitoring could benefit from a carbon trading market in the event the Environmental Protection Agency takes such steps.

Properly designed, a national emissions trading program should provide greater incentives for innovation and improved emissions monitoring. Some environmental policy experts suggest that the EPA's Clean Power Plan creates an avenue for the development of a cap-and-trade program, but that remains to be seen. Some states do, however, have their own cap-and-trade plans.

That path forward for regulation of UAS use and certification, however, remain unclear.

"I'm not sure we're going to see government agencies step in," Christensen says. "They would have to really staff up and train people."

Rather, Christenson says he expects the industry will provide solutions, including certification. In the meantime, NASA's Pasadena lab will continue refining the Mars Rover emission sensor adaptation to Earth's needs.

TRANSITIONING FROM MANUAL WORK TO
DRONE

The Airbase, part of the Airobotics system for aerial-based land surveying. Photo: Airobotics.

I sraeli companies Airobotics, which builds automated industrial drones, and Israel Chemicals Ltd. (ICL) have teamed to demonstrate a new aerial-based land surveying system that gathers data faster and more accurately than traditional surveying methods, Airobotics says in a new case study.

The company says ICL's use of its drone systems marks the first transition from manual-ground based surveying to fully automated drone operations. The result: better, more accurate data, gathered faster and with greater safety.

"I feel like this is the future," says ICL Phosphate Executive Vice President Yakov Kahlon. "The Airobotics platform has provided us with a highly effective tool that is cheaper economically and saves us time. With the platform, we can measure in one day what once took multiple days to measure."

ICL is a worldwide mineral manufacturer that supplies the agriculture, food, and engineered material markets. They have begun working with Airobotics in some of their more diverse terrain areas.

A lot of the company's surveying takes place at ICL's Rotem Amfert site, in Israel's rugged Negev region. The Rotem Amfert site is where the entire process of mineral extraction, processing, and packing occurs.

Now, using Airobotics systems, aerial images taken by the drone are processed on the ground via photogrammetry. These photos are studied for volumetric information. This process in the past would require a worker using a real-time kinematic (RTK) pole and a laser scanner, the case study says. Reducing human labor and using drones provides for a safer, more timely display of information.

Before beginning the partnership, ICL decided to run tests at the Rotem Amfert site to make sure that this new way of surveying would benefit the company and, most importantly, show accurate information. The experiments compared the Airobotics way to the manual method.

A third-party surveyor created a series of 16 ground control points (GCPs). Each point marks a position set by the RTK Global Navigation Satellite System method. The points were color-coded and separated to give ground control to the aerial models and make a standard point cloud model so investigators could see the accuracy of the drone.

Flying at 75 meters, the Airobotics system captured 55 images. Then Correlator3D software processed them to show a digital elevation of the pile. The digital elevation image was compared to the ground work and recorded.

Airobotics says the data showed that its aerial method was more beneficial and accurate than the ground-based system. One of the strengths that the new method showed was its ability to define surface features, which were usually overlooked in the ground work method.

The point cloud that was created by the Airobotics method showed a higher resolution and easier to read, the company says.

Airobotics CEO & Co-founder, Ran Krauss says, "Airobotics' drone solution uses and measures millions of points, which proves to be a much more reliable and accurate way to measure, than the traditional way, which involves measuring a few hundred points."

After three months, the results of the two methods were compared. The difference was 1.37 percent, good enough that ICL began using the Airobotics system. The Airobotics system is now able to run every day, due to prescheduling, which ultimately saves time and money, the company says.

Airobotics has been demonstrating using a UAS versus the traditional ground-based method for surveying. Photo: Airobotics

[VIEWFINDER]

This image, "The Last Moments of Summer," is a composite panorama done by Hover Solutions LLC's chief pilot, Nathanael Showalter, when the company was on a commercial job near Bethany Beach, Delaware, in September 2016. The photo was taken shortly before the end of civil twilight on Sept. 15, the official end of the summer season in Bethany Beach.

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

AUVSI Launches
Remote Pilots Council, King Schools Training Program

AUVSI began two new projects in January to help the industry take advantage of last year's small UAS rule from the Federal Aviation Administration.

The first is a new resource for UAS operators, the Remote Pilots Council (RPC), which is intended to encourage conversation and education between UAS operators and the FAA.

Council activities include in-person meetings, webinars, and surveys, all intended to let UAS operators share their experience and best practices, thereby helping ensure the safety of the National Airspace System.

"Now that we have rules governing the civil and commercial operations of UAS, more businesses and innovators are flying and unlocking the tremendous economic benefits of the technology," says Brian Wynne, AUVSI president and CEO.

The RPC will further enable AUVSI's collaboration with the government to advance UAS responsibly. The council will help to come up with solutions for the challenges that come up from either side.

"The RPC's immediate goals are to bring AUVSI members together to provide feedback on real-world UAS operations, including clarifying and offering suggestions for greater efficiency in the FAA waiver process," says Wynne.

The Remote Pilots Council's first meeting was held Jan. 12 in San Francisco, hosted by AUVSI's Silicon Valley Chapter. In that meeting, Wynne moderated a discussion about the integration of UAS in the NAS which featured Ken Kelley, national FAASTeam manager at the FAA, and Jesse Kallman, director of customer engagement and regulatory affairs at Airware. Airware CEO Jonathan Downey also spoke at the event.

"Enterprises are no longer just testing and talking about drones, they are deploying them. They are looking for ways to improve operational efficiency, increase worker safety, and drive business outcomes," Downey says. "AUVSI's Remote Pilots Council is a great example of our industry coming together in support of scaling commercial operations. We are excited about the RPC because a network of informed, experienced, and safe drone pilots is in an important part of helping enterprise customers scale their operations and see the full value of this powerful technology."

Other meetings were scheduled for Washington, D.C., and Chicago in February, and additional meetings will be held in Boston, Florida and Texas over the next several months.

For more information on future RPC meetings, visit us at
www.auvsi.org/remotepilots

King Schools

The second project is a partnership with King Schools, which will allow training for commercial UAS operators to earn their Remote Pilot Certificate, the new category created by the small UAS rule, alsow known as Part 107.

"Now that we have rules governing the commercial operations of UAS, we want to ensure people understand and follow these rules before taking flight," says AUVSI's Wynne. "King Schools' decades of experience in providing top-rated, computer-based aviation training made them the right partner for us. With their expertise, there is now a credible training course to assist UAS operators in studying for the FAA's aeronautical knowledge test in order to obtain the Remote Pilot Certificate."

The small UAS rule went into effect on Aug. 29, 2016. Among the regulatory requirements, commercial UAS operators must pass an aeronautical knowledge test and obtain a Remote Pilot Certificate with a small UAS rating. The certificate must be renewed every two years. The online Drone Pilot Ground School and Test Prep Course is designed to provide operators with information about the test, as well as information about flying safely and responsibly in the National Airspace System.

More information can be found online at: http://www.kingschools.com/ground-school/drone-pilot/courses/written.

"AUVSI is the perfect partner to best serve our customers," says Martha King, co-founder of King Schools. "Their expertise was extremely beneficial in putting the course together. Their knowledge and experience will continue to be an invaluable contribution to us and the entire drone community."

King Schools is a leader in FAA test preparation, providing video courses to pilots at all levels for over four decades. Hundreds of thousands of people have relied on King Schools courses to pass their FAA tests, and its latest offering is designed to extend the same caliber of test preparation materials to commercial UAS operators.

Special Report:
UNMANNED SYSTEMS
An Integral, and Growing Part of Oil & Gas Industry

by Brian Sprowl

As the world of unmanned systems continues rapid development, more and more industries are using the technology, including the oil and gas industry.

Initially mainly used for conducting inspections, unmanned systems are steadily becoming part of the fabric of this industry in missions involving a variety of tasks, from monitoring pipelines to providing assistance for oil spills.

These systems are not only more efficient than previous techniques of performing different tasks, but they also offer an element of safety, as humans are often removed from potentially dangerous missions.

Maritime

When conducting inspections in the water, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) have long been valuable commodities within the oil and gas industry. Back in 1986, Saab Seaeye Ltd. was formed to produce electrically powered ROVs for the offshore oil and gas industry.

To date, the company has delivered more than 800 of its vehicles, and has achieved several feats when it comes to ROVs — the development of brushless DC motor technology for ROV thrusters, creating distributed intelligence and modular ROV control systems, and also creating a new power distribution concept for deep water applications.

Saab Seaeye has paved the way for several companies and their development of not only remotely operated vehicles, but also AUVs,

that can function in the water to conduct missions related to the oil and gas industry. One of those companies is C & C Technologies.

C & C Technologies developed the first commercial AUV, the C-Surveyor I, designed for surveys in the oil and gas industry. Since developing this landmark system, C & C Technologies' AUV fleet has garnered more than 350,000 kilometers and 55,000 hours' worth of high-resolution survey experience. The company has worked for more than 74 clients in 14 different countries, conducting missions ranging from block studies to pipeline surveys.

There are numerous other companies doing underwater work, including Hydroid, Bluefin Robotics and others, including some companies better known for their work in the skies, such as Lockheed Martin.

Lockheed uses its Marlin AUV to conduct a variety of surveys and inspections including structural surveys, pipeline inspections, bottom debris surveys, and subsea facility inspections. The 10-foot long AUV is capable of operating in tight spaces, for up to 18 hours, and at depths of up to 1,000 feet below the surface.

According to Dan McLeod, program manager of Lockheed Martin's Offshore Systems and Sensors business, the system has performed more than admirably when performing inspections.

"Lockheed Martin's Marlin AUV System has completed several commercial autonomous subsea infrastructure inspections in the Gulf of Mexico," McLeod says on the company website. "Our Marlin System provided real-time

actionable information in hours (as compared to days or weeks) that allowed Chevron to make accurate operating plans for an upcoming subsea recovery operation."

Aerial

On the aerial front, unmanned systems don't have as long a lineage as their AUV counterparts, but they have been making a major impact in the oil and gas industry over the last few years. In 2014, British Petroleum (BP) became the first company to be granted permission by the Federal Aviation Administration to use UAS during its operations. Once granted this permission, BP began using AeroVironment's Puma AE UAV to conduct flyovers of its Prudhoe Bay oilfield on Alaska's North Slope.

At the time that BP was granted permission to use UAS, U.S. Secretary of Transportation Anthony Foxx said, "these surveys on Alaska's North Slope are another important step toward broader commercial use of unmanned aircraft. The technology is quickly changing, and the opportunities are growing."

He wasn't kidding.

In 2016, Silent Falcon UAS were used to conduct inspections and monitor oil and gas production and distribution assets in northwestern New Mexico, on behalf of an international oil and gas company. The inspections, which took place over the course of two days, were completed using two different payloads; one to provide aerial visual inspection, the other to detect leaks and inspect liquid levels in tank batteries

The flights were conducted with two goals

in mind. The first was to simply provide a visual inspection of numerous wells, compressors, tank batteries and pipelines, while the second was to detect leaks known as "fugitive hydrocarbon emissions."

During the flights, video evidence and associated metadata collected were live-streamed to the Silent Falcon's ground control station, further confirming the effectiveness of the system during these operations.

"Our ability to stay aloft for extended long range missions, quickly change payloads, and provide both live-streaming video and data as well as post flight processing, analysis, exploitation and dissemination of the data collected underscores the effectiveness of the entire Silent Falcon system in both flight operations and post flight data analysis," says Silent Falcon CEO John W. Brown.

On a more local level, Peoples Gas, which distributes gas in Pennsylvania, West Virginia, and Kentucky, also began using UAS last year. In this case, the company utilized UAS to find methane gas leaks along 14,000 miles' worth of natural gas pipelines in the region.

"We're flying a drone to get a visual inspection of the pipeline that crosses the bridge," says Peoples Gas spokesman Barry Kukovich, speaking to Pittsburgh's KDKA news. He noted how effective UAS could be when conducting these inspections, especially depending on the location of a leak.

"You can imagine some of the elevations that we have to go up and down. This drone could be much safer for our employees as well."

General Electric (GE) one-upped Peoples

Gas, as last year, the company developed its own UAS capable of sniffing methane at its brand new oil and gas technology center in Oklahoma City. The UAS, known as Raven, proved capable of handling its objective, as it successfully found gas leaking from two oil well sites in Arkansas during its initial trial run.

In the January 2017 edition of *Unmanned Systems*, John Westerheide, GE's Technology Leader at GE's Oil & Gas Technology Center in Oklahoma City, said that GE designed Raven as a customizable "productivity tool" to augment or replace the current methods used to conduct inspections, while also reducing the costs for inspections. The system, which Westerheide said has already gained interest from the industry, was created when GE "saw a need for a better, faster way to identify potential methane leakages."

In *Unmanned Systems'* newest industry feature, focusing on the oil and gas industry, we spoke to representatives from the Lone Star UAS Center of Excellence and Innovation (LSUASC) at Texas A&M University-Corpus Christi, Battelle and Sky-Futures about their use of unmanned aerial systems within the oil and gas industry, as they seek to help drive productivity. Representatives from both entities spoke about the positive impact that UAS have had on the industry, and what the future could hold for these systems in the industry going forward.

Lone Star UAS Center of Excellence and Innovation (LSUASC) at Texas A&M University-Corpus Christi

Designated as a FAA UAS Test Site in 2013, the Lone Star UAS Center of Excellence and Innovation (LSUASC) at Texas A&M University-Corpus Christi performs inspections on behalf of its clients in the oil and gas industry, using both rotary and fixed wing aircraft.

UAS are generally used to conduct pipeline inspections, site surveys and assessment of oil drilling locations, but some of LSUASC's clients have requested UAS to use during refinery inspections and offshore oil rig inspections. Clients typically pick the type of UAS used for an inspection.

According to Jerry Hendrix, Executive Director for the Lone Star UAS Center of Excellence and Innovation at Texas A&M University-Corpus Christi, UAS offer several advantages when conducting inspections, one of which is the ability to complete an inspection in a very efficient manner.

"UAS provide the capability to do things more efficiently and effectively," Hendrix tells Unmanned Systems. Some examples he provided include the ability to operate UAS in dangerous areas after a national disaster, as well in and around wind turbines, and underneath oil rigs.

Safety is another area where UAS are a major plus. Using UAS takes humans out of harm's way, such as instances where they conduct inspections near pipelines, which are located in rugged and remote terrain areas, making travel difficult and dangerous.

The positives of using UAS are two-fold, according to Hendrix. "You not only keep your employee in a safe situation, but you also save the time and cost," he says.

To continue encouraging the use of UAS within the industry, the LSUASC, in partnership with the Texas A&M Engineering Extension Service (TEEX), has developed a new program called the National UAS Credentialing Program (NUASCP). The program will provide credentials for potential oil and gas UAS operators, so that they can meet oil and gas stakeholder requirements.

For Hendrix, he strongly believes that the LSUASC's future is bright, as it continues to expand into a number of industries, including the oil and gas industry.

"The future is expansive and bright as we credential operators nationally to do dangerous operations such as hydroelectric dam inspections, offshore oil platform inspections, power line inspections, extended corridor merchandise deliveries and more."

An unmanned aircraft flies over the Lone Star UAS Center. Photo: LSUASC

> "Correcting potential failure before it occurs saves money and extends the life of the asset, **which is the ultimate goal of every inspection program.**"
>
> -Jerry Hendrix, LSUASC

An offshore exhaust seen in infrared. Photo: Sky-Futures.

Sky-Futures

Launched with the idea of initially operating within the oil and gas industry, Sky-Futures has worked with over 30 oil and gas companies globally since 2009.

For visual inspections, Sky-Futures uses the Intel Falcon 8 UAS, which the company says has proven itself in the North Sea over the last six years. Some of the strengths of the Falcon 8 are its protection against magnetic interference, its redundant GPS systems, and its ability to fly home even if it loses two of its motors.

For inspections taking place in confined spaces such as storage and ship tanks, Sky-Futures uses the Elios UAS, made by Flyability.

Similar to the LSUASC, Sky-Futures also believes that the value in using UAS is the time that they save, and the element of safety they provide by taking humans out of precarious situations.

"I think the largest advantage is time saved," Jay Forte, VP of Operations at Sky-Futures, tells *Unmanned Systems*. "We can inspect most verticals in about 20 percent of the time it takes current inspection methods" such as rope access.

Forte adds that the company can inspect a flare in half a day, without a client needing to shut down, and it can also inspect underneath an offshore platform in a couple of days, which beats the weeks it takes when conducting inspections via rope access. UAS are also extremely valuable because they can take humans out of perilous situations, such as when the Elios is used to inspect tanks.

Forte agrees with Jerry Hendrix of the LSUASC by also acknowledging the role that UAS will play not just in the oil and gas industry, but other industries as well. In terms of the oil and gas industry, he believes that UAS will one day be integrated into all Asset Integrity Management Programs, giving asset owners timely information which can ultimately lead to them saving money.

"These inexpensive UAS inspections will be done more often so that asset owners can start analyzing repeatable data sets more often," Hendrix says. "This will allow them to start predicting failure which leads to preventative maintenance instead of the current method which is a time based, reactive maintenance schedule."

"Correcting potential failure before it occurs saves money and extends the life of the asset, which is the ultimate goal of every inspection program."

Battelle

Battelle's subsidiary SeeByte provides software for AUVs that are used across the world, including within the oil and gas industry. These AUVs can be equipped with a number of different payloads, allowing them to handle a plethora of missions.

To pull together all of the information collected from these missions, SeeByte provides AUVs with its SeeTrack technology, which consolidates inputs from various sensor feeds to create an all-inclusive picture of the situation for operators. By providing this common interface for the vehicles and their sensors, operators can easily view information in one real time display, allowing to make decisions more efficiently and more reliably.

Lockheed Martin's Marlin AUV recently conducted the oil and gas industry's first commercial unmanned off-shore platform and site inspections in the Gulf of Mexico. Photo: Lockheed Martin

SeeTrack is fully compatible with a wide range of marine sensors and systems, so users do not have to worry about a limit on what kind of hardware or vehicle they use.

Similar to UAS, AUVs drastically increase efficiency, while lowering costs and danger, when it comes to conducting oil and gas inspections, says Mike Mellott, manager of electrical and software systems for Battelle's Maritime Systems group. For these reasons, AUVs are ideal to use within the industry.

"Several AUV's can be deployed in fleets operated to perform multiple missions simultaneously," Mellott tells *Unmanned Systems*. "Oil and gas exploration in the oceans is costly in both the transit and on station time for these exploration vessels. Steps to reduce their time on station can save tens of thousands of dollars per day."

In terms of safety, AUVs take humans out of perilous situations, such as instances where there are oil spills. In these situations, instead of personnel in the water, AUVs are used to determine the extent of a leak, and direction of the subsea expression of the oil spill.

AUVs already have a valuable place within the oil and gas industry, but Mellott sees an even bigger place for them going forward in the future.

"In the future, expect to see infrastructure surveys conducted by AUVs," he says. "Especially for pipeline and post storm surveys that are required prior to opening operations."

Entities like the Lone Star UAS Center of Excellence and Innovation at Texas A&M University-Corpus Christi, Battelle and Sky-Futures have fully embraced unmanned systems and the major role that they can play within the oil and gas industry. Other companies and industries may also see positive gains from incorporating unmanned systems into their operations.

To learn more about available systems and the commercial applications for unmanned systems across several industries, including oil and gas, attend AUVSI XPONENTIAL 2017, May 8-11 in Dallas, Texas at the Kay Bailey Hutchison Convention Center.

A SURVEY OF PLATFORMS
USED IN THE OIL & GAS INDUSTRY

by David Klein

Using AUVSI's Unmanned Systems & Robotics Database (roboticsdatabase.auvsi.org), we have been able to survey the range of unmanned platforms being used in the oil and gas industry.

Starting with the air domain, 514 UAS were analyzed (this is unique models of UAS offered on the market, not the total number of systems manufactured). Of these, 38 percent are manufactured in Europe, 31 percent in North America, 26 percent in Asia and the remaining 5 percent in South America, Australia, and Africa. The leading countries are the United States (28 percent), China (14 percent), Italy (6 percent), France (5 percent), United Kingdom (4 percent), Germany (4 percent), Israel (4 percent) and Canada (3 percent).

Next, we looked at the range of designs and sizes of platforms being operated in this industry. Because pipeline surveys often take place over long travel distances, these UAS are usually fixed wing aircraft offering efficient forward flight. We also found that 10 percent of these platforms offer beyond line of sight control.

To conduct more detailed close-up inspections, operators will often use the hover-capable rotary wing UAS. For the most part, they do not offer long endurance times relative to their fixed wing counterparts. However, they generally provide greater precision and a more stable platform to capture images. Recently, some UAS manufacturers have developed models that offer both a multirotor configuration for vertical takeoff in conjunction with a fixed wing to provide the best of both worlds. These types of platforms are even more advantageous because they eliminate the need for a ground footprint in the form of required runways or other launch and recovery equipment.

From top to bottom, Hewë AF-90 from Aerofoundry (the lightest platform in the data set @ 0.51 kilograms); DT-26 from Delair-Tech (near the median takeoff weight @ 8 kilograms); FLYOX I (SA-03) from Singular Aircraft (the heaviest UAS @ 3,800 kilograms).

From left to right, EDF-8 from AVID LLC (the smallest UAS with a ducted fan design); SQ-4 RECON from BCB International, Ltd. (smallest multirotor from the data set); JUMP 20 from ARCTURUS UAV (hybrid multirotor / fixed wing platform).

Next we will take a look at the performance properties of platforms being used in the oil & gas industry. The mid-range max speed for these types of platforms is approximately 70 mph with a cruise speed of 50 mph. The fastest aircraft from the data set is the GT-380 from GT Aeronautics, at 207 mph. The median endurance for these platforms is two hours, with the longest endurance from Vanilla Aircraft's VA001 at 10 days.

From left to right, GT-380 (fastest aircraft from the data set); VA001 (longest endurance).

Similar analysis was also performed for unmanned maritime vehicles (UMVs). Two hundred and twenty two unique models of UMV were found to operate in the oil and gas industry, with 54 percent manufactured in Europe, 37 percent in North America, 5 percent in Asia and 4 percent in Australia. The leading countries are the United States (32 percent), United Kingdom (23 percent), Norway (11 percent), France (9 percent) and Canada (6 percent).

There are three main types of UMVs: Unmanned underwater vehicles (UUVs), also sometimes called autonomous underwater vehicles;

unmanned surface vehicles (USVs); and remotely operated vehicles, or ROVs. UUVs function without operator control and often are used for long-term survey missions. Platforms like the Slocum G2 Glider from Teledyne Webb Research offer autonomy of more than a year using innovative techniques such as buoyancy-driven propulsion. USVs can also offer extended survey capabilities by harvesting solar and wind energy. Platforms like the Boeing/Liquid Robotics Wave Glider combine the advantages of both UUVs and USVs to provide the peak in capability and performance.

From left to right, the Slocum G2 Glider (longest endurance UUV from data set); AutoNaut from MOST (Autonomous Vessels), Ltd. (the longest endurance USV); Wave Glider SV3 from Boeing/Liquid Robotics (a hybrid USV/UUV with endurance of multiple years).

These platforms also range greatly in size:

From left to right, New Generation REMUS 100 from Hydroid, Inc. (the lightest UUV from the data set); Echo Voyager from Boeing (the largest UUV at 50,000 kilograms).

ROVs are available for two main purposes: inspection and observation of oil and gas infrastructure, and construction, intervention, and maintenance. As such, the design and specifications for these

platforms range greatly from the smallest inspection class ROV at just 3 kilograms to large, 29,000-kilogram work class machines.

From left to right, GNOM Standard from Indel-Partner Ltd. (the smallest ROV from the data set); SQX-500 from Marpot (a unique hydrodynamic dual hull design

provides this platform with the fastest max speed at 6.9 mph); and XT1200 from Forum Energy Technologies, (the largest ROV @ 29,000 kilograms).

SENSE and AVOID

Advances in Technologies for UAS Bring NAS Integration Nearer

by Lee Ewing

Progress in development of sense and avoid technologies for unmanned aerial vehicles is bringing them closer to integration into the National Airspace System. While there is no single "silver bullet" solution, industry and government experts say, a combination of technologies is likely to meet the need.

Safe integration of unmanned aerial vehicles into space shared with manned aircraft is crucial to growth of the unmanned systems industry. The Federal Aviation Administration says an unmanned aircraft must be able to sense other aircraft, maintain self-separation that keeps them "well clear" of one another and avoid collisions, regardless of whether the other aircraft has a transponder broadcasting its position and bearing.

The FAA is working to make safe integration possible, but critics say advancement has been too slow.

FAA Administrator Michael Huerta said Jan. 7 at the Consumer Electronics Show that over the last year, progress toward UAS integration has been notable.

"Our challenge is to find the right balance where safety and innovation co-exist on relatively equal planes," he said. "I don't think it's an exaggeration to say we have accomplished more toward this goal in the past year than we have in all previous years alone."

One sign of progress is that for relatively large UAS such as the General Atomics Aeronautical Systems-built Predator and Northrop Grumman-built Global Hawk, a version of the GPS-based Automatic Dependent Surveillance-Broadcast (ADS-B) system increasingly used by manned aircraft has been developed, demonstrated and validated for UAS at NASA's Armstrong Flight Research Center.

"This state-of-the-art technology automatically broadcasts a UAV's exact position 120 miles in every direction every second, as opposed to legacy radar-based transponder systems that 'sweep' for position every 12 seconds," the NASA web site says. "Accurate to within 5.7 feet, this technology integrates commercial ADS-B hardware, radio data-link communications, software algorithms for real-time conflict detecting and alerting, and a display that employs a geobrowser for three-dimensional graphical representations."

Armstrong researchers also are evaluating the utility of a stereo vision system, using two cameras to provide a binocular image, for generating ranging data.

Armstrong engineer Sam Kim says the main challenges the UAS industry faces are to enable unmanned aircraft to sense other aircraft, maintain safe self-separation and avoid collisions.

In Phase One of the effort to develop Minimum Operational Performance Standards for UAS, NASA focused on larger UAS, such as the Ikhana, a civilian version of the Predator, and Global Hawk, says Armstrong project engineer Lisa Fern. The standards require a UAS to have ADS-B and Traffic Alert and Collision Avoidance System (TCAS II) systems as well as actively scanning air-to-air radar. "Now we're seeing an effort to miniaturize that radar for smaller aircraft."

The NASA team now is looking at various sensors that can detect non-cooperative aircraft, meaning those that lack transponders. "The real concern is detecting and avoiding non-cooperative aircraft," Fern says.

In Phase Two, researchers likely will study and test smaller UAS equipped with electro-optical sensors and ACAS Xu, a smaller version of the Airborne Collision Avoidance System that is optimized for UAS. ACAS Xu has been evaluated in Phase One flight tests involving NASA, FAA, General Atomics, and Honeywell International. Further flight testing of ACAS Xu is planned for this summer, probably in June or July, Kim says.

There have been recent advances in miniaturizing Actively Electronically Scanned Array (AESA) radars, Kim says. "Many manufacturers are even looking at things that would fit on a quadrotor type aircraft."

Various technologies will be combined, depending on the need, Kim says. "There really is no one silver bullet-type sensor that would get you everything."

Sanjiv Singh, a research professor at the Carnegie Mellon University Robotics Institute and CEO of Near Earth Autonomy, says, "there are two separate problems.

"One of them has to do with aircraft and standoff and staying well clear of each other. … We might be able to separate unmanned aircraft from commercial airliners by [using] different classes of airspace," he says, because commercial airliners fly high (except for taking off and landing) and drones often fly low.

While regulating airspace can enable safe separation of UAS from airliners, Singh says, "I think the bigger issue, if not all of it, is separating UAS from other things that fly low," such as ultralight aircraft, other UAS and tourist aircraft.

Radars could help, he says, but standard radars are too large, heavy and expensive to be suitable for use on smaller UAS.

Newer technologies such as miniaturized Automatic Dependent Surveillance-Broadcast, (microASD-B), which uses transponders to separate cooperating aircraft, and smaller radars, can help even small UAS detect and avoid airborne objects.

The big challenge now is to prepare for FAA approval of flying unmanned aircraft beyond the operator's visual line of sight, which would require the UAS to guide itself. "That's number one," Singh says. "Number two is it should be able to avoid things in its way." For UAS flying under 500 feet, that means avoiding terrain, trees, power lines, buildings and wires as well as other aircraft.

"The things that I think are most promising right now are new technologies in radar and microADS-B," Singh says.

A small UAS equipped with a Near Earth Autonomy sensor is tested in real-world conditions.

Photo: Near Earth Autonomy.
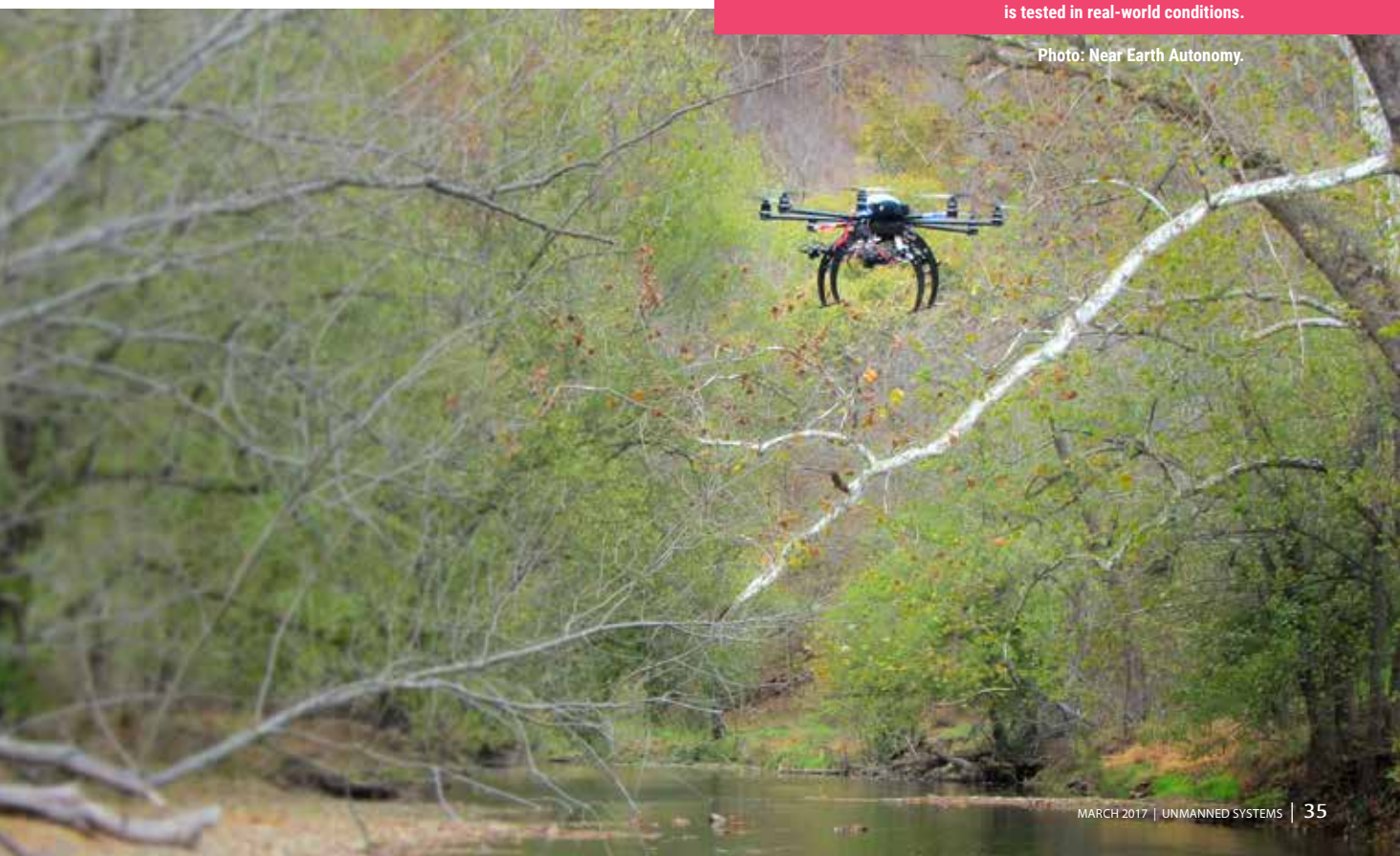
One example of microADS-B is a receiver recently developed by a manufacturer of navigation electronics, uAvionix. Last year, the company introduced pingRX, which it says is the smallest and lightest ADS-B receiver ever made. The company says pingRX weighs 1.5 grams and requires 1/100th the power of conventional ADS-B receivers. It measures 32mm x 15mm x 3mm.

Anil Nanduri, vice president of Intel's New Technology Group and general manager of the perceptual computing UAV segment, says that in the last year or so, there has been a lot of innovation in sense and avoid technologies for UAS, including development and refinement of lidar (light detection and ranging) and the use of two cameras to provide stereoscopic images.

"I feel the vision systems are getting smarter," he says, but there are limitations. "You can't see in fog," he notes. Vision-based technologies can be stymied by fog, haze or other obscuring conditions, Nanduri says, so complementary systems such as optical flow sensors or infrared sensors are needed. On-board data fusion in real time can improve the LIDAR images enough for a UAS to detect other aircraft in sufficient time to avoid collisions, he says.

Smaller radar and lidar systems already are strengthening the ability of small UAS to detect and avoid other aircraft, he says.

Intel has adapted its RealSense Technology, which uses a conventional camera, an infrared camera and an infrared laser projector, for use on small drones like the Ascending Technologies Falcon 8+ and the Yuneec Typhoon H to enable them to safely navigate, gather data and avoid obstacles even when flying low and fast. These capabilities make them ideal for surveying, mapping, industrial inspections and similar missions, the company says. (Intel CEO Brian Krzanich will be one of the keynote speakers at AUVSI's Xponential conference and exhibition in Dallas in May.)

A sense and avoid solution for large high-altitude UAS is likely to rely on fusion of radar and optical sensor systems, says Kunal Mehra, senior vice president for strategy and market development of Scientific Systems Company, Inc. (SSCI).

"Radar can probably do everything lasers can do, with less power," Mehra says. With aircraft like autonomous helicopters that fly low, he says, lasers can play a bigger role, along with some form of visual sensing.

NASA's Ikhana remotely piloted aircraft (front-right) is situated near NASA Armstrong Flight Research Center's Hangar 4802 after an Unmanned Aircraft Systems Integration into the National Airspace System Flight Test Series 4 flight, along with five flight "intruders," shown here. Photo: NASA/Carla Thomas.

The most likely sense and avoid technologies will be a combination of sensors such as radar, electro-optical/infrared, and lasers, Mehra says. "The bottom line is… you need to fuse that radar with something else, like an imaging sensor or camera or a thermal IR to really refine the detections down to a more acceptable accuracy and precision."

"Every technology solution that we work on is likely to become a component of a final system," says Dr. Andrew Browning, SSCI's Deputy Director for Research and Development.

and most lightweight, and we are for the most part keeping up with them from a capability point of view."

Detecting a threat is the first part of the requirement, Browning notes. The second is safely avoiding it. Much research now is focused on avoidance. For example, SSCI has created FORECAST (Fast Online pREdiCtion of Aircraft State Trajectories) software, which mathematically predicts the flight path of an intruder aircraft so that the UAS can safely avoid it.

As early as March, an RTCA (Radio Technical Commission

"Every technology solution that we work on is likely to become a component of a final system,"

Dr. Andrew Browning,
SSCI's Deputy Director for Research and Development

NASA's Ikhana and its ground control system. Photos: NASA

Radar probably will be more effective for these aircraft than lasers, he says, but lasers can help at low altitudes where radar often produces too many false positives and accurate close-range detection is needed. "Lidar definitely has its place on our view, and they are getting smaller, but they're still very power-hungry."

Manufacturers of small UAS like DJI and Parrot are moving to two-camera stereo vision and ultrasound, Browning says. "They are all trying to get to monocular capability," he says, which requires only a single camera and is simpler, less expensive and has longer range.

"At SSCI, we have a monocular solution. We're the smallest

for Aeronautics) special committee is expected to release certain long-awaited proposed standards for airborne sense and avoid for UAS. They likely will include a definition of "well clear" and provide guidance for flying small UAS over people. The proposed standards will cover detection and avoidance of both cooperative and non-cooperative aircraft, says Kelly Markin, project leader for the MITRE Corporation's FAA work on small UAS low-altitude operations.

For dealing with cooperative aircraft, "there's a lot of push in the industry for ADS-B," says Ted Lester, MITRE's lead systems engineer supporting U.S. Air Force and FAA UAS work and co-chair of the Science and Research Panel of the executive committee on UAS.

Near Earth Autonomy prepares for a sensor test. The company has tested sensors on a variety of aircraft. Photo: Near Earth Autonomy

A MITRE presentation last year on initial findings of a survey of small UAS sensors identified three candidates for near-term evaluation: monostatic (standard) radar, acoustic arrays and vector sensors (which measure sound pressure and particle velocity from a single point), and bistatic or multistatic radar.

A pioneer in acoustic sensing, Scientific Applications and Research Associates (SARA), has developed an all-weather Passive Acoustic Non-Cooperative Collision-Alert System (PANCAS) with spherical coverage. It uses the company's Low Cost Scout UAV Acoustic System (LOSAS), which has an array of four lightweight acoustic probes and a custom digital signals processor. PANCAS has been demonstrated on aircraft weighing as little as four pounds.

In addition to the recent advances in airborne sense and avoid systems, there has been steady progress in development and use of ground-based sense and avoid (GBSAA) systems. The U.S. armed forces for years have been using GBSAA to safely guide UAS such as the MQ-9 Reaper to and from their U. S. bases to airspace reserved for military use — without chase planes or ground observers.

As for the future, some researchers say, the final solution for adding UAS to the NAS safely could well be a combination of airborne and ground-based sense and avoid systems. ∎

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A C-Astral Aerospace unmanned aircraft flies equipped with Alta Devices solar cells to provide extended range. Photo: Alta Devices

EXTENDED RANGE

by Rich Tuttle

Beyond Line of Sight Flights Call for Greater Power

As power sources for unmanned vehicles continue to be developed and refined, advocates are looking forward to the next big step in the operation of unmanned aerial systems — approval by the Federal Aviation Administration of routine operations of small UAS beyond the line of sight.

Today, under FAA rules that went into effect last August, commercial operators of small UAS must, among other things, fly only during daylight hours, and within sight.

Three companies — BNSF Railroad, CNN and PrecisionHawk — have been working under FAA waivers since August, flying UAS to inspect hundreds of miles of railroad tracks, gather news over people, and monitor vast farmlands. The idea is to help the FAA to better understand how unmanned aircraft can transform the way businesses operate. The companies' work is aimed at ultimate government approval of regular low altitude flight in the National Airspace System of small UAS beyond visual range.

Developers of solar power for unmanned aerial systems acknowledge that they have a relatively small share of the UAS power market today. Rich Kapusta, chief marketing officer of Alta Devices, in Sunnyvale, California — a unit of China's renewable energy company Hanergy Holdings — says, "all of our engagements are still in the prototype stage where manufacturers are investigating which technologies are going to produce the best result."

But, "part of what we're also waiting on, from an industry perspective, is the ability to fly beyond the visual line of sight," he says.

Once that happens, the need for longer flight times will increase. Solar power will benefit, as will other types of power generation technologies.

The list of such technologies for air, ground and maritime unmanned vehicles, in addition to solar, includes batteries, fuel cells, tethers and lasers.

After combustion, batteries dominate the global UAS power market, and their share of that market is expected to grow at a rate of more than 10 percent a year between now and 2020, according to a study by Technavio, a London-based research company. It bases its projection on several factors, including a reduction in the cost of lithium-ion batteries. In fact, the study says, the costs of such batteries are likely to drop by 60 percent by 2020, and demand is expected to quadruple in the same period.

But, even though commercial and military demand for small UAS is growing, battery makers face the challenge of short endurance, Technavio says. "Typically, a fixed-wing [UAS] has a flight time of an hour, whereas a rotary-wing [UAS] has a flight time of half an hour, after which the [UAS] must be retrieved to recharge or to be replaced with a charged battery."

In a battery, electric power comes from stored energy. But, Technavio says, "efficiency is highly affected due to repeated chemical processes that take place during charging and discharging."

In addition, power limitations of batteries for small UAS mean only a few selected sensors can be carried. Technavio calls for increased R&D efforts in battery technologies, saying "more robust battery systems are needed [to] provide the required energy for longer duration and remote autonomous operations."

Leading vendors in the UAS battery market, Technavio says, are Ballard Power Systems of Burnaby, British Columbia; Cella Energy of Oxfordshire, England; Denchi Power of Thurso, Scotland; Sion Power of Tucson, Arizona, and Tadiran Batteries GmbH of Buedingen, Germany.

Fuel cells are giving batteries a run for their money. Their big selling point "over conventional battery technology, especially over [the] Li-ion battery, is that they have a much higher energy density," according to Technavio. "Thus, they provide 10 times more power to small electric [UAS] than the conventional batteries. This would largely extend the flight endurance of a [UAS], making it capable of long-distance, extended missions."

Julian Hughes, commercial director of Intelligent Energy of Loughborough, England, describes a fuel cell as "a stack of plates, each plate is called a cell, and if you combine oxygen from the air with hydrogen across those plates, a chemical reaction occurs that produces power in the form of electricity, small amounts of heat and even smaller amounts of water vapor, so the byproduct is clean energy.

"The main difference between a fuel cell and batteries" he continues, "is that batteries store energy and you have to recharge the battery once the energy is depleted, whereas a fuel cell ... doesn't store energy, so it's like a mini generator."

First flight of an Intelligent Energy fuel cell took place at Loughborough about a year ago on a DJI Matrice I00 UAS; the flight lasted an hour and a half. At the Interdrone conference in Las Vegas last September, Intelligent Energy flew its fuel cell on a Yuneec Tornado H920 drone. The vehicle can fly for 1.5 to two hours, according to Hughes.

"We think the market's going to be huge," he says. "Even the consumer-based drone companies are all jumping into the commercial space because that's where the higher margins are, and we feel that fuel cells are best suited in that space to begin with. We think there's going to be a great future."

Horizon Energy Systems (HES) of Singapore, working with several other parties, used a fuel cell last year to fly a fixed-wing UAS for nearly six hours. "The entire power system weighed two and a half kilograms. If you were to fly that long on batteries, batteries would have weighed five kilograms," says Mark Shuck, Global VP of Engineering for HES in Austin, Texas.

"We've pretty much hit the limit on batteries," he says. "They're not getting any lighter and they've pretty much come to a halt as far as their energy density." Fuel cells offer a "step change," he says. "It's not a gradual difference ... it can be a factor of two, in some cases more, depending on the type of fuel you use." The best batteries, he says, might be rated at 200 watt-hours per kilogram, while HES offers at least 500 watt-hours per kilogram. And the company has "some technologies that can get us higher than that. So for the same mass, you're looking at twice the flight times." But, Shuck acknowledges, fuel cells are expensive for a number of applications.

Tethers can supply power to unmanned systems. The size of the tether is important, certainly for vehicles that fly, because of weight. "Weight is not your friend," says Lance Vanden Brook, CEO of Cyphy Works, Danvers, Mass. The company says tethers offer some unique advantages for aerial UAS — unjammable communications, reliable command and control and unlimited duration.
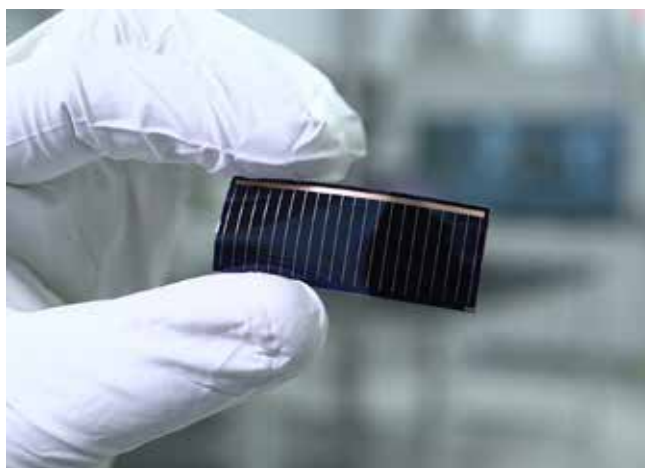
In a telephone interview in late December, Vanden Brook said one of Cyphy's tethered UAS was on the way to a continuous flight of 400 hours. "What that's doing for us is helping us collect a lot of data around the quality of the airframe. Four hundred hours is a lot of time in the air with no breaks. It's been in the air for weeks on end."

There's commercial as well as military interest in tethered drones, according to Vanden Brook. On the military side, the Defense Advanced Research Projects Agency is eyeing the use of drones to detect other drones.

Solar power for unmanned aerial systems "is the one that makes the most sense," says Alta Devices' Kapusta. "It's the most cost-effective way to increase flight times on daytime missions. As a result, I suspect that solar will end up with very high market share, but it's still a year or two away from happening."

He stresses that batteries aren't going away. "When you put solar cells on an aircraft, the battery is still the workhorse. The solar cells charge the batteries whenever there's ample power to do so, but the airplane is still flying from the power that's stored in the batteries themselves.'"

In fact, Kapusta says, "we look at the world in terms of batteries. Wherever batteries exist today, we look for opportunities to put a solar cell on it, whether it drives or flies, or whether it's clothing or on a cell phone, laptop or tablet — whatever it is, if it moves, or if you carry it, or if you wear it, then that's a potential market for Alta Devices' solar technology."

Lasers can also be a power source for unmanned systems, according to Tom Nugent, chief technical officer and cofounder of LaserMotive, based in Kent, Washington.

"We've built and demonstrated a number of proof of concept and pilot technology systems for a number of different applications in unmanned systems where battery limits exist, or where running a copper wire would be really expensive or inconvenient or unsafe," Nugent says.

The company has a proprietary tracking and safety system that delivers power to a vehicle, whether it's moving or stationary, through a line of sight link, and the vehicle is recharged and powered on the move. "Where you don't have that direct line of sight," an optical fiber connection is used.

Nugent says lasers are attractive because they provide a lot of power for little weight, which translates to good payload capacity. And, since energy is being sent from the ground, "you can fly for a long as you want to, or until the motor on your UAV breaks." ∎

A solar-powered AeroVironment Puma aircraft extended its flight time using Alta Devices solar cells, one of which is shown on the left.

Photo : Alta Devices

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CHAPTER NEWS

🌊 Ridge & Valley

On Wednesday, Nov. 9, 2016, with support from the Ridge and Valley Chapter, the Virginia Tech student chapter of AUVSI held its inaugural meeting on the VT campus in Blacksburg, Virginia. About three dozen students gathered for some drone show-and-tell and to hear from UAS pilot Andrew Kriz of the Mid-Atlantic Aviation Partnership. A continuing series of student chapter meetings aims to promote interest in unmanned vehicles among Virginia Tech students and to connect these students with other local enthusiasts, like those affiliated with the Ridge and Valley Chapter.

Virginia Tech Students Gather At The Ridge And Valley Chapter's Inaugural Meeting In Blacksburg, Virginia.

🍑 Atlanta

The AUVSI Atlanta Chapter kicked off 2017 with a chapter meeting on Jan. 19 with 16 members in attendance.

On Jan. 4, the Atlanta Chapter partnered with the Coastal Plains Chapter to host the 2017 Unmanned Systems in Agriculture Conference in Savannah in conjunction with the South Eastern Fruits & Vegetables Show.

The Atlanta Chapter will be hosting a Networking Luncheon on Feb. 16 immediately following the Georgia UAS Working Group Meeting hosted by Gary O'Neal of Georgia's Center of Excellence for Aerospace. The topic for the February Working Group will be surveying and mapping.

☀️ Florida Peninsula

Florida has ranked as the No. 1 state in the nation, during 2015 and 2016, for Federal Aviation Administration-approved commercial drone operations, enabled by Florida's supportive drone legislation enacted July 1, 2015. That legislation was drafted and supported by the AUVSI Florida Peninsula Chapter.

Florida's drone industry is growing robustly. Drones offer great opportunities for enhanced entertainment, economic, and quality of life benefits for Floridians.

Just days after receiving permission from the FAA to fly drones, Walt Disney World announced its first nighttime show using drones. An impressive show using drones at Disney Springs, Orlando, debuted for the 2016 Christmas holidays. Disney has released video showing operators controlling drones that create a Christmas tree of green lights in the sky.

Florida is forecast to achieve significant economic benefit from the rapidly growing commercial drone industry. The forecast benefit to Florida's economy is more than $630 million, while creating more than 3,250 jobs during the next three years alone.

Florida's commercial drone business opportunities continue to expand rapidly, and are being fulfilled safely, and responsibly, and enabled by Florida's supportive drone legislation.

🧭 Pathfinder

The AUVSI Pathfinder Chapter in Huntsville, Alabama, was one of 14 Special Award Sponsors during the 25th Alabama Regional Future City Competition held at the U.S. Space & Rocket Center in Huntsville on Jan. 14. Twenty four teams made up of 6th, 7th, and 8th graders from Alabama and Tennessee competed in three domains: Models, SimCity4 Modeling, and Formal Presentations. We judged all teams on the best use of unmanned systems and our winner of the $150 prize and plaque was the City of "FenAqueous" from the Southside Middle School in Tallassee, Alabama. Their FenAquaeous SimCity design incorporated unmanned systems in space, on land, in water, and underground. They described their selection criteria for robotics and automation as dirty, dull, difficult, or dangerous with examples as to why.

For the ninth consecutive year, the Pathfinder Chapter was one of the major sponsors for the Alabama State FIRST Tech Challenge (FTC) team and many of the competition teams in attendance. This year FIRST (Alabama) hosted its inaugural Alabama State FTC Championship in Huntsville, with 24 middle school and high school competition teams from Alabama, Georgia, Tennessee, Mississippi and West Virginia.

The top two teams move on to the Regional Championship in Atlanta. According to Sheryl Darrow, FTC Affiliate partner, "Over the years, AUVSI Pathfinder has been one of our major sponsors and has purchased most of the equipment we are using." In previous years, FTC have used the funding to purchase the competition cages and this year the $1,500 AUVSI Pathfinder grant was used to purchase a new projector.

Southside middle school winners show off their prize at the Alabama regional future city competition.

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FAROUT

Toyota's Concept-I Driverless Vehicle Aims To Be Your Friend

If Toyota has its way, its Concept-I vehicle will serve as a blueprint for the future of autonomous vehicles, not just for its beautiful design, but for its warmth. The Concept-I won't be known for its literal warmth though, but instead, its "kinetic warmth."

Unveiled during the Consumer Electronics Show in Las Vegas in January, the Concept-I is a staple of Toyota's idea of kinetic warmth, which is meant to make technology warm, welcoming and fun. Toyota credits the idea for kinetic warmth to automakers ignoring humans' emotions when developing autonomous vehicles. Toyota believes that the development of these vehicles has largely been cold, virtually eliminating any connection a human might have with its car, so the company is trying to change that with future designs, like the Concept-I.

"The Concept-i imparts movement, but in a very friendly way," Ian Cartabiano, Toyota's CALTY design studio chief in California, tells ARS Technica in an interview. "We want to combine AI, but we also want a different level of warmth. We want to retain the fun of driving, of engagement and the human hand. We seek liveliness, sculpture, emotion, and warmth."

To bring this warmth to fruition, the Concept-I is equipped with an artificial intelligence system named "Yui," which appears in the vehicle as an "animated parabola" at the center of the dashboard. Yui is designed to do everything from greeting its inhabitants, to anticipating the needs of its driver, all in an effort to make driving easier and warmer.

Aside from communicating with its inhabitants using interior surfaces to convey a variety of messages, Yui also communicates with the outside world to alert other drivers and pedestrians of the moves of the vehicle. Effective communication to the outside world was something that was of the utmost importance for Cartabiano and the design team at Toyota.

"Yui must communicate not only with the driver, but with other passengers in the car, plus others literally outside the car because the relationship of humans and cars is not limited to the inside," Cartabiano says. "Pedestrians, other cars, and the people in those other cars have a need for information, as well."

Yui communicates with the outside world using exterior LEDs, as it transmits messages telling other drivers of its intentions, such as turning or backing up.

While the Concept-I is not in development, and at this point, Toyota doesn't really have any plans to actually develop it, officials within the company strongly believe that the Concept-I is an example of what driving will look like in the years to come.

If only we should be so lucky.
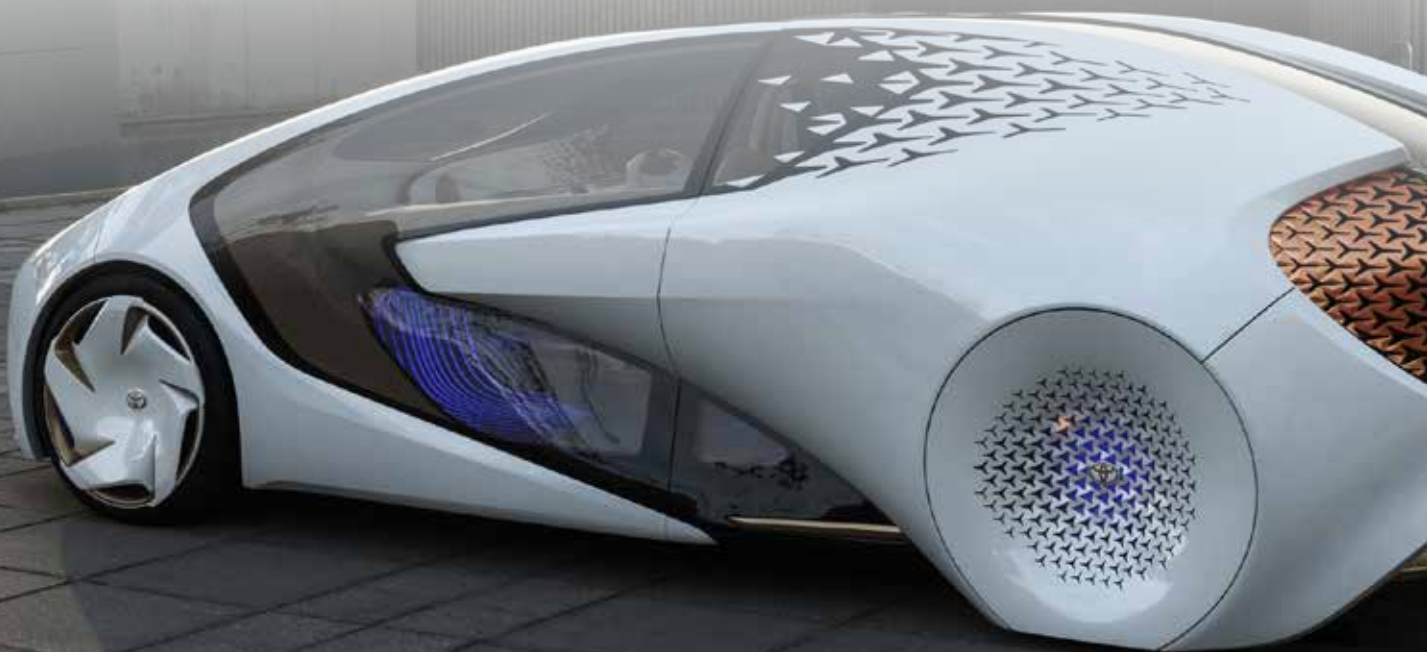
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