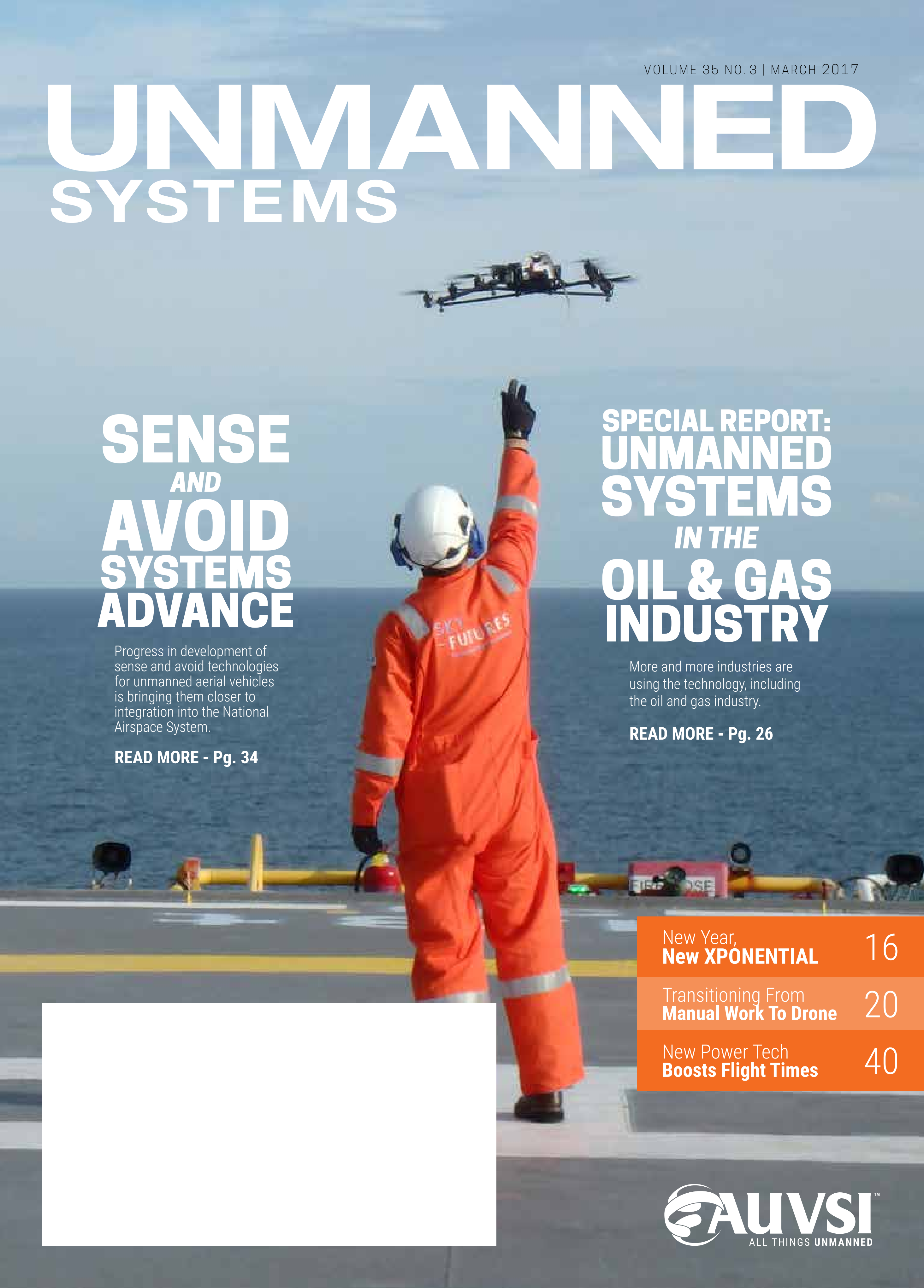
VOLUME 35 NO. 3 | MARCH 2017

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.

READ MORE - Pg. 34

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

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

READ MORE - Pg. 26

AUVSI ALL THINGS **UNMANNED**

Near Earth Autonomy has tested sensors on a variety of small aircraft to help them see and avoid obstacles.

Photo: Near Earth Autonomy.

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.

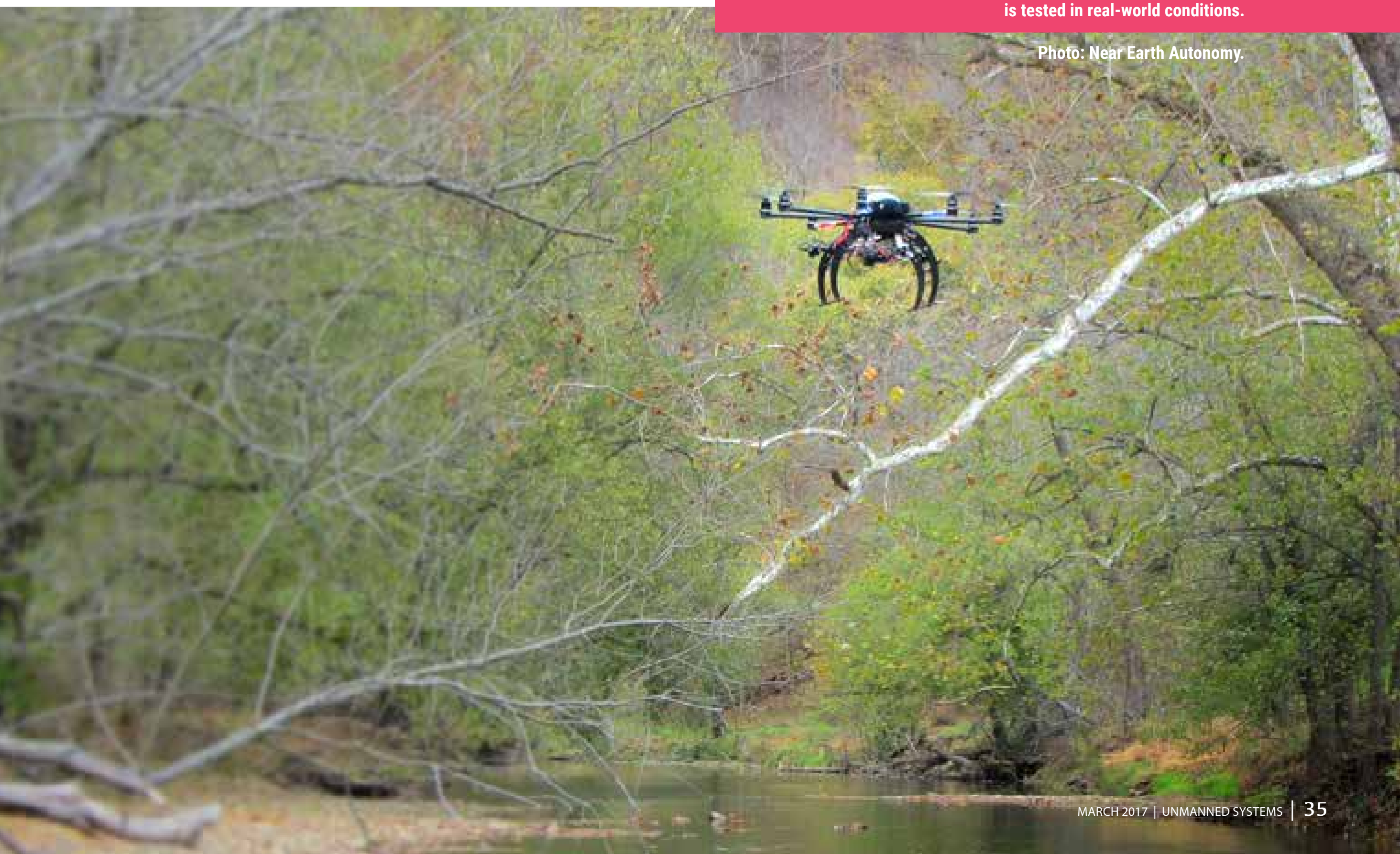


Photo: Near Earth Autonomy.

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.

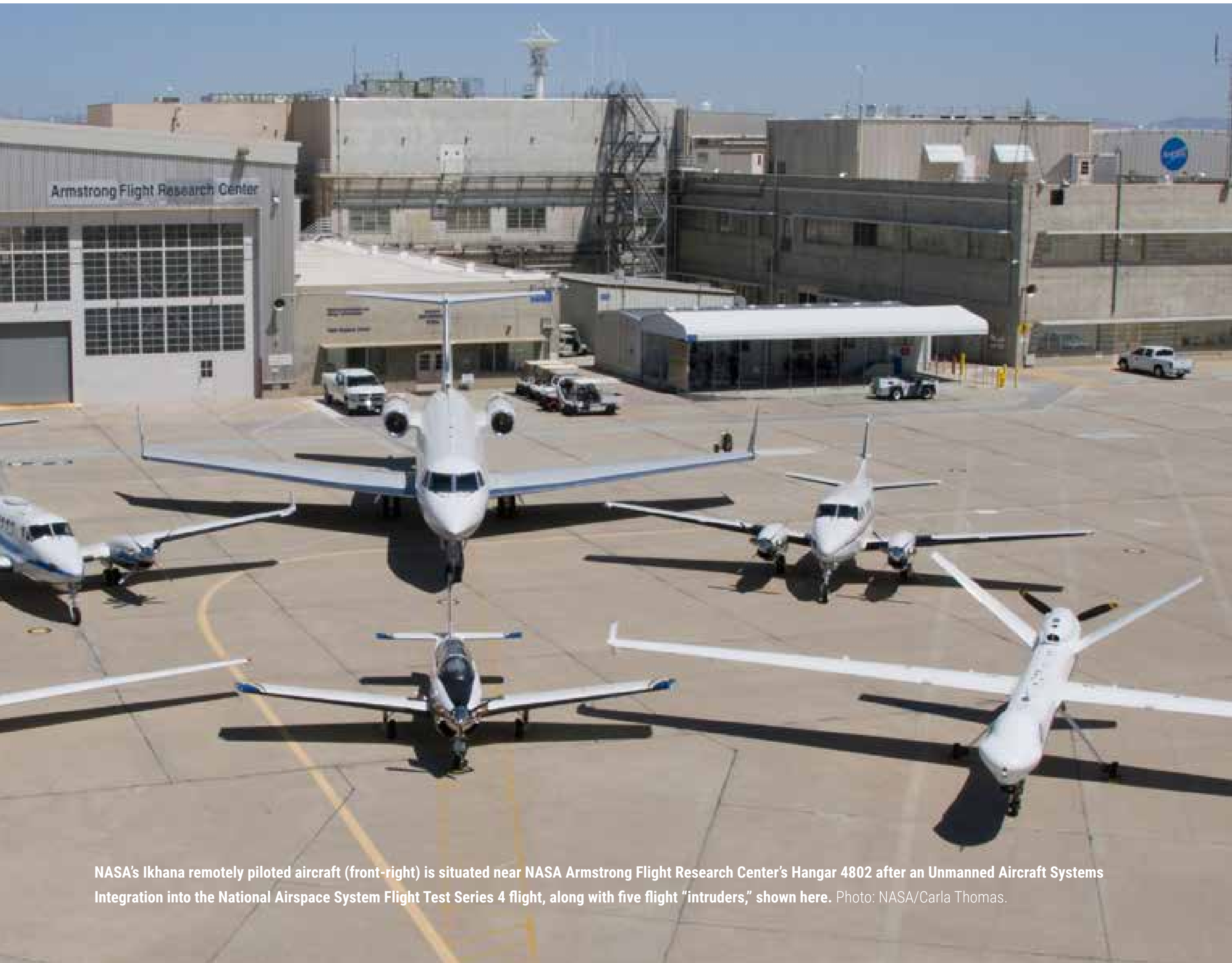
"I feel the vision systems are getting smarter," he says, but there are limitations. "You can't see in fog," he notes. Vision-based technologies can be stymied by fog, haze or other obscuring conditions, Nanduri says, so complementary systems such as optical flow sensors or infrared sensors are needed. 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.

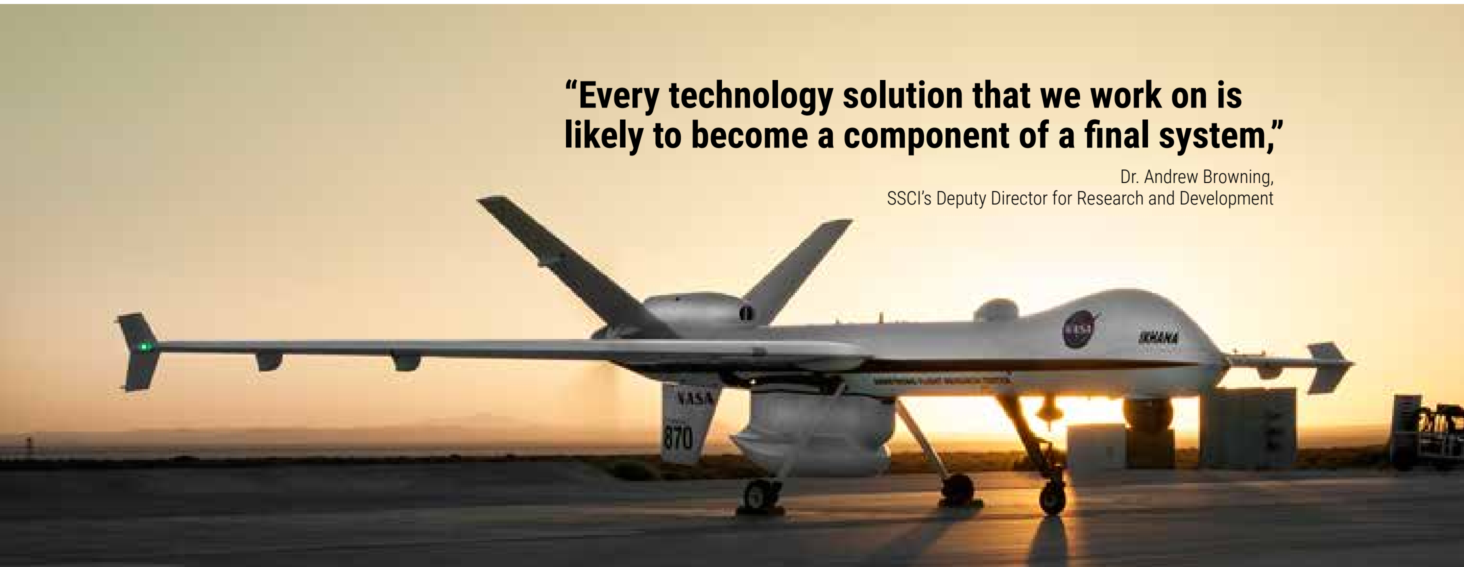
and most lightweight, and we are for the most part keeping up with them from a capability point of view."

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.

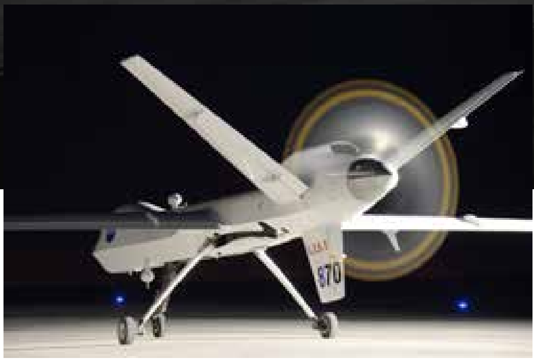
As early as March, an RTCA (Radio Technical Commission

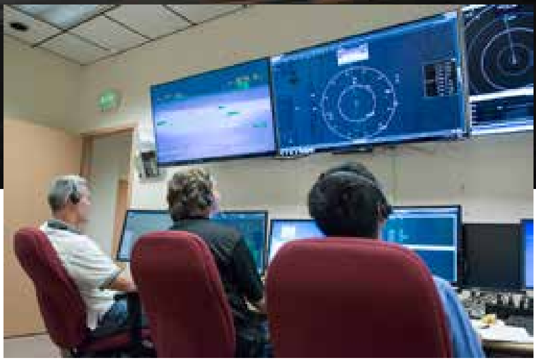
"Every technology solution that we work on is likely to become a component of a final system,"

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



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





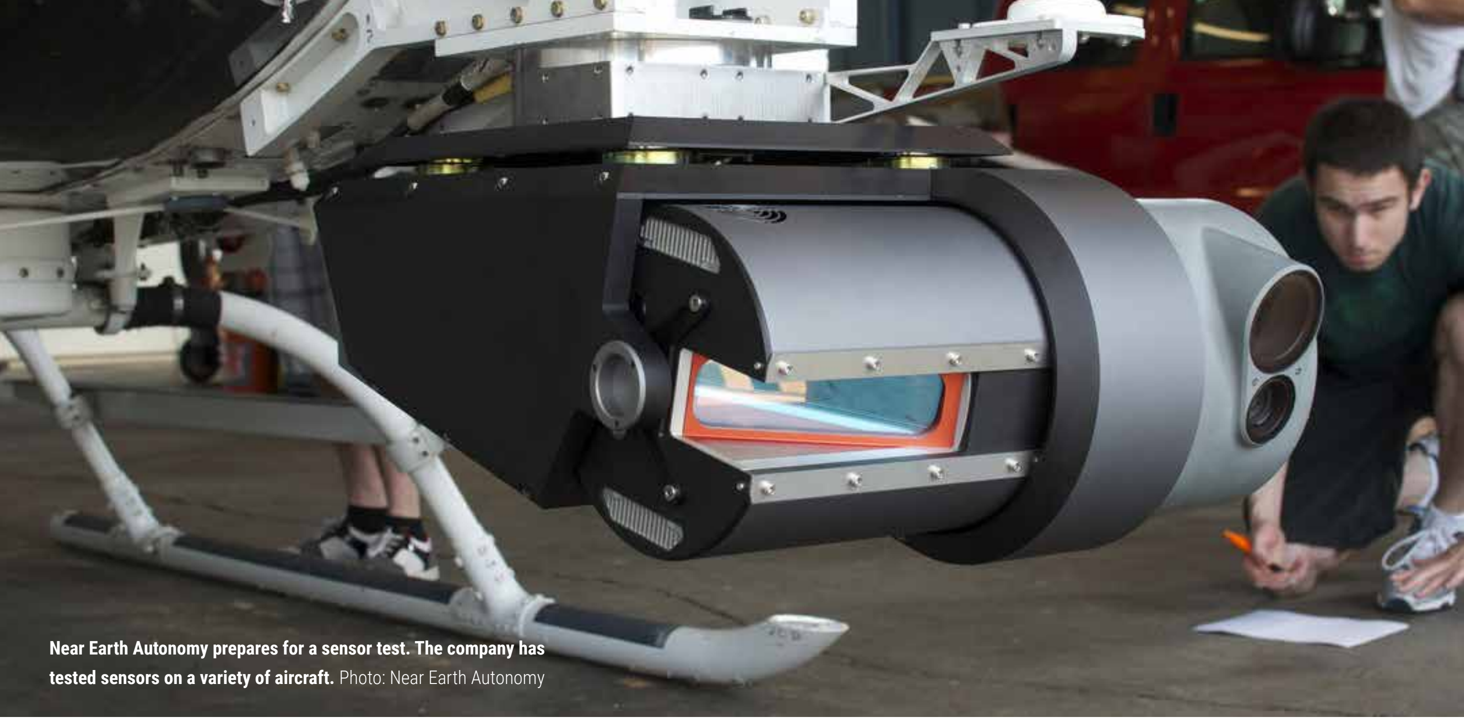
Radar probably will be more effective for these aircraft than lasers, he says, but lasers can help at low altitudes where radar often produces too many false positives and accurate close-range detection is needed. "Lidar definitely has its place on our view, and they are getting smaller, but they're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