Identifying military platforms for quantum sensors PG. 10

Rugged computers struggle with environmentals PG. 22

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MAKING SENSE OUT OF CHAOTIC SKIES

Detect-and-avoid technology is key to squeezing many aircraft into limited airspace

PG. 12

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Contents

JANUARY/FEBRUARY 2025
VOL. 36, NO. 1

Features

Columns

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Military projects seek to combine biology and machines; what sounds familiar about that?

BY **John Keller**
EDITOR IN CHIEF

NASHUA, N.H. – Pentagon researchers are giving substantial attention these days to combining biology and computers in efforts to create hybrid technology able simultaneously to sense, reason, upgrade automatically, and repair themselves.

These qualities are part of at least two notable projects announced since December that seek not only to control biological functions using microsystems and molecular catalysts, but also to integrate synthetic and biological components for bio-hybrid cybernetic creatures able to outperform traditional robots.

I'm not big into science fiction, but does any of that sound familiar?

The projects involved are the Microsystem Induced Catalysis (MICA), and the Hybridizing Biology and Robotics through Integration for Deployable Systems (HyBRIDS) programs.

MICA focuses on using microsystems to control biological functions, and will seek hardware demonstrations of molecular catalysts immobilized to microsystem surfaces and controlled by physical forces generated by the microsystem. Additionally, the program focuses on modeling and simulation of such integrated molecular microsystems.

The MICA program's design and simulation portion will include ways to predict the dynamic performance of molecules integrated with microsystems. The project's fabrication portion will include ways to place and immobilize molecules at microsystem interfaces to help the microsystem control catalyst activity.

A major thrust is placing and attaching catalytic molecules to microsystems to drive biological function. The program will emphasize compatibility with standard microelectronics manufacturing. Approaches should include how to predict molecule structure and function, and how to couple to a field-programmable gate arrays (FPGAs) and CMOS digital logic circuits.

HyBRIDS, meanwhile, seeks to combine living organisms and synthetic materials to create biorobots that compared to traditional robots can offer adaptability, self-healing, and energy efficiency. Bio-hybrid robots aim to capitalize on the precise control of traditional engineered robotic parts while harnessing the capabilities of biological elements. Integrating biological components like cells, tissues, or organisms could extend the functionality of robots, DARPA researchers say.

A bio-hybrid robot is defined as a scaffold equipped with actuators, sensors, and control mechanisms that enable it to interact with its surroundings in an autonomous or semi-autonomous fashion, achieved by merging functional, engineered components with biological materials and components.

So, what's the first thing that comes to mind when scientists start talking about combining biological organisms and machines? I can't help it, but that sounds like the Borg to me. The Borg are fictional cybernetic organisms from the Star Trek franchise of science fiction.

Inhabiting a Borg's body are cybernetic implants to enhance biological functions, sensing, and reasoning, as well as microscopic machines called nanoprobes flowing throughout their blood streams. These nanoprobes maintain the Borg cybernetic systems and repair damage to the Borg's organic components. What was that about the DARPA MICA and HyBRIDS project emphases on self-repair and self-healing?

Now obviously there's nothing in the MICA or HyBRIDS projects that even hints of assimilating other species. There's nothing sinister in these programs stated or even implied; they're talking about combining the best in biological beings and computer technology. Still, it's enough to stir the imagination.

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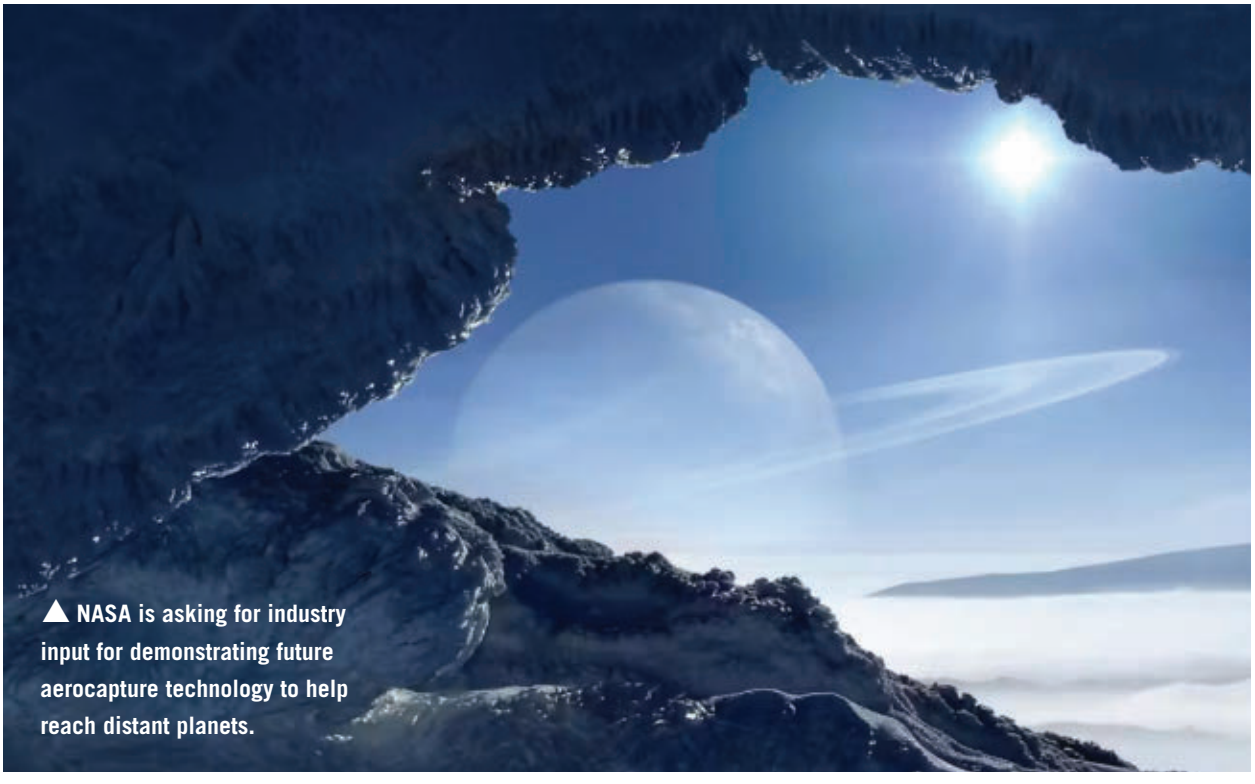


▲ NASA is asking for industry input for demonstrating future aerocapture technology to help reach distant planets.

NASA needs industry's help to demonstrate aerocapture technology for distant space travel

BY **Jamie Whitney**

WASHINGTON–The U.S. National Aeronautics and Space Administration (NASA) Langley Research Center is in the early stages of demonstrating aerocapture technology, and is seeking input from potential contractors capable of providing spacecraft systems and mission operations for the project.

NASA is seeking to develop aerocapture technology, which uses a planet's atmosphere to slow a spacecraft, reducing the need for large propulsion systems. This approach lowers launch mass requirements and increases payload capacity, making it useful for missions to distant targets such as the Solar System's ice giants.

NASA says that two mission concepts are under consideration. Both involve a small entry capsule, known as the Aerocapture Flight System (AFS), which includes an aeroshell, a reaction control system, and a small satellite (SmallSat). In one scenario, the AFS is launched into a geostationary transfer orbit (GTO) using an Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA). In the other, it is released on an Earth intercept trajectory from a spacecraft returning from the Moon.

The aerodynamic lift will be adjusted during atmospheric entry to control the spacecraft's flight path. This will be

achieved using either a center-of-gravity offset or an asymmetric aerodynamic device, such as a trim tab. Government-furnished thermal protection systems will also shield the AFS from the intense heat generated during atmospheric entry. Embedded sensors in the heatshield and backshell will collect critical data on temperature and pressure, while a SmallSat-mounted flight data system will store and transmit this information. To manage trajectory adjustments and maintain attitude control throughout the mission, the AFS will rely on its reaction control system.

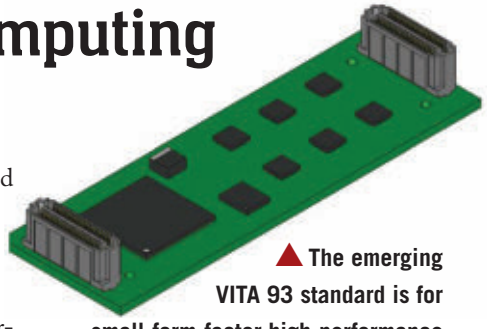
The SmallSat will play a key role in data collection and communication. Following its separation from the AFS, it will operate autonomously, transmitting flight data to ground stations and adhering to NASA's orbital debris mitigation guidelines.

NASA is actively seeking input from businesses capable of contributing to the mission. This includes designing, fabricating, testing, and integrating the AFS with its key components, such as the aeroshell and reaction control system. Companies with expertise in mission design and navigation, particularly for high-energy orbits and lunar-return trajectories, are also encouraged to respond. Additionally, firms experienced in establishing ground systems and managing mission operations across all phases are invited to participate.

Additional information, including technical information, is available at https://sam.gov/opp/7407ff305e664b-37947dc997e48d15bf/view. Responses were due by 15 January 2025 and must be submitted electronically via NASA's Enterprise File Sharing and Sync Box. The primary point of contact for this project is Stacy Hollis, who can be reached at stacy.m.hollis@nasa.gov.

New open-systems standard for high-performance I/O on the horizon small embedded computing

BY **John Keller**



▲ **The emerging VITA 93 standard is for small-form-factor high-performance I/O for military, industrial, and commercial aviation applications.**

SAN ANTONIO, Texas – The embedded computing industry is on the verge of a new open-systems standard for small-form-factor high-performance I/O for military, industrial, and commercial aviation applications.

The VITA 93 QMC standard, soon to be released, will be for small-form-factor embedded computing architectures such as VNX and VITA 90 VNX+, which are credit card-sized computer boards, as well as for the emerging VITA 100 standard, expected sometime next year, which will involve 3U,

6U, and perhaps other form factors, and is expected to replace and augment OpenVPX embedded computing.

VITA 93 QMC is scalable, designed from the ground-up to be rugged enough for military, aviation, industrial, and rail applications. "It's a small-form-factor I/O mezzanine card, with the same concept as XMC, but in a smaller package," says Mark Littlefield, director of systems products at Elma Electronic in Fremont, Calif.

Littlefield made his comments Monday at the Embedded Tech Trends conference in San Antonio, Texas. QMC will have conduction- and convection-cooled versions, yet will be able to mix-and-match conduction and convection cooling in the same enclosure.

One of the goals QMC is to support other embedded computing form factors, such as VME, CompactPCI, CompactPCI Express, and PCI Express edge finger modules, Littlefield says. "It's all about expansion — adding I/O ports to the modules for functionality and storage."

Among the expected applications for QMC are autonomous vehicles, edge computing, and artificial intelligence, Littlefield says. Some of the first designs for QMC will be as replacements for MIL-STD-1553 and CAN bus data interconnects.

Littlefield adds that QMC also could be a replacement for commercial aviation databuses such as ARINC-429. "I see no reason that ARINC 429 couldn't be part of this evolution," Littlefield says, adding that he sees no significant issues of certifying QMC for military and commercial applications.

Wanted: ability to use unmodified vegetation as sensors to detect chemical agents

U.S. military researchers are asking industry for new ways of using local vegetation to help detect, locate, and classify the presence of chemical agents. Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., issued an Exploration Announcement (EA) for the eX Virentia (eXVi) Phase 0 project, which essentially seeks to use plants as chemical agent sensors. The eX Virentia (eXVi) project seeks to use the external observable response of local unmodified vegetation as a proxy sensor to chemical exposure, using local sensing tools and remote sensing systems. This will require an understanding of the complex relationships between observable plant responses to the internal metabolic response of xenobiotic chemical uptake and the implicit variability of the organism within its environment, DARPA researchers say. The eXVi project will focus on studying internal and external effects using techniques such as metabolomics, proteomics, predictive modeling, 3-D imaging, imaging spectroscopy, and other methods. Developing the ability to use local, unmodified vegetation as a witness and reporter to chemical exposure activity could create new approaches to understanding the sources and impacts of chemical contaminants. Companies interested were asked to respond by January. More information is online at https://sam.gov/opp/c1e1ad360998473083e1f2acb34d84a7/view.

BAE Systems will provide actual control units for the future JetZero experimental blended-wing aircraft.

JetZero taps BAE Systems to provide actuator control units for blended-wing aircraft

BY **Jamie Whitney**

ENDICOTT, N.Y.–JetZero in Long Beach, Calif. has selected BAE Systems in Endicott, N.Y. to provide and integrate actuator control units (ACUs) for JetZero's experimental blended wing body (BWB) aircraft.

The ACUs, part of the flight control system, process signals from pilot commands delivered through active control sticks, which BAE Systems will also supply. The ACUs operate as remote actuators in a distributed system, managing localized flight surfaces to enable precise and responsive control. The ACUs will be designed and manufactured at BAE Systems facilities in Endicott, N.Y., and Fort Wayne, Ind.

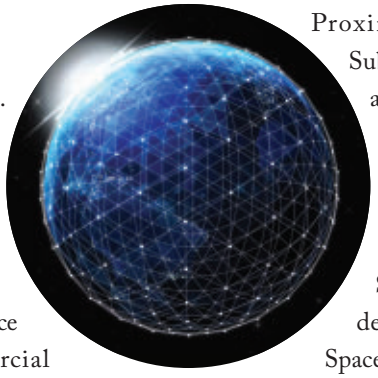
JetZero's BWB aircraft design integrates the wings and fuselage into a single smooth shape, reducing aerodynamic drag. The company says that due to an expected 50% fuel reduction compared to the current tube-and-wing design, the BWB will result in potential lower carbon emissions and operating costs. Its shape will reduce weight and drag and offers great promise in contributing to a more sustainable future in aviation.

"Our mature, highly capable actuator control units play a vital role in our shared vision of sustainable aviation with JetZero, seamlessly integrating with the flight control system," said Gary Battestin, director of Air Transport Systems for Controls and Avionics Solutions at BAE Systems. "This technology enhances overall flight performance, supporting a cleaner and more efficient future for air travel."

BAE Systems said the dual role of supplying both ACUs and pilot control inceptors will streamline integration for the aircraft. The actuation controllers are based on proven, previously certified systems, minimizing risk and reinforcing the company's position as a leader in flight control technology.

NASA picks commercial companies to support Near Space Network

BY **Jamie Whitney**



▲ **Four companies will help NASA expand the Near Space Network's commercial direct-to-Earth communication to enable spacecraft to transmit data directly to ground stations on Earth.**

105057203 © Georgejmclittle | Dreamstime.com

WASHINGTON–The U.S. National Aeronautics and Space Administration (NASA) has selected four companies to expand the agency's Near Space Network's commercial direct-to-Earth capabilities services, which is a mission-critical communication capability that allows spacecraft to transmit data directly to ground stations on Earth.

NASA says the contracts are worth as much as $4.82 billion. The contracts are firm-fixed-price, indefinite-delivery/indefinite-quantity agreements, with project timelines running from February 2025 to September 2029.

Intuitive Machines of Houston will receive two task orders for Subcategory 1.2 GEO to Cislunar Direct-to-Earth (DTE) Services and Subcategory 1.3 xCislunar DTE Services. These contracts aim to support NASA's Lunar Exploration Ground Segment, providing additional capacity to reduce demand on the Deep Space Network and meet requirements for highly elliptical orbits. The company also previously secured a task order for Subcategory 2.2 GEO to Cislunar Relay Services.

Kongsberg Satellite Services of Tromsø, Norway, will receive two task orders for Subcategory 1.1 Earth Proximity DTE, and Subcategory 1.2. These awards will support science missions in low Earth orbit and NASA's Lunar Exploration Ground Segment, also easing demand on the Deep Space Network.

SSC Space U.S. Inc. of Horsham, Pa., will receive two task orders for Subcategories 1.1 and 1.3 to support low Earth orbit science missions and meet the needs of unique, highly elliptical orbits.

Viasat, Inc. of Duluth, Ga., will be awarded a task order for Subcategory 1.1 to support science missions in low Earth orbit.

"NASA's goal is to provide users with communication and navigation services that are secure, reliable, and affordable, so that all NASA users receive the services required by their mission within their latency, accuracy, and availability requirements," the agency stated.

NASA's Goddard Space Flight Center in Greenbelt, Md., will manage the work under the agency's Space Communications and Navigation (SCaN) program. The Near Space Network supports missions up to 1.2 million miles (2 million kilometers) from Earth by facilitating data exchange between spacecraft and mission operators.

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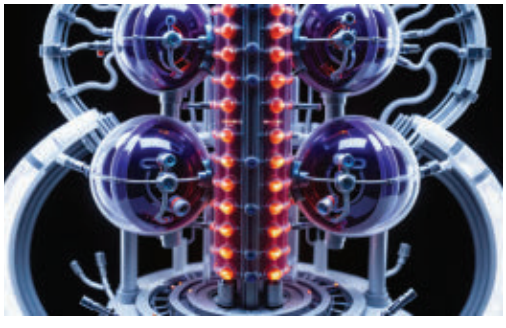
Researchers seek to identify military planes, ships, and vehicles for quantum sensors

BY **John Keller**

ARLINGTON, Va. – U.S. military researchers are ready to find new ways of speeding the installation of quantum sensors to military aircraft, ships, and land vehicles.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have announced plans for the future Robust Quantum Sensors (RoQS) program.



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This detailed rendering of a futuristic scientific device or quantum computer component features a vertical column of glowing red spherical nodes arranged in a double helix pattern.

Quantum sensors are expected to offer capabilities in applications like navigation, environmental monitoring, and medical imaging that are far beyond what traditional sensors can achieve.

Quantum sensors use quantum mechanics to achieve high sensitivity and accuracy by harnessing quantum entanglement, superposition, and tunneling to detect minute changes in physical quantities like magnetic fields, gravitational waves, or temperature.

RoQS will use design approaches that involve photonic systems or solid state systems. While quantum sensors have demonstrated exceptional laboratory performance in magnetic and electrical fields, acceleration, rotation, and gravity, their performance degrades once the sensor is placed on moving planes, ships, and vehicles.

Problems arise with quantum sensors on moving military systems because of electrical and magnetic fields, field gradients, and system vibrations.

RoQS seeks to overcome these challenges by developing quantum sensors that inherently resist performance degradation from platform interference, and demonstrate them on a military land, air, or maritime vehicle. RoQS seeks to switch RoQS-developed quantum sensors onto U.S. military platforms and programs of record.

RoQS will take a two-pronged approach. First, the program seeks to find prime systems integrators able to help with quantum sensor integration, and second, to find the best ways of integrating quantum sensors on select military systems.

Companies interested were asked to contact DARPA by January by email at DARPA-SN-25-27@darpa.mil. Include the special notice number, DARPA-SN-25-27, in all correspondence. More information is online at https://sam.gov/opp/b9cb0255a3814d9e894981e8e160c3a4/view.

Navy asks Ultra Electronics for next-generation software-defined surface-search ship radar

U.S. Navy Surface warship radar experts are ordering new software-defined surface-search radar systems to replace existing radars that suffer from obsolescent technologies or an inability to meet current threats. Officials of the Naval Sea Systems Command in Washington announced an $83.8 million contract to the Ultra Electronics Ocean Systems segment in Braintree, Mass., for production of AN/SPS-73(V)18 Next Generation Surface Search Radar (NGSSR) systems. Navigation and situational awareness are basic functions of all surface warships and these seemingly routine tasks have become more difficult as the ocean becomes increasingly complex. In March 2019 Ultra Electronics won a $28 million contract to develop NGSSR qualification systems. In July 2020 Ultra won a $42.2 million order to acquire the first NGSSR production lot following a contract award for design and production of three qualification systems. Major shipping channels are jammed with ship and radio traffic. Even small fishing boat and pleasure craft operators today can afford navigation radar systems. NGSSR will have a suite of algorithms that extend, enhance, and optimize NGSSR's performance by exploiting the system's software-defined architecture. For more information contact Ultra Electronic Ocean Systems online at https://umaritime.com, or the Naval Sea Systems Command at www.navsea.navy.mil.

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MAKING

▶ A Screening Obscuration Module attached to a Utility Task Vehicle is activated autonomously during the Robotic Complex Breach Concept on Yakima Training Center in Yakima, Wash. Marine Corps photo.

SENSE out of CHAOTIC SKIES

Detect-and-avoid technology is at the heart of global efforts to squeeze as many aircraft as possible in limited airspace, and help crewed and uncrewed aircraft fly together.

BY Jamie Whitney

As the skies and battlefields grow increasingly crowded, the ability for crewed and uncrewed vehicles to avoid collisions and operate safely in dynamic environments has become a cornerstone of modern vehicle design. Detect-and-avoid systems are instrumental in operational success in military and commercial sectors on the ground, in the air, and at sea. These systems combine advanced sensors, embedded computing, and signal processing to provide real-time situational awareness and autonomous decision-making with and without people

The rise of uncrewed vehicles has reached a stage where autonomous systems are replacing human operators, allowing machines to perform complex tasks independently. From underwater reconnaissance to aerial passenger transport and battlefield logistics, the potential applications for these autonomous vehicles are vast.

Artificial intelligence (AI) underpins vehicle autonomy, enabling operations across air, land, and sea with human safety and self-preservation in mind. While these systems are adept at navigating from Point A to Point B, challenges arise when unexpected obstacles appear. This begs the question: why shift decision-making from human operators to machines?

Humans possess extraordinary problem-solving abilities, driven by their capacity to innovate and use tools to alter their environment. Yet, for tasks like ensuring a drone avoids trees or enabling an unmanned ground vehicle to bypass obstacles, autonomy offers clear advantages.

In military contexts, uncrewed vehicles — commonly referred to as drones — reduce risk and cost. Human-piloted missions, whether in the air or deep underwater, inherently carry dangers. Drones eliminate these risks while also overcoming the physical limitations of human operators. Autonomous systems can perform extended missions without requiring rest, food, or other biological necessities, offering greater endurance and operational range compared to manned vehicles.

In the military, detect-and-avoid technology plays a critical role in ensuring mission success and protecting assets. Uncrewed aerial vehicles (UAVs) rely on sophisticated algorithms to navigate hostile environments, while fighter jets use advanced avionics to avoid collisions in complex combat scenarios. These systems must operate seamlessly, often in contested and GPS-denied environments, where accuracy and speed are paramount.

▲ A U.S. Air Force airman prepares to refuel an MQ-9 Reaper UAV at Melrose Air Force Range, N.M. The Reaper can get help from ground-based detect-and-avoid technology to keep it safely on mission and on target.

At the core of these capabilities are embedded computing systems and signal processing technologies. Embedded systems enable real-time data integration from multiple sensors, allowing vehicles to make use of incredible amounts of data to make split-second decisions. Meanwhile, signal processing filters and interprets this data, ensuring reliable detection of threats in cluttered and fast-changing environments.

The impact of these innovations extends beyond military applications. In commercial aviation, detect-and-avoid systems safeguard millions of flights annually, while in the burgeoning advanced air mobility (AAM) industry, they facilitate autonomous deliveries — and soon — flights across crowded urban environments. The automotive and maritime sectors are leveraging similar technologies to push the boundaries of autonomy and safety.

Making decisions

The process begins with sensors that detect obstacles, other vehicles, or potential hazards in the environment. In many cases, a mix of myriad sensors are used to build as complete an operational picture as possible and to provide redundancy. Andrew Baker, principal systems engineer at Honeywell Aerospace Technologies in Phoenix notes that most detect-and-avoid systems use passive visual [camera], microwave [radar], light wave [lidar] and ultrasonic technologies to keep the vehicle out of harm's way.

"Passive visual [sensors] have excellent range and resolution, however at the expense of lighting conditions," Honeywell's Baker told *Military + Aerospace Electronics* in 2024. "In nighttime or bad weather, optical is not going to work well. Radar and lidar work excellent in the dark, but you lose resolution that a camera would provide. Ultrasonic works well in the dark but has very limited range. It is best for proximity detection.

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There is no one sensor that does all. The environment and uses cases will determine what sensor is best. Ultimately using a passive visual with radar will provide the best of all worlds."

Detect-and-avoid systems often incorporate communications capabilities to exchange information with other nearby vehicles or air traffic control.

"Most sensors not only make detections but generate track information of objects that are moving," Baker says. "It is through the track information that determines whether an object is stationary or moving. Cameras, lidars, and radar all have this capability built into their software. Due to the resolution of cameras, they can go one step further and classify what that object is. The Honeywell radar can track up to 30 objects at once."

"ADS-B [Automatic Dependent Surveillance-Broadcast] is another piece of data which is highly used," Baker says. "While UAVs cannot yet broadcast on ADS-B, we can receive and use this information along with the sensor to achieve greater accuracy. In general, detect-and-avoid sensors are used for non-cooperative traffic, which are entities that are not transmitting their locations."

In crewed aircraft, detect-and-avoid systems often broadcast information

▲ A U.S. Marine Corps XQ-58A Valkyrie autonomous tactical unmanned air vehicle, conducts its fourth test flight alongside a U.S Marine Corps F-35B Lightning II jet fighter. Air Force photo.

regarding the location and altitude to other nearby aircraft. Relatively lower tech than automated detect-and-avoid systems, the Traffic Collision Avoidance System (TCAS) will provide pilots with suggestions to climb or descend to encroaching into another aircraft's airspace.

The Automatic Ground Collision Avoidance System (Auto-GCAS) also keeps an eye on altitude and location, but provides, as the name implies, an automatic response from the aircraft, to avoid crashing into terrain.

This technology, made up of a system that uses precise navigation, aircraft performance, and on-board digital terrain data, is used on American military aircraft like the F-35 and F-16, and was developed by Lockheed Martin's Skunk Works division, the Air Force Research Laboratory, and the National Aeronautics and Space Administration (NASA).

According to Ed Griffin, the Lockheed Martin Skunk Works program manager for the Automatic Collision Avoidance Technologies (ACAT) Fighter Risk Reduction Program, the system consists of a set of complex collision avoidance and autonomous decision-making algorithms that use precise navigation, aircraft performance and on-board digital terrain data to determine if a ground collision is imminent. "If the system predicts an imminent collision, an autonomous avoidance maneuver—a roll to wings-level and +5g pull—is commanded at the last instance to prevent ground impact," Lockheed Martin says in its description of Auto-GCAS.

Since the roll-out of the Auto-GCAS system began in 2014, Lockheed Martin says that it has been credited with saving 13 pilots and 12 aircraft. "Based on the data we've seen so far, the Auto GCAS is doing exactly what it was designed to do: save priceless lives and valuable military aircraft," said Griffin. "Many aviation professionals believe autonomy is emerging as the new frontier in aviation and Auto-GCAS currently represents the leading edge of autonomy as it applies to manned platforms."

On the ground

When power demands, mass, or size constraints of the vehicle will not allow the compute power necessary to handle

all of the sensor processing on-board, uncrewed vehicles can be assisted by off-board, ground-based detect-and-avoid (GBDAA) systems. Like edge systems, GBDAA sift through sensor data, often including radar, which provides long-range detection of objects and tracks their position and movement and vision systems, which offer visual confirmation and help identify obstacles. Additionally, Automatic Dependent Surveillance-Broadcast (ADS-B) receivers detect and track ADS-B-equipped aircraft by capturing real-time position data broadcast from those aircraft. Some systems also use radio communication intercepts to gather information from pilots or other sources via traditional radio frequencies. Collectively, these sensors create a comprehensive picture of the airspace, identifying the positions, velocities, and trajectories of aircraft and other objects.

For operations in controlled airspace, GBDAA systems often coordinate directly with air traffic control (ATC). This ensures that conflict resolution aligns with broader airspace management and complies with regulatory standards. Such coordination is vital for maintaining safe and efficient airspace operations. GBDAA systems are particularly advantageous in military applications where unmanned aircraft systems (UAS) frequently operate in complex airspace environments. These systems enable operations in areas with limited radar coverage or air traffic services, facilitate coordination between unmanned and manned aircraft during missions, and enhance situational awareness for operators located in remote locations. By centralizing the detection and avoidance process, GBDAA systems can reduce costs and streamline operations for vehicles that do not have onboard detect-and-avoid capabilities.

As advanced air mobility (AAM) aircraft, also known as "flying taxis," look to takeoff in 2025, a mix of on-board and GBDAA systems may provide a level of safety necessary to operate in congested urban environments, says Jia Xu, CEO of SkyGrid, a Boeing company focused on integrating these aircraft into existing systems.

"SkyGrid's ground-based detect-and-avoid is being developed to meet the required integrity and availability to satisfy the operational requirement to remain well clear of other traffic, even without a pilot onboard," Xu says. "In case a degradation of performance in

our ground-based traffic surveillance is detected, the system will alert the operator in a way like how operators are notified of GPS unavailability today. We anticipate that a hybrid detect-and-avoid solution — e.g., onboard and ground-based detect-and-avoid — may provide adequate mitigation against the failure or performance degradation of either type of detect-and-avoid system. The system is designed to ingest and correlate data from non-cooperative sources that are resilient to the effect of GPS degradations. It should also be said that non-cooperative and independent traffic surveillance functions can also be used to support positioning and navigation independent of GNSS and onboard systems to directly mitigate the effect of GPS degradation and denial.

Xu explains that third-party, ground-based technology services for AAM like the ones SkyGrid provides will offer a common operating picture. "A ground-based third-party service can act as a provider of a high-fidelity and high-integrity digital model of the operating environment, shared among all airspace users. When operators can rely on the same data for aeronautical decision-making, the predictability of operations can be increased, and in the future certain aspects of decision-making can be automated."

In addition, Xu says that third-party services can reduce reliance on ATC through scalability, and provide redundancy to onboard detect-and-avoid technology.

Regarding efficiency, Xu remarks that "A third-party service provider can provide highly automated strategic deconfliction to airspace users. For example, in future AAM networks, third-party service providers such as SkyGrid will help operators plan and schedule flights in ways that prevent airborne conflicts and ground delays. This will be achieved by third-party service providers acting as highly automated systems connecting operators, aerodromes, and air navigation service provider."

▲ **The U.S. Army Ground Vehicle Autonomous Pathways program prototypes software for the navigation of uncrewed vehicles by fusing data from multiple sensors and allowing teleoperations of unmanned ground vehicles. Army photo.**

Ground down

Like their airborne cousins, detect-and-avoid systems on ground vehicles crewed and uncrewed rely on data provided by numerous sensors utilizing vision systems and radio and light waves to ascertain what is going on in the environment around them. Depending on the scenario, land vehicles can be tasked with avoiding collisions with terrain, other vehicles, pedestrians, while keeping passengers safe traveling along a pre-planned route or on-the-fly.

Because ground vehicles will likely encounter many more obstacles than their airborne counterparts, cameras play a larger role in detect-and-avoid systems by enabling the recognition of objects, lane markings, and traffic signs. Lidar, on the other hand, creates a high-resolution 3D map of the surroundings using laser pulses, making it particularly effective in determining object distance and geometry. Radar systems provide accurate detection of object speed and distance, especially in adverse weather conditions, while ultrasonic sensors are instrumental in close-range obstacle detection, often during parking and low-speed scenarios.

Localization is an essential component of ground-based autonomous detect-and-avoid systems, enabling the vehicle to determine its precise position on the road. High-definition maps, enhanced global positioning system (GPS) technology, and inertial measurement units (IMUs) work together to achieve centimeter-level accuracy. Engineers must ensure that the system can handle discrepancies between map data and real-world conditions, such as construction zones or temporary road closures.

AI and machine learning are integral to self-driving systems. Engineers employ AI for object recognition, decision-making, and adaptive learning. Neural networks, for example, classify objects and predict the behavior of other

road users, while reinforcement learning improves system performance through iterative simulations and real-world data analysis. The challenge for engineers lies in training these models to handle edge cases, such as rare or unpredictable scenarios, to enhance system robustness.

Self-driving technology is categorized into five levels of autonomy, from Level 0 — no automation — to Level 5, which is full vehicle autonomy under all conditions. Lower-level detect-and-avoid integration can include lane keep assistance and blind spot warning systems. Engineers must address challenges such as sensor calibration, computational load, software reliability, and system safety to achieve higher levels of automation.

Commercial breakthroughs are helping drive development in uncrewed military vehicles, Kevin O'Brien, technical director for the U.S. Army's Defense Innovation Unit autonomy portfolio, said in late 2022.

"There has been a revolution in the techniques and capabilities of uncrewed ground vehicles occurring in the private sector over the past two decades. We're eager to bring these matured technologies back into the Department of Defense where initial work was inspired by the DARPA Grand Challenges," O'Brien said, referring to the Defense Advanced Research Projects Agency's unmanned vehicle competitions.

Sea legs

A constant in detect-and-avoid technology is the integration of sensors in placing the vehicle in its surroundings and keeping it on mission, but what if there are virtually no landmarks to aid in decision making? Waves and currents create dynamic conditions that require robust filtering and adaptive algorithms to distinguish between obstacles and natural water motion. Unlike land navigation, where fixed landmarks are common, maritime navigation relies heavily on GPS, inertial navigation systems (INS), and, in some cases, celestial navigation due to the lack of consistent reference points. Engineers must also account for weather variability, which can affect sensor performance, particularly for cameras.

One distinctive feature of seaborne detect-and-avoid systems is their need to navigate in three dimensions. While air vehicles also operate in 3D, maritime navigation is uniquely influenced by buoyancy, water currents, and the ability to operate underwater for submersibles.

Engineers must incorporate sonar and hydrodynamic modeling for underwater navigation. Additionally, maritime vessels move slower than land or air vehicles, requiring advanced prediction and planning for obstacle avoidance due to their low maneuverability. While aircraft detect-and-avoid systems can takeover in must anticipate hazards far in advance to ensure timely course corrections.

Marine environments also feature a wide variety of obstacles, ranging from stationary ones like buoys and reefs to mobile ones like other vessels and wildlife. Submerged hazards, invisible to surface-based sensors, demand hybrid sensor arrays for effective detection. Furthermore, the constantly shifting conditions of waves and tides require real-time calibration and adaptive algorithms, as the environment beneath a vessel is always changing.

Unlike land and air systems, which rely on traffic signals or air traffic control, seaborne systems must comply with decentralized maritime laws such as the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs). These laws govern right-of-way, overtaking, and crossing paths, requiring nuanced algorithmic interpretation. Engineers also face communication challenges, as long-range VHF radio and satellite communications are critical for data sharing due to the absence of land-based infrastructure, making off-board computing assistance for detect-and-avoid more difficult.

Processing power

Whether on-board or off, the effectiveness of these systems depends on the quality of the sensors, communication infrastructure, and algorithms that underpin their design alongside the ability to process the signals. Of course, the ability for sensors on a vehicle to produce data is only useful if it can be processed and detect-and-avoid systems can act or make recommendations.

The medium-displacement unmanned surface vessel Sea Hunter sits pierside at Naval Base San Diego, during the Unmanned Surface Vessel Division (USDIV) One Establishment ceremony. USDIV One will focus on unmanned surface vessel experimentation and fleet advocacy for the surface force. U.S. Navy photo.

The large volume of data from these sensors necessitates the ability to process it in real time with nearly no margin of error. To do this, embedded computing systems enable vehicles to have the proper processing power to keep the mission on track and out of preventable danger. While detect-and-avoid systems operate in environments as varied as the crushing depths of the ocean up to the edge of space, the building blocks of the decision-making systems that keep them moving are often made with modularity in mind.

"Detect-and-avoid systems are designed to be modular and interoperable, enabling seamless integration with a variety of sensors, including radar, lidar, and electro-optical/infrared systems," says Aneesh Kothari, president of Systel, Inc. in Sugar Land, Texas. "We design with a modular open standards approach (MOSA), using industry standard interfaces, protocols, and computing architectures to ensure compatibility with existing sensor and communication architectures.

Like everything in the world of aerospace and military electronics, size, weight, and power (SWaP) concerns are top-of-mind in uncrewed technologies, Kothari says.

"SWaP optimization is vital for uncrewed platforms where space is at a premium and weight savings can be measured in ounces. Systel has led the market, bringing innovative products like Sparrow-Strike — launched in 2024 — to market to meet the emerging demands of next-gen uncrewed platforms. Sparrow-Strike is an ultra-small form factor (USFF) MIL-SPEC rugged edge compute solution, integrating the NVIDIA Orin Jetson NX embedded edge AI processing module or an Intel x86 based CPU," Kothari says.

Of course, processing a torrent of sensor data necessary to keep autonomous vehicles moving draws a lot of power — and creates a lot of heat. William Pilaud, Chief Solutions Architect at LCR Embedded Systems in Norristown, Pa., says that managing thermal performance in next-generation ruggedized systems pushes the limits of traditional conduction-cooled systems.

VPX modules, widely used in high-performance systems, are reaching the thermal limits of conduction cooling, which has traditionally relied on VITA 48.2 standards. "We're stuck between a rock and a hard place," Pilaud said, highlighting that components now often draw more than 150 Watts of power.

Emerging cooling solutions, such as air-flow-through (AFT) cooling in VITA 48.8 and liquid cooling in VITA 48.4, offer a path forward, according to Pilaud. Liquid cooling stands out for its efficiency. However, Pilaud acknowledged the practical difficulties, noting, "In the far future, you're going to be dragged kicking and screaming to liquid."

Pilaud also discussed the growing adoption of VITA 48.4, which has seen significant momentum over the past year. He predicted further advancements as the industry works to address gaps in the current standards. Sidewall liquid cooling was mentioned as a potential retrofit solution for older systems, though Pilaud cautioned it may not match the performance of module-level cooling.

Designing VPX backplanes for sensor-heavy systems presents its own set of hurdles, Pilaud says. LCR Embedded Systems' expertise in backplane development, dating back to the early 2000s, has been instrumental in addressing these issues. "LCR has a long track record with designing VPX backplanes…and has a proven track record of signal integrity for industry-standard interfaces such as PCIe," Pilaud says.

Key challenges include maintaining signal integrity despite minor differences in trace routing and limited space for input/output (I/O) within chassis. "Space for I/O is much more limited in the chassis," Pilaud notes, adding that higher-speed sensors and parallel bus interfaces exacerbate the problem. While SOSA is improving standardization, Pilaud emphasized, "It's not fully standardized at the moment."

Rugged computers struggle with environmental requirements

Systems designers are using commercially developed computer technologies in rugged computer systems designed for the edge, which imposes challenges, in size, ruggedization, and thermal management.

▲ **The Systel Kite-Strike rugged computer features rugged ultra-SWaP-optimized artificial intelligence (AI) and computer vision embedded edge computers that integrate NVIDIA Jetson edge-AI system-on-modules for demanding localized edge AI processing.**

BY **John Keller**

Rugged computers are the key to bringing advanced capabilities like artificial intelligence (AI), machine learning, and quantum sensing to military ships, aircraft, and land vehicles designed to operate at the edge of the battlefield.

A host of enabling technologies are coming to bear on rugged computers, such as ARM microprocessors, general-purpose graphics processing units (GPGPUs), and fast Ethernet networking. Nevertheless, the military computing industry has many design challenges to meet in size, weight, and power consumption (SWaP), thermal management and cooling, and tradeoffs between capability and operating environments before the best technologies can be unleashed.

As the military rugged computing industry moves forward, the most important technology trends, influential aerospace and defense applications, open-systems industry standards, and different approaches to meeting design needs will converge to move the industry forward.

Aerospace and defense applications

Talk to experts in military rugged computing, and inevitably what comes up is a discussion of artificial intelligence, and the computing resources necessary to carry out AI — particularly on the edge of the battlefield.

"More than ever over the last five to ten years, we are seeing a bigger demand for edge processing — the need for data processing at the edge, and the use of AI," says Dominic Perez, chief technology officer at the Curtiss-Wright Corp. Defense Solutions segment in Ashburn, Va. "As powerful a tool as AI is, it is extremely resource-intensive."

AI often is the first concern today when it comes to rugged military computing. "The DOD [U.S. Department of Defense] is highly focused on AI, machine autonomy, and uncrewed vehicles; that's where we see more and momentum. That's just naturally where the future is, says Aneesh Kothari, vice president of marketing for rugged computing specialist Systel in Sugar Land, Texas.

Kothari cites the DOD Replicator program as an example. Replicator seeks to develop relatively low-cost AI-equipped uncrewed vehicles to warfighters that are inexpensive enough not to cause big problems when they are lost or destroyed, which U.S. military officials call "attritable."

▲ The Concurrent Helios Rugged Vision System computer is a rugged commercial off the shelf (COTS) vision computer system that is optimized for low size, weight, power and cost (SwaP-C) for use in harsh environments.

The first iteration of Replicator, called Replicator 1, was announced in August 2023 to deliver attritable autonomous systems at a scale of multiple thousands as early as August 2025.

Replicator 1 seeks to use large masses of uncrewed systems not only to put few people in the line of fire, but also unmanned vehicles that and can be changed, updated, or improved with short lead times.

Replicator program

Last September Defense Secretary Lloyd Austin announced the second iteration of Replicator, Replicator 2 to counter small uncrewed aerial systems at critical installations and force concentrations. Replicator 2 is to help overcome challenges in production capacity, technology innovation, authorities, policies, open-systems architectures, and systems integration.

Replicator seeks to strengthen collaboration between the Pentagon and commercial technology developers on developing inexpensive autonomous vehicles. More than 500 companies have participated in Replicator-1, and more than 30 have received contracts.

The drive to develop affordable AI, through programs like Replicator, "are definitely the big push for AI and autonomy," Kothari says. "AI and autonomy will be at every node of that network."

AI, and new generations of rugged computers that drive it, also will be at the heart of new initiatives to fuse sensors into a battlefield common operating picture, as well as efforts to move

The Concurrent Technologies TR MDA/6sd-RCR SOSA-aligned 3U VPX compute-intensive rugged plug in card is SOSA-aligned, and features a processor with as many as 10-cores, large memory capacity, FIPS 140-3 secure storage, and support for virtualization.

5G wireless communications onto the battlefield.

"A common operating picture application is a new concept," says Curtiss-Wright's Perez. "The change is the wealth of sensors and information that can be pulled into the common operating picture. The challenge there is how to get the data fused into the common operating picture, with the right data formats, with data sanitized, and the whole human factors aspect."

Even the next generations of military wireless networked communications will rely on rugged computers and AI, Perez says. "The push for 5G on the battlefield really comes down to a lot of ruggedizing and processing."

Perez also points to the challenge of integrating individually held communications devices into the mobile ad-hoc networking of the future, referred to as MANET. This will involve meshing radios that can act as an extension to the radios that warfighters already carry.

Other AI and rugged computing-driven applications also involve the overall battle picture, says Austin Williams, product manager of rackmount computers at Systel. "You might have vehicle doing complex signals intelligence operations and taking action," Williams says. "That is a massive volume of data and processing. You need that horsepower to run it.

The RTS-210-front 2-slot VPX chassis is part of the LCR Embedded Systems line of ATR chassis designed for 3U VPX SOSA systems in defense applications including DDA systems on uncrewed platforms.

Enabling technologies

High-performance computing is pervasive today; the rise of the data center is perhaps the best example of that. Yet it's light years of difference between leading-edge data center computing and the kind of AI rugged computing envisioned for the battlefield's edge.

To put it bluntly, the battlefield is far from a controlled environment, as data center computing is. Battlefield computers must be rugged enough to withstand shock and vibration, temperature extremes, and careless operators. These kinds of rugged computers also must be size-, weight-, and power-efficient.

"Systel and other integrated computer manufacturing companies came in because you need ruggedized computers at the edge," says Systel's Kothari. "You need rugged edge hardware providing enabling capabilities for those networks. The big push from a computer level is to make products smaller and lighter, more rugged for harsh environments, and integrating higher-and higher-Wattage electronics."

Kothari points to today's data center-grade computing devices such as multicore microprocessors, field-programmable gate arrays (FPGAs), and GPGPUs that must be specially packaged and protected from the rigors of the battlefield to succeed in the rugged military computing market.

Take the Nvidia Jetson GPGPU architecture, which is becoming popular for high-performance rugged military computing. "The Jetson architecture is ARM based, and that is the preferable approach to these AI applications," says Sam Mata, product manager of embedded computers at Systel. "You do lots with it, and it tends to be a very good

▲ The Curtiss-Wright PacStar 453, VPX3-1262, and CHAMP-XD4 rugged computers are examples of how CPU, GPU, and FPGA technology can be packaged for different edge applications and operating environments.

approach to ingesting and manipulating that data. These GPUs are great for AI because they can do a large amount of parallel processing for AI training. It does high-end processing before it talks to the CPU. Very valuable for AI training."

Systel offers two products for battlefield AI that use Nvidia Jetson technology: the Kite Strike and Sparrow Strike rugged computers. "Those are ready to go to get trained by certain algorithms for the sensors responsible for taking in that data," Mata says. The smaller of the two, Sparrow Strike, weighs slightly more than two pounds, and is being designed into a small unmanned aircraft, Mata says. "It's an on-board mission computer on a small UAV on a next-generation defense program. It's a very compact, lightweight, and highly rugged product."

Performance demands

The need for enhanced rugged computing seemingly is unending. "AI at the edge we can help with," says Curtiss-Wright's Perez. "Sensors can pull in a tremendous amount of data, and the resolution of these sensors is an order of

magnitude of what they were previously; that's an order of magnitude increase in compute power. Computer performance will keep marching up, and challenging those who need to ruggedize it."

There's no end in sight for demands for more computing power. "Generally, data is king," says Systel's Williams. "If you only have basic computers out in the field, Nvidia can help make actionable decisions at the soldier level, without spending weeks to find out what's going on.

Yet the challenges of high-performance rugged computers in the field persist — especially for today's computers. The chips keep getting hotter," Williams says. "On rackmount side, you are generating a lot more heat, and your system can throttle. We're also getting into higher vibration and shock."

Design issues

So what are the best approaches for moving commercially developed rugged computer technology from the data center to the field? "We have to play the SWaP balancing game between capabilities and needs, and deal with electromagnetic signatures and thermal signature, as we go into the field," says Curtiss-Wright's Perez.

It's not really a technical issue of sending a supercomputer to the field; people have been doing that for a while," Perez continues. "But supercomputers generate a great deal of heat, and has an EMI [electromagnetic interference] footprint. The challenge is to balance what capabilities you can and should have at the edge, and what can you do if you are denied communications at the edge. Performance per Watt is the name of the game."

There's little choice these days, other than ruggedizing commercially developed technology, rather than developing rugged computers from the ground up. "We've really flipped the script in the last 50 years to where most research funding was sponsored by the federal government; now it's a small fraction," Perez explains. "Industry today is driving what technology is available, and they don't give much thought to how that technology moves to the field."

Heat and cooling are crucial considerations for edge computing, where they're given little thought in the climate-controlled data center. "Not all of these high-end processors can handle that temperature range without a reset in the middle," Perez points out. "On a mission computer, you can't be resetting them all in-situ. We are going to see more and more of this as die sizes decrease and signal processing increases."

Some of the design tradeoffs go deeper than just making technology choices, Perez says. "We still are really learning about how much data we can shove in the brain of a human. We as a community are leaning together what is the most advantageous to put in front of a warfighter. Is it on a screen in a vehicle, or worn on a human? You can't give a human everything at once, and what are the requirements that we need to push it to the edge?"

The role of industry standards

Today's open-systems standards offer to help rugged computer designers respond quickly to demand for enhanced performance and rapid technology insertion. Chief among these standards and design guidelines are the Modular Open Systems Approach (MOSA), and the Sensor Open System Architecture (SOSA) standard. Both seek to reduce or eliminate vendor lock on contractors and projects, support interoperability among different vendors, and facilitate rapid upgrades through technology insertion.

We've been a strong advocate of the SOSA working group," says director of product strategy at rugged computing specialist Concurrent Technologies plc in Colchester, England. "The change they have made toward a small number of open standards for plug-in devices means there is little risk to the primes adopting a product from Concurrent, because if we fail, they easily can buy from other suppliers."

SOSA and MOSA represent big milestones in open-systems design. "That's a big change in the opportunities that we can get into," Forrester says. "We introduced a new product last year, and had a requirement to deliver a significant number of those products at the end of 2024. We went from the product being a concept design to one that was fully SOSA-aligned. We were able to deliver several hundred of those products, which is significantly different over what we could do five years ago. The SOSA dividend is really starting to pay-off."

The next big change where open standards are concerned will be VITA 100, which will offer SOSA-aligned computer cards in 3U, 4U, and 6U sizes, Forrester says. VITA 100 is expected to receive American National Standards Institute (ANSI) approval next year.

The expected 4U size of VITA 100 boards will have the real estate necessary to accommodate the large sizes and bandwidth requirements of current and future integrated circuits. The chipsets we are provided by Intel, Nvidia, and AMD/Xilinx today are too big, and too power hungry to cope in a 3U form factor, Forrester says. "We have customers telling us they need more performance, and that can be impossible in a 3U form factor."

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Axiom Electronics

RTX Raytheon to build 13 electronic warfare (EW) jammers for U.S. and Australian combat jets

BY **John Keller**

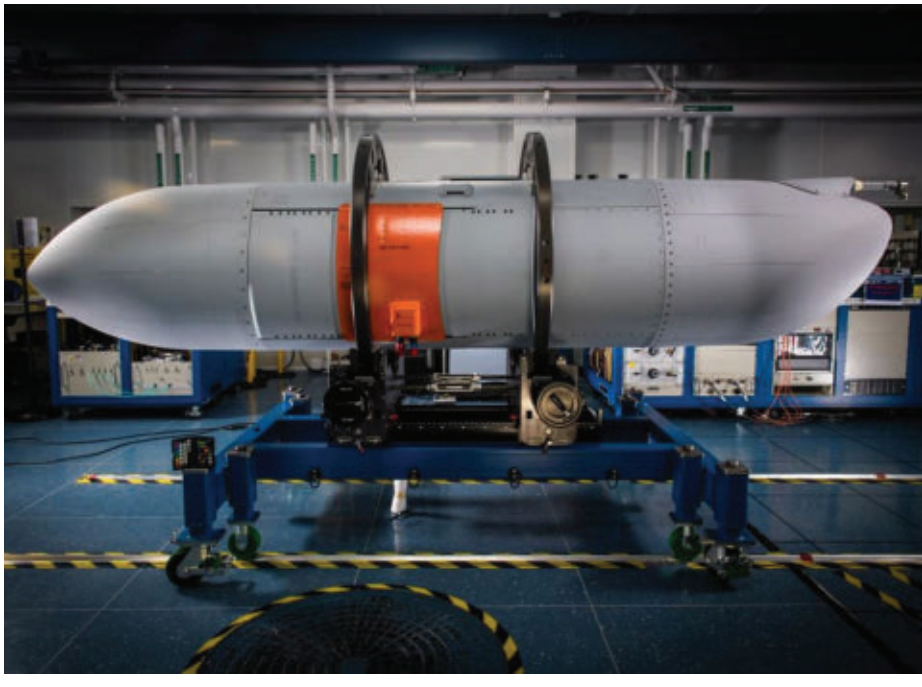
PATUXENT RIVER NAS, Md. – RTX Corp. will build 13 Next Generation Jammer Mid-Band (NGJ-MB) airborne electronic warfare (EW) systems for U.S. Navy and Australian EA-18 Growler combat jets under terms of a $591 million contract.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the RTX Raytheon segment in El Segundo, Calif., to build 13 NGJ-MB ship sets — nine for the Navy and four for the Royal Australian Air Force. Each aircraft has two ship sets.

The NGJ midband is an advanced electronic attack system that denies, disrupts, and degrades enemy communications and air-defense radar systems. It offers a combination of agile active electronically scanned arrays (AESA) and an all-digital back end. The contract includes spare parts, support equipment, and non-recurring engineering.

The NGJ-MB helps the Growler aircraft operate at long ranges, attack several different targets simultaneously, use advanced electronic jamming techniques, and incorporate rapid upgrades through a modular, open-systems architecture.

In September RTX Raytheon won a $192 million contract to upgrade the NGJ-MB system to counter new adversary RF and microwave threats. This upgrade will provide the NGJ-MB with additional frequency coverage.



▲ **The NGJ midband is an advanced electronic attack system that denies, disrupts, and degrades enemy communications and air-defense radar systems.**

Raytheon delivered the first NGJ-MB pod to the Navy for testing in July 2019. The technology also can be scaled to other missions and aircraft.

The NGJ airborne jammer pod is replacing the 40-plus-year ALQ-99 jammer system on the EA-18G — a version of the Navy's carrier-based two-seat F/A-18F Super Hornet jet fighter-bomber that is modified specially for electronic warfare.

The EA-18G leads an airborne attack by disrupting enemy radar, communications, and computer networks with jamming signals and computer viruses. The aircraft also can destroy enemy radar installations with its AGM-88 High-speed Anti-Radiation Missiles (HARM).

Raytheon's NGJ will integrate the most advanced electronic attack technology into the EA-18G, such as high-powered, agile beam-jamming techniques, and solid-state electronics to deny, degrade and disrupt enemy threats while protecting U.S. and coalition forces.

Raytheon's NGJ will provide airborne electronic attack and jamming capabilities, and will include cyber-attack capabilities that use the aircraft's active electronically scanned array (AESA) radar to insert tailored data streams into enemy radar and communications systems.

The NGJ also will have an open-systems architecture for future upgrades. Raytheon will use its gallium nitride (GaN)-based AESA technologies for the NGJ design.

Eventually Raytheon engineers may modify the NGJ to install it aboard the F-35 joint strike fighter, unmanned aerial vehicles (UAVs), as well as to other manned aircraft in addition to the EA-18G.

The Navy also is developing the Next Generation Jammer Low Band (NGJ-LB) in an urgent effort to develop low-band tactical radar jammers using existing technologies for low size, weight, and power consumption (SWaP) applications on the EA-18G Growler EW jet.

L3Harris Technologies in Melbourne, Fla., won a contract in late 2020 to design and build the NGJ-LB, which experts say will be useful in jamming low-band radar systems designed to detect stealth aircraft like the F-35 joint strike fighter. The NGJ-LB transmitter will fit in a pod on Station 6 of the EA-18G.

The system will enhance the performance of frequency coverage, effective isotropic radiated power, spatial coverage, spectral purity, and polarization; obtain existing contractor data related to transmitter group performance; and assess the potential to deploy an open-systems interim pod solution rapidly.

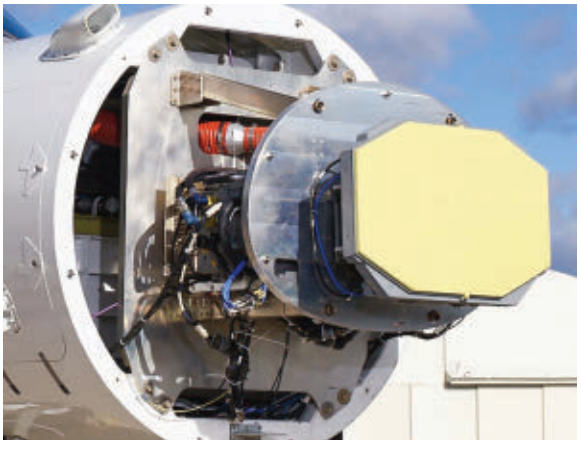
On this contract Raytheon will do the work in Forest, Miss.; McKinney, Texas; El Segundo, Calif.; Andover, Mass.; and Fort Wayne, Ind., and should be finished by January 2028. For more information contact RTX Raytheon online at www.rtx.com/raytheon/what-we-do/sea/ngj, or Naval Air Systems Command at www.navair.navy.mil.

Secure 5G military networking with encryption to link warfighters globally introduced by Persistent Systems

Persistent Systems LLC in New York is introducing the Personal Transport 5 (PT5) accessory for the handheld MPU5 MANET radio networking device to connect teams of warfighters around the world. The PT5 is a dual-function device that connects to the MPU5, simultaneously delivering 5G cellular and Wi-Fi connectivity. The lightweight PT5 securely connects soldiers to host-nation 5G cellular networks, and facilitate Persistent's over-the-horizon Cloud Relay networking to connect warfighters in a global communication fabric. Two independent layers of accredited encryption enable data to traverse foreign host-nation cellular networks securely. Cloud Relay automates establishing Internet Protocol Security (IPsec) VPNs and protects data with Media Access Control Security (MACsec). The PT5 also provides two Wi-Fi 6e access points to create a personal-area network on the soldier, simplifying connectivity of third-party Wi-Fi devices such as computers, sensors, and cameras. The Wi-Fi access points run simultaneously on two frequency bands providing compatibility with legacy 2.4 GHz devices while delivering maximum performance to modern 5 GHz and 6 GHz Wi-Fi 6e devices. For more information contact Persistent Systems online at www.persistent-systems.com/pt5.

Northrop Grumman to build additional AESA airborne radar systems for F-16 jet fighters

WRIGHT-PATTERSON AFB, Ohio – U.S. Air Force aerial warfare experts are ordering additional modern active electronically scanned array (AESA) radar for F-16 jet fighter aircraft under terms of an $30 million order.



▲ **The Northrop Grumman APG-83 AESA fire-control scalable agile-beam radar (SABR) integrates within the F-16's structural, power, and cooling constraints.**

Officials of the Air Force Life Cycle Management Center, Fighter Bomber Directorate, F-16 Division, at Wright Patterson Air Force Base, Ohio, are asking the Northrop Grumman Corp. Mission Systems segment in Linthicum Heights, Md., for production radars for the F-16. This order brings the total value of this AESA radar contract to $1.7 billion.

The APG-83 AESA fire-control scalable agile-beam radar (SABR) integrates within the F-16's structural, power, and cooling constraints without Group A aircraft modification, Northrop Grumman officials say. The company leverages technology developed for the APG-77 and APG-81 radar systems on the U.S. F-22 and F-35 combat aircraft.

In a 2013 competition, Lockheed Martin Corp., the F-16 manufacturer, selected the APG-83 as the AESA radar avionics for the F-16 modernization and update programs of the U.S. Air Force and Taiwan air force.

The bandwidth, speed, and agility of AESA radars enable legacy fighter aircraft like the F-16 to detect, track, and identify many targets quickly and at long ranges, and to operate in hostile electronic warfare (EW) environments.

Northrop Grumman is building APG-83 radar systems for global F-16 upgrades and new aircraft production, as well as for the U.S. Air National Guard. Northrop Grumman also has installed a production APG-83 SABR on a U.S. Marine Corps F/A-18C Hornet jet fighter aircraft, company officials say.

On this order Northrop Grumman will do the work in Linthicum Heights, Md., and should be finished by May 2031. For more information contact Northrop Grumman Mission Systems online at www.northropgrumman.com/who-we-are/business-sectors/mission-systems, or the Air Force Life Cycle Management Center at www.afl-cmc.af.mil.

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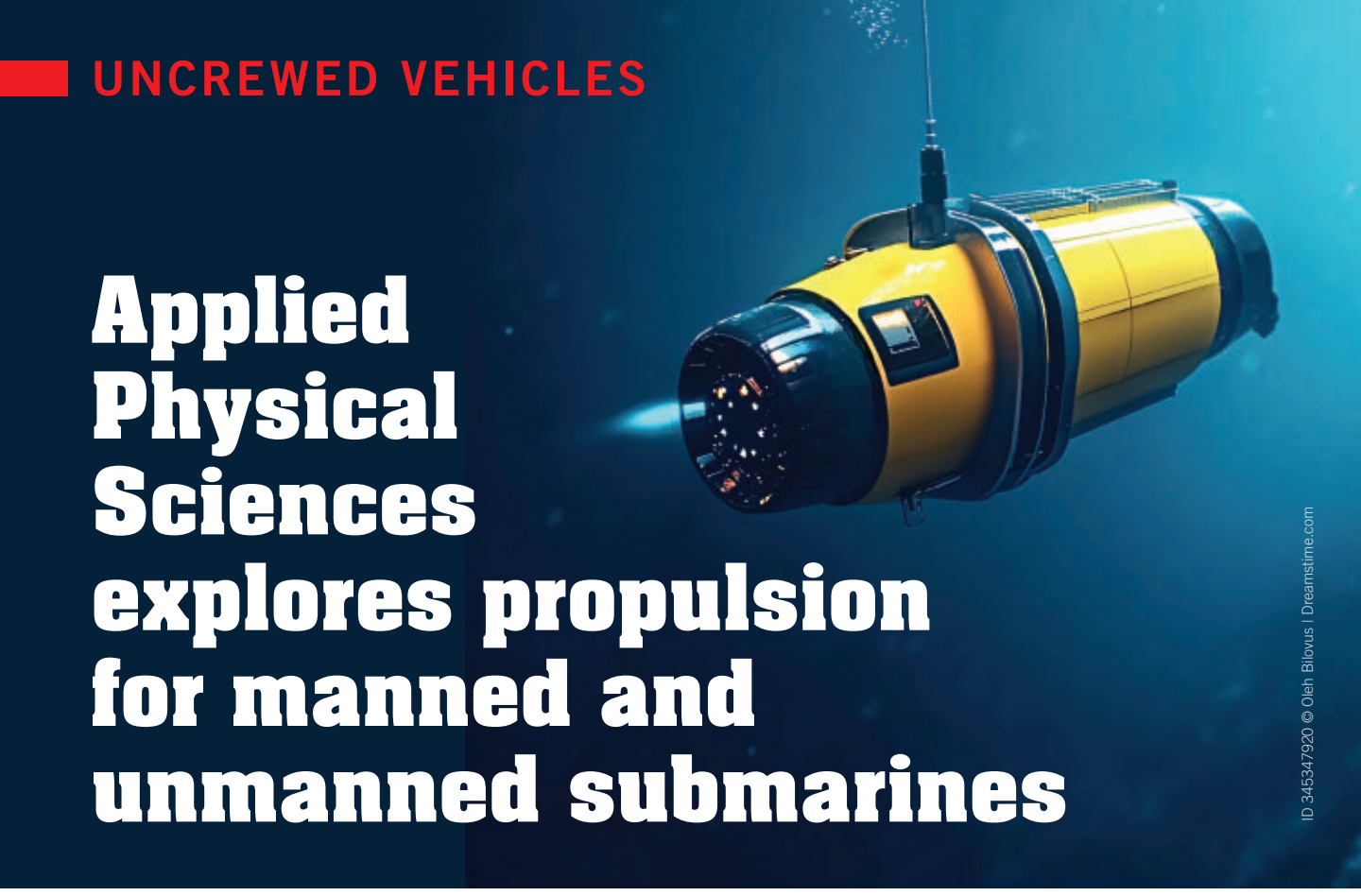
Applied Physical Sciences explores propulsion for manned and unmanned submarines



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BY **John Keller**

▲ U.S. military experts constantly are looking for new propulsion technologies for manned and unmanned submersibles to operate in dangerous areas amid ever-more-sophisticated enemy sonar systems.

ARLINGTON, Va. – U.S. military researchers needed enabling technologies for next-generation propulsion for crewed submarines and unmanned underwater vehicles (UUVs) that will be quieter and more efficient than ever before. They found a solution from General Dynamics Applied Physical Sciences Corp., Groton, Conn.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., announced a $9.7 million order to Applied Physical Sciences for the Advanced Propulsor, Experimental (APEX) project. Applied Physical Sciences initially won a $9.4 million APEX contract in April 2023, and an additional $8.6 million APEX order in September 2023.

The company will continue developing enabling technologies in hydro-dynamics, hydro-acoustics, mechanical engineering, naval submarine architecture, electro-mechanical, and other disciplines. Details are classified.

U.S. military experts constantly are looking for new propulsion technologies for manned and unmanned submersibles to operate in dangerous areas amid ever-more-sophisticated enemy sonar systems.

Today's submarines are quieter than ever before, and are difficult to detect and track even with the most advanced sonar systems. Still, it's a cat-and-mouse game for submarine designers to keep their vessels quiet enough to evade current- and next-generation sonar technologies.

DARPA researchers are looking for submarine propulsion technologies related to efficiency, signature, mechanical design and limits, and operational considerations.

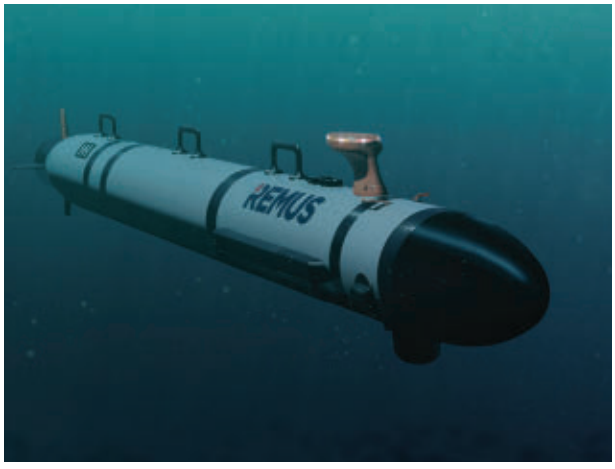
The project's phase 1A base lasted for one year, and considered theoretical propulsion designs and identify knowledge gaps. Phase 1B option will lasted for nine months, and worked toward defining one APEX design approach, then refine the design. The phase 1C option is refining the APEX design.

On this order Advanced Physical Sciences will do the work in Cheswick and Imperial, Pa.; Groton, Conn.; Niskayuna, N.Y.; Concord, Mass.; and Arlington, Va., and should be finished by March 2026.

For more information contact General Dynamics Applied Physical Sciences online at https://aphysci.com, or DARPA at https://www.darpa.mil/program/advanced-propulsor-experimental. ←

Huntington Ingalls to build UUV for counter-mine warfare and undersea surveys

BY **John Keller**



Huntington Ingalls

▲ The REMUS 300 is built for military and commercial applications like mine countermeasures, anti-submarine warfare (ASW), and undersea surveys.

WASHINGTON – U.S. undersea warfare experts needed a small unmanned underwater vehicle (UUV) for applications like counter-mine warfare and undersea surveys. They found a solution from the Huntington Ingalls Industries Unmanned Underwater Systems segment in Pocasset, Mass.

Officials of the Naval Sea Systems Command in Washington announced a $31.9 million order in December for Lionfish small UUVs. Lionfish is based on the Huntington Ingalls REMUS 300 UUV, and is for critical underwater missions.

The Lionfish UUV incorporates advanced modularity and an open-systems architecture into a compact, man-portable

design. Lionfish is the next generation Mk18 Mod 1 Swordfish program, which also uses HII's REMUS technology.

The REMUS 300 is built for military and commercial applications like mine countermeasures, anti-submarine warfare (ASW), and undersea surveys. It can conduct counter-mine operations down to 1,000 feet, and uses side-scan sonar for autonomous large-area underwater surveys that enable operators to review and classify mine-like objects.

The UUV can be moved by two people, and can deploy rapidly from any vessel. Its side-scan sonar and precision navigation provide data to locate targets, including downed aircraft and sunken ships.

Key Features include 30-hour mission duration; speeds to 5 knots; flexible energy options; open architecture; modular and reconfigurable; and removable 1-terabyte hard drive to gather mission data.

The UUV offers capabilities such as counter-mine warfare, rapid environmental assessment; marine archaeology; offshore oil and gas; and renewable energy. Customer-defined missions include intelligence, surveillance, and reconnaissance; and ASW.

The REMUS 300 offers three rechargeable battery options: a 1.5 kilowatt-hour battery; 3 kilowatt-hour battery; and 4.5 kilowatt-hour battery.

Versions of the UUV are 7.5 and inches in diameter; 80, 94, and 104 inches long; weigh 107, 129, and 155 pounds; offer endurance of 10-, 20-, and 30-hours; and ranges of 29, 59, and 89 nautical miles. The UUV has optional camera payloads; gap-filling sonar; environmental sensors, Iridium communications, and nickel-metal-hydride batteries.

On this order Huntington Ingalls will do the work in Pocasset, Mass.; and Hampton, Va., and should be finished by next December. For more information contact Huntington Ingalls Unmanned Underwater Systems online at https://hii.com/what-we-do/capabilities/unmanned-systems/, or Naval Sea Systems Command at www.navsea.navy.mil.

DLR tool detects conflict between crewed and uncrewed aircraft routes

DFS Deutsche Flugsicherung GmbH has partnered with the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) to ensure the safe integration of uncrewed aircraft systems in German airspace as part of the further development of air traffic management. In this context, DFS has acquired extensive rights to use the N-Dimensional Map (NDMap) tool, developed by DLR, which can identify potential conflicts between a large number of crewed and uncrewed aircraft in real-time. Following rigorous testing, the tool's functionality and effectiveness have been validated. In September, DFS and DLR presented the initial test results at the German Aerospace Congress (DLRK) 2024. "Airspace is becoming increasingly complex with new participants such as drones. Efficiently identifying and mitigating potential conflicts in advance is therefore essential for safe traffic management," says Dirk Kügler, Head of the DLR Institute of Flight Guidance. "Our NDMap tool provides a powerful foundation for this." Tests show NDMap can efficiently manage current crewed air traffic and limited uncrewed operations, with capacity for future growth. Simulations of 2050 traffic levels, featuring over 308,000 daily flights, demonstrated its ability to detect conflicts for each aircraft in just 2.1 milliseconds.

NASA explores autonomous surface missions on 'ocean worlds'

Through advanced autonomy testbed programs, NASA is setting the groundwork for one of its top priorities—the search for signs of life and potentially habitable bodies in our solar system and beyond. The prime destinations for such exploration are bodies containing liquid water, such as Jupiter's moon Europa and Saturn's moon Enceladus. Initial missions to the surfaces of these "ocean worlds" will be robotic and require a high degree of onboard autonomy due to long Earth communication lags and blackouts, harsh surface environments, and limited battery life. NASA has been advancing spacecraft autonomy through AI-driven technologies like machine learning and causal reasoning. To support future ocean world missions, it developed the Ocean Worlds Lander Autonomy Testbed (OWLAT) at JPL and the virtual OceanWATERS platform at Ames Research Center. Programs like ARROW (2020) and COLDTech (2021) funded six U.S.-based teams to create and test autonomy solutions on these testbeds. OWLAT simulates a spacecraft lander equipped with a seven-DOF robotic arm, sensors, and a camera to mimic low-gravity operations, enabling dynamic behavior akin to real-world missions. These projects have addressed challenges for autonomous exploration of icy moons.

Navy asks Lockheed Martin to redesign components of F-35 cockpit displays to mitigate obsolescence

BY **John Keller**

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PATUXENT RIVER NAS, Md. – Combat avionics experts at Lockheed Martin Corp. will redesign components of the F-35 combat jet's panoramic cockpit displays to mitigate the effects of parts obsolescence under terms of a $16.3 million contract announced in November.

Officials of the U.S. Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Lockheed Martin Aeronautics segment in Fort Worth, Texas, to redesign the F-35 panoramic cockpit display electronic unit video mixer for the U.S. Navy, Air Force, Marine Corps, and U.S. allies.

The order is to provide overrun funding for diminishing manufacturing sources non-recurring engineering and associated materials for the F-35 panoramic cockpit display redesign to reduce the effects of component obsolescence.

The aircraft that this order affects are those of the U.S. Air Force, Navy, Marine Corps, foreign military sales (FMS) customers, and non-U.S Department of Defense (DOD) participants.

Lockheed Martin won a $43.6 million order in May 2022 to supervise redesign of the F-35 panoramic cockpit display to help maintain and upgrade the aircraft's large cockpit display.

The F-35 jet fighter-bomber has set new standards for combat aircraft cockpit avionics with its 8-by-20-inch panoramic cockpit display, which the company showed in 2010 at the Farnborough International Airshow in Farnborough, England.

This large active-matrix liquid crystal display (AMLCD) is from L3Harris Technologies in Alpharetta, Ga., and from Elbit Systems of America LLC in Fort Worth, Texas. It is an intuitive touch-screen, and can present the F-35 Lightning II pilot with all the information he needs, quickly, and without overwhelming him with too much information.

The panoramic display for the F-35 is divided in two electronically. This design offers full redundancy and enables the display to continue functioning in case of component failure or battle damage.

The panoramic display smart-stitches separate images into one continuous image. It shows a variety of sensor information, attack information, and aircraft status data.

The display reportedly can withstand a puncture or a crack, and still offer all its features on only one side. In a pinch, the F-35 pilot still can rely on his helmet-mounted display in case of catastrophic avionics failure.

On this order Lockheed Martin will do the work in Fort Worth, Texas, and should be finished by January 2029. For more information contact Lockheed Martin Aeronautics online at www.f35.com/f35/index.html, L3Harris Technologies at https://engage.l3harris.com/f-35-mission-critical-technology/p/1, or Naval Air Systems Command at www.navair.navy.mil.

Air Force briefs industry on combat identification of ocean targets using machine learning

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio – U.S. Air Force researchers briefed industry in February on two initiatives that seek to locate and identify ocean targets from satellites and aircraft imagery; and improve predictive air-to-air combat identification.

Officials of the Sensors directorate of the Air Force Research Laboratory outlined for industry the upcoming Maritime Automated Ingestion for Scene-Aware Identification and Localization (MAINSAIL); and Air Target Optimization & Autonomy Activity (ATOMATA) programs.

MAINSAIL focuses on advancing maritime domain awareness capabilities to help identify and localize maritime targets in imagery from overhead assets by developing new technologies to enhance maritime domain awareness.

AUTOMATA, meanwhile, focuses on improving air-to-air combat identification performance using the existing Joint Multi-sensor Automated Combat ID (JMAC) algorithm, with an emphasis on sensing operation using prediction in a distributed-sensor operation.

MAINSAIL seeks to use machine learning and automatic target recognition models for electro-optical and synthetic aperture radar imagery; identify non-imagery information to constrain predicted future locations; represent knowledge about the targets with modern data structures; and associate automatic target recognition and data to identify past locations and predict future locations.

ATOMATA focuses on sensing operation using prediction using tracking, track association, and sensor resource management algorithms; options for distributed operation and characterizations of each; combat identification performance of tracking and sensor resources; additional sensors and features; and additional platforms and geometries.

The project also seeks ways of using multi-platform, multi-sensor closed-loop tracking and sensor management algorithm development; performance assessment of sensor exploitation testing, modeling, and simulation.

Briefings were at the SECRET security level. Email questions or concerns to Jacob Pritchard, the MAINSAIL program manager, at jacob.prichard.3@us.af.mil; or to Alistair Hildenbrandt, the AUTOMATA program manager, at alistair.hildenbrandt@us.af.mil. More information is online at https://sam.gov/opp/f581d3f9d4854cdf9169c-9581d7c767e/view.

U.S. Air Force photo

MAINSAIL focuses on advancing maritime domain awareness capabilities to help identify and localize maritime targets in imagery

The Canadian MQ-9B long-range uncrewed aircraft will use a variety of electro-optical sensors to keep watch over North American polar regions.

General Atomics photo

General Atomics to provide MQ-9B uncrewed aircraft to Canada for polar reconnaissance and maritime patrol

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio – Royal Canadian Air Force needed long-duration uncrewed aircraft for polar and maritime reconnaissance missions. They found a solution from General Atomics Aeronautical Systems Inc. in Poway, Calif.

Officials of the U.S. Air Force Life cycle Management Center at Wright-Patterson Air Force Base, Ohio, announced a $108 million foreign military sales contract to General Atomics in late December for Canada MQ-9B SkyGuardian remotely piloted aircraft.

MQ-9B, which is based on the General Atomics MQ-9 Reaper unmanned aerial vehicle (UAV) delivers long endurance and range, with automatic takeoff and landing under satellite communications (SATCOM)-only control.

The MQ-9B can be configured with electro-optical sensors for missions like long-range reconnaissance, anti-submarine and anti-ship warfare, electronic warfare (EW), and mine countermeasures. These UAVs will operate in polar and maritime regions, perform border surveillance, monitoring large-scale events, supporting disaster response, reconnaissance missions, and precision strikes.

The uncrewed aircraft will be able to operate in open airspace using the General Atomics-developed Detect and Avoid system. In addition to Canada, other operators of the MQ-9B are the United Kingdom, Belgium and the U.S., and Japan.

The first deliveries of MQ-9B UAVs to Canada are expected in 2028, and the fleet of MA-9Bs will be operational with Canadian military forces in 2033. Canada will purchase a fleet of MQ-9B SkyGuardian UAVs and ground-control stations.

The MQ-9B will be able to fly as long as 40 hours in all weather conditions, it has the Lynx multi-mode radar and an infrared imaging sensor. It can carry payloads that weight a total of a payload capacity of 4,751 pounds distributed across nine hard points, and will be able to carry 250- and 500-pound bombs.

Adapted for Arctic conditions, the drones will be based at 14 Wing Greenwood in Nova Scotia and 19 Wing Comox in British Columbia, with operational control centralized at a military facility in Ottawa.

For more information contact General Atomics Aeronautical Systems online at www.ga-asi.com, the Royal Canadian Air Force at www.canada.ca/en/air-force.html, or the U.S. Air Force Life Cycle Management Center at www.aflcmc.af.mil.

SWIR LEDs for aerospace and defense infrared imaging through dust, fog, and smoke introduced by EPIGAP OSA

EPIGAP OSA Photonics GmbH in Berlin is introducing the OCI-490 series high-power shortwave infrared (SWIR) light-emitting diodes (LEDs) for infrared imaging through fog, dust, and smoke; materials sorting and detection; and non-intrusive imaging for biometrics and surveillance. The SWIR LEDs offers a wavelength range from more than 1720 to 2300 nanometers with a 1 amp and 41-milliwatt optical output. The energy-efficient family of SWIR LEDs delivers strong illumination with very low heat output for mission-critical operations. The high-power devices can be used in non-intrusive imaging. Invisible to the naked eye, the SWIR LEDs enable discreet biometric and surveillance imaging for medical, industrial, and defense applications. When used in material identification, the extended wavelength SWIR LEDs reveal material characteristics to improve sorting and quality control tasks in pharmaceutical and agricultural industries. The SWIR wavelengths enhance visibility when imaging through dust, fog, and smoke with results in harsh environments such as extreme heat, humidity, or vibration. Devices are available from ultraviolet to SWIR. For more information contact EPIGAP OSA Photonics online at www.epigap-osa.com/products/leds/smd/high-power-smd.

Water-cooled high-power laser sensor for measuring very high power lasers introduced by MKS Instruments

MKS Instruments Inc. in Andover, Mass., is introducing the Ophir 20K-W high-power laser sensor for measuring very high power lasers. This water-cooled thermal sensor measures powers from 100 Watts to 20 kilowatts over the spectral range of 800 to 2000 nanometers and 10.6 microns. A deflecting cone and annular absorber enable the sensor to withstand power densities as high as 10 kilowatts per square centimeter. The sensor delivers a 3.5-second response time, shortening the time required for measurement. A 55-millimeter aperture is insensitive to beam size or angle of divergence, which means greater flexibility when manipulating beams and more consistent power delivery even when the input beam changes slightly in size or direction. The laser sensor features safety features that protect the sensor and operators. It features an interlock output that shuts down the laser to protect it from overheating. For more information contact MKS Instruments online at www.mks.com.

Spectral radiant power test and measurement for light-emitting diodes (LEDs) offered by Gigahertz-Optik

Gigahertz-Optik Inc. in Amesbury, Mass., is introducing two versions of the company's BTS256-LED test and measurement system for photometric, colorimetric, and spectral radiometric testing in the visible spectral region. These compact portable spectral radiant power measurement devices focus on single-ultraviolet or infrared light-emitting diodes (LEDs), and include a built-in integrating sphere with cone-shaped measurement port enabling hand-held or fixtured testing of circuit board-mounted LEDs for radiant power, SPD, and peak intensity. These spectral radiant power measurement devices also offer on-board UV or IR auxiliary LEDs for absorption correction under software control typically found only on fixed bench-top LED measurement systems. These testers enable the user to bring the measurement tool to the test LED for use in either in a hand-held or fixtured setup in incoming QC, R&D, production control or other test applications. The BTS256-LED-UV calibrated spectral range is 200 to 550 nanometers with a bandwidth of 5 nanometers (optical bandwidth correction per CIE 214). It measures radiant power levels from 10 microwatts to 2 Watts (typ. 350 nanometers LED).

The BTS256-LED-IR calibrated spectral range is 750 to 1100 nanometers with a bandwidth of 5 nanometers (optical bandwidth correction per CIE 214). It measures radiant power levels from 0.3 microwatts to 5 Watts (typ. 900 nanometers LED). The testers are operated and controlled using the supplied S-BTS256 application software which allows device settings like integration time, measurement settings, mathematical corrections, evaluations and all other functions. Traceable calibration and certification of the BTS256-LED testers is performed in Gigahertz-Optik's ISO/IEC 17025 calibration laboratory that is accredited by DAkkS (D-K-15047-01-00) for the spectral responsivity and spectral irradiance according to ISO/IEC 17025. For more information contact Gigahertz-Optik online at www.gigahertz-optik.com.


RTX Raytheon

MISSILE GUIDANCE

▶ RTX Raytheon for shipboard air-defense missiles with dual-mode guidance

Shipboard missile-defense experts at RTX Corp. will provide the U.S. Navy with quick-reaction missiles to protect surface warships from aircraft, missiles, and small surface vessels, under terms of a $118.5 million order announced in late October.

Officials of the Naval Sea Systems Command in Washington are asking the RTX Raytheon segment in Tucson, Ariz., to provide Rolling Airframe Missile (RAM) Block 2/2A/2B. The order includes guided missile round packs, spare parts, and recertification.

The air-defense RAM and the MK 49 launcher and support equipment make up the RAM MK 31 Guided Missile Weapon System (GMWS). RAM is a ship self-defense weapon designed to protect Navy surface warships of all sizes, ranging from 500-ton fast attack craft to 95,000-ton aircraft carriers.

A supersonic, lightweight, quick-reaction, fire-and-forget weapon, the RAM missile system is designed to attack enemy helicopters, aircraft, and surface craft. It uses passive RF and infrared dual-mode guidance for engaging several threats simultaneously.

RAM Block 2 for shipboard use has a large rocket motor, advanced control section, and an enhanced RF receiver able to detect quiet threat emitters. It is more maneuverable and longer range than its predecessors.

The MK 44 guided missile round pack and the MK 49 guided missile launching system together hold 21 missiles. Existing shipboard sensors can provide the system with target and pointing information.

The MK 44 missile, also part of the SeaRAM anti-ship missile defense system, is replacing the M601A1 Gatling gun in the Phalanx close-in weapon system with an 11-round launcher.

The Phalanx system's infrared sensor suite and internal combat management system reduces its dependence on the ship's combat system and enables a fast reaction.

The RAM is an international cooperative program between the U.S. and Germany. Raytheon shares development, production, and maintenance with the German companies MBDA Missile Systems in Schrobenhausen, Germany; Diehl BGT Defence (DBD) in Überlingen, Germany; and RAM-System GmbH (RAMSYS) in Ottobrunn, Germany.

On this contract Raytheon and its partners will do the work in Ottobrunn, Germany; Tucson, Ariz.; Keyser, W.Va.; Glenrothes Scotland; Cincinnati; and other locations, and should be finished by July 2028.

For more information contact RTX Raytheon online at www.rtx.com/raytheon, or Naval Sea Systems Command at www.navsea.navy.mil.

SUPERCONDUCTING MAGNETS

▼ Textron to build mine warfare unmanned surface vessel (USV) with high-temperature superconducting magnets

U.S. Navy ocean mine warfare experts are asking Textron Systems Corp. in Hunt Valley, Md. to build a counter-mine system for surface warships and uncrewed surface vessels that capitalizes on enabling technologies in high-temperature superconducting magnets.

Officials of the Naval Sea Systems Command in Washington announced an $18 million order to Textron for production of the Mine Sweep Payload Delivery Systems (MSPDS). Options could increase this order's value to $106.2 million.

The MSPDS surface counter-mine system locates and detonates acoustic and magnetic influence mines, and capitalizes on experimental Magnetic and Acoustic Generation Next Unmanned Superconducting Sweep (MAGNUSS) technologies, developed by Textron under supervision of the Office of Naval Research in Arlington, Va. MAGNUSS uses a high-temperature superconducting magnet with an advanced acoustic generator.

Textron

Textron's MSPDS mine warfare system reached initial operating capability in 2022. As of October 2023, the company has delivered two pilot systems and four low-rate production crafts and payloads. The Navy use these existing units to support its Littoral Combat Ship operations. MSPDS is for the Navy's Mine Countermeasures Unmanned Surface Vessel (MCM USV), which will use several payload delivery systems, including the MSPDS, Minehunting Payload Delivery System, and Payload Delivery Systems For Mine Neutralization.

The Navy has been moving the mine countermeasures mission to the Littoral Combat Ship (LCS) as a suite of mission modules like the MCM-USV as a deployable system on the LCS to complete the minesweeping mission.

The advantage of using the MAGNUSS and its high-temperature superconducting magnet aboard an unmanned surface vessel (USV) is the ability to run at very high electrical currents with near-zero resistance, which can sweep magnetic influence mines when coupled to an acoustic generator.

In addition to the recent advancement of high-temperature superconductor magnets to provide a non-towed magnetic source, Navy researchers have been developing a non-towed, underwater acoustic source with low-drag as an alternative to a legacy acoustic generator that still enables additional benefits to the non-towed magnetic source.

The modularity of the high-temperature superconductor magnet and acoustic generator potentially could be deployed on any craft of opportunity — not just aboard the MCM-USV.

Textron engineers are building a high-temperature superconductor magnet and an acoustic generator; integrating the mechanical, electrical, and command and controls (C2) systems of the two systems with each other; and integrating the complete payload with the MCM-USV and its hull.

On this order, Textron will do the work in Cockeysville and Beltsville, Md.; Naples, Fla.; Houston; Salt Lake City; and Yaphank, N.Y., and should be finished by next fall.

For more information contact Textron Systems online at www.textronsystems.com/products/cusv, or Naval Sea Systems Command at www.navsea.navy.mil.

UNDERSEA WARFARE

▼ Lockheed Martin for updated MK 48 submarine-launched sonar-guided torpedoes

U.S. Navy undersea warfare experts are asking Lockheed Martin Corp. to build and support components for submarine-launched MK 48 heavyweight torpedoes under terms of a $245.4 million contract announced in September.

Officials of the Naval Sea Systems Command in Washington, are asking the Lockheed Martin Rotary and Mission Systems segment in Liverpool, N.Y., for

engineering and maintenance for production, spares, engineering support, and hardware repair of components for MK 48 heavyweight torpedo all-up round.

The MK 48 torpedo is standard armament for the Navy's fleet of Los Angeles-, Virginia-, and Seawolf-class fast attack submarines, as well as Ohio-class ballistic- and cruise-missile submarines. The torpedo also is for

Lockheed Martin

Australian Collins-class attack submarines, and Taiwanese submarines. This contract involves torpedoes for the U.S. Navy, the Royal Australian Navy, and other U.S. allies.

The MK 48 torpedo is 19 feet long, 21 inches in diameter, and weighs 3,500 pounds. It can be used as deep as 1,200 feet at distances as far as five miles. The torpedo can travel as fast as 28 knots and has a 650-pound high-explosive warhead.

The much-upgraded MK 48 torpedo has been in service since 1972, and is the U.S. Navy's primary submarine weapon for use against enemy submarines and surface ships.

The MK 48 and its improved Advanced Capability (ADCAP) torpedoes can be guided from a submarine by wires attached to the torpedo. They also can use their own active pinging sonar or passive listening sonar to carry out programmed target search, acquisition, and attack procedures.

The torpedo is designed to detonate under the keel of a surface ship to break the keel and sink the ship quickly. After a miss, the torpedo can circle back for another attempt at hitting its target. The torpedo's seeker has an active electronically steered 2D phased array active sonar.

The latest version of the MK 48 is the MK 48 Mod 7 Common Broadband Advanced Sonar System (CBASS) with expanded operational capabilities for shallow waters along coastlines and inside harbors, as well as in the deep-water open ocean.

The CBASS broadband sonar enhancement makes the torpedo more effective against new enemy submarines in harsh acoustic environments. It uses modern commercial-off-the-shelf (COTS) technologies in an open-architecture computing environment, and can be improved with regular hardware and software upgrades.

The MK 48 Mod 7 CBASS kit's evolutionary design and modular nature makes the upgrade of older version MK 48 torpedoes to the Mod 7 CBASS capability a relatively straightforward effort without requiring significant torpedo redesign and certification.

The CBASS torpedo also has the ability of multiband operation with active and passive homing; advanced counter-countermeasure capabilities; effectiveness against low-Doppler shallow submarines, fast deep diving submarines, and high-performance surface ships; autonomous fire-and-forget operation or wire-guide capability to enable post-launch monitoring and updates via the submarine combat system; and running Otto Fuel II as the propellant.

The MK 48 Mod 7 CBASS provides the ability to transmit and receive over a wide frequency band and use broadband signal processing techniques to improve the torpedo's search, acquisition, and attack effectiveness.

On this contract Lockheed Martin will do the work in Liverpool, N.Y.; Clearwater, Fla.; and in Braintree, Mass.; and should be finished by September 2027.

For more information contact Lockheed Martin Rotary and Mission Systems online at www.lockheedmartin.com/en-us/capabilities/maritime-systems.html, or Naval Sea Systems Command at www.navsea.navy.mil.

goTenna

TACTICAL NETWORKING

▲ Air Force to help goTenna improve military mesh network radio communications with encryption

U.S. Air Force navigation and guidance experts needed next-generation mesh network radio technology. They found a solution from goTenna Inc. in Jersey City, N.J.

Officials of the Air Force Life Cycle Management Center's Theater Battle Control Division at Hanscom Air Force Base, Mass., announced a $15 million contract to goTenna to design and build a next-generation small, lightweight, affordable, and efficient radio capability (Pro X3) to expand overall Pro X series capabilities.

Tactical communications that enable mission-critical command and control down to the individual operator in hostile and austere environments. The company's Aspen Grove mesh networking protocol provides long-range, short-burst, low-SWaP mobile mesh networking. Aspen Grove's zero-control-packet approach is efficient and scalable at low bit rates.

The key benefits of the Aspen Grove protocol stack apply to many types of wireless or wired communications. Today, Aspen Grove is implemented in the goTenna's Pro X Series products to promote the scalable distribution of low-bandwidth information.

These data types include SMS, PLI, map objects, voice messages, low-resolution images, and sensor information. The company's Pro X2 system functions as a standalone relay can pair with a mobile phone.

The mesh network delivers mission-critical situational awareness beyond the edge of traditional connectivity. It is tested to distances as far as 15 miles line-of-sight with a standard body-mounted configuration.

Elevated ground gives the Pro X2 a range of 55 miles line-of-sight; 164.8 miles ridgeline-to-ridgeline; 130.5 miles air-to-ground using an aerial relay with a coverage.

The Pro X2 uses short burst transmissions, frequency hopping, and Aspen Grove Mesh Network protocols. It can share location and messages, and with the goTennaATAK plugin. It also uses AES 256-bit encryption, and has a battery life of nine hours per charge.

The Pro X2 meets the ruggedization guidelines of MIL-STD-810, weighs 3.5 ounces, and can deploy off-grid networks in minutes, company officials say.

On this contract goTenna will do the work in Jersey City, N.J., and should be finished by July 2026.

For more information contact goTenna online at gotenna.com, or the Air Force Life Cycle Management Center at www.aflcmc.af.mil.

SPACE OPTICS

▼ Honeywell moves to next phase of developing liquid mirror technology for astronomy telescopes

U.S. military researchers needed a size-scalable liquid mirror for space and ground telescope applications. They found a solution from Honeywell Aerospace Technologies in Phoenix. Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington,

Honeywell

Va., announced a $7.9 million contract for the second phase of the Zenith program.

Zenith seeks to develop a telescope's liquid mirror that can maintain its shape even if tilted out-of-plane. A liquid mirror is a reflecting surface created by spinning a shallow dish of a reflective liquid, like mercury to form a parabolic shape.

Liquid mirrors are for liquid-mirror telescopes that are less expensive than glass mirrors, can adapt their shape, and forms a parabolic shape, which is ideal for focusing light.

Zenith seeks to create liquid mirrors that re tiltable, scalable, damage-resilient, suitable for space and ground telescopes, and require no motion to operate in monolithic and segmented designs.

DARPA began the 50-month Zenith program in January 2023. Its first phase sought to design a scalable liquid mirror lens, with material development and field control, to enable a 0.5-meter diameter liquid mirror lens with out-of-plane tip and tilt angles larger than 10; a 1-degree slew rate; and wavefront control correctable to 550 nanometers.

Now Honeywell will tackle the program's second phase, which is to demonstrate the first-phase design with fluid component reflectivity of greater than 0.65; an aperture size of 3 meters in diameter; out-of-plane tip and tilt angles of greater than 25 degrees; 3-degree-per-second slew rate; wavefront control correctable to 550 nanometers; and fluid of greater than 0.65.

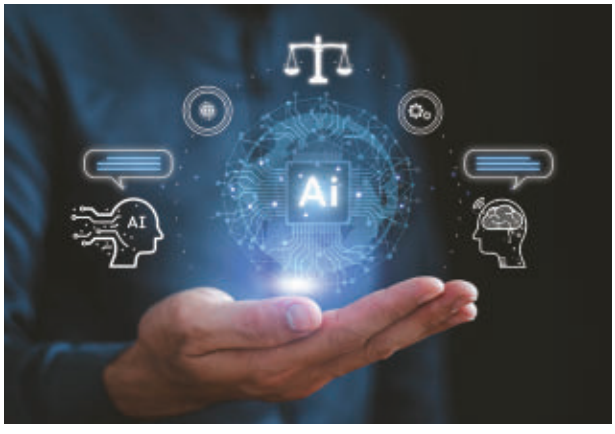
Astronomers today are limited by the size and costs of available telescope optics; as the primary optics get larger, their cost grows exponentially. Space-based mirrors, in addition, are vulnerable to catastrophic damage from hypervelocity space debris.

Today's liquid mirror telescopes are easier to build, less expensive, and are more damage-resistant than traditional glass telescopes. The Zenith program is developing modeling tools, materials, surface and field controls sufficient to demonstrate a 2-meter-diameter liquid mirror telescope and a 1 meter diameter segmented liquid mirror.

If successful, Zenith can result in liquid mirrors and liquid mirror telescopes for astronomy that behave like traditional point-and-slew telescopes, at significantly larger aperture sizes, and have applicability to ground and space applications.

On this contract Honeywell will do the work in Avon, N.Y.; Des Plaines, Ill.; Atlanta; Phoenix; and in Cambridge and Ottawa, Ontario, and should be finished by November 2026.

For more information contact Honeywell online at aerospace.honeywell.com, or DARPA at www.darpa.mil/program/zenith.



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ARTIFICIAL INTELLIGENCE

▲ COVAR to explore ethical use of AI and machine autonomy in military applications

U.S. military researchers wanted to explore the ethics and technical challenges of using artificial intelligence (AI) and machine autonomy in future military operations. They found a solution from COVAR LLC in McLean Va.

Officials of the Munitions Directorate of the U.S. Air Force Research Laboratory at Eglin Air Force Base, Fla., announced an $8 million contract to COVAR for the Autonomy Standards and Ideals with Military Operational Values (ASIMOV) project. The Air Force Research Laboratory awarded the contract on behalf of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va.

ASIMOV aims to develop benchmarks to measure the ethical use of future military machine autonomy, and the readiness of autonomous systems to perform in military operations. The rapid development of machine autonomy and artificial intelligence (AI) technologies needs ways to measure and evaluate the technical and ethical performance of autonomous systems. ASIMOV will develop and demonstrate autonomy benchmarks, and is not developing autonomous systems or algorithms for autonomous systems.

The ASIMOV program intends to create the ethical autonomy language to enable the test community to evaluate the ethical difficulty of specific military scenarios and the ability of autonomous systems to perform ethically within those scenarios.

COVAR will develop prototype modeling environments to explore military scenarios for machine automation and its ethical difficulties. If successful, ASIMOV will build some of the standards against which future autonomous systems may be judged.

COVAR will develop autonomy benchmarks — not autonomous systems or algorithms for autonomous systems — THAT will include an ethical, legal, and societal implications group to advise the performers and provide guidance throughout the program.

The company will develop prototype generative modeling environments to explore scenario iterations and variability across increasing ethical difficulties. If successful, ASIMOV will build the foundation for defining the benchmark with which future autonomous systems may be gauged.

ASIMOV will use the Responsible AI (RAI) Strategy and Implementation (S&I) Pathway published in June 2022 as a guideline for developing benchmarks for responsible military AI technology. This document lays out the five U.S. military responsible AI ethical principles: responsible, equitable, traceable, reliable, and governable.

A measurement and benchmarking framework of military machine autonomy will help inform military leaders as they develop and scale autonomous systems — much like Technology Readiness Levels (TRLs) developed in the 1970s that today are used widely.

ASIMOV is a two-phase, 24-month program.

For more information contact COVAR LLC online at covar.com, the Air Force Research Laboratory Munitions Directorate at www.afrl.af.mil/RW/, or DARPA at www.darpa.mil/program/autonomy-standards-and-ideals-with-military-operational-values.

TRUSTED COMPUTING

▶ Peraton Labs, Vanderbilt, and Galois to ensure trusted computing software for safety-critical applications

U.S. military researchers are asking Peraton Labs in Basking Ridge, N.J., to develop hardware and software design and development tools to guarantee that software runs correctly by combining formal methods and side-channels.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., announced a $2.8 million contract to Peraton Labs for the Continuous-correctness On Opaque Processors (COOP) program to develop new trusted computing approaches.

COOP seeks to develop secure design and development tools and techniques to guarantee that software is running correctly if and only if the device physics is correct by combining formal methods and side-channels to unify computer science and physics.

Peraton Labs joins two other research groups on the DARPA COOP program. Vanderbilt University in Nashville, Tenn., won a $5.4 million COOP contract, and Galois Inc. in Portland, Ore., won a $26.4 million COOP contract.

COOP solutions will guarantee software correctness on any digital processor with low overhead. Analog and mixed-signal hardware are of interest, but only after achieving program goals for digital hardware.

Reliability physics is grounded in mathematics and can serve as the rigorous, stable, and tautological basis for formal analysis. Still, side-channels only can detect errors; they cannot correct the errors.

Today's safety-critical system design principles such as triple modular redundancy with majority voting or n-variant redundancy could detect, isolate, and correct errors continuously, but the performance penalties are prohibitive for mass deployments.

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The solution lies in developing new techniques that can achieve revolutionary improvements in continuous-correctness guarantees and performance.

The COOP program uses these definitions:

> availability, or the ability to guarantee that data, information, and processing can be accessed by authorized entities when needed;

> confidentiality, or the ability to guarantee that data, information, processing, etc., are not disclosed to unauthorized entities;

> continuous-correctness, or the ability to identify and correct errors over time within program metrics;

> control boundary, or the physical and logical boundaries between what the COOP solution can control, and what the solution has shared or no control;

> correct, or computation is correct if the computation output as expected in time and value;

> digital-side-channel, or manifestations of software running on hardware that is not physical;

> error, or a condition that makes the computational output incorrect;

> formal methods, or tools and techniques that provide rigorous mathematical proofs of specified properties;

> informal methods, or tools and techniques that are logical and rigorous but that do not require mathematical proof;

> integrity, or the ability to guarantee that data, information, and processing are not altered by unauthorized entities;

> mission-critical software, or any software that requires continuous-correctness guarantees;

> multi-modal-side-channel, or a combination of one or more distinct side-channels plus zero or more digital-side-channels;

> oracle, or an abstraction in formal methods to represent the axiomatic source of correct answers;

> opaque, or hardware or software with information about its behavior documented and known;

> processor, or digital hardware that runs software; proof, or an independently verifiable argument using mathematics;

> reference monitor, or a trusted entity that enforces control boundaries by completely mediating accesses; and

> side-channel, or physical manifestations of software running on hardware.

Peraton, Vanderbilt, and Galois engineers will develop a threat model that is expected to change, as control boundaries depend on the proposed solutions. A COOP solution that completely mediates all accesses between a processor and the rest of the system can assume that only the processor and non-mission-critical software are untrusted.

The opaque processor and non-mission-critical software components are free to attempt to violate the computational integrity of mission-critical software as long as the goal is not a denial-of-service attack on the system, except when the denial-of-service vulnerability was newly introduced by the proposed approach. It is within the physical limitations of the components and behavior would not render the component commercially non-viable.

To ensure that COOP solutions can be integrated with processors that are manufactured separately, Peraton, Vanderbilt, and Galois will develop solutions between two system boundaries. COOP solutions could reside within a processor package, but not on the same die. COOP solutions also could reside within a computer case, but not outside where additional resources are available.

Potential embodiments of a COOP solution include integration within a processor's package, co-located on a board, and independently located on a daughter card. Any proposed embodiment must be able to sense multi-modal side-channels within the computer case.

There are two program-identified technical challenges to COOP program goals: provable physics-based software error isolation; and continuous provable error correction. The COOP program is interested in tools and techniques that can provably isolate mission-critical software errors.

The first phase of the COOP program will demonstrate a solution on a general-purpose processor with multi-threaded cores in simulation. The second phase will demonstrate the COOP solution on real hardware.

For more information contact Peraton Labs online at www.peratonlabs.com, Vanderbilt University at www.vanderbilt.edu/research, Galois at www.darpa.mil.

COMPUTER BOARDS

▼ SOSA-aligned single-board computer introduced by Acromag

Acromag Inc. in Wixom, Mich., is introducing the VPX7600 single-board computer for defense, aerospace, and scientific applications. This 3U OpenVPX computer board has the Intel 11th Generation Tiger Lake-H Xeon W-11000E processor and aligns to the SOSA I/O intensive profile. An XMC mezzanine site and I/O peripherals offer great flexibility. Intel's E810 Ethernet controller supports 100 Gigabit Ethernet on the data plane and 10 Gigabit Ethernet on

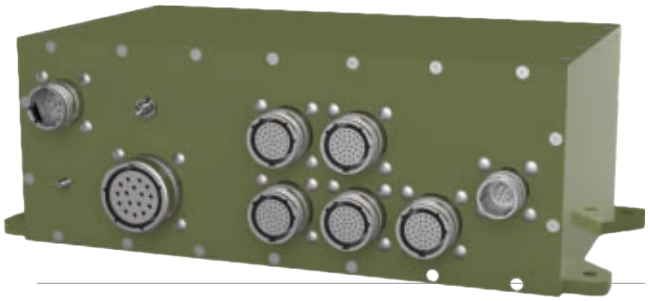
the control plane. An NVMe solid-state drive provides as much as 1 terabyte of M.2 data storage, and backplane I/O includes 2.5 Gigabit Ethernet, DisplayPort, USB 3.2, SATA III, RS232/422, and GPIO. Conduction-cooled and air-cooled with front I/O versions are available. The base embedded computing model employs Intel's W-11865MRE 8-core central processor connected to 32 gigabytes of dual-channel DDR4 ECC SDRAM and a 64-gigabyte NVMe M.2 BGA solid-state drive. A PCI Express Gen 4 x8 interface to the Intel E810 100 Gigabit Ethernet controller ports 100GBASE-KR4 on the data plane and 10GBASE-KR on the control plane to P1. P2 connects a 2.5GBASE-T/1GBASE-T Ethernet port with TSN support. A DisplayPort 1.4 interface supports 4K video resolution, with HBR3 data rates on the backplane. The XMC site host interface provides eight lanes of Gen4 PCI Express to P15 and P16 rear I/O or front I/O access on the air-cooled version. A field-programmable gate array (FPGA) implements a Crossfield Technology HOST 3.0 / VITA 46.11 Tier 3 / IPMI 1.5 Compliant IPMC. Board support packages are available for Windows, Linux, and VxWorks. For more information contact Acromag online at www.acromag.com.

CONNECTORS

▼ Low-force high-current connector assemblies introduced by Mill-Max

Mill-Max Manufacturing Co. in Oyster Bay, N.Y., is introducing the #36 contact connectors designed to accept a wide range of lead sizes, while providing low insertion force and high current carrying capacity in power and signal connections. The receptacles assembled with the #36 contact are produced in a variety of termination styles to address the many interconnect requirements typically found in electronic assemblies such as circuit board jacks for power connections. The Mill-Max #36 power and signal contact connectors accept lead diameters of 0.022 to 0.042 inches, with initial insertion force averages ranging from 180 to 560 grams. The relatively low forces for these contacts make for easy mating and de-mating of multi-pin connections. The wide acceptance range enables them to be used across applications for power and signal connections. These receptacles exhibit 4 to

10 milliohms of contact resistance, and 16 amps max of current-carrying capacity, 12.8 amps de-rated for communications equipment, pumps, fans, DC motors, and industrial-control equipment. Mill-Max is offering eight receptacles assembled with the #36 contact with termination styles including through- hole solder mount, press-fit for plated through holes, surface mount, and wire termination. All except the 0479 fiber plug style have gold plating on the shell and 30 micro inches gold plating on the contact. The 0479 has a matte tin shell finish. For more information contact Mill-Max online at www.mill-max.com.



COMMUNICATIONS

▲ Ethernet switch with time-sensitive networking (TSN) introduced by Concurrent

Concurrent Technologies in Colchester, England, is introducing the Hermod II rugged 10 Gigabit Ethernet switch for military and industrial ground vehicles. Engineered to withstand extreme temperatures, dirt, and wet conditions, Hermod II introduces time-sensitive networking (TSN) capabilities to prioritize and schedule real-time data traffic for continuity in critical operations. Hermod II represents the industry's transition from legacy low-bandwidth, deterministic interfaces to high-bandwidth Ethernet backbones, company officials say. TSN enables Hermod II to offer the deterministic performance, and bridge the gap between legacy and TSN-enabled traffic for seamless integration. Hermod II offers a ruggedized design that operates reliably in extreme environmental conditions; TSN support that enables real-time traffic management; and versatile integration that serves as a gateway to support legacy systems during modernization. For more information contact Concurrent online at https://concurrent.tech.

CABLE ASSEMBLIES

▼ Semi-rigid and conformable cable assemblies introduced by Pasternack

Pasternack, an Infinite Electronics brand in Irvine, Calif., is introducing semi-rigid and conformable cable assemblies for high-performance signal routing applications in telecommunications, aerospace, and defense. These cable assemblies provide enhanced flexibility, performance and customization for RF systems and applications, and come in 0.047-inch, 0.086-inch, 0.141-inch, and 0.250-inch sizes. Assemblies come with semi-rigid and conformable cables, and offer connector types that include 1.85, 2.4, 2.92, and 3.5 millimeters in SMP, SMPM, SSMC, SMA, and TNC. These assemblies also come in straight, right-angle, and bulkhead configurations, with the additional option of bare copper or jacketed cables. Cable assemblies offer shielding to ensure minimal signal interference in demanding environments. The conformable cables can bend into custom shapes for tight or complex spaces, and are durable and cost-efficient. For more information contact Pasternack online at www.pasternack.com.

SPACE ELECTRONICS

▲ Radiation-tolerant electronic subsystems for space introduced by Aitech

Aitech Defense Systems Inc. in Chatsworth, Calif., is introducing space-rated electronic subsystems for military and commercial Earth observation, communications, power control, and robotics applications. These radiation-tolerant subsystems for space are designed to meet the growing demands for shorter development times and lower costs among satellite buses, subsystems, and payloads. Space subsystems for Earth observation consist of integrated and qualified hardware and software, engineering analysis of commercial off-the-shelf (COTS) space-ready systems, real-time data processing, high-resolution imagery. Communications subsystems are for high-speed secure connectivity between internal and external communications systems, cameras, local edge computing, and shared storage. Computation, and data handling subsystems are to ease development of payload sharing and interface satellite buses, satellite swarm, constellation positional, mission management. Power-control

subsystems limit output power and the power on/off switching times to prevent transients from coupling to the system backplane. Robotics subsystems provide power and signal to control a motor or servo device to enable autonomy and improved decision-making across space applications for higher adaptability in rugged conditions. For more information contact Aitech online at https://aitechsystems.com/space/.

CABLE AND CONNECTORS

▼ Microwave cable assembly for 5G data communications introduced by Samtec

Samtec Inc. in New Albany, Ind., is introducing the LL043 series Nitrowave high-performance microwave cable assembly for test and measurement, 5G data communications, aerospace and defense, and semiconductor applications. These flexible low-loss microwave coaxial cable assemblies are orange in color, and offer optimized construction for phase and amplitude stability. An interlayer enables consistent electrical performance throughout the cable's life span, with low-density PTFE dielectric material. Flex life is tested to 400,000 cycles and torque life to 1,000,000 cycles with 90-degree turns.(+/-90-degrees). The LL043 series microwave cable assembly is optimized to 43.5 GHz; with a maximum voltage standing wave ratio (VSWR) of 1.4:1. Shielding techniques with consistent contact resistance between layers, results in 100-decibel minimum shielding effectiveness against

electromagnetic interference. Connector end options include SMA plug or SMA bulkhead jack to 26.5 GHz, or 2.92- and 2.4-millimeter plugs to 43.5 GHz. LL043 is available in standard assembly lengths of 12, 24, and 39.37 inches. For more information contact Samtec online at www.samtec.com/products/ll043.

INTERCONNECT PRODUCTS

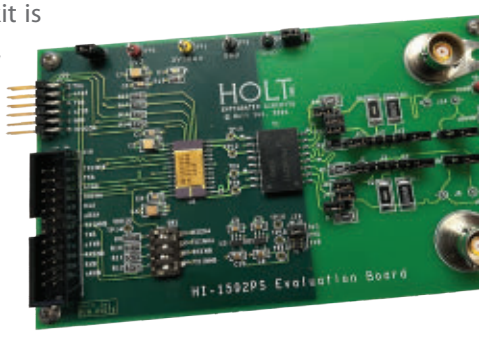
▼ Rugged non-magnetic SWPM connectors offered by Amphenol RF

Amphenol RF in Danbury, Conn., is introducing sub-miniature push-on micro (SMPM) printed circuit board non-magnetic connectors for quantum computing, medical, and military and aerospace applications where the presence of magnetic material in the components may cause interference. These connectors are in straight jack configuration featuring either full detent of smooth bore retention. They are engineered with non-ferrous metals and alloys. The 50 ohm non-magnetic SMPM jacks offer reliable electrical performance to 26.5 GHz, and are engineered with gold-plated beryllium copper bodies. They are compatible with all existing non-magnetic SMPM bullets for board-to-board or cable-to-board applications. SMPM connectors use a snap-on locking mechanism for quick mating and unmating. These parts can be identified by the NM stamp on the body. Non-magnetic SMPM connectors offer misalignment tolerance, small size, high frequency range, and several configurations. For more information contact Amphenol RF online at www.amphenolrf.com.

AVIONICS DATABUSES

▼ Kit to interface radiation-hardened transceiver with MIL-STD-1553 databus introduced by Holt

Holt Integrated Circuits in Aliso Viejo, Calif., is introducing the ADK-1592 development kit to interface Holt's HI-1592 radiation-hardened transceiver with a MIL-STD-1553 protocol controller or field-programmable gate array (FPGA). The development kit is for launch vehicles, high-altitude aircraft, and low-orbit satellites that use MIL-STD-1553 databus communications. The HI-1592 is latchup-immune



and proven to withstand a single-event upset (SEU) with an LET of at least 67.7 MeV-cm2/mg, and is radiation tolerant to a total ionizing dose (TID) of 100 krad(Si). The kit features 1.8-, 2.5-, and 3.3-volt compatible digital I/O to interface with a broad range of FPGAs and controllers. The development kit connects to an external MIL-STD-1553 databus controller board via an industry standard PMOD port. This port connects the controller digital transmit and receive signals needed to interface the transceiver with a MIL-STD-1553 bus. An alternative connector is available which provides access to additional digital transceiver signals, such as Rx Enable and Tx Inhibit. The kit ships with DIP switches set for PMOD port use by default. The transceiver board loops back the digital transmit signals to the controller and connects to a MIL-STD-1553 bus for direct or transformer-coupled configurations via the on-board triaxial bus connectors. For more information contact Holt Integrated Circuits online at www.holtic.com. ←

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Two companies are working together to design nuclear electric propulsion technology for extraplanetary human and robotic missions.

Ad Astra and SpaceNukes partner to develop nuclear electric propulsion

BY **Jamie Whitney**

HOUSTON–The Ad Astra Rocket Company in Houston and SpaceNukes in Los Alamos, N.M., are working together to advance nuclear electric propulsion (NEP) technology for extraplanetary human and robotic missions. High-power NEP systems use significantly less propellant than chemical rockets and enable rapid solar system transportation without relying on depots or sunlight.

The collaboration combines Ad Astra's two decades of experience with the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) and SpaceNukes' Kilopower reactor technology, developed under NASA's KRUSTY program and the Space Force's JETSON initiative.

VASIMR differs from traditional electric propulsion systems, which operate at lower power levels of 1 to 50 kilowatts, by scaling up to hundreds of kilowatts or more. Its design also extends operational life and allows the use of a variety of propellants. Kilopower reactors, meanwhile, provide high-temperature capabilities, launch safety, and adaptability to high power needs, making them well-suited for integration with VASIMR. The combined system could reduce travel times and improve mission efficiency by directly coupling reactor power to propulsion systems.

The companies have signed a Memorandum of Understanding to develop and demonstrate NEP technologies, with plans to conduct a flight program by the end of the decade and commercialize the system in the 2030s.

"Nuclear Electric Propulsion will achieve game-changing performance via stepwise technology evolution. Our plan will begin with a 100 kilowatts plus NEP system as a steppingstone to a less than 5 kg per kW multi-megawatt NEP system with the capability to reduce the round-trip human transit time to Mars from more than a year to a few months," said Dr. David Poston, chief technology officer of SpaceNukes.

Dr. Franklin Chang Díaz, CEO of Ad Astra, compared the breakthrough to nuclear-powered submarines: "High-power NEP will enable 'The Nautilus Paradigm' to extend into space, opening the entire solar system to human exploration. We are proud, through this alliance, to help lay the groundwork for this achievement."

Lilium

FAA seeks industry input on new advanced aviation technology center

BY **Jamie Whitney**

WASHINGTON–The U.S. Federal Aviation Administration (FAA) is inviting industry comments to help shape the future FAA Center for Advanced Aviation Technologies to move advanced air mobility (AAM) and other emerging aviation technologies into the National Airspace System (NAS).

The center's mission will focus on research, testing, and partnerships that address the regulatory, technical, and challenges of new aviation technologies, including powered-lift aircraft and autonomous systems.

One of its main tasks is establishing an airspace laboratory and flight demonstration zones to test and validate air mobility operations and technologies. These facilities will serve as controlled environments to ensure new aviation concepts meet safety and performance standards.

Another focus is the creation of testing corridors designed to evaluate air traffic control (ATC) requirements, operational procedures, and performance standards for AAM integration. These corridors will allow for live and simulated testing of innovative aviation systems.

The center also will foster partnerships among industry, colleges, and government to advance aviation technologies, including electric- and hydrogen-powered aircraft and autonomous systems.

In addition to these activities, the center will support research on concepts like high-volume urban air mobility (UAM) operations and other advanced technologies. This research will address regulatory and technical challenges that may currently hinder these concepts' adoption.

FAA officials say they plan to use the center to assess complex scenarios, including high-traffic air mobility operations and the integration of advanced air mobility systems. Simulations and live demonstrations, involving piloted, remotely piloted, and autonomous aircraft, will be conducted in designated zones to ensure their safe operation.

The FAA is seeking participation from communities and organizations with strong aeronautical infrastructure. Areas with large commercial airports or air logistics centers are of particular interest, as are those with advanced aviation manufacturing expertise and existing FAA facilities or research activities.

The agency also is emphasizing locations in diverse environments like cities and the countryside for testing AAM technologies. Academic institutions with advanced aviation programs and public/private partnerships in aviation technology development are strongly encouraged to contribute.

The FAA asked for industry responses by 6 Jan 2025, to Chersharon King, who can be reached via email at Chersharon.y.king@faa.gov. Additional information, including documentation, is available at https://sam.gov/opp/3285a5f0e-7b342cd9a83e0d4ad0a9c94/view.

▲ **Pictured is the Lilium Jet, an all-electric vertical take-off and landing jet.**

Intuitive Machines and Nokia to deploy first cellular network on the moon

BY **Jamie Whitney**

HOUSTON–Intuitive Machines in Houston and Nokia in Espoo, Finland, have integrated Nokia's Lunar Surface Communication System (LSCS) into the Athena lunar lander, which is scheduled to travel to the Moon's south pole as part of Intuitive Machines IM-2 mission, which will attempt to establish the first cellular network on the Moon.

The LSCS, developed by Nokia Bell Labs, was installed on one of Athena's upper carbon-composite panels following testing and validation. Intuitive Machines engineers incorporated several safety features to ensure the network survives the journey, withstands launch and landing stresses, and operates effectively on the Moon.

▲ **The Intuitive Machines Athena lander is slated for launch no earlier than late February from NASA's Kennedy Space Center.**

Additional components of the LSCS have been installed on two lunar mobility vehicles: Intuitive Machines' Micro-Nova Hopper, named Grace, and Lunar Outpost's Mobile Autonomous Prospecting Platform (MAPP) rover. Once on the lunar surface, these vehicles are designed to establish connections with the network on Athena, enabling mission-critical communications.

The LSCS uses 4G/LTE cellular technology adapted for the lunar environment. It will support surface connectivity between the lander and vehicles, allowing for high-definition video streaming, telemetry, and command-and-control communications. Data collected via the network will be relayed back to Earth using Intuitive Machines' direct-to-Earth transmission service.

"We intend to prove that cellular technologies can provide the reliable, high-capacity, and efficient connectivity needed for future crewed and uncrewed missions to the Moon and eventually Mars," said Thierry E. Klein, President of Bell Labs Solutions Research at Nokia. "Cellular technology has irrevocably transformed the way we communicate on Earth. There's no reason it can't do the same for communications on other worlds."

The Micro-Nova Hopper is designed to explore permanently shadowed lunar craters and test new sensor technologies that could identify resources such as water ice. It will scan for hydrogen, a key indicator of ice deposits, and transmit the data over Nokia's network to Athena, which will send it back to Earth. The MAPP rover will map the Moon's surface and collect environmental data during a multi-day exploration of the south pole region.

The LSCS and Micro-Nova Hopper were developed under NASA's Tipping Point initiative, which supports industry-driven technologies for commercial space capabilities and future NASA missions.

"We believe delivering Nokia's 4G/LTE system to the lunar surface is a transformative moment in the commercialization of space and the maturity of the lunar economy," said Intuitive Machines CEO Steve Altemus. "Whether it's Nokia connecting surface assets or Intuitive Machines transmitting that data back to Earth, these innovations represent foundational capabilities for the Artemis generation."

The Athena lander is slated for launch no earlier than late February from NASA's Kennedy Space Center.

▲ A pilot seated at a realistic aircraft training terminal.

ID 82463288 © Noka4ka | Dreamstime.com

FAA partners with the National Flight Alliance to modernize flight training

BY **Jamie Whitney**

WASHINGTON–The U.S. Federal Aviation Administration (FAA) has named the National Flight Training Alliance (NFTA) in Washington as its partner in the effort to modernize 14 CFR Part 141, the regulatory framework governing flight training programs.

The FAA announced the partnership in December, and tasks NFTA with collaborating with flight training providers and the general aviation industry to develop updates to regulations.

"This is the first FAA/association partnership of its kind, and NFTA is grateful to the FAA for selecting our organization for this historic and key role in flight training modernization," says NFTA CEO Captain Lee Collins. "In just three years since its founding, NFTA has gathered a deep bench of experienced industry leaders and doers in flight training who are committed to ensuring that government rules and guidelines regarding flight training are consistent with and supportive of innovative best practices in modern flight training."

The modernization effort will focus on several priorities. NFTA plans to develop a new regulatory framework designed to remove obstacles to efficiency in today's flight training environment. It will work to integrate emerging technologies and updated training methods aimed at improving student outcomes and professional qualifications.

Another goal is to enhance efficiencies in flight training, which the organization hopes will result in tangible cost reductions for students, lowering barriers to entry for aspiring pilots. NFTA also seeks to expand participation in modernization efforts by engaging a broad range of flight training providers to move beyond the current fragmented approach.

The initiative emphasizes the importance of adopting data-driven standards and incorporating safety management systems into flight training operations. Additionally, NFTA aims to improve training quality across all levels of aviation to strengthen overall system safety.

"We see this anticipated level of cooperation and collaboration as ushering in a new era of aviation, and NFTA is eager to advocate for flight training providers and our general aviation colleagues and vendors—in partnership with the FAA—to maximize the safety, quality, and use of advanced technology in professional flight training for the next generation of commercial pilots," Collins says.

Qatar Airways picks Unilode Aviation Solutions to digitize unit load devices

Qatar Airways Cargo in Doha, Qatar needed a partner to digitize its fleet of more than 42,000 unit load devices (ULDs). They found their solution from Unilode Aviation Solutions in Zurich, Switzerland. The collaboration will enable Qatar Airways Cargo to use Unilode's technologies for real-time tracking, sensory data collection, and improved asset management. The integration aims to streamline operations, optimize resource allocation, and enhance performance across the airline's global passenger and cargo network. A ULD is a standardized container or pallet designed for transporting cargo, baggage, and mail on commercial aircraft. ULDs enable the air cargo industry to load efficiently, secure, and unload goods. Their main function is to optimize space in an aircraft's cargo hold while ensuring the safe storage of items during flight. Unilode's digital system includes its E-ULD mobile app and web portal for real-time tracking, which is supported by an enterprise data warehouse offering advanced analytics to improve ULD utilization. The expanded tag-and-reader network will also extend across Qatar Airways Cargo's global operations. Ross Marino, CEO of Unilode, described the partnership as a major milestone. "This collaboration reinforces our commitment to delivering technology-based solutions and reshaping ULD digitalization across the industry."

NASA tests trio of commercial lunar rovers

The U.S. National Aeronautics and Space Administration (NASA) is playing host to a trio of commercial lunar rovers at the NASA Johnson Space Center in Houston. The lunar terrain vehicles (LTV) tested came from Intuitive Machines in Houston, Lunar Outpost in Arvada, Colo., and Venturi Astrolab in Hawthorne, Calif. NASA announced that each company provided the agency with a static mockup of their LTVs at the end of September, with the first round of testing being completed in December. Tests took place in the agency's Active Response Gravity Offload System (ARGOS) test facility. NASA engineers conducted tests where suited astronauts and engineers performed tasks, maneuvers, and emergency drills on the rovers. These human-in-the-loop tests provided feedback on design functionality, controls, and safety. Astronauts evaluated the vehicles' displays and interfaces, helping identify design improvements. This feedback was shared with commercial developers to refine their rover designs based on real-world insights. NASA astronauts and engineers tested two spacesuit prototypes–the Exploration Extravehicular Mobility Unit (xEMU) and Axiom Space's lunar spacesuit–during evaluations focused on crew interactions with Lunar Terrain Vehicle (LTV) mockups. Emergency rescue scenarios were also tested, simulating the recovery of an incapacitated astronaut. Each rover design is required to enable single-person rescue operations, ensuring compliance with NASA's safety standards.

Honeywell and NXP partner to advance autonomous flight technology

Honeywell in Phoenix and NXP Semiconductors N.V. in Eindhoven, the Netherlands are expanding their partnership to advance aviation technology for autonomous flight. The partnership aims to enable artificial intelligence (AI)-driven technology for improving flight planning and operational efficiency while supporting quicker transitions to updated chipsets and technologies. Honeywell and NXP will also develop large-area displays for next-generation cockpits, featuring thinner, high-resolution screens designed to enhance visual clarity and system efficiency. The collaboration includes efforts to simplify transitions to new avionic systems and extend the life cycle of critical aviation technologies, delivering long-term value for aircraft manufacturers and operators. NXP's domain-based architecture, originally developed for automotive applications, will be adapted for aviation. This includes high-compute capabilities, integrated cybersecurity, and functional safety features. The architecture will be integrated into Honeywell Anthem, the first cloud-connected cockpit system. The companies plan to expand this work to include AI and machine learning for building controllers. For aerospace, Honeywell will use a variety of NXP processors, including the i.MX 8 and S32N processors, to deliver high-performance solutions tailored to diverse aircraft needs. These processors will enhance Honeywell Anthem's real-time AI-driven capabilities, improving safety and performance both in the air and on the ground.