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Pentagon payday

Requested DOD budget of $718.3 billion has roughly 40 percent of funds earmarked for electronics and related technology. PAGE 5

Thinking small

Modern aerospace and defense applications with a focus on small size, weight, power consumption, and cost. PAGE 24

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AI in unmanned military systems

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30 YEARS

APRIL 2019
VOL. 30, NO. 4

Military & Aerospace Electronics

COVER STORY

Military & Aerospace Electronics® (ISSN 1046-9079), Volume 30, No. 4. Military & Aerospace Electronics is published 12 times a year, monthly by PennWell® Corporation, 1421 S. Sheridan, Tulsa, OK 74112. Periodicals postage paid at Tulsa, OK 74112 and at additional mailing offices. SUBSCRIPTION PRICES: USA $185 1yr., $327 2 yr., $466 3 yr.; Canada $280 1 yr., $479 2 yr., $618 3 yr.; International $335 1 yr., $638 2 yr., $834 3 yr. POSTMASTER: Send address corrections to Military & Aerospace Electronics, P.O. Box 47570, Plymouth, MN 55447. Military & Aerospace Electronics is a registered trademark.

BY **JOHN KELLER**, EDITOR IN CHIEF

Good times continue for the U.S. defense industry, as Pentagon money continues to roll-in

Remember last year when we considered the 2019 U.S. Department of Defense (DOD) budget request to be one of the biggest of all time? Well fast-forward a year, and the 2020 military budget request is even bigger.

Last spring when top Pentagon leaders were asking Congress for $686.1 billion, many of us thought it would be the largest DOD budget we might ever see. At the time, it was a breath of fresh air, after what seemed like years of sequestration, and congressional continuing resolutions, things were finally were looking up.

Now comes the 2020 DOD budget request, and the news for the nation's defense industry just keeps looking better. The Pentagon is asking for $718.3 billion next year, which is up 4.7 percent over the 2019 request — promising another record year for U.S. defense spending.

The 2020 budget focuses on technologies like unmanned vehicles and automation; artificial intelligence (AI) and machine learning; hypersonic weapons; and directed-energy weapons.

Roughly 40 percent of the entire DOD budget goes for military electronics and related technologies, such as computers, sensors, communications, integrated circuits, electronic warfare (EW), surveillance and reconnaissance, and power electronics. That translates to about $288 billion for the defense electronics industry next year.

The electronics-heavy Pentagon budget for research, development, test, and evaluation (RDT&E) in 2020 is on the upswing, as well. DOD officials are asking Congress for $104.29 billion for RDT&E projects next year. That's up 8.7 percent from the $95.96 billion DOD researchers received this year. Federal fiscal year 2020 begins next Oct. 1.

Enjoy the moment, Pentagon Comptroller David Norquist told the defense industry last fall.

So where's all this money going? Here are some examples: cyber security and trusted computing would receive $9.6 billion next year, highlighted by $3.7 billion for offensive and defense cyberspace operations; $5.4 billion for cyber security; and $61.9 million to modernize the DOD general-purpose cloud computing environment.

Unmanned and autonomous projects would receive $3.7 billion; artificial intelligence and machine learning would receive $927 million; hypersonic weapons development would receive $2.6 billion; and directed-energy technologies like laser weapons would receive $235 million, according to DOD.

The U.S. Defense Advanced Research Projects Agency (DARPA), one of the Pentagon's premiere research organizations, would receive a 3.8 percent increase in 2020, up from $3.43 billion to $3.56 billion.

DARPA is asking for $512.4 million for network-centric warfare technologies — an 18.1 percent increase; $232.1 million for command, control, and communications systems — a 24.8 percent increase; $163.9 million for sensor technologies — an 11.7 percent reduction; and $128.6 million for advanced electronics technologies — a 15.8 percent increase.

U.S. Special Operations Command is asking for $245.8 million for aviation systems — a 39.8 percent increase; $167.6 million for operational enhancements — a 62.8 percent increase; $72.6 million for maritime systems — a 71 percent increase; $68.3 million for warrior systems — a 9.1 percent reduction; $42.4 million for unmanned intelligence, surveillance, and reconnaissance (ISR) — a 6.1 percent reduction; and $20.7 million for the MQ-9 Reaper surveillance and attack unmanned aerial vehicle (UAV) — a 12.5 percent increase.

Missile defense next year would receive $13.6 billion, including $1.7 billion for 37 SM-3 Aegis ballistic missile defense weapons; $1.5 billion for missile-defense studies; $1.7 billion for ground-based midcourse defense; $800 million for 37 Terminal High Altitude Area Defense (THAAD) missiles; and $700 million for 147 Patriot advanced capability (PAC-3) missile enhancements.

There's much more in the 2020 DOD budget. The defense industry can be grateful at least for another year. ←

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General Dynamics to refurbish Army Stryker vehicles in deals worth $2.7 billion

Armored combat vehicles experts at General Dynamics Land Systems in Sterling Heights, Mich., will repair, retrofit, and support U.S. Army M1126 Stryker combat vehicles to like-new condition under terms of two separate five-year contracts announced in late February collectively worth $2.7 billion. Officials of the Army Contracting Command in Warren, Mich., are asking General Dynamics for retrofit, damage repair, and reset-refurbishment services to support the Stryker family of vehicles; as well as for Stryker wholesale supply, performance-based, logistics services. A reset contract involves the repair and retrofit of battle-worn or damaged products to a like-new condition, which means to refurbish to near zero miles and hours of wear and tear. The Stryker family of eight-wheeled armored fighting vehicles from General Dynamics Land Systems is a derivative of the Canadian LAV III combat vehicle from a General Dynamics-General Motors Defence Canada team, and is based on the Swiss Piranha III 8×8 combat vehicle. Stryker is designed as a deployable fighting vehicle that is more lethal than light vehicles like Humvees, yet is lighter and more maneuverable than heavyweight combat vehicles like the M1 Abrams main battle tank. For more information contact **General Dynamics Land Systems** online at www.gdls.com, or the **Army Contracting Command-Warren** at www.tacom.army.mil.

Sikorsky-Boeing's Future Vertical Lift helicopter takes maiden flight

On March 21, the Sikorsky-Boeing SB>1 DEFIANT helicopter achieved first flight at Sikorsky's West Palm Beach, Fla., site. The aircraft, developed by Sikorsky and Boeing,

Special Forces sets May technology demonstration for artificial intelligence (AI)

BY **John Keller**

TAMPA, Fla. — Weapons experts at U.S. Special Operations Command (SOCOM) at MacDill Air Force Base, Fla., are inviting companies to demonstrate new enabling technologies in artificial intelligence (AI), machine learning, and robotic process control; hyper-enabled operator; and next-generation imagery, surveillance, and reconnaissance (ISR).

SOCOM will sponsor a technology demonstration called the Disrupter Event from 20 to 22 May 2019 at Tampa Convention Center, 333 South Franklin St., Tampa, Fla. 33602. The event happens at the same time as the Special Operations Forces Industry Conference (SOFIC) at the Tampa Convention Center.

U.S. Special Operations Command is inviting companies to demonstrate enabling technologies in artificial intelligence (AI), machine learning, and robotic process control in May.

During the event, participants private one-on-one session with evaluation panel to pitch, demonstrate, and discuss their solutions. SOCOM officials want to enter into agreements with industry partners with promising solutions. If the SOCOM technology demonstration evaluation panel favorably evaluates a solution brief at the demonstrations, negotiations may begin immediately.

This event is considered competitive in the same manner as a broad agency announcement or commercial solutions opening, and solutions will be evaluated independently for technical merit.

Applications for artificial intelligence, machine learning, and robotic process automation may for predictive maintenance; warfighter mental and physical health; cyber protection and resilience; logistics; contract management; and partnered force operations.

Technologies may involve cognitive problem-solving software; power-efficient chips and solid-state circuits; AI-enhanced smart phones and portable devices; simulations and cognitive modeling assessment tools; autonomous or cognitive capabilities for drones, vehicles and robotics; and tools and that reduce cognitive workload.

Capabilities of interest for artificial intelligence, machine learning, and robotic process automation include perception; speech recognition; document analysis; signals analysis; natural language processing; recommendation engines; and autonomous action, navigation, and movement.

Technologies of interest for hyper-enabled operator include edge computing and analytics; layered and automated tactical communications and

navigation; tailorable human machine interfaces; adaptable flexible sensors; biometric and forensic analysis tools; social network mapping and sentiment measurement tools; interoperability and integration standards and models; heuristic or probabilistic techniques to speed decision making; telemetry and Internet of battlefield things; intuitive mobile applications; and technologies that increase stand-off identification and characterization.

Technologies of interest for next-generation ISR include imagery, surveillance, and reconnaissance tools; standoff biometrics; micro and nano technology; unattended sensors; data aggregation; spectrum detection and location; meshed and layered networking; multi-domain sensor fusion; cognitive man-machine interfaces; social network mapping; and predictive sentiment analysis tools.

Companies interested should submit white papers no later than 3 April 2019 online at https://sofwerx.wufoo.com/forms/wo6tj441xqosqn. For questions or concerns contact John Kenney by email at john.kenney@socom.mil, or by phone at 813-826-5671. ←

More information is online at www.sofwerx.org/disrupter, www.sofwerx.org/wp-content/uploads/Disrupter-TFAs-5-Mar-2109-002.pdf, *or* https://www.fbo.gov/spg/ODA/USSOCOM/SOAL-KB/USSOCOM2019DISRUPTER/listing.html.

has unique two-coaxial main rotors and a rear mounted pusher propulsor design. The helicopter is part of the Army's Joint Multi-Role technology demonstration program which has the purpose to define requirements for a medium-lift Future Vertical Lift aircraft. The helicopter is participating in the Army's Joint Multi-Role-Medium Technology Demonstrator program. Data from DEFIANT will help the Army develop requirements for new utility helicopters expected to enter service in the early 2030s. The Pentagon's fiscal year 2020 budget request released earlier in March included approximately $790 million for Future Vertical Lift research and development, including $152 million for FVL advanced technology.

Boeing to build 78 F/A-18E/F carrier-based combat jets in $4 billion deal

Combat aircraft designers at the Boeing Co. will build 78 F/A-18E/F Super Hornet Block III carrier-based jet fighter-bombers for the U.S. Navy under terms of a $4 billion contract announced in mid-March. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Boeing Defense, Space & Security segment in St. Louis to build 61 single-seat F/A-18E and 17 two-seat F/A-18F Super Hornets under terms of this five-year contract. The twin-engine carrier-capable multirole fighter and light-attack F/A-18E/F combat jets and their avionics are based on the McDonnell Douglas F/A-18 Hornet, which entered U.S. Navy squadrons in 1983, but are larger and more advanced derivatives. The F/A-18E/F has a larger wing and a longer fuselage to carry more fuel and more powerful engines. The Block III configuration adds enhanced network capability, longer range, reduced radar signature, an advanced cockpit system, and enhanced communications system. Boeing will begin converting existing Block II Super Hornets to Block III early in the next decade. The fighter's life also will be extended from 6,000 hours to 10,000 hours, Boeing officials say. For more information contact **Boeing Defense, Space & Security** online at www.boeing.com/company/about-bds, or **Naval Air Systems Command** at www.navair.navy.mil.

Radiation detection offers remote inspection of shipping containers and trucks

Physicists at the University of Maryland have developed a powerful new method of radiation detection by using an infrared laser beam to induce a phenomenon known as an electron avalanche breakdown near the material. The new technique can perform remote detection of shielded material from a

2020 $718.3 billion DOD budget is up; eyes hypersonics, laser weapons, trusted computing

BY **John Keller**

WASHINGTON — Leaders of the U.S. Department of Defense (DOD) are asking Congress for $718.3 billion in federal fiscal year 2020, which represents a 4.7 percent increase over this year's military budget, according to budget figures released last month, which would represent another record year for U.S. defense spending.

The 2020 DOD budget request focuses on technologies like unmanned vehicles and automation; artificial intelligence (AI) and machine learning; hypersonic weapons; and directed-energy weapons in their fiscal 2020 budget request to Congress. Fiscal year 2020 begins next October 1.

Roughly 40 percent of the entire DOD budget goes for military electronics and related technologies, such as computers, sensors, communications, integrated circuits, electronic warfare (EW), surveillance and reconnaissance, and power electronics.

Cyber security and trusted computing would receive $9.6 billion next year, highlighted by $3.7 billion for offensive and defense cyberspace operations; $5.4 billion for cyber security; and $61.9 million to modernize the DOD general-purpose cloud computing environment.

Unmanned and autonomous projects would receive $3.7 billion; artificial intelligence and machine learning would receive $927 million; hypersonic weapons development would receive $2.6 billion; and directed-energy technologies like laser weapons would receive $235 million, according to DOD documents.

Modernizing the nation's nuclear forces is a cornerstone of the record 2020 budget proposal for the U.S. Department of Defense.

Missile defense next year would receive $13.6 billion, including $1.7 billion for 37 SM-3 Aegis ballistic missile defense weapons; $1.5 billion for missile-defense studies; $1.7 billion for ground-based midcourse defense; $800 million for 37 Terminal High Altitude Area Defense (THAAD) missiles; and $700 million for 147 Patriot advanced capability (PAC-3) missile enhancements.

Space would receive $14.1 billion next year, including $3.7 billion for establishing the U.S. Space Force; $1.7 billion for four national security space launches; $1.8 billion for one GPS III secure navigation satellite; and $1.6 billion for space-based overhead persistent infrared surveillance.

New aircraft would receive $57.7 billion, including $11.2 billion for 78 F-35 joint strike fighters; $2.3 billion for 12 KC-46 aerial tankers; $2 billion for 24 F/A-18E/F carrier-based jet fighter-bombers; $800 million for six VH-93 presidential helicopters; $1.5 billion for six P-8A Poseidon maritime patrol and surveillance aircraft; $1.5 billion for six

U.S. Marine Corps CH-53K heavy-lift helicopters; and $1.1 billion for eight F-15EX air-superiority jet fighters.

DOD also wants $34.7 billion for military surface ships and submarines, including $2.2 billion in research for the future Columbia-class ballistic missile submarine to replace Ohio-class boats; $2.6 billion for one Ford Class aircraft carrier; $10.2 billion for three Virginia-class fast attack submarines; $5.8 billion for three Arleigh Burke-class destroyers; $1.3 billion for one new frigate; $1.1 billion for two fleet replenishment oilers; $200 million for two towing, salvage, and rescue ships; and $447 million for two large unmanned surface vehicles.

For ground systems DOD wants $14.6 billion, including $1.6 billion for 4,090 joint light tactical vehicles (JLTVs); $2.2 billion to modify 165 M-1 Abrams main battle tanks; $400 million for 56 amphibious combat vehicles; and $600 million for 131 armored multi-purpose vehicles.

For munitions and weapons DOD wants $1.1 billion for 40,388 joint direct attack munitions (JDAMs); $1.4 billion for 10,193 guided multiple launch rocket systems (MLRS); $700 million for 125 RIM-174 SM-6 shipboard missiles; $400 million for 1,925 small-diameter bombs; $700 million for 9,000 Hellfire missiles; $600 million for 430 joint air-to-surface standoff missiles; and $200 million for 40 long-range anti-ship missiles (LRASMs).

Nuclear weapons modernization would receive $31 billion next year, including $3 billion for B-21 long-range strike bomber research; $2.2 billion for Columbia-class ballistic missile submarine research; $700 million for the Long-Range Stand-Off Missile; and $600 million for the next-generation land-based intercontinental ballistic missile (ICBM) — also known as the Ground-Based Strategic Deterrent (GBSD). ←

Pentagon seeks $104.29 billion military research budget — an increase of 8.7 percent

BY **John Keller**

WASHINGTON — The U.S. Department of Defense (DOD) is asking Congress for an 8.7 percent increase in the military research and development budget next year, in what would be a major boost for crucial enabling technologies in communications, surveillance,

distance, and improves on current technologies that require close proximity to the radioactive material. With additional engineering advancements, the remote detection method could be scaled up and used to scan trucks and shipping containers at ports of entry, providing a powerful new tool to detect concealed, dangerous radioactive material. The researchers described their proof-of-concept experiments in a research paper published in the journal Science Advances. As radioactive material emits decay particles, the particles strip electrons from — or ionize — nearby atoms in the air, creating a small number of free electrons that quickly attach to oxygen molecules. By focusing an infrared laser beam into this area, Schwartz and his colleagues easily detached these electrons from their oxygen molecules, seeding an avalanche-like rapid increase in free electrons that is relatively easy to detect.

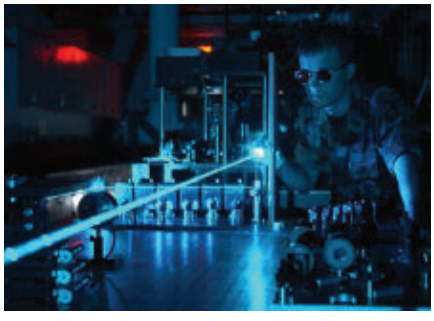
Deadly Boeing crashes raise questions about commercial aircraft automation

Two Boeing 737 Max 8 jets, a variant of the world's most popular jetliner, crashed within six months of each other in a rate of failure that raises questions about the airplane's cockpit automation. Preliminary data from the first of the crashes, Lion Air Flight 610, suggests that the automated system forced the plane into a steep dive soon after takeoff. At least half a dozen pilots have complained about unexpected nose dives from the system. To be sure, automation is widely used in commercial avionics and has been praised for making the skies much safer. But there are growing concerns among pilots and safety experts that the industry is relying too much on automation, especially overly complex systems. Boeing, meanwhile, is facing questions about its decisions to withhold information from regulators about the anti-stall technology implicated in the Lion Air crash. ←

computers, electronic warfare (EW), electro-optics, and related electronics technologies.

DOD officials are asking for $104.29 billion for electronics-rich research, development, test, and evaluation (RDT&E) projects in the department's fiscal 2020 budget request, which was released in mid-March. That's up 8.7 percent from the $95.96 billion DOD researchers received this year. Federal fiscal year 2020 begins next Oct. 1.

The research budget typically is heavy in technology development, and is where the Pentagon pays for electronics technologies considered to be critical for tomorrow's weapon systems.



The Pentagon is seeking a major boost for crucial enabling technologies in communications, surveillance, computers, electronic warfare (EW), electro-optics, and related electronics technologies in the 2020 military research budget.

Of this RDT&E request, the U.S. Air Force is asking for $46.07 billion; defense agencies for $25.17 billion; the U.S. Navy and Marine Corps for $20.43 billion; and the U.S. Army for $12.4 billion. This represents a plus-up for each service branch over this year: 11 percent for the Air Force; 4.6 percent for defense agencies; 9.5 percent for the Navy and Marine Corps; and 9 percent for the Army.

The U.S. Defense Advanced Research Projects Agency (DARPA), one of the Pentagon's premiere research organizations, would receive a 3.8 percent increase in 2020, increasing from $3.43 billion to $3.56 billion.

In applied research in 2020, DARPA is asking for $512.4 million for network-centric warfare technologies — an 18.1 percent increase; $232.1 million for command, control, and communications systems — a 24.8 percent increase; $163.9 million for sensor technologies — an 11.7 percent reduction; and $128.6 million for advanced electronics technologies — a 15.8 percent increase.

In basic research DARPA is asking for $442.6 million for information and communications technologies — a 9.3 percent increase; $337.6 million for tactical technology — a 9.1 percent increase; and $332.2 million for electronics technology — a 5 percent reduction.

In other defense agencies, the U.S. Missile Defense Agency (MDA) in 2020 is asking for $7.25 billion — a 1.7 percent increase. In advanced technology development, MDA is asking for $1.16 billion for the ballistic missile defense midcourse defense segment — a 44 percent increase; $727.5 million for Aegis shipboard ballistic missile defense — an 18.7 percent reduction; $571.5 million for ballistic missile defense enabling programs — an 8.6 percent reduction; and $564.2 million for ballistic missile defense command and control — an 11.1 percent increase.

The Office of the Secretary of Defense (OSD) is asking for $5.29 billion for research and development in 2020 — a 10.2 percent reduction; the Chemical and Biological Defense program is asking for $1.05 billion — a 5.4 percent increase; the U.S. Special Operations Command (SOCOM) is asking for

$820.3 million — a 34 percent increase; and the Defense Information Systems Agency (DISA) is asking for $542.9 million — a 92.4 percent increase.

In Special Operations Command advanced technology development programs, SOCOM is asking for $245.8 million for aviation systems — a 39.8 percent increase; $167.6 million for operational enhancements — a 62.8 percent increase; $72.6 million for maritime systems — a 71 percent increase; $68.3 million for warrior systems — a 9.1 percent reduction; $42.4 million for unmanned intelligence, surveillance, and reconnaissance (ISR) — a 6.1 percent reduction; and $20.7 million for the MQ-9 Reaper surveillance and attack unmanned aerial vehicle (UAV) — a 12.5 percent increase. ←

Skyborg unmanned combat aircraft to push bounds of artificial intelligence (AI)

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — U.S. Air Force researchers are approaching industry for mature enabling technologies for a prototype a low-cost unmanned combat aircraft called Skyborg, which will have artificial intelligence (AI) and modular payloads for a wide variety of fighter and ground-attack capabilities.

Officials of the Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, issued a capability request for information (FA8650-19-S-9340) in March for the Skyborg Autonomous Unmanned Combat Air Vehicle project.

Researchers are interested in a prototype inexpensive, quick-turnaround, autonomous unmanned combat air vehicle (UCAV), which will be a modular, fighter-like aircraft that can take on increasingly complex technologies and tasking to support the warfighter.

Once fielded, Skyborg will enable warfighters to adjust Skyborg's payload and autonomy modularly to support an array of missions. Researchers are interested only in technologies that quickly can move to operational use.

Advanced autonomy and artificial intelligence (AI) are poised to change the character of the international

battlefield substantially in the near future, Air Force researchers explain. Researchers want to field an autonomous system that meets an immediate operational need, as well as that can jump-start complex AI development, prototyping, experimentation, and fielding.

Air Force officials plans to proceed at an accelerated timeline, with experiments and demonstrations planned for as early as 2020.

Skyborg will be attritable, meaning it will have a lost enough cost to sacrifice it in combat to attack high-value targets. It also will be reusable after flying routine missions. It also has the ability of an intelligent system to compose and select independently among different courses of action.

Its artificial intelligence embedded computing will have modular components and protocols that conform to open-systems standards, which integrate easily with third-party products. Open systems mitigate risks associated with technology obsolescence, vender-unique technology, and single sources of supply and maintenance, Air Force researchers explain.

Skyborg must have an open AI software architecture and toolkits that enable timely modifications and upgrades of complex autonomous behaviors; have modular open-systems mission hardware; and meet military certification and acquisition requirements.

Desired, but not required, in Skyborg are the ability autonomously to avoid other aircraft, terrain, obstacles, and hazardous weather; conduct autonomous takeoffs and returns; have separate sensor payloads and flight computers to allow for modular adjustments and adaptability; and have mission-planning software that integrates with next-generation Air Force mission planning tools that emphasize modularity and openness.

The Air Force is approaching industry for enabling technologies for a prototype a low-cost unmanned combat aircraft called Skyborg, which is expected to push the bounds of artificial intelligence (AI).

Researchers also want an autonomous aircraft that can operate with personnel who have limited engineering or pilot experience.

Companies interested were asked to email responses by 15 April 2019 to AFRL.SDPE.Skyborg@us.af.mil. Email questions or concerns to Skyborg Contracting Officer Mike Wafzig at michael.wafzig@us.af.mil. ←

More information is online at https://www.fbo.gov/spg/USAF/AFMC/AFRLWRS/FA8650-19-S-9340/listing.html.

Air Force asks industry to build OLED micro displays for military upgrades

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — U.S. Air Force researchers are surveying U.S. companies that can build organic light emitting-diode (OLED) micro displays to help upgrade currently fielded U.S. military electronics.

Officials of the Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, issued a request for information (FA8650-19-S-5018) on Monday for the Defense Production Act (DPA) Title III Technology Market Research, Organic Light Emitting Diode (OLED) Microdisplay Technology Production Capability project.

OLED is a next-generation display technology that is replacing liquid crystal displays (LCD) in applications like small displays for wearable electronics, mobile micro displays, and small size, weight, and power consumption (SWaP) uses.

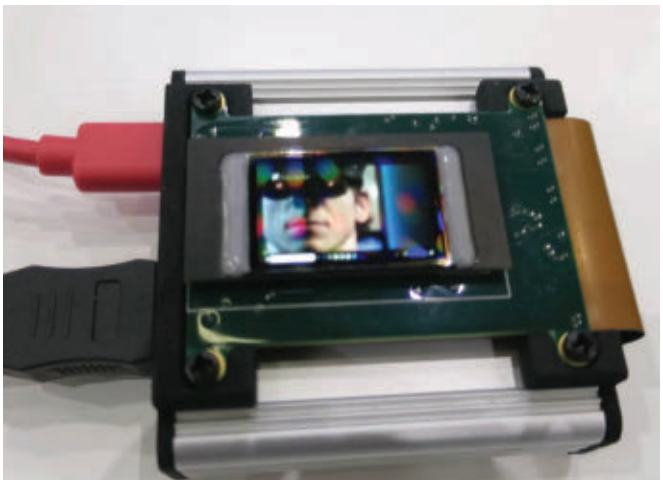
OLEDs, which can be about the size of a coin, are made from thin films of organic light emitting materials that emit light when electricity is applied. They have a much simpler structure and have several advantages, compared to LCDs.

For Air Force purposes, an OLED micro display has a minimum format of

640 by 480 pixels, with and a pixel pitch no larger than 15-microns. Relevant OLEDs must qualify to function in military environments for shock and vibration, and operate in temperatures from -40 to 65 degrees Celsius.

These displays must maintain contrast ratios better than 10,000:1, and a minimum dimming range down to 0.1-foot Lamberts for white. Monochrome brightness must be better than 3,000-foot Lamberts and RGB color OLED better than 50-foot Lamberts, and the displays must be daylight-readable and maintain nighttime performance.

Technology advancements must address achieving a 2,048-by-2,048-pixel color pixel format within a 1.25-inch package that can display a minimum of 256 measurably different gray levels.



Air Force electro-optics experts are searching for companies able to build advanced OLED flat-panel displays for future military electronics upgrades.

Air Force researchers also are interested in current and future manufacturing capabilities that will help to create an economically viable military and commercial supplier of military-grade OLED micro-displays.

Companies interested were asked to email their intentions to respond by 25 March 2019 to the Air Force's Timothy Kramer at Timothy.Kramer.5@us.af.mil.

To respond to this request for information email 10-page unclassified white papers to Timothy Kramer at Timothy.Kramer.5@us.af.mil. For questions or concerns contact Timothy Kramer by phone at (937-713-9886, or by email at Timothy.Kramer.5@us.af.mil.

More information is online at https://www.fbo.gov/spg/USAF/AFMC/AFRL-WRS/FA8650-19-S-5018/listing.html.

Artificial intelligence (AI) IN UNMANNED VEHICLES

Computer scientists and unmanned vehicles designers work to find the right balance between machine autonomy and human-assisted operations in the next generation of military systems on land, at sea, and in the air.

BY **J.R. Wilson**

One of the biggest buzzwords in military and commercial technology development today is autonomy — self-driving cars; aircraft with no pilot onboard; land, sea, and underwater vehicles without human controllers.

Unmanned aerial vehicles (UAVs), remotely controlled by humans, have been a key part of the world's militaries for 20 years, led by the U.S. and demonstrated with devastating effect during the Second Gulf War.

The first U.S. UAV, which at first used what is now considered a primitive technology in the First Gulf War, was merely following the path created by Israelis in the 1980s as they sought to reduce the number of human pilots killed or captured flying low altitude surveillance missions over hostile territory.

Yet unmanned flight is one thing; and autonomous flight can be something else. None of the thousands of UAVs produced and deployed by nearly every nation on Earth in the past 20 years has been fully autonomous; there always has been a human in the loop.

True autonomy would remove the human element, with the autonomous unmanned vehicle (AUV) operating entirely on its own, reporting back to humans on what it has found during an intelligence, surveillance and reconnaissance (ISR) mission. Potentially, such platforms also could be armed

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and act on their own in a hunter/killer mode, but current international agreements prohibit any armed attack without a human "pulling the trigger".

Full autonomy requires the use of another major technology challenge — artificial intelligence (AI) — which is replete with its own controversies, not only technological, but also ethical, moral, and legal.

The Textron Systems Common Unmanned Surface Vehicle is the U.S. Navy's first unmanned surface vehicle program of record.

History of autonomous vehicles

What may surprise many who believe all these to be wonders of the 21st century's new age of technology is the relatively long history of unmanned and autonomous vehicles. This history far predates their introduction into the modern world in the late 20th Century.

What is generally considered to be the first autonomous vehicle, in fact, was designed by Leonardo da Vinci around 1500. His self-propelled cart used high-tension springs to move without being pushed or pulled and a steering mechanism that could be set in advance to send it along a predetermined path. As with many of da Vinci's inventions — including the helicopter and parachute — there is no evidence his cart was ever built.

The first autonomous platform actually produced and deployed was the Whitehead Torpedo in 1868. Inventor Robert Whitehead took existing short-range torpedoes, which traveled under momentum from their initial firing, and installed a pressurized system that enabled them to propel themselves underwater, maintaining depth, for several hundred yards. It had the same impact on naval warfare at the time as the Predator UAV had on aerial warfare nearly a century and a half later. Torpedo guidance also evolved rapidly after that, with expanded influence on other weapons, including aircraft.

The autopilot, part of nearly every major aircraft in the world today, was invented in 1933 by Sperry Gyroscope Co. in New York and gained worldwide fame when pioneering pilot Wiley Post used it on a 13,000 mile, round-the-world flight. "Mechanical Mike" used gyroscopes to track the aircraft's heading by interfacing with flight controls to keep it on course.

Another form of autonomy is the car cruise control, which maintains a set speed while engaged. Although the Teeter Cruise Control was invented in 1945, it did not see commercial use until 1958.

The race to the moon led to the first self-driving vehicle actually built, the Stanford Cart, in 1961, when engineering graduate student James Adams proposed a way for a lunar rover to move about the moon's surface despite the 2.5 second transmission delay from remote controllers on Earth.

In 1977, Japan-based Tsukuba Mechanical Engineering advanced the concept of self-driving cars with a passenger vehicle that used cameras to detect street markings while moving at nearly 20 miles per hour.

A decade later, German engineer Ernst Dickmanns took that a step further, placing a bank of cameras and 60 microprocessing modules on the front and back of a car and creating what he called "dynamic vision" — an imaging system that focused only on objects relevant to the vehicle's movement. His VaMoRs eventually was able to travel at speeds up to 60 mph on Germany's high-speed Autobahn.

From 2004 to 2013, the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., sponsored a series of challenges for academic, industrial, and private inventors to develop a car that could self-navigate through a variety of environments, from a 150-mile desert course in 2004 to a 60-mile urban setting in 2007. While none of the entrants completed the desert challenge, four cars succeeded in traversing the urban route within that challenge's six-hour time limit.

AI and autonomy

Since then, self-driving trams, taxies, and personal vehicles have been introduced, with varying degrees of success. Accidents involving these vehicles have slowed what some had expected to be a rapid transition in urban transit, but continuing advances in technology make their eventual widespread adoption a virtual certainty, with Chinese computer scientist and AI expert Andrew Ng recently saying they "will join human drivers on our roads sooner than most people think".

Ng also predicts the development of true AUVs will require a "public-private partnership and a community of legislators and researchers and technology companies and automobile manufacturers."

There is considerable disagreement across industry on when fully autonomous systems will be deployed by the military. All agree such systems will require at least a low level of AI — and therein lies the most oft-cited problem: The legal, moral and ethical considerations involved in having a robotic platform capable of self-guidance and action on the battlefield — even more so if that platform is weaponized.

Scott Engle, director of business development and capture at Mercury Systems in Andover, Mass., addressed both of the overarching questions surrounding AI and full autonomy: How soon and how likely?

"There clearly is the ability technologically to do a lot of systems autonomously, but the industry realizes if there is a catastrophic accident, the public's confidence will be diminished and their support lessened," he says. "The industry is proceeding cautiously, but not at revolutionary breakneck speed, which I think is appropriate."

Military leaders may be even more cautious when it comes to AI. "By their very nature, the military is less cautious," Engle says. "The question about full autonomy on the battlefield is do you want a system that does not have a human in the loop controlling when weapons are released, so the military is very cautious about deploying fully autonomous systems with the ability to do harm. More quickly will be support systems, such as medevac and supply delivery."

The Textron Systems Aerosonde HQ is a variant of the company's proven Aerosonde Small Unmanned Aircraft System with vertical-take-off-and-landing capabilities.

Sean Baity, Technology Director for Unmanned Systems at Textron Systems in Hunt Valley, Md., agrees about the speed with which such systems can be produced.

Rapidly evolving technology

"The technology is evolving very rapidly. The hardware and software aspects are fairly accessible, no longer requiring exquisite platforms or yet-to-be developed math; they are now point and click. Right now it is building confidence in those systems in more challenging environments in commercial and military applications," he says.

HR3000 is a rugged, half-rack width, short depth 3U server. Part of Systel's Puma-Bolt space saver server series, which is being fielded for Marine expeditionary vehicle programs.

"That is going very quickly, with sizable investments and defense interested in bringing that level of rigor and confidence into defense systems," Baity says. "One area leading this effort is UUVs [unmanned underwater vehicles], which are out there now and can operate for months at a time without

any human intervention. That is a challenging environment, but does not have the considerations of civil air space safety."

AeroVironment Inc. in Monrovia, Calif., has a long history in the production of UAVs for the military and, more recently, for commercial use. Steven Gitlin, vice president of corporate strategy, also sees the technology outpacing the military's concept of operations (CONOPS).

"It's a quickly evolving space with lofty ambitions and a lot of horsepower and we've been able to deliver some basic autonomy capabilities that we believe, over time, can deliver more value to the customer," Gitlin says. "Anything that can enable a customer to perform their mission more safely, efficiently and cost-effectively is attractive. And that's what unmanned vehicles have done already. It's a continuum."

In terms of technologies necessary to enable the next generation, he adds, "there's a lot of development going on in machine vision, AI, neural nets, machine-to-machine communication. Those calls need to happen very quickly and the more complex the environment and task, the faster those calls need to take place." AI's role will be making the right decisions at the right time to achieve the intended outcome, being able to recognize a situation and make a decision that reaches the appropriate outcome, he says.

One of the most enthusiastic supporters of AI-based systems is Lockheed Martin Corp. in Bethesda, Md. In a January 2019 paper, the aerospace giant predicted a future where AI plays a major role in just about every part of military and civilian life.

"In an AI-enhanced future, humans will become better at everything; they'll also become safer and less vulnerable to danger," the paper states. "AI-enabled autonomous systems are

The Textron Systems Shadow Tactical Unmanned Aircraft System has more than 1 million flight hours of experience from operations around the world.

The Textron Systems Aerosonde Small Unmanned Aircraft System has more than 300,000 flight hours of experience from land and sea operations around the world. At any given point in time, there is an Aerosonde system operating somewhere in the world.

changing the way militaries operate and protect their forces, the way first responders fight fires, how researchers explore the far reaches of space and the ocean's depths."

"Effective manned/unmanned teaming reduces the high cognitive workload, allowing the warfighter to focus on creative and complex planning and management," the paper continues "Autonomous systems also have the ability to access hazardous mission environments, react more quickly and provide persistent capabilities without fatigue."

Some analysts predict global sales of $100 billion in unmanned vehicles through 2025, 80 percent of that on UAVs. But those figures do not account for AUVs, which, if shown to be successful, could raise the figure far higher for military and commercial sales combined, with one of the largest applications being agriculture, where automation already has taken a strong hold.

Autonomy in unmanned vehicles

Boeing, the world's largest aerospace and defense company, also is a major supporter of unmanned technologies today and fully autonomous unmanned vehicles tomorrow. In mid-February, the U.S. Navy awarded Boeing Defense, Space & Security a $43 million order to build four Orca Extra-Large Unmanned Undersea Vehicles (XLUUVs). At seven feet in width, the XLUUV is among the largest unmanned submersibles ever conceived for long-endurance surveillance missions or undersea cargo vessels to deliver sensor payloads and other UUVs.

The Navy and DARPA have been working with Boeing and Lockheed Martin for several years on a variety of large UUV efforts, such as the Large-Displacement Unmanned Underwater Vehicle project. The LDUUV is an autonomous submarine no larger than 80 inches in diameter that will be used to help develop concepts for using the larger XLUUVs.

While the operating environment for UUVs is less complex than that for either UAVs or UGVs, it nonetheless presents several unique obstacles for an unmanned system. First, direct communication from a manned submarine or surface ship is impossible. Instead,

the UUV must cope with rapidly changing thermal layers to large aquatic animals like whales, to fishing nets, minefields, and even sunken ships. To be successful, a long-range underwater vessel needs some form of AI to handle those obstacles as well as changing conditions related to its mission.

AI is actually a multi-layered concept, ranging from machine learning, to adaptive reasoning, cognitive computing, and to full artificial intelligence. The first has been in use for several years, the second more recently, the third is still under development, and the final step has some way to go. Each, however, has a role to play in AUV development and deployment.

"AI is a software function," says Mercury's Engle. "The key with software in general is programmers have sets of requirements they have to write software to answer. But with autonomy, you can't possibly list every possible problem you may encounter while flying, for example. We can only program for what we know the problems are today. The promise of AI is the ability to create software that can handle a situation it hasn't encountered before, approaching the problem much the way a human would, drawing on past experience to deal with a new problem."

Technology eventually is expected to catch up. "Technology is evolving," says John Bratton, Mercury's director of product marketing for sensor and mission processing. "In terms of processing, now we have the ability to process a lot of the algorithms needed for AI. But an overarching theme has to be infrastructure. For example, the ability of an unmanned vehicle to have an understanding outside the norm will depend on the increased bandwidth of 5G, which also is very low latency. And a lot of decisions will need to be made in real time."

Autonomy and safety

One concern of those involved in the development of AI and AUVs in the U.S. is the possibility of falling behind two of the nation's chief rivals and potential combat adversaries: China and Russia. Both have made it clear they are working hard on both technologies — and China has boasted of its advances in 5G. In addition, neither government faces the potential weight of public opposition should something go wrong.

"In the last 10-to-15 years, across the world, we've gotten used to the concept of digital convergence," Bratton says. "The functionality that goes into smart phones, with a full back-up of cloud data center resources behind it, it will be a critical enabler for autonomy. Those same technologies are now being seen in other applications, such as automotive."

Safety also plays a big role. "There is the potential for us to be behind the Russians and Chinese [in military AI and AUVs], who may not have the same safety mindset," Bratton says. "The U.S. has a goal of saving every possible person and minimizing the risk to every soldier. But that's more sociological than technical. This is a brand-new domain and we don't fully understand the liability issues. If an autonomous vehicle runs someone down, who is liable — and what were the circumstances involved? There are no absolutes with AI outputs, so it will be a little more interesting."

Falcon-Strike is a C5ISR small form factor, high performance multi-mission computer fielded for fixed and rotary wing missions as well as ground-vehicle counter-UAV applications.

The extensive certification programs are almost certain to change significantly.

"Going through certificating with an air vehicle currently is very long and arduous, with only a few companies seeking certification," says Mercury's Engle. "But there are hundreds of start-ups popping up all over the world that eventually will show up at the FAA [and its overseas equivalents] and ask to be certified. How to scale this industry to handle the evaluation and approval of all those systems is something we have to resolve. And that's just aviation. Before a ground vehicle can be deployed, does some federal agency have to validate it is ready to go? I think that is another thing slowing this industry down."

Textron's Baity says he believes the true force driving future AUV development will not be the military, but the commercial world.

The role of commercial AI

"The economy of scale for the components that enable progressive autonomy will be important, such as the computing and sensor and data fusion capabilities developed for the auto industry," Baity says. "That also impacts perception. Fully autonomous systems will emerge in areas with a low probability of causing harm, such as underwater or in space. We will see them in commercial applications such as warehouses, but basically an environment that can be described in a deterministic way. To avoid safety issues or overburden the military user is not useful."

Much of it depends on the evolution of computer technology, Baity continues. "The computation aspects will continue to progress and increase capabilities, especially in the perception aspect, in resilience and modality, not depending on one form of perception but a combination of sensors. For the foreseeable future, humans will remain on the loop as we address the cognitive workload of that operator to manage that system, which involves systems that can provide the right answer to manage those systems effectively. The other aspect is verification. In defense, you have programs that run through proving out and developing confidence, which will remain, but the economics of that are high. Standards compliancy and plug-and-play are part of that to create technologies we can afford to deploy."

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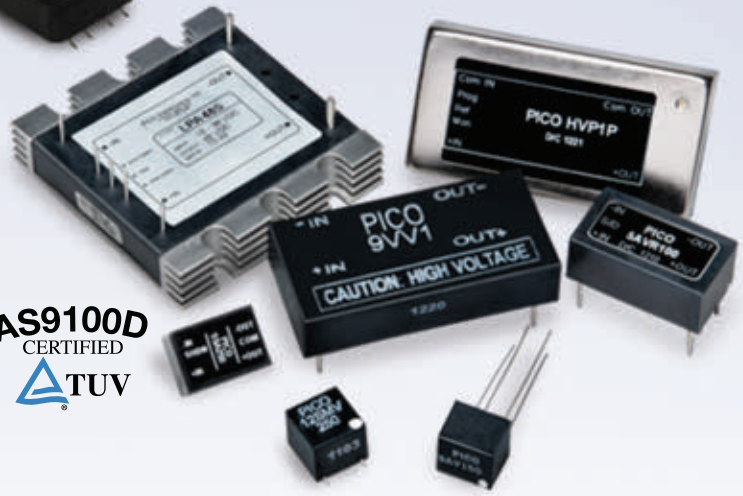

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FLIR Systems in Wilsonville, Ore., acquired Endeavor Robotics (nee iRobot) last February, is expanding its portfolio from sensors to robotic systems, with a long-term focus on autonomy.

"In the future, we will be looking to integrate manned and unmanned systems across multiple domains, including unmanned air and ground systems, collaborating in the battle space as well as working with manned systems," says Roger Wells, vice president/general manager for unmanned systems & integrated solutions at FLIR's Government & Defense Business Unit. "This gives us the opportunity to move from sensors, where we have a long and robust history, to intelligent sensors and sensing to fully integrated solutions designed to meet the needs of the missions."

It's likely we will see more of this in the future. "We see unmanned autonomous systems becoming much more pervasive, in our personal lives and on the battlefield," Wells continues. "It is evolving by leaps and bounds every day. We are getting to the point in our technology development — especially in terms of SWaP [size, weight and power] — where we can package tremendous amounts of capability into small units. The architectures are allowing the systems to more effectively integrate into the force structure as well as operate in autonomous ways across a wide spectrum of missions. The analytics, AI and applications are allowing our systems to be more effective at understanding the environment and conducting their mission relative to what they are sensing. This is providing a unique set of capabilities to small units on the front line, with systems around them supporting that."

Enabling technologies for AI

To handle a fully autonomous system, from navigation to sensors to communications — perhaps, eventually, weapons — will require a complex, multi-level AI system with a single interface to all of those to avoid SWaP parameters that make the system too large to be practical.

"Through integrating, ruggedizing the right hardware, we can enable an AI footprint in a single system rather than several difference pieces in the past," says Aneesh Kothari, vice president of marketing at rugged computer specialist Systel Inc. in Sugar Land, Texas. "It also provides a single point of integration for all the sensors these platforms will carry. The number of things now possible is quite remarkable. And such systems divert weight and operational requirements from the individual soldier."

Many improvements have come only recently. "It seems to be evolving very rapidly, especially in the past two years," Kothari says. "You can see that across the military services, such as the Army's robotic combat vehicle, smaller-form-factor UAVs, UGVs being looked at as forward deployed units, the Navy's autonomous helicopter. The mandate for AUVs is quite common across the board, making what was science fiction only a few years ago quickly becoming reality."

Unmanned systems have proliferated across all domains, from the Boeing-built U.S. Air Force unmanned X-37B mini-shuttle, to the Orca, to driverless cars to UAVs. The next step, fully autonomous platforms, appears to be technologically close, and depends only on advances in artificial intelligence.

"AI is a vision of what could be, with a tremendous amount of work underway, such as machine learning and other aspects that simplify things down to a 'check engine' light level," says Textron's Baity. AI will make sure that confidence is established and maintained in the system and mitigates the cost of training and maintenance. There is a desire to minimize the amount of training required so you can walk up to a system and know how to use it, much as you do with a telephone.

"The area of autonomy is a broad one and people feel very passionately about it," Baity continues. "It is something that will benefit our lives and our ability to get the job done. We want to make sure they are extensions of human intent and managed in that manner, covering customer needs in air, land and sea."

COMPANY LIST

AeroVironment Inc.
Monrovia, Calif.
www.avinc.com

Boeing Defense, Space & Security
Huntington Beach, Calif.
www.boeing.com/defense/autonomous-systems

Crystal Group
Hiawatha, Iowa
www.crystalrugged.com

FLIR Systems
Wilsonville, Ore.
www.flir.com

Lockheed Martin Corp.
Bethesda, Md.
www.lockheedmartin.com/en-us/capabilities/autonomous-unmanned-systems.html

Mercury Systems Inc.
Andover, Mass.
https://www.mrcy.com

Systel Inc.
Sugar Land, Texas
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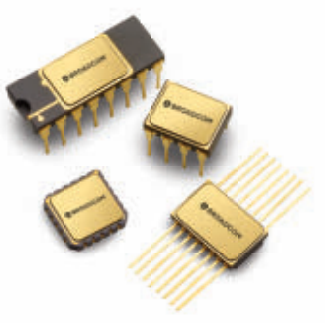

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Military power electronics seeks to increase voltage and efficiency

Power control for aerospace and defense applications aims at sometimes-conflicting demands for custom designs, open-systems standards, and the ever-present quest for small size, weight, power consumption, and cost (SWaP-C).

BY **John Keller**

Modern aerospace and defense electronics applications are calling for power control and conditioning components that offer increasing amounts of power density, efficiency, and voltages to meet often-stringent requirements of small size, weight, power consumption, and cost (SWaP-C).

At the same time, however, the power industry is confronting requirements from other directions — namely growing needs for high-power systems like laser weapons, all-electric aircraft, and many other applications that are demanding high power and low SWaP-C.

"Things are getting smaller and more powerful," says Jeffrey Ham, principal applications engineer at Vicor Corp. in Andover, Mass. "The smaller we can make something and the more powerful we can make it, enables our customers to meet their needs."

Designing electronics that are smaller and more powerful than ever before is an imperative that runs across the industry's waterfront, and power electronics is no different. "SWaP-C challenges are still paramount," says Robert Russell, vice president of product marketing at Vicor. "Our idea is to improve on the SWaP-C metric while letting our customers do what they are good at, so they can do what they do."

The ability to take-on SWaP-C is one of the strongest pitches that Vicor officials make to their customers. "Our products draw a lot of interest for size and weight, where customers need a lot of power in a small package," says Tom Curatola, field applications engineer at Vicor. "They look at our expertise to pack a lot of power into a small package."

Elma Electronic is in the rugged embedded computing business, yet company engineers have designed their own VPX and small-form-factor embedded power modules to meet customer needs.

One design approach Vicor takes to meet SWaP-C requirements is replacing traditional brick packaging with the company's DCM packaging approach, which helps them design devices that are two to three times smaller than the company's previous-generation power bricks. Vicor DCM products are not really bricks, but are power components that are in a much smaller package. For DC-DC converter applications, to meet SWaP-C requirements, that DCM family is gaining momentum very rapidly," says Vicor's Russell.

Increasing voltage challenges

One of the primary challenges for power systems designers today is squeezing every last bit of power out of ever-more-tightly packaged power components. "Everybody always asks for higher power density and efficiency," says Leonard Leslie, vice president of engineering at VPT Inc. in Blacksburg, Va.

"We get requests for increased power in the same package, and less power dissipation from our products," Leslie says. "As systems get more complex, and as they try to do more in the same space and weight, they are pushing for a more dense solution." VPT engineers are approaching this challenge with updated power topologies like synchronous rectification. "Some of the things we've worked on are wider input

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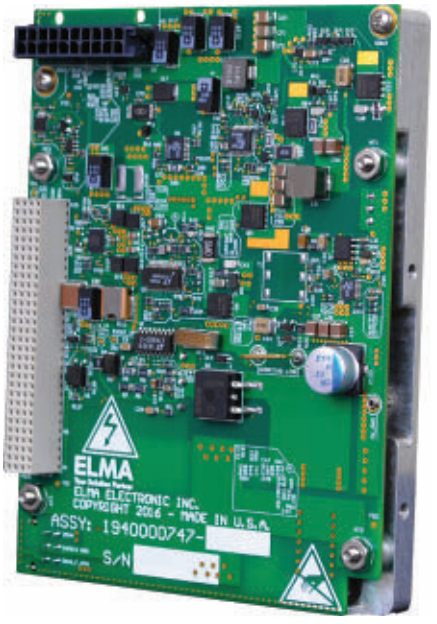
voltage ranges to meet mil-specs without additional modules in front of the converters," he says.

New kinds of packaging can be key to meeting today's power challenges. "To move to higher voltages, we need packages that meet clearances for safety," says Vicor's Ham. "Having a higher-voltage device lets you use less copper to drive current. We need to reduce the amount of current flowing around at a given voltage level. The driver is the customer's desire to reduce the size of his payload without adding more copper for moving current at lower voltages." The U.S. Army-Marine Corps Joint Light Tactical Vehicle (JLTV), for example, is moving up to 600-volt systems for a variety of power needs — sometimes even higher — Ham points out.



Elma Electronic engineers have designed their own CompactPCI small-form-factor embedded power modules to support the company's line of small rugged embedded computers.

Not only can higher voltages help increase overall system power, but they also play a role in keeping SWaP to a minimum. A relevant application is tethered unmanned aerial vehicles (UAVs), which receive their operating power and instructions through a thin cable to the ground. "In the tethered drone market, anything that can be done to reduce the size of the tether is important, so the higher the voltage, the smaller the cable size that is necessary."

Not only do systems designers need higher-voltage systems than they have in the past, but they also need cleaner and more precise power control.

"Some of the things that before might have been acceptable include living with harmonics," says John Santini, chief technologist at Data Device Corp. (DDC) in Bohemia, N.Y. "Now they are saying we can't afford those harmonics anymore, and need a true power factor corrector. The Navy, for example, for years has used multi-pole transformer rectifier setups, or some kind of passive power factor correction. Now our customers are saying we need active power factor correction, so then you are driven to an active solution."

Shift to high power

It's a given that military electronics designers want more power at their disposal, and it's up to the power industry to give it to them. "I'm seeing a lot more high-power and high-voltage opportunities — 270 volts and up," says Steven Goldman, product line manager for solid-state power controller products at DDC. "That's a big shift for us, and we are going to higher voltages and higher power."

Much of the shift to higher-power systems comes from the hybrid and electric vehicle industry. Military systems designers want to take advantage of these maturing power technologies as they move to ever-more powerful systems.

"We are seeing a lot of higher-power requirements driven by motive systems," explains DDC's Santini. The commercial electric power market is centered on 370 volts for the automotive market. There are small hybrid vehicles and some high-power drives that are centered on 400 volts."

This has military systems designers thinking about how to implement tomorrow's systems like all-electric drones. "That's when you start seeing 370-volt buses instead of just 270-volt buses in military applications," Santini says.

Additional high-power military applications involve the emerging generation of laser weapons, as well as systems that are moving away from hydraulic actuation to electric power. "In high-power systems, we are seeing customers looking even for 1,000-volt systems," says DDC's Goldman. "This is pushing us to the higher-power requirements; they need all the power they can get. Those laser weapons use a super-capacitor to power and fire the weapon."

The VPT SVPL series of space-qualified point-of-load DC-DC converters is designed for the harsh radiation environment of space applications.

In response to high-power demands, DDC last year introduced the RP-28001000N0 MIL-STD-704F-compliant 12-channel, 270-volt DC, 150-amp solid-state power controller, initially for vetronics in military land vehicles.

The RP-28001000N0 offers programmability, system health diagnostic and prognostic data, and high power density in a compact and rugged form factor. It employs DDC's technology, with more than a million nodes installed on military and aerospace systems since 1988, including on the Joint Light Tactical Vehicle (JLTV). "We have had a lot of requests for that board since we introduced it," says DDC's Goldman. "Ever since we went to 150- and 270-volt devices it has inserted us in a lot of different applications, like mission pods, electro-optical sensors, radars, and things going into manned and unmanned aircraft pods."

Vicor Corp. is looking beyond the traditional power brick module to offer new designs that are two to three times smaller than previous-generation power products.

The trend to higher power has no end in sight. "The biggest thing is we will have applications in 270 volts DC and 370- and 400-volt buses because it is widely used in commercial automotive," says DDC's Santini. "There's also a lot of discussion about solar power. For forward-based soldiers, the environment is not really known, and solar power is a big benefit because you don't have to truck in fuel as much. Some of the bigger solar systems are 300- and 400-volt systems."

Of course, systems designers cannot design for high power without considering electronics cooling and thermal management. "All our systems are conduction cooled," says Michael Agic, business unit manager for power control products at DDC.

"People who really use a lot of power think about cooling — and they think about liquid cooling," Agic continues. "Then there are customers who are not really power users — they have pods that do specific functions — and for them thermal management is an afterthought. For those we have to guide the customer along."

Standards, COTS, and custom

In this era of open-systems industry standards, most people might thing that power control and conditioning components would be jumping quickly on the standards bandwagon, but actually the opposite is true. "We are doing a lot of customization for 5- and 3.3-volt systems," says Dan Arnhols, western sales manager at Milpower Source in Belmont, N.H. Milpower Source specializes in extremely rugged power components and subsystems in aerospace and defense applications. "If we design for 12-volt systems, the customization happens with 5- and 3.3-volt systems," Arnhols says. "Everyone wants something unique."

Even at the electronic enclosure and chassis level, requests for custom power designs are routine. "One trend involves some kind of custom power supply design," says Ram Rajan, senior vice president of engineering at Elma Electronic in Fremont, Calif. It's always a challenge for a power supply company to engage in programs because of the initial low volumes."

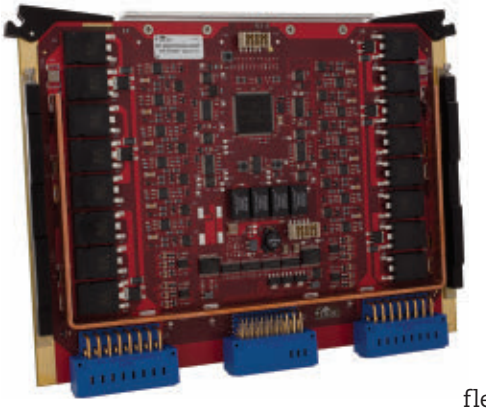
The increasing use of rackmount embedded computing systems that conform to industry standards like OpenVPX presents its own set of

VPT Inc. in Blacksburg, Va., is offering several different radiation-hardened power electronics devices for use aboard manned spacecraft and satellites, as well as for high-altitude aircraft.

challenges. "It's very difficult to find an off-the-shelf solution that conforms to our rack-mount requirements," Elma's Rajan says. "The trend is custom power supplies because they need shelf-management solutions. It's very program-driven, and is difficult for commodity power supply companies to meet those requirements."

Milpower Source engineers are meeting demands for custom power with libraries of power designs that can go together quickly for custom power solutions. "Milpower has 3,000 individual power designs," Arnhols says. "We have a library of already-proven circuits we can mix and match to tailor for a customer's application; we don't have to go back and re-invent the wheel. That's a big plus for our customers, who are very nervous that a custom design will have a lot of issues, but we remove that in a custom design."

That's not to say that open-systems standards are not taking part in power electronics; quite the contrary.



DDC's rugged 12-channel solid-state power controller board provides control, protection, and continuous monitoring to 150 amps to 12 independent electrical system loads.

DDC's 280-Watt power converter supplies 28 volts of power for in-flight entertainment and USB charging ports for portable electronic devices on passenger aircraft.

VPX and VITA 62

The ANSI VITA 62 specifications for VPX modular power supplies define the power-generation requirements for power modules that support a VITA 62 slot on the VPX backplane. It uses the standard VPX 3U/6U form factor, and offers functionality that includes N+1 failover, VBAT, and 50-millisecond hold-up. It also defines connectors that mate with a VITA 62-compatible backplane.

VITA 62.1, meanwhile, provides requirements for building a high-voltage 3-phase 3U-class front-end power supply module that can power a VPX chassis. The module will fit within the standard envelope defined for VPX modules in the VITA 48.0 standards.

"We are focusing on VITA 62 to be able to have a common architecture and a common set of features that people can mix and match to create a system," says Milpower's Arnhols. "Innovation is putting power on a 3U or 6U form factor, and DOD [the U.S. Department of Defense] is mandating VITA 62 going forward. Our innovation is dealing with the challenges of putting power in a very small space, and dealing with the thermal issues that people need to deal with.

"People want as much power as they can get in a single board, and get the output that their customer requires," Arnhols continues. "They want flexibility in the VITA 62 power card, and that is what we bring to the table. We can say, here is our standard power card, yet deliver custom changes, usually at no extra charge."

Vicor also is joining the VPX parade with new VITA 62 products. "In VPX we are seeing a lot of adoption," says Jim Kotopka, the company's director of business development. "That's why we are investing heavily in that area, and are developing a family of products to support it."

Elma is directly involved in the embedded computing business, yet in the recent past company engineers designed their own VITA 62-compliant power supplies. Now that the VITA 62 market is taking shape, however, "we want to step away from that," Rajan says. "VPX solutions filled a niche, but now we are moving to small-form-factor applications with power supplies that fill a small slot." ←

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Raytheon to build three prototype AMDR radar systems for Burke-class destroyer

Surface warship radar experts at the Raytheon Co. will build three advanced-prototype versions of the new AN/SPY-6(V) Air and Missile Defense Radar (AMDR) under terms of $402.7 million U.S. Navy order announced in March. Officials of the Naval Sea Systems Command in Washington are asking the Raytheon Integrated Defense Systems segment in Marlborough, Mass., to provide three low-rate initial production (LRIP) versions of the AMDR for late-model Arleigh Burke-class (DDG 51) Aegis destroyers. LRIP means building small quantities of the system to enable Navy experts to test the it thoroughly to ensure it meets Navy requirements. This phase also enables Raytheon to tool-up for full-rate production. LRIP is the first step in switching from customized hand-built prototypes to the final mass-produced end product. The AMDR will supersede the AN/SPY-1 radar, which has been standard equipment on Navy Aegis Burke-class destroyers and Ticonderoga-class cruisers.

Northrop Grumman starts full-scale development of AARGM-ER radar-killing missile

U.S. Navy aerial warfare experts are beginning full-scale development of a new and advanced radar-killing missile designed to enable U.S. jet fighter-bombers to suppress enemy air defenses preceding bomber attacks. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced a $322.5 million contract in March to the Northrop Grumman Corp. Innovation Systems segment (formerly Orbital ATK) in Dulles, Va., for engineering and manufacturing development (EMD) of the AGM-88G Advanced Anti-Radiation Guided Missile – Extended *[PAGE 34]*

Harris to provide EW avionics to protect Kuwaiti combat aircraft from missiles

BY **John Keller**

PATUXENT RIVER NAS, Md. — Electronic warfare (EW) experts at Harris Corp. will provide sophisticated EW systems to the government of Kuwait that are designed to protect combat aircraft from incoming radar-guided missiles.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., has announced a $43.3 million order to the Harris Electronic Systems segment in Clifton, N.J., for additional lot 16 AN/ALQ-214 A(V)4/5 EW jammers for F/A-18E/F Super Hornet fighter-bombers for the Kuwaiti military.

The AN/ALQ-214(V)4/5 is an electronic jammer component of the integrated defensive electronic counter measures system (IDECM) avionics. It protects fighter-bombers from radar-guided surface-to-air and air-to-air missiles.

One year ago Boeing agreed to sell 28 Super Hornets to Kuwait worth as much as $1.2 billion. Of this order, 22 will be single-seat F/A-18E models and six will be F/A-18Fs — the two-seat version of the jet. The U.S. State Department approved the Super Hornet sale to Kuwait in November 2016.

The ALQ-214 component of the IDECM EW system has been delivered to the U.S. Navy and to the Royal Australian Air Force for contemporary versions of the Boeing F/A-18 combat aircraft. The system blends sensitive receivers and active countermeasures to form an electronic shield around the aircraft, Harris officials say.

Last month Harris won a $168.8 million order to provide the U.S. Navy with

Harris is providing the AN ALQ-14 electronic warfare (EW) system to help protect Kuwaiti military aircraft from radar-guided missiles.

78 AN/ALQ-214 A(V)4/5 EW jammers for F/A-18C/D and F/A-18E/F combat jets.

The RF countermeasure system engages incoming missiles autonomously with a series of measures designed to protect the aircraft from detection. The AN/ALQ-214(V)4 is a smaller and lighter version of its predecessors, and has an open-architecture design that is ready for integration on several different kinds of aircraft.

The system is designed to counter radar-guided anti-aircraft missiles with electronic countermeasures (ECM) techniques that deny, disrupt, delay, and degrade the enemy missile launch and engagement sequence. The system identifies, ranks, and counters incoming missiles, and displays engagements to the flight crew for situational awareness.

On this order Harris will do the work in Clifton, N.J.; as well as in San Jose, San Diego, Rancho Cordova, and Mountain View, Calif., and should be finished by August 2022.

For more information contact Harris Electronic Systems online at www.harris.com/es, or Naval Air Systems Command at www.navair.navy.mil.

Vadum to support EW project to counter waveform-agile enemy radar with machine learning

BY **John Keller**

CRANE, Ind. — U.S. Navy avionics experts are looking to electronic warfare (EW) experts at Vadum Inc. in Raleigh, N.C., to support a project that aims at developing detection and classification techniques that identify new or waveform-agile radar threats and automatically respond with an electronic warfare (EW) attack.

Officials of the Naval Surface Warfare Center Crane Division in Crane, Ind., announced a five-year $9.4 million sole-source contract to Vadum to support the Reactive Electronic Attack Measures (REAM) project.

REAM seeks to develop ways of keeping up with rapidly changing enemy radar frequencies, recognizing patterns in frequency shifts, and automatically devising methods to jam or spoof these frequencies-on-the fly.

The REAM project is developing detection and classification techniques that identify new or waveform-agile radar threats and automatically respond with an electronic attack.

Today's airborne EW systems are proficient at identifying analog radar systems that operate on fixed frequencies. Once they identify a hostile radar system, EW aircraft can apply a preprogrammed countermeasure technique.

Yet the job of identifying modern digitally programmable radar variants using agile waveforms is becoming more difficult. Modern enemy radar systems are becoming digitally programmable

The U.S. Navy EA-18G Growler electronic warfare jet, shown above, may benefit from machine learning to counter future waveform-agile radar systems.

with unknown behaviors and agile waveforms, so identifying and jamming them is becoming increasingly difficult.

Things will get worse in the future as radars develop the ability to sense their environment with artificial intelligence and machine learning, and adapt their transmission characteristics and pulse processing algorithms to defeat attempts to jam them.

New approaches like REAM seek to enable systems to generate effective countermeasures automatically against new, unknown, or ambiguous radar signals in near real-time. They are trying to develop new processing techniques and algorithms that characterize enemy radar systems, jam them electronically, and assess the effectiveness of the applied countermeasures.

Waveform-agile radar systems of the future will shift frequencies quickly in a pre-programmed electronic dance to foil electronic warfare attempts to defeat them.

Last April the Northrop Grumman Mission Systems segment in Bethpage, N.Y., won a $7.3 million contract to develop machine-learning algorithms for the REAM program. The company is moving machine-learning algorithms to the EA-18G carrier-based electronic warfare jet to counter agile, adaptive, and unknown hostile radars or radar modes. REAM technology is expected to join active Navy fleet squadrons around 2025.

On this contract, the Navy is choosing Vadum sole-source to avoid roughly $5.9 million in cost duplication, and prevent as much as three years' unnecessary schedule delay, Navy officials say.

Vadum specializes in EW modeling and simulation. The company has expertise in RF and wireless circuit and systems design; electronic board design, layout, and fabrication; embedded hardware and software design; RF modeling and simulation; computational electromagnetics; antennas; wireless testing; cell phone forensics; servo and stepper motor control; algorithm and digital signal processing development; cryptography; data compression; and RF detection.

On this contract Vadum will do the work in Raleigh, N.C., and will be finished by February 2024.

For more information contact ***Vadum*** *online at* www.vaduminc.com, *or the* ***Naval Surface Warfare Center-Crane*** *at* www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane.

Air Force asks L-3 to build radar proximity sensor to trigger air-burst munitions

BY **John Keller**

HILL AIR FORCE BASE, Utah — Airborne weapons experts at L-3 Technologies Inc. will design and build an avionics radar proximity sensor to enable combat aircraft pilots the heights at which their bombs and smart munitions explode over targets under terms of a $131.8 million eight-year U.S. Air Force contract.

Officials of the Air Force Life Cycle Management Center at Hill Air Force Base, Utah, are asking the L-3 Space & Sensors-Cincinnati segment in Cincinnati to build the Cockpit-Selectable Height-of-Burst Sensor (C-HOBS).

This new avionics subsystem will replace the now-fielded Northrop Grumman DSU-33D/B height-of-burst sensor, as well as address obsolescence issues. Northrop Grumman has been building the DSU-33D/B sensor since 1999, and recently delivered the 200,000th system.

The L-3 Cockpit-Selectable Height-of-Burst Sensor (C-HOBS) will trigger a wide variety of munitions for damage-inducing air bursts.

C-HOBS is a radar proximity sensor that provides high precision variable proximity function to the fuze system. The sensor will provide manual and cockpit-selectable heights of burst, precision height sensing, and possible terrain discrimination.

The sensor will interface with various weapons systems — particularly the Joint Direct Attack Munition (JDAM) the on U.S. Navy and Air Force bomber aircraft.

C-HOBS is a modification program to resolve obsolescence issues with the DSU-33D/B sensor and to improve sensor performance. It will maintain the same form, fit and function as the DSU-33D/B, and will address certain targets of opportunity to future-proof the sensor. Details of the C-HOBS specifications are classified.

Upgrades of the C-HOBS program include manual and cockpit-selectable radar-guided height-of-burst with improved system performance for JDAM and the Next Generation Area Attack Weapons (NGAAW) missions, Air Force officials say. L-3 is expected to build as many as 60,000 C-HOBS units.

On this contract L-3 will do the work in Cincinnati, Ohio, and will be finished by April 2027.

*For more information contact **L-3 space & Sensors-Cincinnati** online at* https://cinele.com, *or the **Air Force Life Cycle Management Center-Hill Air Force Base** at* www.hill.af.mil.

Northrop Grumman to upgrade SATCOM data link aboard E-6B airborne command post

BY **John Keller**

PATUXENT RIVER NAS, Md. — Satellite communications (SATCOM) experts at Northrop Grumman Corp. will build and test advanced SATCOM capability for the U.S. Navy E-6B Mercury strategic airborne command post and communications relay aircraft under terms of an $37.5 million order announced in March.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Northrop Grumman Mission Systems segment in Herndon, Va., to provide modifications to the E-6B aircraft involving the plane's Multi-Role Tactical Common Data Link (MR-TCDL).

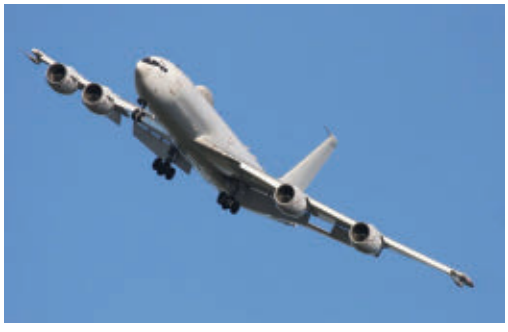
Northrop Grumman will provide seven MR-TCDL data link B-kits, one mission avionics systems trainer B-kit, and A- and B-kit spares for the MR-TCDL upgrade aboard the E-6B Mercury.

The Boeing E-6 Mercury is an airborne command post and communications relay aircraft based on the 1950s-vintage stretched Boeing 707-320 narrow-body passenger jetliner. compared to the original 707 jetliner, the E-6 Mercury has new engines and other system upgrades.

The plane conveys instructions from the National Command Authority to deployed Navy nuclear ballistic missile submarines, as well as to land-based atomic missiles and nuclear-armed bombers.

The E-6 Mercury's MR-TCDL provides secure Ku line-of-sight and Ka SATCOM systems for the E6-B aircraft. The data link includes two Ku line-of-sight channels and one Ka satellite communications channel. Other equipment includes power conditioning, cooling, electrical, and network distribution. The system also has equipment that interfaces Block II B kits into the existing E6-B avionics architecture.

The E-6B provides command and control of U.S. nuclear forces should ground-based control become inoperable. The plane is based on the four-engine Boeing 707 passenger jetliner.



Northrop Grumman will build new SATCOM equipment for the Navy E-6B Mercury airborne command post, which maintains communications with submerged ballistic submarines at sea.

The plane has a battle staff area and new flight deck systems based on modern Boeing 737 avionics. The E-6 flew in 1987, and the first E-6B was accepted in December 1997. The last production E-6B was delivered to the Navy in late 2006.

On this contract modification Northrop Grumman will do the work in Salt Lake City, San Diego, and Boston, and should be finished by October 2021. ←

For more information contact ***Northrop Grumman Mission Systems*** *online at* www.northropgrumman.com, *or* ***Naval Air Systems Command*** *at* www.navair.navy.mil.

[FROM PAGE 30] Range (AARGM-ER). The AARGM-ER is an advanced and extended-range version of the High-Speed Anti-Radiation Missile (HARM). It is a new variant of the AGM-88E missile that equips Navy carrier-based fighter-bombers and electronic warfare jets.

Construction moves forward on gallium nitride (GaN) radar system in Alaska

Construction is moving forward on a U.S. military project to build a new ballistic missile defense system in Central Alaska that involves a gallium nitride (GaN)-based solid-state active electronically scanned array (AESA) early warning radar. Officials of the U.S. Army Corps of Engineers in Anchorage, Alaska, announced a $128.7 million contract to ASRC Construction Holding Co. LLC in Anchorage, Alaska, to build the Long Range Discrimination Radar (LRDR). The LRDR, planned for service in 2020 is part of the U.S. ground-based midcourse defense anti-ballistic missile system. The U.S. Missile Defense Agency (MDA) in Huntsville, Ala., awarded the Lockheed Martin Corp. Rotary and Mission Systems segment in Moorestown, N.J., a $784.3 million contract in late 2015 to build the LRDR. The LRDR program is the backbone of the MDA's layered defense to protect the U.S. homeland from ballistic missile attack. It will be a long-range radar that will provide precision metric data to improve ballistic defense discrimination and replace existing sensors in the Ballistic Missile Defense System (BMDS). LRDR will keep pace with evolving ballistic missile threats and increase the effectiveness of ground based interceptors, Lockheed Martin officials say. For more information contact ASRC Construction online at http://asrcconstruction.com; Lockheed Martin Rotary and Mission Systems at www.lockheedmartin.com, or the Army Corps of Engineers Alaska District at www.poa.usace.army.mil. ←

Navy eyes sonar, communications, and power upgrades for Black Pearl UUVs

BY **John Keller**

STENNIS SPACE CENTER, Miss. — U.S. Navy researchers are looking for companies able to upgrade unmanned underwater vehicles (UUVs) for research programs in anti-submarine warfare (ASW) and mine countermeasures.

Officials of the Naval Research Laboratory (NRL) at Stennis Space Center, Miss., issued a request for information on Tuesday (N00173-19-RFI-WR02) for the Unmanned Underwater Vehicles (UUVs) for Undersea Research project to upgrade the 21-inch-diameter Black Pearl UUV with new capabilities.

Navy researchers want to add two-way Iridium satellite communications (SATCOM) to the Black Pearl UUV; alter the unmanned submersible's payloads bay; determine the best way to accommodate side-scan and multi-beam sonar; and manufacture new UUVs and control systems, tail sections, and batteries.

Bluefin Robotics, a division of the General Dynamics Corp. Mission Systems segment in Quincy, Mass., is manufacturer of the Black Pearl. The company won a $7.1 million contract in April 2014 design and build the Black Pearl autonomous underwater vehicle — an underwater drone for research in long range and multi-static mine hunting and ASW programs, as well as in new distributed sensing research. Bluefin experts were to build as many as five next-generation underwater drones based on the company's Bluefin 21 UUV.

The Navy wants to find a contractor to develop improved capability for two-way Iridium SATCOM. This involves developing a new software driver for the Iridium board, developing software to enable basic two-way messaging, and developing software to help upload missions to the UUV via Iridium. Also needed are software drivers and mechanical structures to accommodate Navy research payloads in the payload sections.

The contractor also will build and test five upgraded Black Pearl UUVs including tail sections for each of the Black Pearl UUVs; a battery power section for each UUV; and a nose section for each UUV. Also needed is a set of topside support equipment to enable the UUVs to operate together as a system, sharing some of the common topside equipment.

This will include two RF deck boxes with antennas; two Iridium deck boxes with antennas; one Sonardyne Dunker kit; two RDF receivers and antennas (quantity 2); five battery chargers; two vehicle carts; two vehicle and support equipment shipping cases; one vehicle toolkit; and two ruggedized operator laptop computers and software.

Spare parts needed include three antennas; three tail cones; three propellers and duct kits; four vehicle power switches; three 1.85-kilowatt batteries; five wet cables; 15 drop weights; 30 drop-weight burn wires; three RDF emergency transmitters; three O-ring kits; three fastener kits; three joining bands; 18 barrel nuts; six nose line with float and float hardware; one MEH board set; one SVS+P sensor; and one AvTrak 6.

The Navy is anticipating sonar, communications, and power upgrades for Black Pearl unmanned underwater vehicles.

Optionally, the Navy may want structural and battery upgrades to the Reliant UUV to make it like the Black Pearl — a state-of-the-art 21-inch-diameter UUV with GPS/INS/DVL navigation capability, low noise propulsion, and onboard energy sufficient to carry out missions longer than 24 hours. The vehicle uses a graphics-based PC mission planning tool.

The original Black Pearl design has a 3-to-5-nautical-mile per hour operating speed, a 400-meter depth capability, a minimum of 18 kilowatt-hour energy storage, and a real-time GPS-aided fiber optic gyro (IXSEA PHINS III), inertial navigation system (INS) integrated with Doppler velocity log instrument capable of measuring the vehicle's horizontal position, velocity, and attitude.

The position accuracy drift rate while traveling submerged on a straight line, is 0.15 percent of distance traveled, or less. The system has an over-the-horizon (OTH) communication capability for periodic vehicle status, monitoring, and redirection using Iridium SATCOM system while the vehicle is on the surface.

The UUV supports several payload types, supplied by NRL researchers,

Air Force ramping-up production of subsonic Long-Range Anti-Ship Missile (LRASM)

U.S. Air Force airborne weapons experts are ramping-up production of the next-generation AGM-158C Long-Range Anti-Ship Missile (LRASM) for use against high-priority enemy targets like aircraft carriers, troop transport ships, and guided-missile cruisers. Officials of the U.S. Air Force Life Cycle Management Center at Eglin Air Force Base, Fla., have announced a $172.1 million contract to the Lockheed Martin Corp. Missiles and Fire Control segment in Orlando, Fla., to build 50 LRASMs as part of Lot 2 production. This contract is the second order for LRASM production. Lockheed Martin won an $86.5 million contract in July 2017 to manufacture the first 23 LRASM munitions in Lot 1 production. That contract marked the first production award for the air-launched variant of the anti-ship missile for the U.S. Navy and Air Force. LRASM is a joint project of the U.S. Defense Advanced Projects Agency (DARPA) in Arlington, Va., the Navy, and the Air Force to design an advanced anti-ship missile that can launch from the Navy F/A-18E/F Super Hornet jet fighter bomber, as well as from the Air Force B-1B Lancer long-range strategic bomber. The missile travels at high subsonic speeds, and likely will give way in the future to expected new generations of hypersonic missiles. Submarine-launched versions are under consideration.

Add-on kits create high-altitude flying torpedoes for P-8A Poseidon

Airborne weapons experts at the Boeing Co. are building add-on kits to create flying torpedoes that can attack submerged enemy submarines from long ranges and from high altitudes. The Naval Sea Systems Command in Washington announced a $9.3 million that may include broadband low frequency sonars for MCM and ASW; environmental data sensors such as water depth, speed of sound in water along vehicle path, water temperature, and water current); and payloads for acoustic modem research (ACOMMS).

It can carry several sensors and payloads at once in swappable payload sections and battery modules for in-field mission reconfiguration. The UUV is a deep-rated ocean drone that can be launched and recovered from a simple A-frame or docking head.

The Bluefin 21 design is 16.2 feet long, 21 inches in diameter, and weighs 1,650 pounds. It can dive to nearly 15,000 feet, can operate for 25 hours on one battery charge, and moves at speeds to 4.5 knots while using a total of 13.5 kilowatts of electricity.

The UUV is a popular vehicle for deep-dive research and counter-mine operations. The UUV is the basis for the Navy General Dynamics Knifefish surface-mine countermeasure unmanned underwater vehicle (UUV).

Companies interested in the Black Pearl UUV upgrade project were asked to email responses to The Navy's Ryan Wheelock by 31 Jan. 2019 at ryan.wheelock@nrlssc.navy.mil. ←

More information is online at https://www.fbo.gov/spg/DON/ONR/Code3235/N00173-19-RFI-WR02/listing.html.

Air Force orders four MQ-9 Block 5 unmanned attack drones and mobile control stations

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio —Unmanned aerial vehicle (UAV) designers at General Atomics in Poway, Calif., will provide the U.S. Air Force with four new MQ-9 Block 5 Reaper attack drones and four mobile ground-control stations under terms of a $123.3 million contract.

Officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio, are asking the General Atomics Aeronautical Systems

General Atomics will build four MQ-9 Block 5 unmanned combat aircraft, and four ground-control stations, shown above.

segment to provide these four armed Reaper UAVs and their ground-control stations, which are variations of the General Atomics MQ-1 Predator UAV.

The latest version of the Reaper — the MQ-9 Block 5 — is designed for surveillance and attack missions using a suite of airborne sensors and the AGM-114 Hellfire air-to-ground missile. Ground crew monitor and control the UAV from its ground-control station, including firing weapons.

General Atomics refers to the Reaper Block 5 as the Predator B, which has been in production since 2013. Users are the U.S. Air Force and the British Royal Air Force. Other MQ-9 Reaper users are France, Italy, The Netherlands, and Spain.

Compared to the MQ-9 Reaper Block 1 models, the Reaper Block 5 unmanned aircraft has increased electrical power, secure communications, auto land, increased gross takeoff weight, weapons growth, and streamlined payload integration capabilities. Pilots traveling with the Reaper use the mobile ground control station to launch and land the aircraft, while U.S.-based pilots handle most of the flying and weapons delivery.

The Reaper has a high-capacity starter generator and upgraded electrical system with a backup generator that can support all flight-critical functions. The drone has three independent power sources to accommodate new communications such as dual ARC-210 VHF/UHF radios with wingtip antennas for simultaneous communications among multiple air-to-air and air-to-ground parties; secure data links; and an increased data transmission capacity. The Reaper Block 5 can carry heavier payloads or additional fuel.

The turboprop-powered, multi-mission Reaper armed drone can fly for more than 27 hours between refueling at speeds to 240 knots at altitudes to 50,000 feet. The medium-endurance UAV can carry payloads as heavy as 3,850 pounds, including 3,000 pounds of external stores like Hellfire missiles.

The Reaper can carry as many as four Hellfire missiles, two GBU-12 Paveway II laser-guided bombs, or two 500-pound GBU-38 Joint Direct Attack Munitions (JDAMs). Twice as fast as Predator, the Reaper carries 500 percent more payload and has nine times the horsepower, General Atomics officials say.

The Reaper has a fault-tolerant flight control system, triple-redundant avionics system, and is powered by the Honeywell TPE331-10 turboprop engine, integrated with digital electronic engine control (DEEC) to improve engine performance and fuel efficiency at low altitudes.

The Reaper cab carry electro-optical and infrared (EO/IR) sensors, Lynx multi-mode radar, multi-mode maritime surveillance radar, electronic support measures (ESM), laser designators, and a variety of weapons.

The sophisticated drone has redundant flight-control surfaces; can fly remotely piloted or autonomously; has a MIL-STD-1760 stores management system; seven external payload stations; C-band line-of-sight data link control; Ku-band beyond line-of-sight and satellite communications data link control; more than 90 percent system operational availability; and can self-deploy or fly aboard C-130 utility aircraft.

On this contract General Atomics will do the work in Poway, Calif., and should be finished by December 2020. ←

For more information contact ***General Atomics Aeronautical Systems*** *online at* www.ga-asi.com, *or the* ***Air Force Life Cycle Management Center*** *at* www.wpafb.af.mil/aflcmc.

order to the Boeing Co. Defense, Space & Security segment in St. Louis to design and build the High Altitude Anti-Submarine Warfare Weapon Capability (HAAWC) Air Launch Accessory (ALA). The HAAWC ALA enables the Raytheon MK 54 lightweight torpedo carried aboard the Navy Boeing P-8A Poseidon long-range maritime patrol jet to glide through the air from altitudes as high as 30,000 feet, essentially transforming the torpedo into a glide weapon that the P-8A aircraft can release from high altitudes. As the flying torpedo nears the water, it jettisons its wings and tail and takes on its original role as a smart torpedo that can detect, track, and attack enemy submarines autonomously. After shedding its control surfaces, the HAAWC ALA activates a parachute that lowers the torpedo into the water to begin its run toward the target. When launched from 30,000 feet the HAAWC-equipped MK 54 torpedo will glide for seven to 10 minutes before entering the water.

Northrop Grumman joins Raytheon BBN in tapping sea life for next-generation ASW

Marine scientists at Northrop Grumman Corp. are joining Raytheon BBN Technologies Corp. to investigate new ways of using sea life to detect and track potentially hostile manned submarines and unmanned underwater vehicles (UUVs) over vast areas of the world's oceans. Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., announced a potential $5.1 million contract to the Northrop Grumman Mission Systems segment in Linthicum Heights, Md., for the Persistent Aquatic Living Sensors (PALS) program. Northrop Grumman joins Raytheon BBN Technologies in Cambridge, Mass., which won a potential $6.4 million contract for the PALS project last month. The DARPA PALS contract to Northrop Grumman is for $3.2 million, and has options to increase that to $5.1 million. ←

Navy to install laser weapons in 2021 to defend destroyer from boats and UAVs

In the next two years, the Navy wants to deploy laser weapons aboard a guided-missile destroyer as the service learns to integrate directed energy weapon systems on warships, says the Navy's director of surface warfare "We are going to burn the boats if you will and move forward with this technology," Rear Adm. Ron Boxall said during the Booz, Allen, Hamilton and CSBA Directed Energy Summit 2019. The service is targeting 2021 to install a High Energy Laser and Integrated Optical-dazzler with Surveillance weapon system aboard a West Coast Arleigh Burke-class Flight IIA destroyer, Boxall said. The 60-kilowatt HELIOS, much more powerful than the 20-kilowatt laser weapon system the Navy tested aboard afloat forward staging base USS Ponce five years ago, is designed to counter small attack boats small unmanned aerial vehicles.

Laser weapons could defeat threats like drone swarms, rockets and artillery

Why use laser weapons instead of bullets, shells, or missiles? To begin with, lasers are accurate and quick acting, since they are fast as light and mostly unaffected by gravity? This could make weapons ideal for swatting down small, speedy targets, such as incoming rockets and artillery shells. Laser precision also could be handy for disabling ground or sea vehicles without killing their occupants. Of course, a soundless, invisible and recoilless weapon is also pretty stealthy — if you can get close enough to use it. Most importantly, lasers could be very cheap. Contemporary missile-defense systems, such as Israel's Iron Dome or the U.S. GMD antiballistic missile system, are much more expensive than the missiles they are designed to shoot down,

Boeing, Lockheed Martin to build stealthy IRST avionics for F-15C jet fighter

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — U.S. Air Force air combat experts are asking electro-optics engineers at the Boeing Co. and Lockheed Martin Corp. to design and build six additional infrared search and track (IRST) sensors for the F-15C Eagle jet fighter to enable the aircraft to detect, track, and attack enemy aircraft in a stealthy way without making its presence known.

Officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio, have announced a potential $40 million order to the Boeing Co. Defense, Space & Security segment in St. Louis to integrate six IRST Block II systems for the single-seat F-15C jet fighter.

The F-15C's IRST is a long-wave infrared detection system that targets aircraft in a radar-denied environment. The system, which Boeing is buying from the Lockheed Martin Missiles and Fire Control segment in Orlando, Fla., uses infrared search and track technology to detect and provide weapon-quality track solutions on potentially hostile aircraft.

For the F-15C, Lockheed Martin is providing the company's Legion Pod sensor system, which consists of a passive longwave infrared receiver, a processor, inertial measurement unit, and environmental control unit. The infrared receiver, processor, and inertial measurement unit fit inside the sensor pod, which attaches to a weapons station underneath the aircraft.

The Boeing F-15C jet fighter is a twin-engine all-weather tactical aircraft designed for air supremacy. The

Electro-optical designers from Boeing and Lockheed Martin are building stealthy infrared search-and-track (IRST) systems for an F-15C jet fighter upgrade to enhance the plane's stealth characteristics

large jet fighter, designed in the 1970s, augments later-model Air Force F-22 jet fighters in the air interdiction and air superiority roles.

The F-15C's IRST Block II is based on the F-15K/SG aircraft's infrared receiver, which was inspired by the IRST design of the now-retired Navy F-14 Tomcat jet fighter. IRST Block II will include improvements to the infrared receiver and updated processors.

Even amid electronic attack or heavy RF and infrared countermeasures, IRST provides autonomous, tracking data that increases pilot reaction time, and enhances survivability by enabling first-look, first-shoot capability, Lockheed Martin officials say.

Infrared sensors like the IRST detect the heat from an aircraft's engine exhaust or even the heat generated by the friction of an aircraft as it passes through the atmosphere. Unlike radar, infrared sensors do not emit electronic signals, and do not give away their presence to adversaries.

This ability can enable F-15C pilots to make positive identification of enemy

aircraft at long ranges, and enable them to fire their air-to-air missiles at their maximum ranges.

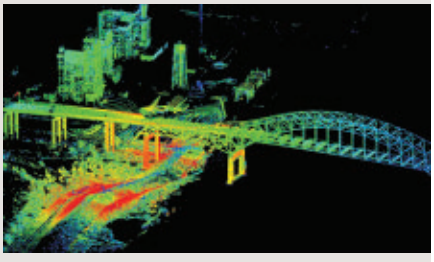
Data from the IRST system can stand alone or fuse with other on-board sensor data situational awareness. Lockheed Martin also is building IRST systems for the Air Force F-16 jet fighter and for the Navy F/A-18E/F Super Hornet jet fighter-bomber.

On this contract Boeing and Lockheed Martin will do the work in Orlando, Fla., and in St. Louis, and should be finished by October 2022. ←

For more information contact Boeing Defense, Space & Security online at www.boeing.com/company/about-bds, www.lockheedmartin.com, or Naval Air Systems Command at www.navair.navy.mil.

JASR Systems eyes chip-scale lidar for 3-D mapping, navigation, and communications

WRIGHT-PATTERSON AFB, Ohio — Researchers at JASR Systems in Solana Beach, Calif., are developing chip-scale, lightweight, and affordable light detection and ranging (lidar) sensors for military 3-D mapping, foliage-penetrating electro-optical sensors, navigation, and long-range communications.



The U.S. Air Force is working with JASR Systems to develop chip-scale, lightweight, and affordable light detection and ranging (lidar) sensors for military 3-D mapping, foliage-penetrating electro-optical sensors, navigation, and long-range communications.

Officials of the U.S. Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, have announced an $8.2 million contract to JASR to develop chip-scale optical phased arrays and lidar systems that use technology from the Modular Optical Aperture Building Blocks (MOABB) project of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va.

The DARPA MOABB project, begun in late 2015, developed enabling technologies for affordable chip-scale lidar sensors using free-space optical technology with ultra-low size, weight, and cost with much faster beam scanning speeds than are typically available today.

The MOABB project aimed at developing and demonstrating enabling technologies for an integrated photonic device able to generate, amplify, transmit, and receive free-space optical radiation over a wide angle.

Companies involved in the DARPA MOABB sensors project are Lockheed Martin Coherent Technologies in Louisville, Colo.; TREX Enterprises Corp. in San Diego; Analog Photonics LLC in Hingham, Mass.; and Teledyne Scientific & Imaging LLC in Thousand Oaks, Calif.

With MOABB, DARPA researchers aimed at building planar, millimeter-scale transmit/receive units with

making them untenable were they to face mass attacks. The same problem exists at the tactical level when considering how to counter the future threat of weaponized drone swarms: basically large flocks of small, expendable drones designed to overwhelm enemy defenses. For systems hooked up to a power generator, the ammunition supply could be virtually unlimited.

Infrared search and track (IRST) gives jet fighter aircraft stealthy vision

Look on the nose of many modern jet fighter aircraft such as the Eurofighter Typhoon and you'll spot a large bulbous protrusion coming from just near the cockpit. While it has a rather unassuming appearance, this aperture forms an important role in the fighter's detection and fire control functionality, acting like a powerful thermal camera to spot distant enemy targets and using that data to neutralize the threat. The beauty of infrared search and track technology (IRST) technology is it is completely passive and does not highlight the location of the aircraft, unlike when a pilot decides to use the on-board radar, which can give away its position as radio frequency energy bursts out. IRST can also work in all weather conditions as it uses the infrared rather than the visible part of the electromagnetic spectrum. So important is this stealthy capability, particularly as China and Russia develop their own stealth aircraft with advanced detection capabilities, that the US is retrofitting many of its advanced fighter aircraft – including the navy's F/A-18E/F Super Hornet and the air force's F-15 Eagle – with an IRST capability. It is hoped that with these new "eyes" Western fighter jets will be able to sense adversary aircraft first and kill them before being seen themselves. ←

a high fill factor aperture, non-mechanical beam steering, and integrated amplification.

Among the project's goals was to fabricate a coherent 10-centimeter transmit/receive array with distributed gain built with wafer-scale processing, and demonstrate the coherent array in a packaged lidar system capable of 3-D imaging from as far away as 100 meters.

Free-space optical systems have tremendous potential for sensing, illumination, and communications, DARPA scientists say. The micron-scale wavelength allows for 0.001-degree angular resolution and antenna gain of more than 100 decibels from a modest 10-centimeter aperture.

The frequency in the hundreds of terahertz range and wide operating bandwidths enable high-speed data transmission and 3-D imaging with sub-millimeter range resolution.

Applications for these features span the space from 3-D mapping, foliage penetrating lidar, navigation, and long-range communications.

While free-space optical systems offer compelling capabilities, they are too big, heavy, and expensive for many applications. Above a 10-centimeter aperture, their size and weight are dominated by the bulky lenses, mirrors, stabilized mechanical components, and large volume of empty space of the telescope or imaging system.

On the other hand, aperture smaller than 10 centimeters still require bulky mechanical gimbals to steer the telescope and the back-end optics like lasers and detectors.

Instead, the MOABB project sought to capitalize on developments in integrated photonics that offer the potential for high-speed, non-mechanical beam-steering. Researchers believe that efficient sources, detectors, amplifiers, and low-loss waveguides can be fabricated on one planar platform for high-power, large scale apertures.

On this contract JASR will do the work in Solana Beach, Calif., and should be finished by November 2020. ←

*For more information contact **JASR Systems** online at www.jasr.systems, or the Air Force Research Laboratory at www.wpafb.af.mil/afrl.*

Navy orders infrared-guided RAM missile systems to protect surface ships

WASHINGTON — Shipboard missile-defense experts at the Raytheon Co. will provide the U.S. Navy and U.S. allies with the Rolling Airframe Missile (RAM) Block 2 to protect ships from aircraft, missiles, and small surface vessels under terms of a $91.1 million order.

RAM is a ship self-defense weapon designed to protect ships of all sizes, ranging from 500-ton fast attack craft to 95,000-ton aircraft carriers.

The Rolling Airframe Missile (RAM) Block 2, shown above, homes-in on its targets with infrared sensors.

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 guidance for engaging several threats simultaneously.

RAM Block 2 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, 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. ←

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

PRODUCT applications

MILITARY AVIONICS

Harris tapped to build AN/ALQ-214 EW avionics for Navy F/A-18 jet fighter bombers

Electronic warfare (EW) experts at Harris Corp. will provide the U.S. Navy with 78 sophisticated EW systems designed to protect Navy combat aircraft from incoming radar-guided missiles.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced a $168.8 million order to the Harris Electronic Systems segment in Clifton, N.J., for 78 lot 16 AN/ALQ-214 A(V)4/5 EW jammers for Navy F/A-18C/D and F/A-18E/F Hornet and Super Hornet carrier-based fighter-bombers.

The AN/ALQ-214(V)4/5 is an electronic jammer component of the integrated defensive electronic counter measures system (IDECM) avionics, which comes to the Navy from a joint venture of Harris and BAE Systems. It protects Navy fighter-bombers from radar-guided surface-to-air and air-to-air missiles by jamming the enemy missile guidance systems.

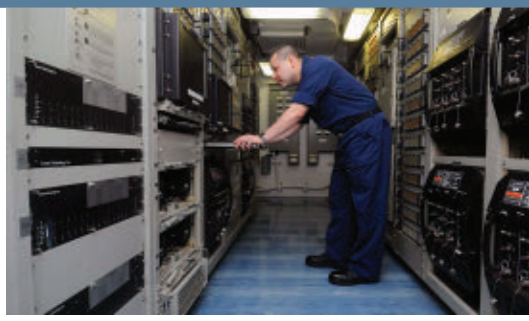
The ALQ-214 component of the IDECM EW system has been delivered to the Navy as well as to the Royal Australian Air Force for contemporary versions of the Boeing F/A-18 fighter-bomber. The system blends sensitive receivers and active countermeasures to form an electronic shield around the aircraft, Harris officials say.

The RF countermeasure system aboard the Navy's F/A-18 jet fighter-bombers engages incoming missiles autonomously with a series of measures designed to protect the aircraft from detection.

The AN/ALQ-214(V)4 a smaller and lighter version of its predecessors, and has an open-architecture design that is ready for integration on several different kinds of aircraft.

The system is designed to counter radar-guided anti-aircraft missiles with electronic countermeasures (ECM) techniques that deny, disrupt, delay, and degrade the enemy missile launch and engagement sequence. The system identifies, ranks, and counters incoming missiles, and displays engagements to the flight crew for situational awareness.

On this contract Harris will do the work in Clifton, N.J.; as well as in San Jose, San Diego, Rancho Cordova, and Mountain View, Calif., and should be finished by May 2022. For more information contact Harris **Electronic Systems** online at *www.harris.com/es,* or **Naval Air Systems Command** at *www.navair.navy.mil.*



RF AND MICROWAVE

Navy asks Thales to provide power amplifiers for AN/USC-61(C) ship communications

RF and microwave experts at the Thales Group will continue supplying power amplifier components for HF radio communications aboard U.S. Navy surface warships and submarines under terms of $30.9 million contract.

Officials of the Space and Naval Warfare Systems Command (SPAWAR) in San Diego are asking Thales Defense and Security Inc. in Clarksburg, Md., to continue building and delivering High Frequency Distribution Amplifier Group (HF-DAG) system components and engineering services.

The HF-DAG replacement program is designed as a substantial technology upgrade to the existing HF communications systems deployed on U.S. Navy ships. The HF-DAG contract calls for Thales to provide 1000-Watt power amplifiers and flexible power management units (FPMUs).

The HF-DAG supports automated communications in a wide band of frequency spectra that supports transmit and receive communications modes like duplex/simplex voice, continuous-wave (CW), teletype, digital exchange, amplitude modulation (AM) and Link 11 HF networking.

The HF-DAG communications group supports the Navy's AN/USC-61(C) Digital Modular Radio (DMR) communications suite from the General Dynamics Corp. Mission Systems segment in Scottsdale, Ariz. The Electromet Corp. in Hagerstown, Md., provides electronic enclosures for the Navy's shipboard DMR communications suites.

The Navy awarded this contract to Thales sole-source because the company's broadband

HF components are the only ones that interface with the AN/USC-61(C) DMR shipboard communications system, Navy officials say.

SPAWAR is awarding this contract on behalf of the Navy Program Executive Officer for Command, Control, Communications, Computers, and Intelligence (PEO C4I), Communication Program Office (PMW/A 170) in San Diego.

The HF-DAG supports AN/USC-61(C) maritime radios to enable Navy surface warships and submarines to communicate over high frequency (HF), ultra-high frequency (UHF) line of sight, UHF satellite communications (SATCOM), and very high frequency (VHF) radio bands.

The AN/USC-61(C) DMR is a shipboard software-defined radio (SDR) that has become standard for the U.S. military. The compact, multi-channel DMR provides several different waveforms and multi-level information security for voice and data communications.

The radio includes Embedded type 1 encryption; embedded red/black baseband switching and routing; co-site performance; reduced manpower requirements; single point of control for HF/VHF/UHF/SATCOM radio communications; and built-in test (BIT).

Software-defined radio waveforms are computer programs that enable SDR-enable radios to operate on different frequency bands with different encryption and cyber security functions. The AN/USC-61(C) operates on Navy surface ships, submarines, and other military platforms using frequencies from 2 MHz to 2 GHz.

General Dynamics has certified the DMR to pass secure voice and data at multiple independent levels of security (MILS) over HF, VHF, UHF, and SATCOM channels, and to withstand the effects of electromagnetic interference and other harsh operating conditions.

The DMR also is certified by the Joint Interoperability Test Command (JITC) to be compliant with the U.S. government's MIL-STD-188-181B/182A/183A requirements for UHF SATCOM. General Dynamics builds the AN/USC-61(C) using open-architecture standards.

On this five-year HF-DAG contract, Thales will do the work in Clarksburg, Md.; and West Sussex, England, and should be finished by January 2024, For more information contact **Thales Defense and Security** online at *www.thalesdsi.com*, or **SPAWAR** at *www.public.navy.mil*.

RUGGED COMPUTERS

Rugged computer servers from Systel chosen for shipboard networking

Naval shipboard electronics enclosures specialist Falstrom Company in Passaic, N.J., needed rugged high-density computer servers for the U.S. Navy's Network Tactical Common Data Link (NTCDL). They found their solution from Systel Inc. in Sugar Land, Texas.

Systel will support NTCDL in partnership with Falstrom, which will design, build, qualify, and deliver below deck electronic rack assemblies to the BAE Systems Electronic Systems segment in Nashua, N.H., the program's prime contractor.

Falstrom specializes in custom rugged enclosures and electronic assemblies for naval shipboard radar, conventional and nuclear power panels, avionics test equipment, and computer enclosures.

Systel is supporting NTCDL with high-density 1U and 3U embedded computing servers for high-speed communications and position, navigation, and timing (PNT) services.

Systel's rugged servers feature several central processing units and graphics processing units for high-performance parallel processing, high-density secure data storage, and high-speed optical fiber data networking.

Two years ago BAE Systems won an $87.7 million Navy contract to develop NTCDL technology that enables Navy surface warships to transmit and receive real-time intelligence, surveillance, and reconnaissance (ISR) data from several sources simultaneously.

The system also enables the Navy to exchange command and control information across disparate networks. The NTCDL helps the Navy share large quantities of critical ISR data across shipboard electronics and networks.

NTCDL provides a real-time exchange of voice, data, imagery, and full-motion video from aircraft, surface warships, submarines, and warfighters on land. It helps the Navy network operations using currently fielded common data link (CDL) equipment, as well as next-generation manned and unmanned systems.

Initial NTCDL systems will go aboard Navy aircraft carriers and large-deck amphibious assault ships. NTCDL is a modular, scalable system designed to increase link capacity and embrace waveform evolution.

The technology uses an open-systems architecture with non-proprietary interfaces, and is reprogrammable to adapt to new and evolving mission needs. BAE Systems is building NTCDL technology at its facilities in Wayne, N.J., and Greenlawn, N.Y.

BAE Systems is working with partner Ball Aerospace to advance the two companies' joint Multi Link CDL Systems development. Ball is building the Ku-band phased array antenna suite for BAE Systems on the NTCDL project.

These multi-beam planar phased array antennas from Ball Aerospace are based on silicon germanium (SiGe) technologies on one circuit board, which results in a low-profile antenna.

The antennas initially will be installed on naval aircraft carriers to enable the ships to communicate with a range of intelligence, surveillance, and reconnaissance (ISR) platforms. Ball will do the NTCDL work in Westminster, Colo.

For more information contact **Systel** online at *www.systelusa.com*, BAE Systems Electronic Systems at *www.baesystems.com*, or Ball Aerospace at *www.ball.com/aerospace.*

SENSORS

Northrop Grumman to install EW and electro-optical missile-defense on P-8A jets

Military avionics experts at Northrop Grumman Corp. will provide electronic warfare (EW) and missile-defense subsystems for the U.S. Navy P-8A Poseidon maritime patrol jet under terms of a $27.3 million contract.

Officials of the Naval Air Warfare Center Aircraft Division in Lakehurst, N.J., are asking the Northrop Grumman Mission Systems segment in Rolling Meadows, Ill., to integrate the AN/AAQ-24 large aircraft infrared countermeasures system (LAIRCM) and the ALQ-213 electronic warfare management system on P-8A production aircraft lots 9 and 10.

These aircraft will be for the Navy, as well as for the governments of Australia and the United Kingdom.

The ALQ-213, built by Terma North America Inc. in Arlington, Va., is a low-power electronic warfare (EW) management unit that uses no forced air cooling, has a dual-core PowerPC microprocessor and a large field programmable gate array (FPGA). The unit also has a Wind River VxWorks operating system. It offers a non-ITAR controller for a military aircraft survivability equipment (ASE) suite, which provides automatic threat reaction and decision support algorithms and on-board training for P-8A aircraft crews.

The Terma ALQ-213(V) has an expansion slot for drop-in of one special purpose circuit cards. The expansion slot provides a fast PCI express interface to the dual-core CPU and can be supported by a dedicated external connector, with minimal impact to the unit design.

The electronic warfare management unit typically integrates several aircraft survivability equipment sensors and effectors via one or more MIL-STD-1553B data buses and discrete and serial interfaces. The electronic warfare management unit can integrate cockpit multi-function display and control units or provide graphical human interaction via Terma's advanced threat display.

The Northrop Grumman AN/AAQ-24(V) LAIRCM electro-optical missile warning sensor is designed to provide missile-warning capability to protect large military aircraft from infrared-guided, heat-seeking missiles — particularly those from shoulder-fired launchers like the U.S.-made Stinger Block 2 and Russian-made SA-14 missiles.

The LAIRCM is a derivative of the AN/AAQ-24 Nemesis Directional IR Countermeasure (DIRCM) system. It jams the incoming missile's seeker with a IR laser energy beam, and operates autonomously without intervention from the aircraft crew.

On this contract Northrop Grumman will do the work in Rolling Meadows, Ill., and should be finished by February 2021. For more information contact **Northrop Grumman Mission Systems** online at *www.northropgrumman.com*, or the **Naval Air Warfare Center Aircraft Division-Lakehurst** at *www.navair.navy.mil/lakehurst*.

CATEGORY PLEASE

Navy chooses sensors from Safran Optics 1 for perimeter security

U.S. Navy surveillance researchers needed an electro-optical and infrared sensor for U.S. Marine corps perimeter security. They found their solution from Safran Optics 1 Inc. in Bedford, N.H.

Officials of the Naval Surface Warfare Center Crane Division in Crane, Ind., announced a potential $12 million five-year contract to Optics 1 in March to build, repair, and support Ground-Based Operational Surveillance System (G-BOSS) Light Optical Camera (GBLOC).

Optics 1 engineers will build a tripod mounted electro-optical and infrared sensor that provides daylight and night-vision imagery for detecting, classifying, and identifying targets as part of the Marine Corps G-BOSS sensor suite.

G-BOSS is a self-erecting, trailer-mounted tower that provides a stable, elevated platform for sensors and communications to provide beyond-the-fence surveillance for Marine Corps installations. The system typically is deployed in the Middle East and other locations for perimeter security.

Each G-BOSS tower can operate independently and has a 107-foot or 80-foot tower; a multi-spectral electro-optic/infrared sensor suite composed of a FLIR Systems Star SAFIRE IIIFP camera with a laser pointer and range finder; a ThermoVision 3000 camera with a global Positioning System (GPS); a man-portable surveillance and target acquisition radar (MSTAR); and a Ground Control Station (GCS) with optional Remote Ground Station (RGS).

G-BOSS can integrate signals from unmanned aerial vehicles (UAVs) using the VideoScout video management system and from the tactical remote sensor suite unattended ground sensors. G-BOSS typically is deployed at Marine Corps forward operating bases, command outposts, battle positions, and entry control points.

Safran Optics 1 specializes in laser rangefinders, markers, visual augmentation systems, precision north finding and inertial navigation systems, targeting solutions, and custom systems.

Optics 1 produces the PASEO advanced panoramic sight for armored personnel carriers and main battle tanks. It is for fire-on-the-move capabilities for vehicle gunner and commander stations, and can perform forward artillery observation.

The company also produces the Airborne Reconnaissance Targeting Integrated System (ARTIS) 410 multispectral ultra-long-range observation and precision-targeting system with high-definition sensors and advanced embedded computing. It works at standoff distances during the day and night, and is designed to identify targets quickly in four spectral wavebands: color CMOS, near-infrared (NIR), short-wave infrared (SWIR), and mid-wave infrared (MWIR).

On this indefinite-delivery/indefinite-quantity contract, Optics 1 will do the work in Bedford, N.H., and should be finished by March 2024.

For more information contact Safran Optics 1 online at www.optics1.com, or the Naval Surface Warfare Center-Crane at www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane. ←

To submit new products for consideration, contact John Keller at jkeller@pennwell.com.

INTERCONNECT PRODUCTS

Coaxial cables for distributed indoor antenna systems introduced by Pasternack

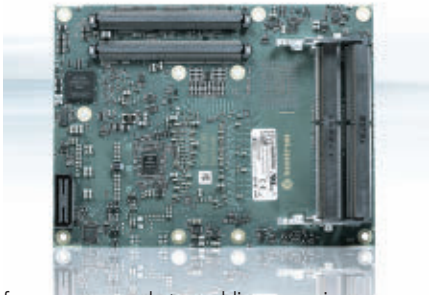
Pasternack Enterprises Inc. in Irvine, Calif., is introducing a line of low-PIM coaxial cables for distributed antenna systems in indoor wireless applications, wireless infrastructure, multi-carrier communication systems, WISP networks, small

cell installations, and PIM testing. Pasternack's new series of low-PIM coaxial cable assemblies consists of 18 standard configurations with PIM levels of less than -160 dBc. This product line is made with lightweight, flexible UL910 plenum-rated SPP-250-LLPL RF coaxial cable which can operate in temperatures from -55 to 125 degrees Celsius. They come with 4.3-10, 7/16 DIN, 4.1/9.5 mini-DIN, and Type-N connectors, which also include right-angle connector options for distributed antenna systems applications. These high-quality cables deliver low insertion loss and voltage standing wave ratio (VSWR), are 100 percent RF and PIM tested, and come with the PIM test results marked on the cables. Pasternack's new low-PIM coaxial cable assemblies are in stock and ready for immediate shipment with no minimum order quantity. More information is online at *www.pasternack.com*.

COMPUTER BOARDS

COM Express modules for communications and surveillance introduced by Kontron

Kontron in Augsburg, Germany, is introducing the COM Express-bDV7 and COM Express-bCL6 COM Express embedded computing modules for communications, surveillance and security, industrial control, and medical imaging. The COM Express-bDV7 has as much as 128 gigabytes of non-ECC/ECC DDR4 memory and Intel Atom C3000 processors in Basic Type 7 form factor, and the COM Express-bCL6 module has the 8th generation Intel Xeon E or Intel Core processors in Basic Type 6 form factor. Both optionally can be equipped with



four memory sockets enabling a maximum memory expansion of 128 gigabytes. Kontron customers benefit immediately from the availability of the 32 gigabytes of SO-DIMMs. The COM Express-bDV7 embedded computing module is based on processors from the Intel Atom C3000 product family and offers scalable computing power and network options for energy-efficient entry-level server platforms. It offers server-level computing power with as many as 16 processor cores. The COM Express-bCL6 is based on the 8th generation Intel Core or Intel Xeon E processor family with mobile chipset (CM246/QM370 PCH), and is available in various processor versions, including six-core processor models. For more information contact **Kontron** online at *www.kontron.com*.

DIGITAL SIGNAL PROCESSING

FMC mezzanine card for EW, radar, and communications introduced by Abaco

Abaco Systems in Huntsville, Ala., is introducing the FMC172 wideband low-latency FPGA mezzanine card (FMC) for advanced embedded computing applications in electronic warfare (EW),

digital radar, wideband receivers, wireless communications, and software-defined radio (SDR). The module brings A/D converter and D/A converter functionality on one card. The FMC172 is based on a high-performance A/D converter from Texas Instruments and D/A converters from E2V. It offers LVDS interfaces, delivering as much throughput as 6.4 gigasamples per second A/D conversion on one channel, or two channels at 3.2 gigasamples per second. It also offers as much as 6 gigasamples per second D/A conversion. The FMC is suitable for advanced Digital RF Memory (DRFM) systems. When paired with Abaco's FPGA carrier cards like the VP889 or VP869, the FMC172 can help systems designers solve difficult challenges when designing modern DSP systems. The FMC172 allows flexible control of clock source, sampling frequency, and calibration through I2C communication. The A/D converter has individual calibration circuits for fine-tuning of gain, offset, and phase. For more information contact **Abaco Systems** online at *www.abaco.com*.

EMBEDDED COMPUTING

Small-form-factor embedded computing for artificial intelligence (AI) offered by Aitech

Aitech Defense Systems Inc. in Chatsworth, Calif., is working together with Concurrent Real-Time Inc. in Pompano Beach, Fla. to integrate the RedHawk Linux real-time operating system (RTOS) with two of Aitech's NVIDIA Jetson TX2-based small-form-factor embedded computing systems — the military-grade A176 Cyclone and the industrial-focused A177 Twister. Typical uses include high-data-throughput and processing like image and data manipulation, digital filters, image and frame object edge detection,

image recognition, and data analysis in military and industrial applications. Using the Jetson TX2 and the advanced development environment of RedHawk Linux, the two units enable deep learning capabilities in a growing number of artificial intelligence (AI) environments. RedHawk offers open-source Linux technology, advanced graphics user interface (GUI) debugging and analysis tools, and multi-core computing architecture support for high performance embedded computing (HPEC) systems. For more information contact **Aitech** online at *https://rugged.com/gpgpu-products*, or **Concurrent Real Time** at *www.concurrent-rt.com*.

AVIONICS

Rugged ARINC 429 avionics interface lightning protection offered by Holt

Holt Integrated Circuits in Mission Viejo, Calif., is introducing the HI-35930 ARINC 429 avionics databus interface chip, which provides a drop-in for existing HI-3593 designs that call for lightning protection. Dual line receivers meet the lightning requirements of specification RTCA/DO160G Section 22 Level 3 pin injection test waveforms without the need for any external components. Aside from the addition of lightning protection, the device is identical to HI-3593, featuring a SPI host interface, integrated line driver, and on-board DC-DC converter power supply for single-supply 3.3-volt operation. ARINC 429 avionics databus interface users may capitalize on software compatibility with the previous device in new lightning-protected designs, says Anthony Murray, director of marketing communications at Holt Integrated Circuits. Other device variants include digital-only options for use with external line receivers and line driver. These devices are for higher rated levels of lightning protection or isolation. For example, HI-35933 enables galvanic isolation utilizing external Holt line receivers (HI-8460) and lightning protection on the transmitter using an external Holt lightning-protected line driver, HI-8597. For more information contact **Holt Integrated Circuits** online at *www.holtic.com*.

BOARD PRODUCTS

6U OpenVPX blade servers for artificial intelligence (AI) introduced by Mercury

Mercury Systems Inc. in Andover, Mass., is introducing the EnsembleSeries HDS6603B blade servers in a rugged 6U OpenVPX package for rugged defense applications and upgrades that involve sensor fusion, deep learning, and artificial intelligence (AI). Powered by dual Intel Xeon E5 processors using "Broadwell" microarchitecture, the HDS6603B blade server has the cooling, packaging and interconnect technologies found in earlier generations of Mercury Xeon E5 blades. These open-systems technologies have a technology readiness level of nine (TRL-9). Intel's Broadwell architecture reduces fabrication geometry to increase clock speed and core count options, while lowering the power consumed. With as many as 28 cores from dual 2.2 GHz, QPI-enabled devices, each HDS6603B blade delivers 1.61 teraFLOPs of general-purpose processing power. Mercury's blade servers offer long life-cycles, high-performance, environmental resiliency, interoperability, and size, weight, and power (SWaP) optimization. EnsembleSeries HDS6603B blades offer optional BuiltSECURE technologies to counter nation-state reverse engineering with systems security engineering (SSE) that enables turnkey or private and personalized security solutions to be configured. For more information contact **Mercury Systems** online at *www.mrcy.com*.

RUGGED COMPUTERS

Rugged computer for high shock and vibration introduced by Crystal Group

Rugged computer specialist Crystal Group Inc. in Hiawatha, Iowa, is introducing the RE1529 rugged embedded computer for aerospace and defense applications that must operate in harsh environmental conditions. Engineered with commercial off-the-shelf (COTS) technologies, the RE1529 is designed and tested for low size, weight, and power consumption (SWaP) aircraft applications. The rugged computer includes Intel chipsets and processors, and is stabilized in a compact, rugged enclosure to provide compute power over a long operational life. The RE1529 is manufactured with lightweight composites and delivered with Xeon D multi-core processors, as much as 128 gigabytes of ECC DDR4 RAM, and has nine internal 7- and 9-millimeter SATA solid-state drive (SSD) bays. The system measures 6 by 15.4 by 9.6 inches, and weighs 7.5 pounds, and provides a server class architecture that also accommodates input/output and third-party card requirements. This product has been designed to survive extreme shock and vibration, as well as other environmental conditions to meet or exceed military requirements. It is manufactured in the U.S., and comes with a 5-year warranty. For more information contact **Crystal Group** online at *www.crystalrugged.com*.

PROCESSOR BOARDS

FPGA-based XMC data converter for RF and microwave tasks introduced by Pentek

Pentek Inc. in Upper Saddle River, N.J., is introducing the model 71810 data converter Switched Mezzanine Card (XMC) for demanding RF and microwave tasks like modulation-and-demodulation, encoding-and-decoding, encryption-and-decryption, and channelization of the signals between transmission and reception. The XMC is based on the Xilinx Kintex Ultrascale field-programmable gate array (FPGA) and has LVDS digital I/O. The model 71810 routes 38 pairs of LVDS connections from the FPGA to an 80-pin connector on the front panel. When mounted on a compatible single board computer or other XMC carrier, the model 71810 provides a customizable

I/O signal status and control interface. The model 71810 can be populated with Kintex UltraScale FPGAs, ranging from the entry-level KU035 (with 1,700 DSP slices) to the high-performance KU115 (with 5,520 DSP slices). The model 71810 optionally can be configured with a P14 PMC connector with 24 pairs of LVDS connections to the FPGA for custom I/O to the carrier board or backplane. An additional option for a P16 XMC connector with an 8X gigabit link to the FPGA supports serial protocols. For more information contact **Pentek** online at *www.pentek.com.*

EMBEDDED POWER

Vicor Power introduces VITA 62 power supplies for military VPX embedded computing

Vicor Power Systems in Andover, Mass., is introducing a line of VITA 62-compliant power supplies designed for 3U Open VPX embedded computing systems. The embedded computing power supplies achieve high-efficiency and high-power density in a rugged, conduction-cooled chassis. The initial products operate from a nominal 28- or 270-volt DC input, with predefined output voltages ranging from 3.3 to 12 volts, delivering as much as 600

PRODUCT & LITERATURE SHOWCASE

Watts of power. Customers requiring different output voltages or power levels can request a customized power supply to meet their own specifications. This family of products has been tested to meet MIL-461F and MIL-704F. In addition, the 28-volt input version also meets MIL-1275D, as well as VITA 62 VPX. For more information contact **Vicor Power** online at *www.vicorpower.com*.

EMBEDDED COMPUTING

Embedded server for harsh-environment applications introduced by VersaLogic

VersaLogic Corp. in Tualatin, Ore., is introducing the Grizzly embedded computing server for use in aerospace, defense, and other harsh-environment applications. The VersaLogic Grizzly comes in a 110 by 155 by 48-millimeter package, and features an Intel 16-core processor, high speed 10-Gigabit Ethernet channels, and operation in temperatures from -40 to 85 degrees Celsius. High-performance processing and data collection is moving out of the server rack and out to the edge, even in non-friendly environments, company officials say. Grizzly is for applications ranging from smart-grid and smart-city applications, to transportation, security, and defense. Designed

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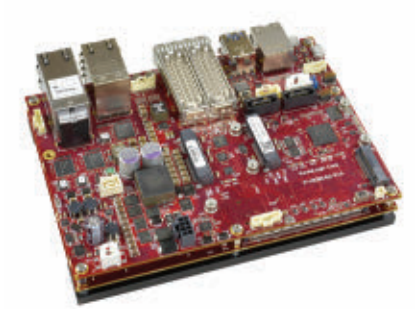


and tested to MIL-STD-202H for high impact and vibration, the Grizzly is a 16-core embedded computer with two SFP+ interface connectors to support high-speed 10 Gigabit Ethernet. They accept plug-in adaptors for copper connections, short-reach fiber, and long-reach fiber connections. The Grizzly also includes standard 1-Gigabit Ethernet ports, USB 3.0, digital I/O, and SATA 3 ports. Two mini-PCI Express sockets support plug-in on-board expansion devices, such as GPS modules. For more information contact **VersaLogic** online at *www.versalogic.com*.

CONNECTORS

2.2-5 form factor RF connector for critical signal capacities introduced by Molex

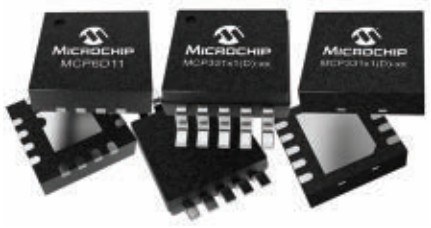
Molex Inc. in Lisle, Ill., is introducing the compact 2.2-5 RF connector system and cable assemblies for high-frequency and low passive intermodulation (PIM). Molex developed the 2.25 form factor together with the 2.2-5 consortium by adapting and miniaturizing the 4.3-10 form factor. Molex 2.2-5 RF connectors are 53 percent smaller than 4.3-10 connectors, and capable of frequencies to 6 GHz. Wireless and 5G network infrastructures require coaxial jumpers that can deliver premium electrical performance and robust environmental capabilities to withstand the elements. Molex 2.2-5 RF cable jumpers are factory fabricated and provide a IP68 NEMA rating when mated, protecting the connector system from dust and water ingress. Molex offers custom assemblies integrating 2.2-5 form factor connectors in a range of mating options for design flexibility, ease of installation, and optimal electrical performance. The IP68 2.2-5 system features an air dielectric

interface enabling superior bandwidth and low insertion loss in 5G networks and any application with critical signal capacities and space. For more information contact **Molex** online at *www.molex.com*.

HIGH-TEMPERATURE ELECTRONICS

A/D converters for high-temperature industrial applications introduced by Microchip

Microchip Technology Inc. in Chandler, Ariz., is introducing the MCP331x1(D)-xx family of 12 successive approximation register (SAR) A/D converters and a companion differential amplifier for applications that must operate in high temperatures and electromagnetic environments. These devices are designed for applications like high-precision data acquisition, electric vehicle battery management, motor control, and switch-mode power supplies that demand high-speed and high-resolution analog-to-digital conversion. The MCP331x1(D)-xx family includes a one megasample-per-second AEC-Q100-qualified 16-bit SAR for automotive and industrial applications. The MCP6D11 differential amplifier provides a low-distortion interface. The MCP331x1(D)-xx family ranges in resolution from 12-, 14-, and 16-bit, with speed options ranging from 500 kilosamples per second to 1 megasample per second. These devices have a fixed low analog supply voltage (AVDD) of 1.8 volts and 1.6 milliamps typical operation. These devices support a 1.7-to-5.5-volt digital I/O interface voltage (DVIO) range to eliminate the need for using external voltage level shifters. The MCP331x1(D)-xx high-temperature family contains single-ended and differential input voltage measurement options. For more information contact a **Microchip Technology** online at *www.microchip.com*.



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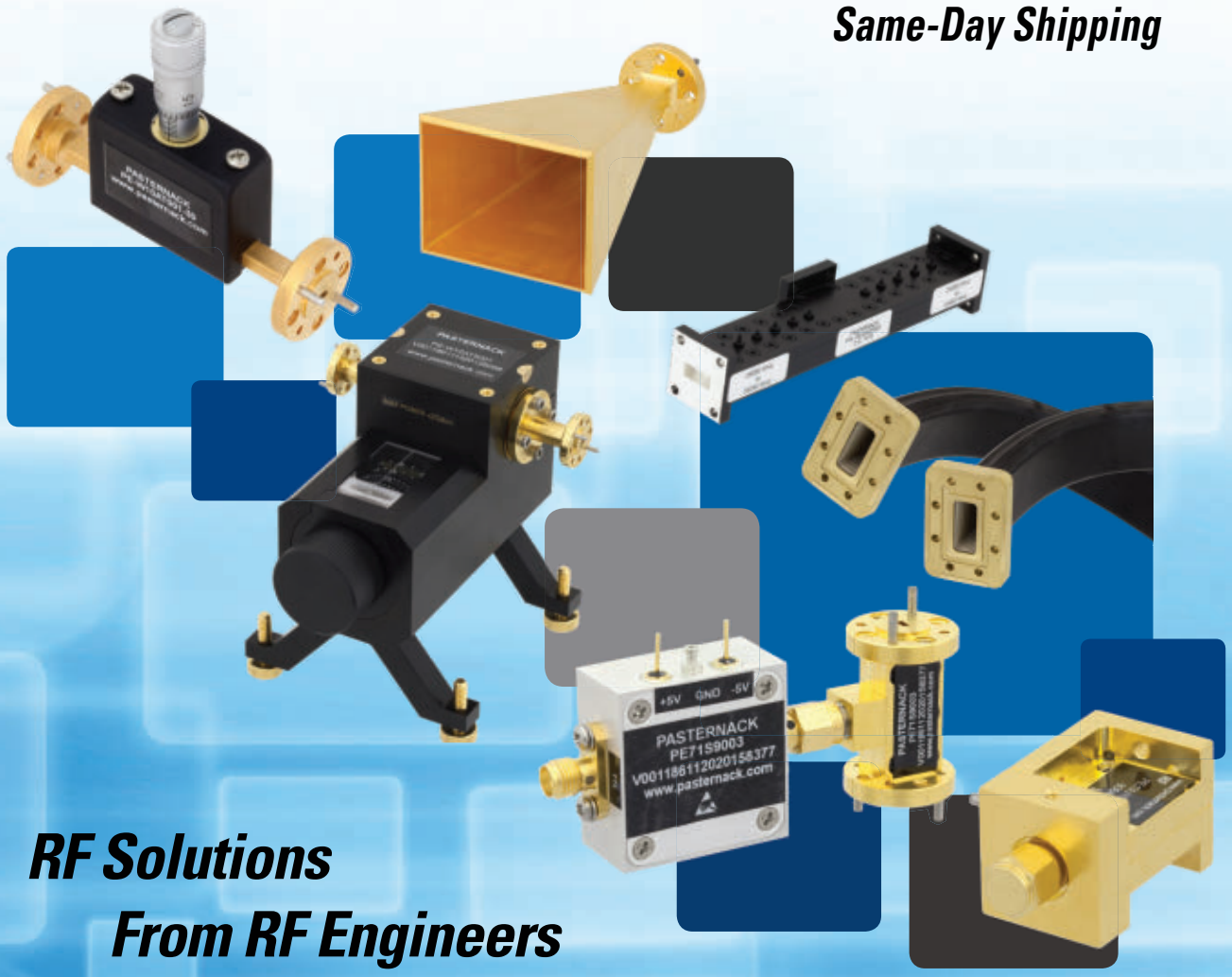

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