APRIL 2015

Military & Aerospace Electronics®

CELEBRATING 25 YEARS 1990 2015

ENABLING TECHNOLOGIES FOR NATIONAL DEFENSE

Cooling hot electronics

High-performance embedded computing industry has a range of thermal management tools available. PAGE 18

Wireless networking

Researchers eye 100-gigabit-per-second airborne wireless data links. PAGE 26

militaryaerospace.com

Persistent surveillance

Round-the-clock ISR puts new pressure on size, weight, power consumption, and cost. PAGE 8

PennWell®

Keysight N5193A UXG Agile Signal Generator

Switch frequency, amplitude and phase in just 250 ns

Generate wide chirps that are 10% to 25% of carrier frequency

Use pulse descriptor words to generate long pulse trains and individually control pulse characteristics

The UXG is a powerful threat simulator that can create realistic electronic warfare signal scenarios. By blurring the lines between analog and vector technologies, the UXG offers fast switching, phase coherency, wide chirps, and per pulse control to generate increasingly complex simulations so you can get closer to reality. Compared to a typical LO, you can test enemy threats at a higher level of realism. And compared to a large threat simulation system, you can test much earlier in the validation process.

Simulate the worst. Protect the best.

View our demo video and download an app note at:
www.keysight.com/find/UXG4EW

USA: 800 829 4444
CAN: 877 894 4414

Scan to view video demo.

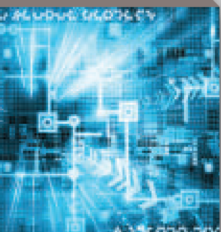
KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Agilent's Electronic Measurement Group has become **Keysight Technologies.**

APRIL 2015
VOL. 26, NO. 4

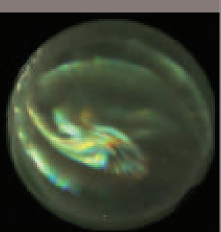
Military & Aerospace Electronics



COVER STORY

Intelligence, surveillance, and reconnaissance (ISR) is becoming a round-the-clock affair worldwide, which is placing new challenges on size, weight, power consumption, and cost for sensors and signal processing technologies.

High-performance embedded computing industry has a wide range of electronics cooling and thermal management tools available as signal processing pushes the limits of system size and power density.



MILITARY & AEROSPACE ELECTRONICS ©2015 (ISSN-1046-9079) is published monthly by PennWell Corp.,1421 S. Sheridan, Tulsa, OK 74112. Periodicals postage paid at Tulsa, OK 74101 and additional mailing offices. Editorial offices are located at 98 Spit Brook Road, Nashua, NH 03062-5737. Subscription Prices: Free to qualified subscribers in North America. Other subscribers in U.S.A: $175.00 one year; $309.00 two years; $440.00 three years. Other subscribers in Canada: $270.00 one year; $465.00 two years; $600.00 three years. All other international: $325.00 one year; $620.00 two years; $810.00 three years. Digital edition $70.00 yr. Call (847) 763-9540 for subscription information. We make portions of our subscriber list available to carefully screened companies that offer products and services that may be important for your work. If you do not want to receive those offers and/or information, please let us know by contacting us at List Services, Military & Aerospace Electronics, 98 Spit Brook Road, Nashua, NH 03062. **POSTMASTER:** Send change of address form to *MILITARY & AEROSPACE ELECTRONICS Subscription Services*, PO Box 3425, Northbrook, IL 60065. All rights reserved. No material may be reprinted without permission from the publisher. Back issues of Military & Aerospace electronics may be purchased at a cost of $16.00 each in the U.S., $22.00 Canada, and $27.00 elsewhere. **Printed in the USA / GST NO. 126813153 / Publications Mail Agreement No. 875376**

BY **JOHN KELLER**, EDITOR IN CHIEF

Early indications of a healthy DOD budget next year

We have first indications from Congress on prospects for defense spending next year. Although what we've seen up to now is a mixed bag, early indications are good.

The U.S. Department of Defense (DOD) in February submitted its largest discretionary budget request in four years, with healthy increases in procurement and research—the accounts containing the largest share of electronics, electro-optics, and cyber security spending. The Pentagon's fiscal 2016 budget proposes spending $534.3 billion in discretionary spending like procurement, research, operations, maintenance, military construction, salaries, and health care. It's the largest discretionary defense request since 2012.

The DOD fiscal 2016 discretionary budget request is up 7.7 percent over this year's enacted DOD budget of $496.1 billion. This year, fiscal 2015, was the smallest DOD budget since 2008. The budget request calls for the first topline budget increase and the first increase in procurement spending in four years, as well as the first increase in research and development spending in at least six years.

The budget request would spend nearly $115 billion on procurement of defense items like ships, submarines, aircraft, battle tanks, drones, and other military hardware. That's up nearly 12 percent from 2015's enacted procurement levels of $102.8 billion, and up even more from the 2015 procurement request of $90.6 billion.

In research, development, test, and evaluation (RDT&E), DOD proposes spending nearly $70 billion, up 9.3 percent from this year's enacted RDT&E spending level of $64 billion, and up even more from this year's requested level of $63.5 billion.

While Congress still faces spending challenges that could threaten these high spending levels, a pro-defense Republican House and Senate ultimately could mean the DOD's fiscal 2016 request could turn out to be a minimum. It's up to Congress over the next eight months to decide if even more money is headed for military accounts. Then, last month, the House Budget Committee proposed a DOD base budget of $523 billion for fiscal 2016. That plan would cut $11.3 billion from the DOD request of $534.3 billion for fiscal 2016. Despite those proposed minor cuts, however, this would represent a 5.4 percent increase over this year's congressional approved Pentagon spending levels of $496.1 billion. Federal fiscal year 2016 runs from 1 Oct. 2015 to 30 Sept. 2016.

At this very early stage in the congressional budgeting process, things seem to be proceeding as they should. In simplified terms, the normal process calls for a congressionally approved budget (so far, so good), then approval of authorization bills, and finally approval of appropriations bills, which actually clear the way for cutting checks.

Bear in mind these are VERY early indications; it's unlikely that Congress will approve any concrete DOD budget spending bills until next fall at the earliest. To be clear, I'm trying to control expectations as much as possible, because the final results six months from now could be a lot different from how they look today.

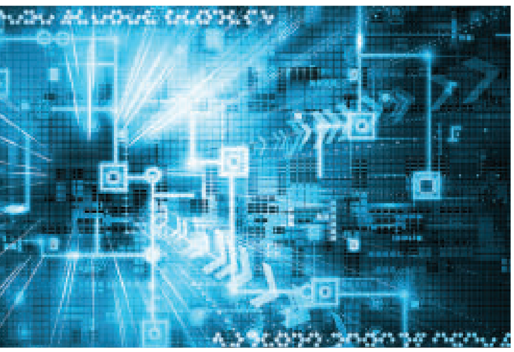
House Budget Committee proposals would represent a nice increase from the fiscal 2015 budget. Furthermore an orderly congressional budget procedure likely would clear the way for abolishing the Draconian across-the-board cuts that sequestration would mandate. Getting rid of sequestration would go a long way to alleviating the crippling uncertainty that has plagued the defense industry over the past few years. Clear indications from Congress, with spending cuts or not, will give the defense industry the information it needs to make long-term financial plans with confidence.

These simply are the first signs on a very long road. Let's be glad the first signs are good.

DARPA launches cyber program to safeguard private and proprietary data

BY JOHN KELLER

ARLINGTON, Va.—Military researchers are kicking off a cyber security program to develop ways to keep information private, as well as to understand how to build information systems that ensure private data can be used only for its intended purpose and no other. Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., issued a solicitation (DARPA-BAA-15-29) for the Brandeis program, which aims to develop ways of protecting information.



Military researchers are looking for ways to ensure private data can be used only for its intended purpose and no other.

The ability of technology to collect and share information has grown beyond all expectation. DARPA is reaching out to industry for ways to continue the benefits of information sharing, while safeguarding the information of individuals and businesses. The Brandeis program seeks to develop the technical means to protect private and proprietary information. Government experts today typically must choose between maintaining privacy and tapping into huge reservoirs of important data. The Brandeis program seeks to find a third option: finding a safe and predictable way to share data that preserves privacy. The program has four technical areas: privacy-preserving computation; human data interaction; experimental systems; and metrics and analysis.

Privacy-preserving computation seeks to establish techniques that future system designers can use as building blocks. Human data interaction involves enabling humans to control data by expressing high-level intentions with new interfaces that capture privacy intentions. Experimental systems involves new ways to build privacy-aware systems to protect data at source, and ways to test these ideas in practice. Metrics and analysis will quantify the benefits and costs, developing analysis tools to assess privacy technologies as they are used.

DARPA could award several contracts in each of the four technical areas, worth a cumulative total of as much as $60 million. The program will last for 4.5 years and will have three 18-month phases. Companies interested should upload proposals no later than 29 April 2015 to DARPA at https://baa.darpa.mil. ←

MORE INFORMATION IS online at *https://www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-BAA-15-29/listing.html.*

IN BRIEF

IBM advances chip-level electronics cooling

Microelectronics experts at IBM are taking the next step in a U.S. military research program to design convective or evaporative microfluidic cooling directly into microchip designs and packaging. The Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base, Ohio, awarded a $2.3 million contract to the IBM Thomas J Watson Research Center in Yorktown Heights, N.Y., related to the Intrachip/Interchip Enhanced Cooling (ICECool) electronics cooling program. The U.S. Defense Advanced Research Projects Agency in Arlington, Va., oversees the program.

Navy seeks 1553-to-Ethernet interface

U.S. Navy avionics experts want interface boxes for use on the Marine Corps UH-1Y utility helicopter and AH-1Z attack helicopter. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., issued a sources-sought notice to find companies able to provide off-the-shelf 1553-to-Ethernet avionics databus interface boxes. Navy experts are looking for candidate 1553-to-Ethernet boxes that monitor 1553 data from the aircraft and convert it to an Ethernet interface for use with other aircraft systems. ←

Navy picks nine software companies for important battle-management systems

BY JOHN KELLER

PATUXENT RIVER NAS, Md.—Nine U.S. defense companies will share as much as $99 million to develop and maintain military software for U.S. Navy battle-management systems. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced the contracts for the Navy Strike Planning and Execution Systems program office (PMA-281).

The nine companies will compete for individual task orders over the next five years that involve software development, test and evaluation, maintenance, integration, training, and fielding of Strike Planning and Execution Systems. The companies are: BAE Systems Information Solutions; DCS; Dynetics; Progeny Systems; Raytheon Intelligence, Information and Services; Tapestry Solutions; Northrop Grumman Information Systems; QinetiQ North America; and Lockheed Martin Information Systems and Global Solutions.

The Navy's Strike Planning and Execution Systems program office is responsible for the acquisition and life cycle management of mission planning, control system, and execution tools. Among these are the Electronic Knee Board (EKB); Joint Mission Planning System (JMPS); Joint Mission Planning System–Expeditionary (JMPS-E); Theater Mission Planning Center (TMPC); Air Wing Ship Integration (AWSI); and Unmanned System Common Control System (CCS).

The EKB provides pilots with flight information charts, instrument approach plates, tactical charts, imagery, and other digital products. The JMPS provides information, automated tools, and decision aids to plan aircraft, weapon, and sensor missions. The JMPS-E is a Web-based mission planning system. The TMPC provides precision targeting, route planning, mission distribution, and strike management of Tomahawk cruise missile missions from sites located ashore and afloat. Air Wing Ship Integration includes the Digital Camera Receiving Station, Naval Strike Warfare Planning Center, Integrated Strike Planning and Execution, and Carrier Ready Room Transformational Technologies Upgrade. The Unmanned System Common Control System will provide an open software architecture that is agile and scalable to support evolving requirements.

Nine companies will compete for software development and maintenance orders for military battle-management systems.

FOR MORE INFORMATION visit *www.navair.navy.mil.*

Keeping one step ahead with persistent surveillance

Intelligence, surveillance, and reconnaissance (ISR) is becoming a round-the-clock affair worldwide, which is placing new challenges on size, weight, power consumption, and cost for sensors and signal processing technologies.

BY **J.R. Wilson**

The Aeroscraft 40D Sky Dragon aerostat is designed for a wide range of ISR missions.

Persistent surveillance of an adversary has been a goal, requirement, and major difficulty for every military commander since prehistoric humans first engaged in combat. For most of the past several thousand years, intelligence, surveillance, and reconnaissance (ISR) was a combination of spies within the enemy's camp, stealthy soldiers getting as close to enemy positions as possible, and someone climbing to the highest point available and watching enemy activities below.

The first and third of those comprised "old school" persistent ISR. Nineteenth-century technology added surveillance from balloons and the first beyond line-of-sight, nearly instantaneous communications—the telegraph. The 20th century brought observation aircraft, wireless communications, the first non-human sensors—radar, sonar, infrared, electro-optic (EO)—unmanned aerial vehicles (UAVs), satellites, computers, and data fusion.

The rapid advance of 21st-century technology—commercial and military—is seeing evolution and revolution in the concept of persistent ISR. It also is seeing the resurrection of one of those early technologies—balloons, in the form of aerostats (tethered balloons) and blimps—as well as an expansion of maritime ISR.

Also of increasing importance are sensor fusion, especially at the source, and real-time networking of data from multiple sources, then turning that into useful information for end users, from the combatant commander to the individual warfighter. In that regard, industry and the military see benefits to integrating and networking all domains and sensors.

"Let me start with an hypothesis: It is a specter of time and distance. In space, they cover thousands of miles per hour; in the air, hundreds; at sea, maybe a few tens and on land, the same or less. So those operating in those domains have different perspectives on sensing and

The Aeroscraft 3200 mid-size aerostat and relocatable ground mooring station.

The Persistent Threat Detection System, developed by Lockheed Martin, has provided more than 1 million hours of 24/7 persistent surveillance for coalition forces in theater.

surveillance," explains Mike Worden, director for integrated intel solutions at defense contractor Lockheed Martin Corp.

"An infantryman's area of regard is the range of a mortar or indirect fire; on a ship, you'd better be able to see over the horizon; in the air, you may be dealing with an entire theater," Worden says. "So when you come to that appreciation of the customers' surveillance areas of regard to achieve their mission, it's small wonder you see the Air Force and Navy thinking more broadly about networking sensors to cover large swaths of area.

"When you come to the ground and surface/subsurface, because the range of things that can affect your mission have increased (cyber, missile range, etc.), there is a natural evolution where you don't just have a network of space or air sensors; they are connected to surface and subsurface sensors to create a 3D, all-domain network, cross-domain correlations and solutions," Worden continues. "You must make sure you have a 3D view of what's happening, because what is going on below the surface can affect the surface or even the air. That cross-domain effort is a big deal and a great technological challenge, to bring that 3D persistency, which is something we have to explore in the future."

The power of aerostats

Earle Olson, business development manager for Fast Protocol Solutions at TE Connectivity Aerospace, Defense and Marine Division in Harrisburg, Pa., says aerostats and UAVs have become increasingly valuable ISR assets.

"Their field of view [FOV] has been somewhat small, in full-motion video and IR, but that has taken a step up recently to 16 kilometers, very accurate FOV, and retaining the knowledge gained for long durations," Olson says. "To do that, to get SWaP-C [size, weight, and power-cost] in play without compromising performance, has been the challenge, trying to find solutions to meet that need and empower those technologies to deliver to the warfighter the performance they demand and need."

The U.S. Air Force has been the leader in overall ISR activities for several generations of technology—aerial and space-based—with the Army relying on Air Force data plus their own smaller, shorter range UAVs and a growing element of ground networked sensors. In addition to the P-3 Orion turboprop anti-submarine and maritime surveillance aircraft and anti-submarine sonobuoys, the Navy has invested considerable money, research, and development in recent years to expand short-term and persistent ISR sensors, signals processing, platforms, and data fusion. Those range from the new P-8 Poseidon multimission maritime aircraft (replacing the P-3) to UAVs designed to operate from carriers and smaller ships to shipboard tethered aerostats and a new generation of blimps.

"The Navy views unmanned air systems as trucks, with certain capabilities, but the key is for it to be agile enough to have an interchangeable set of sensors that will evolve independently of the platform itself, which provides SWaP that will not change as rapidly as the sensors," says Dave Weddel, defense & intelligence director for strategy planning at the Lockheed Martin Information Systems & Global Solutions segment in Denver.

"The P-8 is a tremendous increase in naval capability, allowing a significant amount of time-on-station and ability to get on station rapidly," Weddel says, citing current and developing Navy unmanned aircraft like Fire Scout; Triton, a land-based Navy derivative of Global Hawk; Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS); Scan Eagle, now in place for small ships; and the Marine Corps Small Tactical Unmanned Aerial System (STUAS).

"So you have a variety of systems that really span the capabilities of the ships, based on mission and endurance," Weddel continues. "While the Navy isn't the leading edge, they are really all in. The Navy also is doing a fair amount of underwater unmanned work, which also is progressing with prototype development to extend the search and reach of submarines.

"The Navy has for years done acoustic monitoring, with P-3s and P-8s," Weddel says. "It isn't a mesh network, but all the buoys dropped are monitored by the aircraft. That continues. There is a move in underwater and air toward a meshed network; there are some challenges regarding the scope and size of the net and related comms, but it remains a vision of the services."

The Aeroscraft Sky Cobra tactical aerostat helps fill a variety of ISR roles.

ISR on the ground

From a ground perspective, the Army and Marines have a different range of categories for persistent ISR than those of the Air Force or Navy, including mast-mounted sensors, small unattended ground sensors, and aerostats.

"We're finding more small-form-factor processing with the sensor doing some of the at-site processing," says Mike Southworth, product manager for small form factor systems at Curtiss-Wright Defense Solutions in Ashburn, Va. "There is a big push to have low SWaP, so Intel and ARM processors continue to shrink, power consumption drops, and performance increases. Each generation of processors is a direct benefit as we seek a 25 percent reduction in size. As we integrate ARM-based systems, those architectures are even smaller.

"On the networking side, there is demand for high-speed connectivity to have situational awareness on the sensors and platforms, including 10-gigabit, and are migrating to higher density 1 gigabit and 10 gigabit. We've also had demand for traditional systems to manage IP network traffic. To do that, we've taken embedded, industrial, and Cisco-based systems and ruggedized them for Army airships and ground systems."

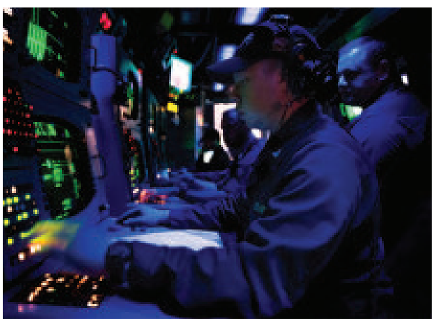
Aeroscraft Corp. in Montebello, Calif., builds lighter-than-air (LTA) products—airships and aerostats aligned to support ISR missions. John Wertz, the company's engineering program manager, and Louis Pu, electrical engineering manager, say the company has been working on tethered and free-flying platforms, typically carrying EO cameras or small radars.

Aeroscraft's 40D Sky Dragon, a conventional airship resembling the Goodyear blimp, features advanced technology, such as fly-by-wire. In January 2015, the company began production on the 40E variant, which has a higher payload. The airships are pressurized, with no internal structure, operating with standard engines and high-octane aviation gasoline.

The two aerostats are built for manned operations, although the possibility of converting the 40E to unmanned is under consideration. The minimum crew is one, although as many as seven can be taken on board—sensor operators, co-pilots, even passengers—depending on the mission. Both versions can operate from a large surface ship, with a range of about 200 miles, normal operating altitude of 2000 to 3000 feet, and a maximum attitude of 10,000 feet.

"The primary sensor on the 40D is a gimbal camera, such as the FLIR Systems Star Saphire, SDS, and Wescam. The 40E can carry a 1000-kilogram payload, plenty for signal processing, a radar, and downlinks. We've integrated select radars on some of our aerostats and could do the same on the 40E," Wertz says.

"The aerostats have a rigid structure, with altitude depending on the size of the platform. The 3200 is our largest—39 meters long, 20,300 cubic meters volume, at around 5000 feet altitude," Wertz says. "The 1170 has a ceiling of about 4,000 feet. The Sky Crow, developed for the U.S. Rapid Equipping Force, is being used in Afghanistan now. It's the second smallest, at 1000 feet altitude (above ground level). A 500-pound multi-mode electronic scanning array radar was recently integrated on the 3200 for air-to-air, ground moving target, sea surveillance, etc."



To collect and fuse intelligence, Lockheed Martin developed a software technology test bed to show how quickly a variety of intelligence, surveillance, and reconnaissance capabilities can be validated.

Economy of ISR

Worden, a retired Air Force major general and former head of the Air Combat Command, says over-the-horizon radars, space-based sensors, and aerostats, depending on the mission, can be more cost-effective than UAVs or manned aircraft for persistent ISR.

"If they are tethered or closer to the ground, they seem to be a better price point. They [airships] are not very fast, some have weather-based challenges, and they're not as responsive as fixed-wing speeds, so there is a trade-off in cost-per-hour and speed," Worden says.

"Fuel-powered, typically fixed-wing but also some rotor, UAVs are more mobile, can handle more weather. Fixed wing are getting more and more persistent, but will run into a cost barrier against aerostats/airships in some applications," Worden says, adding that a number of issues need to be resolved for those alternative methods to play a larger ISR role.

Aeroscraft officials say they also believe that airships can return to Navy service in the same role they played prior to 1961, when the Navy retired the last of what had been a major fleet of anti-submarine warfare (ASW) airships.

"I think it would be very valuable for the Navy to look at going back to a technology that was so useful and effective in the past. For any group of Navy ships, aerial surveillance is performed around them and some of that burden can be carried by aerostats flown off the decks of smaller ships at 1,000 to 2,000 feet, which gives a much better line-of-sight to the horizon to identify threats much sooner," Aeroscraft's Pu says.

"We also have seen requests from the Navy for extended early warning protection, especially against the proliferation of sea-skimming anti-ship threats," Pu continues. "And for new unmanned technology for the airships for early detection or extending communications networks for the fleet out in the open ocean—easy deployment, long endurance. For port surveillance, an aerostat or airship in the sky overhead would provide persistence with a larger range to track ships coming into port. You also can monitor port infrastructure."

Lockheed Martin's Worden agrees this wide variety of platforms offers opportunities to meet future U.S. military requirements for persistent ISR—but emphasizes the platform is only part of the solution. At least equally important is breaking the "stovepipes" that keep sensor data isolated and make turning the vastly growing volume of raw data into useful information, in real-time, much more difficult.

"If you talk about trying to achieve a coherent relationship between sensors—and it's not easy to work through traditional builds of stovepiped systems—you can choreograph their use to fulfill a particular mission," Worden says. "So this heterogenous environment requires a common language that would allow exposure to stakeholders and an ability to command and control those assets in a prioritized way to more efficiently and capably achieve the mission.

"It's easy to say everything will be networked, but there are a lot of steps and costs required to uncover the stovepipes, get everything speaking the same language—especially when there are proprietary elements that need to be addressed and, in some cases, preserved—and standardize interfaces to create a truly networked persistent environment," Worden adds.

Surveillance everywhere

Today's persistent ISR overlays all five military domains: air, land, sea, space, and cyber—not as individual activities by individual services, but as joint networked systems using real-time and archival data fusion. With ever-increasing volumes of data gathered by more and better sensors in an already bandwidth-constrained battlespace, next-generation persistent ISR will require more signal processing and data fusion be done on the sensor platform, but with a precision approaching artificial intelligence (AI).

Worden also notes how those new levels of persistent ISR will require a merging of legacy, current, and future technologies. "You have traditional assets, such as an aircraft pod used for targeting, that, when not needed for a higher priority use on that platform, could provide surveillance capability," he says. "So how do you collect value from them, non-intrusively, to build a better picture, then process that data on limited bandwidth? How close can you process certain things to the sensor itself to minimize the downlink while making sure you have a balance and sufficient coverage while collecting a mosaic of what all the sensors are reporting and create a better awareness of what's going on for the end users?

"The next generation probably won't just deal with the stovepipe and common language problems, but also how you manage bringing in multi-end capability, manage bandwidth, do sufficient processing, so what's happening in the battlespace is highlighted," Worden says. "There's little question the modularity and multi-'int' and correlations and bandwidth appreciation and cyber security and interfaces to create this network are all in need of maturation. Any new sensors or interfaces will have to adhere to certain standards so they can communicate and collaborate. That's a lot of technical work and collaboration between industry and government."

As sensors shrink in size and grow in capability, allowing more to be placed on a single platform, doing as much processing as possible before downlinking data is becoming vital. Marc Couture, product manager for digital signal processing (DSP), graphics processing units (GPUs), and VPX embedded computing at Curtiss-Wright Defense Solutions, says persistent surveillance programs historically were simpler, measured in megapixels, and had nowhere near the massive ingress of sensor data or processing found in today's battlespace, much less tomorrow's.

"Often you gathered data, transmitted some of it down a CDL [common datalink]—which typically is very limited—and had a ground operations person looking for objects of interest; so on the platform, you tried to pick out what looked like a tank or a SAM launcher," Couture explains. "In recent years, because there is so much processing horsepower and the sensors are now multi-channel and gigapixel, a lot of processing is done in real-time on the platform. Processing, Exploitation, and Dissemination [PED] has some smart algorithms that can find chip-outs and orthorectification, which is more important than ever, because you may have two or three UAVs circling over a wide area, so you compare data among them, even though they never fly over exactly the same spot."

Sensor processing

Orthorectification is the process of correcting the geometry of an image, using elevation data to correct terrain distortion in aerial or satellite imagery.

"You can have multiple 'almost-servers' in the sky, providing a distribution of data so those on the ground can request a certain area on the map while somebody else wants something else," Couture says. "There also is solid-state storage, almost like a TiVo, so if an IED goes off, you can play back some of the data to determine when it was planted and by whom. All of that requires a lot of processing, often not just one type—Intel, GPUs, FPGAs [field-programmable gate arrays], optical, and IR [infrared] arrays. It's a heterogeneous mix to get all this on board, but it is limited by space and power, which requires more fuel and reduces mission time. So you want more capability per unit for SWaP."

Storage is a big part of persistent surveillance, with a growing use of flash storage and demand for high density. One issue is the perception that single-level cell (SLC) technology for flash solid-state memory is a hard-and-fast requirement for reliability, not normally seen for commercial flash, says David Jedynak, chief technology officer for COTS Solutions at Curtiss-Wright. Multi-level cell (MLC) flash memory technology, typically seen in commercial-grade computing, is significantly less expensive than SLC.

High-density optical interfaces like these from TE Connectivity are built to survive with high-density physical contact and expanded beam interfaces to protect the fiber core.

Today's data center market is seeing advances in enterprise MLC (eMLC), which takes advantage of the lower-cost technology with some modifications making it more applicable to long-term surveillance. The result has been a higher demand for MLC and eMLC.

Cyber security issues

"Another issue is security," Jedynak says. "Surveillance itself may be fairly benign, but at some point what has been observed may turn into something that should be classified. Which raises a conundrum on what is classified and what is not and how do you separate the secure from non-secure. Without being able to triage that on the platform, you have to build more secure platforms, constructing signal paths, processing, and storage all in a secure environment. An unmanned platform may land somewhere we no longer have control of it, so the security of the data gathered, as well as its systems, are important. With system surveillance, we also have to ensure the system itself is well interconnected with the rest of the operational picture 'at home'. There are a lot of challenges with that."

RF interconnects like the family from TE Connectivity play an important role in ISR.

One approach to platform-based information assurance and security is leveraging Cisco technologies, Curtiss-Wright's Southworth adds.

"The data in many Cisco-based routers have capability for commercial or even NSA encryption, so it can be encrypted in transit. When it comes to storage, there are similar options to encrypt the data with FIOPS [Fair Input/Output Per Second] or even Type One and provide assurance those architectures are secure," Southworth says. "There is another trend toward consolidation of multiple LRUs within the platforms to simplify system integration, pack more into a space once dedicated to a single function."

There are five common gauges by which persistent ISR has been measured: time-on-station; sensor capabilities and resolution' platform and sensor power; platform size in relation to sensors and signal processing; and range.

Future challenges, however, including growing investment in countermeasures, advances in technology, changing operational environments, and near-peer adversaries are changing that, as well.

"Those rankings depend on mission needs and requirements," says Worden. "It would be foolish to say time-on-station is more important than resolution, for example. Once you have selected the best sensors for the mission, you can consider trade-offs on the others. Time-on-station is important, range is important to persistence, as is power; platform size plays a role, as well. But the rank order could shift based on mission. It's really the sensor and resolution, today and in the future, then you worry about SWaP, time-on-station, and range. As sensors get smaller and lighter, you can adjust the platform size or number of sensors."

Sensors and platforms

Matching sensor size with platforms continues to be a design challenge. "As we get into the next generation of airframes, you have to worry about sensors fitting on the F-35 and still keep the aircraft's primary mission going," says Louise Doyon, Lockheed Martin's program manager for Signals Reconnaissance. "Having sensors and stations networked together, openly, rather than stovepiped. With more open architecture on the platforms, ground stations and fixed surveillance sites, you can harness persistence without always having everything far out at range.

"The labs obviously are working on new smaller, more capable sensor technologies that can better grab the threats to come," Doyon continues. "But they also are not ignoring the fact the next war is likely to be very different from the one we've been fighting the past 15 years. Most sensor technologies being built now are ensuring you have onboard processing to maximize bandwidth and only send down what's needed. But if you have greater bandwidth, those same sensors can send all their lower level data down to the next level for greater analysis. So they are trying to put the requirement on the sensor to be in both environments and provide greater flexibility for them and their platforms."

The future, then, will see major changes and advances in sensors, signal processing, platforms, missions, data fusion, and every other aspect of persistent ISR.

"Current ISR is growing in capability, reporting what is, but the next generation will combine that with connective analytics," Lockheed Martin's Weddel predicts.

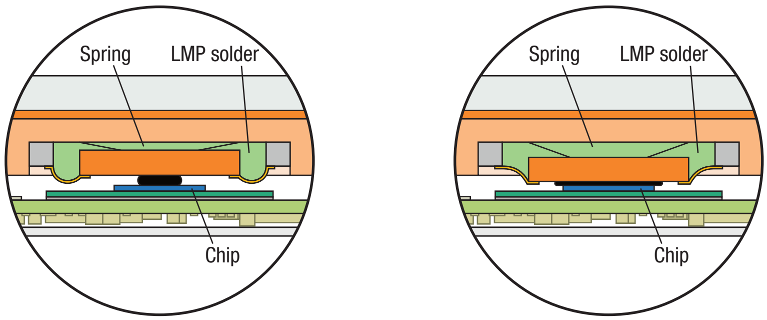
"The next element is autonomy for unmanned systems. Whether in the air, on the ground or on or under the water, there is an increasing move to find how unmanned systems can be trusted with autonomy or semi-autonomy to continue the mission away from their host," Worden adds.

"Power underwater is a greater priority than in other domains, especially when talking about persistence," Worden concludes. "You have to anticipate that one way to disable the power of a network is to interdict the data flow. When the command signal goes down, that is where autonomy comes into play, so the platform can continue to operate for some time until links can be reestablished. We have experiences there; the question is what is the next step in an increasingly complex environment." ←

Keeping cool with hot electronics

High-performance embedded computing industry has a wide range of electronics cooling and thermal management tools available as signal processing pushes the limits of system size and power density.

BY **John Keller**



These drawings depict the GE Thermal Management Technology Bridge, which uses a structure that changes shape with the introduction of heat to create an efficient thermal path for cooling hot components.

High-performance embedded computing (HPEC) designers for aerospace and defense applications have to be more cautious than most when it comes to the theoretical. Sure, they can dream about virtually unlimited processing capability in the future, but the realities of electronics power consumption and thermal management quickly drag them back to Earth.

While systems designers have a seemingly unquenchable thirst for increases in computing performance, HPEC engineers know all too well about the performance limits imposed by harsh operating environments, high-performance processors that operate at astronomical temperatures, tight operating spaces, and the need to keep electronics cool without adding size and weight.

There's just no escaping it: The higher the operating temperature of an embedded computing system, the shorter time it can operate reliably without failures. While high computing performance is a requirement for military systems, the need to lengthen mean time between failure (MTBF) in military systems is imperative. High MTBF imposes high maintenance costs, weapons systems in the shop instead of in the field, and puts lives at risk. None of these are acceptable to today's military.

In the high-performance embedded computing world, mechanical engineering concerns can far outweigh computer engineering concerns as systems designers struggle to meet customer expectations for ever-higher levels of processor performance that can operate reliably in small, lightweight systems. This reality is driving the industry's most advanced innovations in electronics cooling and thermal management approaches that can help keep system performance up to acceptable levels while keeping mean times between failures high.

"We forget, sometimes, just how fundamental the mechanical world is with some of the things we're doing in the processing world," admits John Bratton, product and solutions marketing manager at HPEC designer Mercury Systems in Chelmsford, Mass.

One of the primary reasons that HPEC designers are more concerned with power and thermal management issues than they are with computational issues revolves around the use of commercial off-the-shelf (COTS) processing equipment. "We are taking technologies designed for the commercial environment and making them operate in a more rugged military and aerospace environment," explains

POWER YOUR CRITICAL MISSION

A Full Range of Proven DC-DC Power Converters, EMI Filters and Accessories

Avionics & Military Features

- 1-120+ watts
- MIL-PRF-38534 Class H and Class K
- 100% hermetic
- -55°C to +125°C
- DLA SMDs available

Hi-Rel COTS Features

- 5-200+ watts
- Six-sided metal or potted packaging
- Rugged environmental screening
- -55°C to +100°C

Space Series

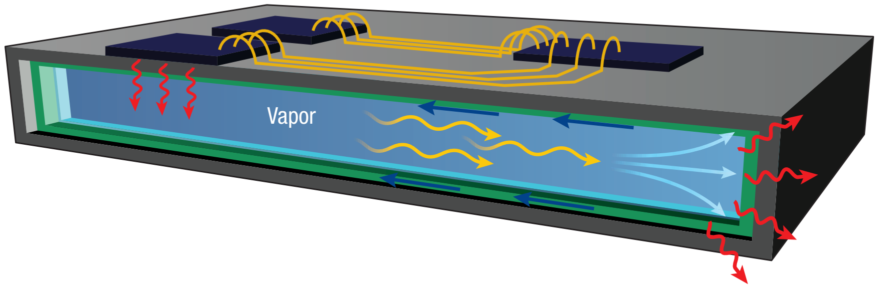
- 5-120+ watts
- Developed for TOR compliance
- TID: 100 krad (Si)
- SEE: 85 MeV
- -55°C to +125°C
- MIL-PRF-38534 Class H and Class K
- DLA SMDs available
- Engineering models typically ship from stock
- Other radiation levels and custom versions available

VPT

Power Your Critical Mission Today

www.vptpower.com

EFFICIENT & RELIABLE | 20 YEAR PROVEN HERITAGE | CERTIFIED QUALITY | SHIPS FROM STOCK



The GE Thermal Ground Plane approach combines evaporative cooling and capillary action to cool extremely hot electronics.

William Lueckenbach, chief consulting engineer at HPEC specialist GE Intelligent Platforms in Huntsville, Ala.

HPEC designers typically must confront the most demanding requirements for embedded computing. "The absolute biggest systems that have the densest power and performance applications typically are on the airborne side, specifically for large sensor processing for radar, imaging sensors, and SIGINT applications," says Jacob Sealander, chief architect and business capture manager at the Curtiss-Wright Corp. Integrated Systems division in Santa Clarita, Calif. "Designers say here is the space I have available, and I need the most horsepower possible for that space, with everything you can possibly put in that space."

COTS processor hardware from companies like Intel Corp. in Santa Clara, Calif.; Freescale Semiconductor in Austin, Texas; Xilinx Inc. in San Jose, Calif.; Altera Corp. in San Jose, Calif.; and Nvidia Corp. in Santa Clara, Calif., mean that even some of the most advanced processors are available to everyone. What's not available to everyone—and what is becoming the differentiator between HPEC practitioners, is each company's approach to electronics cooling and thermal management.

"Everyone has the same building blocks—the Intel and Freescale chips, and the GPGPUs [general-purpose graphics processing units]," Lueckenbach says. "You get to the point where you can't get the heat out of the box, so you derate, or throttle-back the processor so you don't overheat it."

Computing power, in other words, is a given; those who will prevail in the HPEC marketplace are those who excel at electronics cooling and thermal management.

"Whoever can remove the most heat can deliver the most performance to the customer," Lueckenbach says. "That is a product differentiator. All vendors can deliver the same processor with the same performance, but whoever does the best job thermally can deliver the highest performance or the lightest-weight computer."

Using COTS processors in military embedded systems may sound straightforward, but the ever-shrinking size of COTS microprocessors presents its own set of challenges.

"From a cooling perspective, you need to look at power density," says Curtiss-Wright's Sealander. "If power is distributed evenly it's not a big challenge, but with smaller die you need to dissipate 70 to 100 watts in the space of a die maybe one quarter inch by one quarter inch. That power density is off the charts."

Thermal management approaches

Essentially, there are four ways to cool electronics: conduction, convection, refrigeration, and liquid cooling.

Conduction cooling—by far the most common method in embedded computing systems that must operate in high shock-and-vibration environments—essentially uses heat pipes, heat sinks, and other heat conduits to draw thermal energy away from hot processors to and dissipate the heat into the environment. Conduction cooling also is beneficial in operating environments with dust, dirt, sand, and other contaminants because it can seal processors and other sensitive electronics away from the ambient environment.

Convection cooling flows streams of air over hot processors, most often with fans. This approach is relatively inexpensive, but can threaten the reliability of deployed military electronics. Convection-cooled systems can expose sensitive electronics to contaminants in the air, and moving parts like fans are prone to failure at the worst possible times, leaving systems vulnerable to overheating.

Refrigeration essentially uses small air conditioners, or refrigerators, to cool electronics. While effective, this approach is costly, large, and heavy. It involves coolant and complex refrigeration systems that not only are expensive, but that can be prone to failures. Because of its high costs this approach is the rarest approach to electronics cooling and thermal management, and typically is used on where nothing else will suffice.

Liquid cooling uses inert fluids like 3M Fluorinert to flow closely enough to hot electronic components to carry heat away. Liquid cooling is one of the most effective ways to cool electronics—think of the difference on a hot day between standing next to a fan or jumping into a swimming pool. Still, liquid cooling has some of the same negative issues as refrigeration—it's complex, expensive, and can be prone to leaks and failures.

With all these thermal-management tools at their disposal, HPEC designers can't afford to rest on the status quo, because they are being squeezed from two sides, by their suppliers on one side, and by their customers on the other.

The need for change

Embedded computer processing technology is moving ahead quickly. Processors are becoming more powerful, but in many cases they also are running progressively hotter. At the same time, systems integrators who are the HPEC customers are feeling pressure from their military patrons who constantly demand more computing performance for advanced applications in electronic warfare (EW), signals intelligence (SIGINT), radar and sonar processing, and advanced secure wireless communications.

Complicating the picture, still, are systems integrators who are clamoring for high-performance embedded computers that are small and lightweight enough for small unmanned vehicles, forward-deployed command posts, and even new generations of wearable computing.

"We are fighting different battles as the manufacturers deliver smaller and more powerful processors and FPGAs [field-programmable gate arrays]," says GE's Lueckenbach. "Smaller means more density."

High-performance embedded computing in EW, SIGINT, and radar processing applications is becoming more powerful, and smaller in size, but these advances are coming at a price that involves thermal management. Some of today's most demanding applications are approaching the need to dissipate heat computer boards using 200 watts of power. Below 170

to 180 watts per card typically can rely on conventional conduction and convection cooling, but above that—especially in high-shock-and-vibration environments—often pushes thermal-management needs beyond conventional solutions.

Higher power and higher performance are not the only factors driving change in thermal management for embedded computing. Airborne military applications also have special factors involving rapid changes in altitude, prolonged operations at high altitudes, and the punishing high temperatures of aircraft parked or moving along super-heated runways in desert areas of the world.

At high altitudes, for example, air is very thin, and does not cool efficiently. Rapid changes from warm areas on the ground to cold areas at high altitudes can place stresses on electronics involving thermal coefficients of expansion. Moving from very hot to very cold in a short period of time can stress or even crack solders or other places where materials are joined.

Extreme temperatures on airport runways in areas like the deserts of the Middle East can compound electronics cooling by combining high outside temperatures with high-temperature electronics operating even at idle levels.

All this means that HPEC designers must move forward in how they implement conduction, convection, refrigeration, and liquid cooling for electronic systems not only to meet the staggering demands of their customers, now and in the future, but also to differentiate themselves from their competitors in this demanding market.

New cooling approaches

Designers at GE Intelligent Platforms are tapping into their corporation's research labs to come up with some innovative thermal management techniques that Lueckenbach predicts could be designed into deployed embedded computing products within the next few years.

One approach, from researchers at GE, is the GE Thermal Management Technology Bridge, which provides a passage for heat from processors and other hot components to a heat sink, and on through the subsystem chassis.

Mercury Systems is using air-flow-by cooling to control temperatures on extremely hot electronic modules.

The technology relies on a self-contained cartridge with a flexible membrane that systems designers can attach to a heat sink during the manufacturing process. The membrane encloses a low-melting-point solder and heat spreader with a metallic spring. When the device heats up during normal system operation, the solder turns to liquid. This allows the spring to align the internal heat spreader flush to the die surface, filling the flexible membrane and creating a bond between the two surfaces to transfer heat.

GE researchers have come up with this thermal bridge as an alternative to today's typical use of metallic heat frames, which can be cumbersome to assemble and difficult to align properly. Even worse, this approach can introduce internal stresses that in extreme cases can crack die and solder balls.

Another GE thermal management innovation is called the thermal ground plane, which Lueckenbach explains works on the same principle as a heat pipe. This approach substitutes a two-phase, heat-transfer system for aluminum or copper heat-transfer frames, which can be inadequate with new generations of hot, high-power embedded computing systems.

The inside of the thermal ground plane is filled partially with a working fluid under saturation conditions. As heat enters the ground plane, the liquid evaporates, creating an increase in vapor pressure that moves vapor from hot to cool areas. The vapor releases heat to an outside cold wall as the vapor condenses. The condensed working fluid then flows back into the hot section by capillary forces. This heat transfer cycle continues as system heat vaporizes the fluid.

The thermal ground plane has 50 times the thermal conductivity of solid copper, matches the coefficient of thermal expansion with the semiconductor materials that are generating heat, and can operate effectively at more than 10 Gs of continuous acceleration.

GE engineers have demonstrated thermal ground plane technology in the GE Intelligent Platforms 3U VPX MAGIC1 compact rugged computers that combines high-performance central processors with hot-running, general-purpose graphics processing units.

The GE thermal ground plane is not a perfect solution for all operating conditions, Lueckenbach points out. "The challenge you have under normal situations is the capillary action can be affected by acceleration or gravity," he says. It could be a poor conductor of heat if the capillary action does not return the liquid."

A third thermal-management approach at GE is called Dual Cool Jets, which borrows from the GE Dual Piezo Cooling Jet technology that GE developed for cooling LED lighting and for airfoil fluidics. This approach seeks to remove heat from the exterior surfaces of the chassis after internal heat-transfer methods have moved the heat to the external surfaces.

GE Dual Piezo Cooling Jet technology is a piezoelectric micro fluidic device that does not require bearings or lubrication, which suits it for aerospace and defense applications where sand, dust, and other contaminants are present. The front side of the system is open for air ingestion and expulsion, and uses a 100-to-175-Hz AC voltage applied to the piezo elements to excite a resonance mode of the system.

The low-frequency range of operation results in a low acoustic A-weighted noise output. As both piezo elements experience the same mirrored bellowing resonance shape, air expels at high velocity during the out stroke and ingests into the device in the intake stroke.

This air-flow-by-cooled chassis from Mercury Systems implements the newly ratified VITA 48.7 thermal-management standard for embedded computing.

Despite the many cooling options available in the embedded computing market, designers often simply want to use technology that's available today without the need to redesign modules when they move up in power. Curtiss-Wright in the next year may introduce new electronics enclosures with special cooling built in to enable designers to use today's high-power computing modules without modification in embedded systems.

A standards approach

Embedded computing organizations like the VITA Open Standards, Open Markets trade association in Fountain Hills, Ariz., are coming up with new embedded computing thermal-management standards help meet the needs of the latest generations of high-performance embedded computing.

One of these standards is VITA 48.7, called air-flow-by cooling, which the organization ratified just last fall. This approach, championed by Mercury Systems, seeks to devise an elegant way of cooling electronics with air, rather than simply blasting hot electronics with fans, Mercury's Bratton says.

"The traditional way of cooling with air is the CFM [cubic-feet-per-minute] approach, which is just blasting it with air," Bratton says. "Mercury isn't really blasting with air today, but is using true air management to control the air." It uses 1-inch-pitch cards with controlled air flowing between them to remove heat. This approach cools both sides of the card, and has adjacent modules help each other to get the heat out.

A related electronics cooling approach, called air flow through, is similar but uses a 1.5-inch pitch. Reflected in the VITA 48.5 industry standard, air-flow-through cooling is particularly useful in systems that use high-power mezzanine cards for image and signal processing, says Curtiss-Wright's Sealander. "If you have a 40-to-50-watt FPGA or graphics processor on a mezzanine, air flow through is a really great way to cool them."

"Both standards try to solve the same problem: how to cool 200 watts in a 6U card," Bratton says. A side benefit of these approaches is affordable costs. Neither air-flow-by nor air-flow-through cooling is substantially more expensive than traditional convection cooling. "They are not any more expensive than the traditional ways; they're just better," he says.

The trick to air-flow-by cooling involves static air pressure. "We know where the hot spots are on the card," Bratton says. "It has to do with the kind of fan you are using." We use CAD simulations to create where the heat will be, and the fins where the hot spots will be."

Although air-flow-by and air-flow-through cooling appear adequate for systems approaching 200 watts at sea level, high altitudes, or other tough conditions may call for more than air cooling, Bratton says. That's where different approaches to liquid cooling come in.

Mercury is working on a liquid-cooling method similar to air-flow-by, except it uses liquid instead of air. "We plug into the backplane and use no-drip connectors. The coolant circulates inside a jacket, which completely encompasses the whole module," Bratton says.

One big benefit to this approach is it can work with either air or liquid. "You can use liquid flow-by without liquid, and it then is air-flow-by cooling," Bratton says. It's more expensive than just air-flow-by cooling, but has the flexibility to taken on a host of thermal-management challenges.

Curtiss-Wright's Sealander says liquid cooling is a must when embedded systems reach power consumption of 200 to 300 watts per slot. The VITA 48.3 and 48.4 standards involve liquid-flow-through (LFT) cooling, which is a quantum leap beyond air-flow-through for electronics cooling.

"The benefit of LFT is providing solutions for the 300-watt-per-slot range, but you also can cool solutions into the 800- or 900-watts-per slot because of how effective that approach is," Sealander says.

With cooling approaches such as these, Bratton explains, the embedded computing industry has the cooling capacity to handle nearly any embedded computing processor architecture in the foreseeable future.

"We have a lot of head room with the technology we have today and as far as we can see," Bratton says.

Marines order sixth G/ATOR radar

U.S. Marine Corps are ordering two more early versions of a long-delayed and expensive radar system designed to protect Marines on attack beaches from rockets, artillery, mortars, cruise missiles, unmanned aerial vehicles (UAVs), and other low observables. Marine Corps Systems Command officials at Quantico Marine Base, Va., announced a $113.3 million contract modification to the Northrop Grumman Corp. Electronic Systems segment in Linthicum Heights, Md., for two low-rate initial production (LRIP) versions of the Ground/Air Task-Oriented Radar (G/ATOR). LRIP represents small-quantity production for real-world testing before authorities make the decision to enter full-rate production.

Navy orders IED jammers from Sierra Nevada Corp.

U.S. military explosives-disposal experts are ordering additional electronic warfare (EW) jammers for deployed infantry warfighters to counter improvised explosive devices (IEDs) in dangerous parts of the world. Officials at the Naval Surface Warfare Center in Indian Head, Md., announced a $27.9 million contract modification to Sierra Nevada Corp. in Sparks, Nev., for a yet-undetermined number of the AN/PLT-5 IED electronic jammers to support explosive ordnance-disposal personnel. ←

Can military radar and communications systems share the same frequencies?

BY **John Keller**

Military researchers are working with industry to find ways for radar and communications systems to share the same radio frequencies.

ARLINGTON, Va. — U.S. military researchers are moving forward with a project to enable radar and communications systems to share radio frequencies in an effort to spur efficiency and alleviate congestion in the electromagnetic spectrum.

Officials of the U.S. Defense Advanced Research Projects Agency have released a broad agency announcement (DARPA-BAA-15-24) for the second phase of the Shared Spectrum Access for Radar and Communications (SSPARC) project. SSPARC phase two seeks technologies for the coexistence of RF communications and radar systems to improve radar and communications joint operational capabilities through spectrum sharing.

The second phase of the SSPARC program will build on technologies developed over the past 18 months by four companies during the program's first phase, which aimed at improving radar and communications capabilities while avoiding cross-platform interference.

The four organizations involved in SSPARC phase one are Michigan Technological University (Michigan Tech) in Houghton, Mich.; SAZE Technologies LLC in Silver Spring, Md.; the Lockheed Martin Corp. Advanced Technology Laboratories in Cherry Hill, N.J.; and Science Applications International Corp. (SAIC) in McLean, Va.

Spectrum congestion is a growing problem, DARPA officials explain. It increasingly limits operational capabilities due to the increasing deployment and bandwidth of wireless communications, the use of network-centric and unmanned systems, and the need for increased flexibility in radar and communications spectrum to improve performance and overcome sophisticated countermeasures.

Radar and communications together consume most of the desirable spectrum below 6 GHz, DARPA experts say. The SSPARC program seeks to develop RF sharing technology that enables spectrum access within this desirable RF range for radar and communications systems.

Projects under Phase 1 of SSPARC studied two radars, the AN/SPY-1 Aegis radar and the AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR), as well as several communications systems, including the Joint Tactical Radio

System (JTRS) Wideband Networking Waveform (WNW), Harris Adaptive Networking Wideband Waveform (ANW2), and Long-Term Evolution (LTE), a fourth-generation commercial wireless communications standard.

The end goal of phase two coexistence projects is to develop the spectrum sharing technology to the state of a limited field demonstration. After SSPARC phase two is finished, DARPA officials plan to launch an 18-month third phase that will include extensive field testing with radar and communications users. Tests will assess mitigation of nuisance jamming and problems caused by malfunctioning communications devices.

The second phase will support two types of spectrum sharing; spectrum sharing between military radars and military communications systems to increase both capabilities simultaneously when operating in congested and contested spectral environments; and spectrum sharing between military radars and commercial communications systems to preserve radar capability while meeting national and international needs for increased commercial communications spectrum.

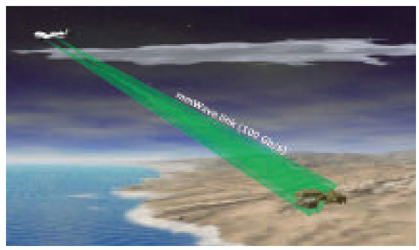
Although SSPARC technology is expected to be widely applicable, the program focuses on challenges that involve S-band from 2 to 4 GHz ground or naval-surface electronically steered phased array or multifunction radar systems that combine air surveillance, air tracking, non-cooperative target identification, and weather monitoring. The top-level challenge is to integrate and balance the suite of separation mechanisms so the overall system simultaneously achieves maximum performance for the systems sharing the spectrum, acceptably low interference, and acceptable cost.

DARPA experts also want to find ways to protect radar and communications systems from electronic warfare jamming and cyber attacks with techniques like minimization, encryption, obfuscation, and short-time validity of shared information. ←

MORE INFORMATION IS online at https://www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-BAA-15-24/listing.html.

Researchers eye 100-gigabit-per-second airborne wireless data links

BY **John Keller**


Military researchers seek ways to send voice, imagery, and video over secure wireless data links at speeds to 100 gigabits per second.

ARLINGTON, Va.—U.S. military researchers are moving forward on a project to develop a military wireless data link able to transmit data at speeds as fast as 100 gigabits per second within one RF and microwave frequency channel.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., released a solicitation (DARPA-BAA-15-22) for the second and third phases of the 100 Gb/s RF Backbone (100G) program. These phases of the 100G program will reduce the number of participating contractors from six to two, and the two companies picked will share about $27 million. The program seeks to create a high-availability airborne communications link with fiber-optic-equivalent capacity and long reach that can propagate through clouds, rain, and fog.

The six contractors from the program's first phase are Northrop Grumman Aerospace Systems, Raytheon Network Centric Systems, Battelle Memorial Institute, Silvus Technologies, Trex Enterprises, and Applied Communication Sciences. The winning two contractors will develop a prototype airborne data link that uses advances in high-order modulation and spatial multiplexing to achieve 100-gigabit-per-second wireless data throughput at ranges of 62 miles for air-to-ground links and 125 miles for air-to-air links from manned or unmanned aircraft flying at about 60,000 feet.

The 100G prototype resulting from the program's second and third phases will operate in the 71-to-76 GHz and 81-to-86 GHz bands, and will be flight tested at a government test facility, such as the China Lake Naval Weapons Center near Ridgecrest, Calif., DARPA officials say. The program's 100-gigabit-per-second airborne data links are to connect the major nodes of military networks, and to handle voice, video, Internet, and enterprise data flows. ←

MORE INFORMATION IS online at https://www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-BAA-15-22/listing.html.

Army orders 19 MQ-1C Gray Eagle UAVs

U.S. Army aviation experts are ordering 19 MQ-1C Gray Eagle reconnaissance and attack drones under terms of a $132.7 million contract to General Atomics Aeronautical Systems in Poway, Calif. The MQ-1C Gray Eagle unmanned aerial vehicle (UAV), an upgraded MQ-1 Predator, is a medium altitude long endurance (MALE) aircraft. The aircraft can be fitted with the AGM-114 Hellfire missile or GBU-44/B Viper Strike guided bomb for attack missions. The Gray Eagle has a synthetic aperture radar/ground moving target indicator system, and targeting capability from an AN/AAS-52 multi-spectral targeting system under the nose. The aircraft can carry a payload of 800 pounds.

Lockheed Martin to upgrade UUV

Naval Sea Systems Command awarded a $28.8 million contract to the Lockheed Martin Mission Systems and Training segment in Riviera Beach, Fla., to upgrade three low-rate initial production 1 versions of the Remote Multi-Mission Vehicle (RMMV) unmanned underwater vehicle (UUV) to version 6.0 for use as the Remote Minehunting System aboard the U.S. Navy's Littoral Combat Ship. The RMMV is based on the Lockheed Martin AN/WLD-1 Remote Minehunting System.

DARPA wants unmanned sensors to monitor Arctic land, sea, and air traffic

BY **John Keller**

DARPA is approaching industry for unmanned sensors that operate in harsh conditions to monitor arctic surface, air, and submarine traffic.

ARLINGTON, Va.—U.S. military researchers are asking industry to develop unmanned sensors able to operate in harsh environments to monitor surface, aircraft, and submarine traffic above the Arctic Circle.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., released a solicitation (DARPA-BAA-15-28) for the Future Arctic Sensing Technologies project, which seeks to capitalize on commercially developed technologies to monitor the Arctic region for military activity.

For this project, DARPA remote sensing experts are asking for proposals for low-cost unmanned air, surface, and subsurface sensing systems for the Arctic, including ways to deliver sensor information to remote sites.

The Arctic increasingly sees military and commercial activity, yet U.S. capabilities to monitor these activities are limited, DARPA researchers say. The Arctic has little fixed infrastructure to support sustained operations, and remote-sensing systems must be rugged and durable enough to operate in the harsh Arctic cold.

Today's unmanned systems are developing the range and environmental performance for the Arctic, researchers point out, and commercial electronics can provide low-cost and energy-efficient sensing systems capable of low temperature operation.

Satellite communications (SATCOM) technologies like Iridium and Argos enable data relay from remote Arctic systems to manned analysis and observing centers, researchers say.

DARPA wants to capitalize on these kinds of technologies for Arctic sensor systems. Proposed solutions should be rapidly deployable above the Arctic Circle, environmentally benign, and capable of unrefueled operation in the Arctic environment for at least 30 days.

Systems should sense, identify, and report data on aircraft, surface vehicles, people traveling on foot, surface ships, and submarines that may have significance for military surveillance.

DARPA has about $4 million to spend on this project, and several contract awards are possible. Bids were due by mid-April. E-mail questions or concerns to DARPA at DARPA-BAA-15-28@darpa.mil.

MORE INFORMATION IS online at *https://www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-BAA-15-28/listing.html.*

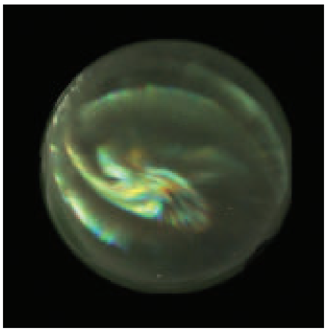
Hyperspectral sensors from Ball Aerospace to go on advanced weather-forecasting satellites

BY John Keller

OGDEN, Utah—Weather satellite experts at Tempus Global Data in Ogden, Utah, needed hyperspectral sensors to be placed in geosynchronous Earth orbit for detailed weather observations. They found their solution from Ball Aerospace & Technologies in Broomfield, Colo.

Tempus Global Data officials have chosen Ball Aerospace to build six Sounding & Tracking Observatory for Regional Meteorology (STORM) hyperspectral atmospheric sounding sensors that will fly as a hosted payload in GEO orbit. STORM hyperspectral sensors are designed to take high-fidelity measurements of atmospheric conditions, data not currently available. This new information is expected to help forecasters make better predictions of hurricane landfalls, tornado formation, and other weather events. Hyperspectral sensors can make quick measurements of vertical temperatures, water vapor, and wind profiles to help weather forecasters provide detailed warnings. Ball also will oversee the building of two additional sensors that will be free fliers.

The idea is to place six hyperspectral sensors in fixed positions in geosynchronous orbit around the Earth. The orbiting sensors can make quick repeat measurements in areas of interest without waiting for low-Earth-orbit satellites to come back into position. Geostationary hyperspectral sensors can help reduce repeat times for specific weather features to minutes. Hyperspectral imaging divides a scene into many different bands of the electromagnetic spectrum, both visible and invisible to the human eye. Slicing into many different light bands helps reveal important details not otherwise apparent.



Weather forecasting is becoming more sophisticated with satellite-based hyperspectral imagers from Ball Aerospace.

Experts at Utah State University in Logan, Utah, developed the STORM hyperspectral sensors and will continue to participate in sensor technology development, while Ball Aerospace, as prime contractor, will oversee and build the sensors. Tempus Global Data specializes in providing complex views of the atmosphere in three dimensions. The company will create data visualization tools using algorithms that combine in-depth views of water vapor, temperature, and wind velocity, enabling views of weather conditions that may be forming in clear skies. ←

FOR MORE INFORMATION visit **Ball Aerospace** at *www.ballaerospace.com*.

Marine Corps settles on Kollsman laser rangefinders

U.S. Marine Corps electro-optics experts are asking Kollsman, a subsidiary of Elbit Systems in Merrimack, N.H., to build as many as 1,500 handheld tactical laser rangefinders small enough for individual Marine infantrymen to carry. The Marine Corps Systems Command at Quantico Marine Base, Va., are awarding Kollsman a five-year, $73.4 million contract to build low-rate initial production and full-rate production versions of the Common Laser Range Finder-Integrated Capability (CLRF-IC). The CLRF-IC handheld laser rangefinders are to help deployed Marines detect, identify, and pinpoint targets during the day, at night, and in bad weather.

Argon flat-panel sonar displays replace CRTs

U.S. Navy submarine sonar experts needed flat-panel color displays to replace cathode ray tube (CRT) displays for sonar technicians aboard U.S. submarines. They found their solution at Argon Corp. in Great Neck, N.Y. Officials of the Naval Undersea Warfare Center Division in Newport, R.I., intend to purchase Argon 17-inch ruggedized display units in support of the Submarine Fleet Maintenance Activities and NAVSUP. These displays will upgrade legacy CRT sonar displays in the fleet with flat-panel technology offering increased display size within the same physical footprint, lower power consumption, and air-cooling instead of water-cooling. ←

COMBAT NETWORKING

Vetronics networking from Curtiss-Wright chosen for combat vehicle upgrade

Vetronics networking experts at Strategic Communications in Louisville, Ky., needed a rugged network router and switch for an upgrade to the U.S. Marine Corps AAVC-7 amphibious assault vehicle. They found their solution at Curtiss-Wright Defense Solutions in Salt Lake City. Strategic Communications selected Curtiss-Wright to provide Cisco IOS-based Parvus DuraMAR 5915 router and Parvus DuraNET 30-2020 switch subsystems for the AAVC-7 vetronics upgrade.

The Marine Corps amphibious assault vehicle has several variants. The AAVC-7A1 command version for which Curtiss-Wright is providing vetronics networking gear does not have a turret; communications equipment takes up much of the vehicle's cargo space. This version only has two crew radios and, in addition to the VIC-2, it carries two VRC-92s, a VRC-89, a PRC-103 UHF radio, a MRC-83 HF radio, and the MSQ internetworking system to control the various radios.

The Curtiss-Wright Parvus DuraMAR 5915 is a MIL-STD rugged Cisco 5915 mobile IP router subsystem with integrated Gigabit Ethernet switch. It integrates Cisco's 5915 embedded services router (ESR) card in a rugged chassis designed for harsh military vehicle and aircraft installations.

FOR MORE INFORMATION visit **Curtiss-Wright** online at *www.cwcdefense.com.*

EMBEDDED COMPUTING

North Atlantic to provide data-control for Navy landing craft

Navy ship building experts needed a data acquisition and control system for a next-generation landing craft. They found the solution at North Atlantic Industries (NAI) in Bohemia, N.Y. L-3 Maritime Systems designers in Newburyport, Mass., selected NAI's SIU35 sensor interface unit embedded computer for the Navy's Ship to Shore Connector program, which will replace the current fleet of Landing Craft Air Cushion vessels.

The NAI SIU35 rugged I/O and communications subsystem for data acquisition and control provides modularity and distributed interfaces over Ethernet using commercial off-the-shelf products. The NAI SIU35 will enable systems designers to populate each board with as many as 15 different function-specific modules.

FOR MORE INFORMATION visit **NAI** online at *www.naii.com.*

MILITARY AVIONICS

BAE Systems to provide military aircraft IFF transponders

Navy experts are asking BAE Systems Information and Electronic Systems Integration in Greenlawn, N.Y., to provide hundreds of identification-friend-or-foe (IFF) transponders for military jet fighter-bombers, helicopters, and trainer and transport aircraft under a $34.3 million contract.

BAE Systems will provide 53 AN/APX-117A(V), 10 AN/APX-118A(V), and 661 AN/APX-123A(V) IFF transponders for the U.S. Navy, U.S. Army, U.S. National Guard, and the governments of Qatar, Australia, Korea, Turkey, and Denmark. BAE Systems also will provide change kits, remote control and radio control units, receiver/transmitters, single-board computers, power supplies, signal processors, and more.

FOR MORE INFORMATION visit **BAE Systems** at *www.baesystems.com.*

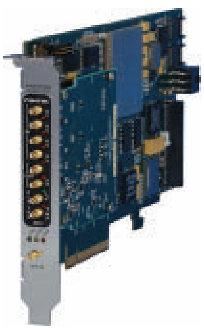
new PRODUCTS

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

EMBEDDED COMPUTING

Virtex-7-based PCI Express FMC carrier for DSP applications introduced by Pentek

Pentek Inc. in Upper Saddle River, N.J., is introducing the Flexor model 7070 PCI Express FPGA mezzanine card (FMC) embedded computing carrier with a Virtex-7 field-programmable gate array (FPGA) for demanding digital signal processing (DSP) applications. As a stand-alone signal processing board, it provides a development and deployment platform for demanding DSP applications. Combined with any of Pentek's FMCs, it creates a complete radar and software radio solution, company officials say. The Flexor model 7070 has a high pin-count VITA 57.1 FMC site, 4 gigabytes of DDR3 SDRAM, PCI Express (Gen. 1, 2 and 3) interface up to x8, optional 12x user-configurable gigabit serial I/O, and optional LVDS connections to the FPGA for custom I/O. The module comes preconfigured with a suite of built-in IP functions for data capture, synchronization, time-tagging, and formatting.



FOR MORE INFORMATION visit **Pentek** online at *www.pentek.com*.

POWER ELECTRONICS

Rugged power supplies for harsh-environment applications introduced by Crystal

Crystal Group in Hiawatha, Iowa, is introducing the RPS425DC1U and RPS585DC2U rugged power supplies for DC applications within demanding environments. The EMC DC power supplies meet MIL-STD-461 and DO-160, and use ATX motherboards in 1U and 2U rackmount servers. The RPS425DC1U and RPS585DC2U deliver 425 and 585 watts peak output power respectively, and are engineered for 28-volt DC input power compatible with aircraft electrical sources. Designed with modular output with ATX pinouts for server-class motherboards, these power supplies are available in an IPC form factor and require no additional components for EMI filtering.

FOR MORE INFORMATION visit **Crystal Group** at *www.crystalrugged.com*.

RF AND MICROWAVE

GaN RF amplifier for S-Band radar introduced by Comtech PST

Comtech PST Corp. in Melville, N.Y., is introducing the BMPC318358-900 gallium nitride (GaN) amplifier for S-Band radar applications. The AB linear design operates over the 3.1-to 3.5 GHz RF and microwave frequency band and can be modified to support 2.9-tp3.1 GHz radar applications. The amplifier has options for control of phase and amplitude to allow for integration into high-power systems using conventional binary or phased array combining approaches for power levels to 10 kilowatts.

FOR MORE INFORMATION visit **Comtech PST** online at *www.comtechpst.com*.

INTERCONNECT TECHNOLOGY

Watertight connector for avionics and night-vision introduced by LEMO

LEMO USA in Rohnert Park, Calif., is introducing the 0T series small-size watertight connector for aerospace and defense applications like aircraft communications, land vehicles, night-vision equipment, and simulation. The 0T series connector with Push-Pull technology is based on the LEMO B series, and includes a special construction with an inner-sleeve and extra sealing to enable IP68 water protection for avionics and similar applications. The 0T series is available in 2-to-9-contact configurations, and designers can terminate contacts by soldering to the wire, crimping onto the wire, or directly to a printed circuit board. A keying system ensures correct connector alignment and the connector outer shell offers full EMI shielding.

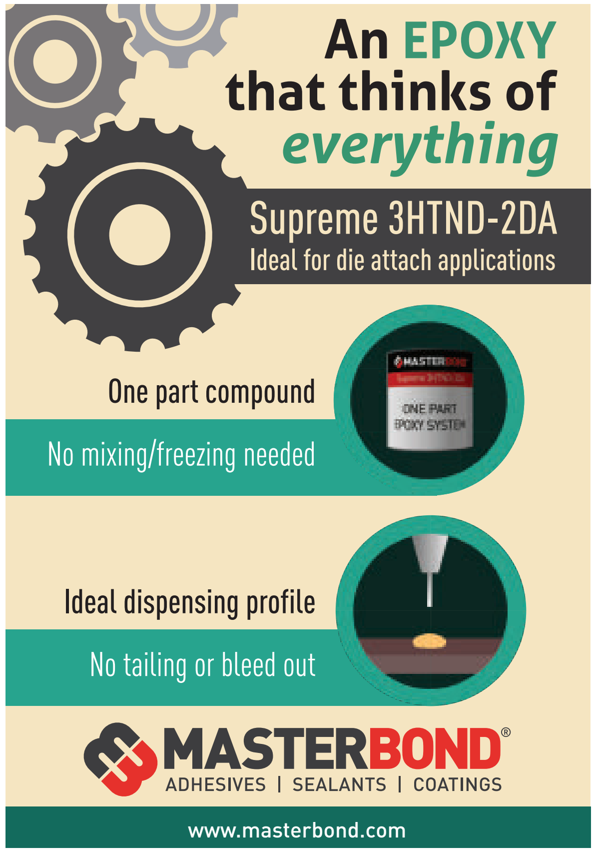
FOR MORE INFORMATION visit **LEMO USA Inc.** online at *www.lemo.com*.

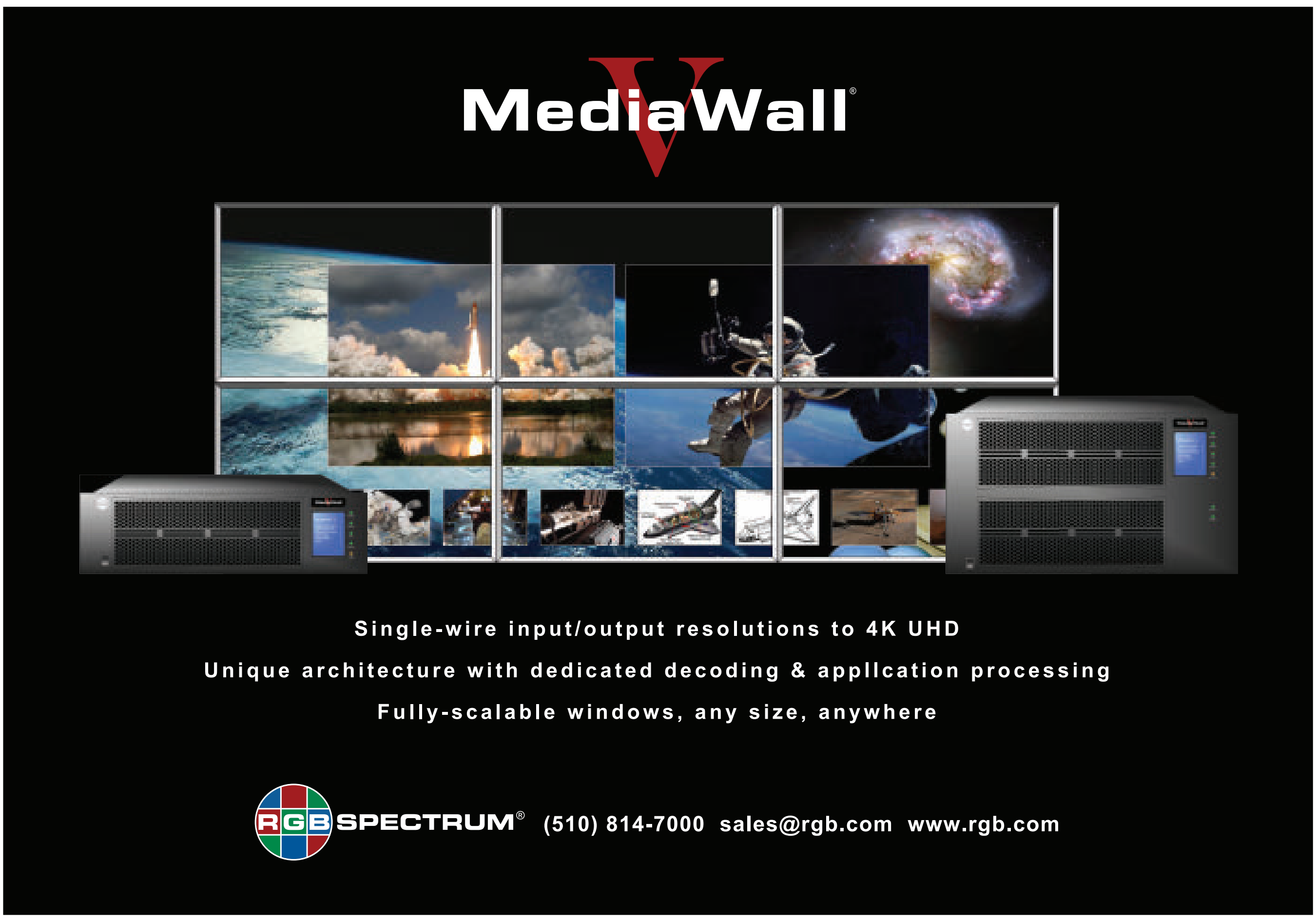
ST-9020 rugged computer system with 20" display, MIL STD shock & vibration qualified

DU-19/U rugged monitor

For full line of rugged systems contact:

IBI SYSTEMS, INC.
6842 NW 20TH AVE, FORT LAUDERDALE, FL 33309
PHONE; 954-978-9225, WEB: www.ibi-systems.com





ADVERTISERS INDEX

Military & Aerospace Electronics

GROUP PUBLISHER Alan Bergstein
603 891-9447 / alanb@pennwell.com

EDITOR-IN-CHIEF John Keller
603 891-9117 / jkeller@pennwell.com

EXECUTIVE EDITOR Courtney E. Howard
509 413-1522 / courtney@pennwell.com

CONTRIBUTING EDITOR
WESTERN BUREAU J. R. Wilson
702 434-3903 / jrwilson@pennwell.com

EDITORIAL GRAPHIC DESIGNER Cindy Chamberlin

PRODUCTION MANAGER Sheila Ward

SENIOR ILLUSTRATOR Chris Hipp

AUDIENCE DEVELOPMENT MANAGER Debbie Bouley
603 891-9372 / debbieb@pennwell.com

AD SERVICES MANAGER Glenda Van Duyne
918 831-9473 / glendav@pennwell.com

MARKETING MANAGER Kristi Guillemette
603 891-9126/ kristig@pennwell.com

SUBSCRIPTION INQUIRIES
Phone: **847 763-9541 • Fax: 847 763-9607**
E-mail: **mae@halldata.com**
Web: **http://www.militaryaerospace.com/subscribe.html** or
https://www.sub-forms.com/dragon/init.do?site=PNW20_MFcontact

PennWell®

Editorial offices
PennWell Corporation,
Military & Aerospace Electronics
98 Spit Brook Road LL-1, Nashua, NH 03062-5737
603 891-0123 • FAX 603 891-0514 • www.milaero.com

Sales offices
EASTERN US & EASTERN CANADA & UK
Bob Collopy, Sales Manager
603 891-9398 / Cell 603 233-7698
FAX 603 686-7580 / bobc@pennwell.com

WESTERN CANADA & WEST OF MISSISSIPPI
Jay Mendelson, Sales Manager
4957 Chiles Drive, San Jose, CA 95136
408 221-2828 / jaym@pennwell.com

REPRINTS Jeanine Pranses
717 505-9701 x344 / jeanine.pranses@theygsgroup.com

DIRECTOR LIST RENTAL Kelli Berry
918 831-9782 / kellib@pennwell.com

Corporate Officers
CHAIRMAN Frank T. Lauinger

PRESIDENT/CHIEF EXECUTIVE OFFICER Robert F. Biolchini

CHIEF FINANCIAL OFFICER/SENIOR VICE PRESIDENT Mark C. Wilmoth

Technology Group
SENIOR VICE PRESIDENT/PUBLISHING DIRECTOR Christine Shaw

BPA WORLDWIDE
AMERICAN BUSINESS MEDIA
The Association of Business Media Companies