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Power and thermal management

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Challenges of sensor fusion

Solving the problems of information overload and incomplete or missing information. PAGE 14

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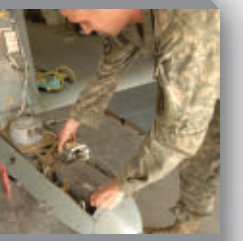
VOL. 25, NO. 4

Military & Aerospace Electronics



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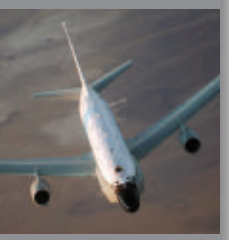

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THE POWER MANAGEMENT LEADER

BY **JOHN KELLER**, EDITOR IN CHIEF

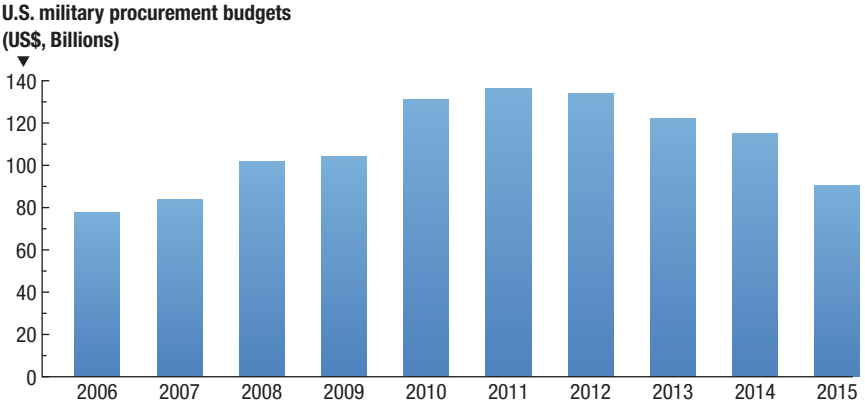
When does the military risk making a research cut too far?

Cutting-edge U.S. military technology relies on innovations in commercial industry. We know this because the U.S. Department of Defense (DOD) budget earmarked for military research and development is on a long downward slide.

A 10-year analysis of the DOD's annual requests for research, development, test, and evaluation (RDT&E) shows the Pentagon's planned spending for priority military technology research has fallen 21.5 percent since its 2010 peak during the past decade. The Pentagon's RDT&E request in 2010 was for $80.92 billion. Since then military research requests have diminished every year, and for fiscal 2015, which begins next Oct. 1, U.S. military leaders have asked for just $63.55 billion.

That's the lowest technology research request the Pentagon has made since 2007. We should ask ourselves, when does the military risk making a research cut too far?

Okay, I know that sixty-three and a half billion dollars is a lot of money by any measure. Still, is it sufficient to cover U.S. military technology needs over the next decade or so, amid a world political scene that is descending into turmoil in the Middle East, the Western Pacific, and most lately in the Ukraine, Eastern Europe, and other regions?



Is the technology developed in commercial industry sufficient to meet growing military needs? Perhaps it is; maybe I'm just being alarmist. Still, I see the downward trend in the nation's military research budget over the past five years and I'm not reassured.

Don't get me wrong, commercial technology is great, and it's getting better. Electronics miniaturization, high levels of electronics integration, high-performance embedded computing, digital communications and networking, and the like are far more advanced than they've ever been. Still I'm concerned, because if it's commercial technology, then it's available to everyone, friend and potential foe alike. I reckon that more often than not it's the U.S. military RDT&E budget that drives the unique technology development that's necessary to keep our fighting forces on the technological leading edge.

Let the military research budget atrophy, and bad things can happen. It's simply not enough to maintain the status-quo in these tumultuous times. The size of U.S military forces is shrinking, with force reductions planned, weapon systems slated for retirement, and more U.S. and overseas military base closures on the horizon. What shouldn't shrink is the high level of U.S. military technology, and the size of the DOD's research budget is a direct measure of our nation's resolve to remain on the technological leading edge. Once lost, that edge is difficult, expensive, and time-consuming to get back.

In today's global economy, it might not even be possible. We should think about that before passively watching the Pentagon's RDT&E budget shrink any further.

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news

Military spending for electronics and communications stable after steep decline

BY JOHN KELLER

WASHINGTON—Leaders of the U.S. Department of Defense (DOD) propose spending $10.67 billion in federal fiscal year 2015 for procurement and research in military communications, electronics, telecommunications, and intelligence (CET&I) technologies.

That level of $10.67 billion would represent a slight increase in the DOD budget from the $10.07 billion that Congress enacted for CET&I this year, and is down from the Pentagon's fiscal 2014 request of $11.62 billion. The Pentagon's CET&I allocation as recently as 2012 was $15.14 billion. The DOD's 2015 budget proposal was released in March.

The 2015 DOD request for CET&I procurement and research does not include military activities with substantial electronics content, such as aircraft avionics, vetronics, and missile guidance; when these are added, DOD spending levels for military electronics and defense electro-optics could approach $90 billion, industry analysts believe.

Experts estimate that total DOD electronics, information technology, and electro-optics spending is roughly 15 percent of the total DOD budget. Most of the DOD's technology spending is in the procurement, research, and development accounts.

In fiscal 2015, Pentagon leaders propose spending $601 billion, including $495.6 billion in discretionary budget authority, $79 billion in overseas contingency operations, and $26.4 billion in a new Opportunity, Growth, and Security Initiative fund.

Fiscal 2015 begins next October 1.

The DOD's CET&I budget request for next year includes $7.6 billion for procurement—up 5 percent from this year's enacted level of $7.3 billion. The DOD's total CET&I budget request also includes $3.04 billion for research and development, which is up nearly 11 percent from this year's enacted level of $2.8 billion.

The U.S. Army in 2015 is asking for $3.4 billion in CET&I procurement and research, which is down from this-year's enacted level of $3.6 billion, and down from this year's request of $4.5 billion.

The Air Force next year is asking for $3.14 billion for CET&I procurement and research, which is up from this year's enacted level of $2.53 billion, and also up from this year's request of $2.93 billion.

For defense agencies next year, the Pentagon is asking Congress for $445 million for CET&I activities, which is down from this year's enacted level of $484.5 billion, and down from this year's request of $507 million.

The Pentagon's proposed budget for 2015 now goes to Congress, where lawmakers are scheduled to craft a final military spending plan by next fall.

IN BRIEF

TriQuint joins with RFMD to create $2 billion RF and microwave company

TriQuint Semiconductor Inc. and RF Micro Devices Inc. will merge into a $2 billion RF and microwave company, with aerospace and defense playing a major part. This transaction combines product lines that include power amplifiers, power management integrated circuits, antenna control, switches, and filters. It will also strengthen the combined company's service to the defense and aerospace advanced gallium nitride (GaN) applications. The transaction is expected to close in the second half of this year.

U. Md. teams with Lockheed Martin to boost quantum computing

Computer scientists at Lockheed Martin Corp. in Bethesda, Md., and University of Maryland in College Park, Md., are working together to bring about a fundamental transformation in quantum computing, which offers greater power than traditional digital computers and a different way of solving problems. This new technology may help solve some of the most challenging problems, and could kick-start a new era in supercomputer development.

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L3 researchers to extend Internet connectivity to the front lines

BY JOHN KELLER

ARLINGTON, Va.—Military communications experts at L-3 Communication Systems-West in Salt Lake City will develop technology to extend high-speed Internet services to U.S. Army and Marine Corps infantrymen operating on the front lines beyond the reach even of forward-operating bases (FOBs) and tactical operations centers (TOCs).

The Hotspots program will use unmanned aerial vehicles to extend tactical Internet connectivity to warfighters on the front lines.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., awarded a $15.5 million follow-on contract to L3 for the second—and possibly the third—phase of the DARPA Mobile Hotspots program to extend mobile networking to front-line warfighters.

For the Mobile Hotspots program, L2 experts will continue developing a scalable, mobile, millimeter-wave communications backbone with the capacity and range necessary to connect dismounted warfighters with FOBs and TOCs; intelligence, surveillance, and reconnaissance (ISR) assets; and fixed communications infrastructure.

The backbone is intended provide reliable end-to-end data delivery among the hotspots, as well as from ISR sources and command centers to the hotspot users. In essence, Mobile Hotspots seeks to provide cell-tower-class performance to front-line warfighters without the infrastructure, DARPA officials say.

To do this, L3 experts will capitalize on air, mobile, and fixed assets—most of which deployed units already have—that provide a gigabit-per-second tactical backbone network extending to the lowest-echelon warfighters.

CONTINUED ON PAGE 10 ➔

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L3 CONTINUED FROM PAGE 6

L3 experts are trying to develop advanced pointing, acquisition, and tracking (PAT) technologies for providing high connectivity to the forward-located mobile hotspots. Advanced PAT technology is key for connectivity to small unmanned aerial vehicles (UAVs), for example, enabling them to serve as flying nodes on the mobile high-speed backbone, DARPA officials say.

Providing high-bandwidth communications for troops in remote forward operating locations is not only critical but also challenging because a reliable infrastructure optimized for remote geographic areas does not exist, DARPA researchers point out.

Additional needs like communication support for data feeds from UAVs and transmitting information to troops on patrol in remote areas presents a host of new challenges where dropped signals can create a serious threat to a warfighter's situational awareness.

"Mobile Hotspots will require the development of steerable antennas, efficient millimeter-wave power amplifiers, and dynamic networking to establish and maintain the mobile data backhaul network," says Dick Ridgway, manager of the DARPA Mobile Hotspots program.

"We anticipate using commercial radio protocols, such as WiFi, WiMax, or Long Term Evolution (LTE), as a cost-effective demonstration of the high-capacity backbone. However, the millimeter-wave mobile backbone developed during this program will be compatible with other military radios and protocols."

L3's objective in the Mobile Hotspots program is to design a scalable mobile communications backbone with the capacity and range necessary to connect Army and Marine Corps infantrymen

with forward-operating bases, tactical operations centers, remote intelligence and surveillance sources, and fixed communications infrastructure.

The program capitalizes on recent availability of commercial components to build millimeter-wave point-to-point links operating at E-Band frequencies of 71–76 GHz and 81–86 GHz to form the high-capacity backbone.

The program will take advantage of advances in efficient power amplifiers at E-Band frequencies to achieve the equivalent isotropically radiated power (EIRP) necessary to meet the range goals with small steerable antennas.

On this contract, L3 staff will do the work in Salt Lake City; North Hampton, Mass.; Fort Lee, N.J.; Malibu, Calif.; Nashua, N.H.; Guthrie, Okla.; and Springville, Utah. Work should be finished by March 2015. ←

FOR MORE INFORMATION visit **L-3 Communication Systems-West** online at *www2.l-3com.com/csw*, or **DARPA** at *www.darpa.mil*.

Lockheed Martin to replace mission computers, weather radars in C-5M cargo jets

BY JOHN KELLER

WRIGHT-PATTERSON AFB, Ohio—Military avionics experts at the Lockheed Martin Corp. Aeronautics segment in Marietta, Ga., will upgrade the mission computer and weather radar systems in the giant C-5M Super Galaxy cargo jet under terms of an $84.3 million contract.

The contract calls for Lockheed Martin to begin full-scale development of the C-5 Core Mission Computer/Color Weather Radar, which is part of a long-term program to extend the life of the Air Force C-5 fleet beyond 2040.

By the end of 2017 Air Force leaders expect to have a fleet of 52 C-5M aircraft. Awarding the contract were officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio.

The C-5 is larger than a Boeing 747 and is one of the largest military transport aircraft in the world. The aircraft, which has been in the Air Force transport fleet since 1970, is large enough to fit six Greyhound buses, lined up two abreast. The

Lockheed Martin experts will upgrade avionics in the C-5M Super Galaxy military cargo jet.

aircraft is designed to perform strategic airlift, emergency aeromedical evacuation, transport of brigade-size forces and equipment, and delivery of oversize cargo.

The C-5 Core Mission Computer (CMC) and Weather Radar replacements will mitigate the obsolescence of the current CMC and weather radar. This effort will replace the current mission computer, as well as replace the weather radar with a commercial off-the-shelf color weather radar.

Since 2002 the C-5M has undergone a major series of upgrades, including the Avionics Moderniza-

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C-5M CONTINUED FROM PAGE 11

tion Program to install a mission computer, a glass cockpit with digital avionics including autopilot and automatic throttles, and communications, navigation, and surveillance components for air traffic management. The aircraft also has received new engines.

The C-5M has been susceptible to information-assurance problems, Air Force officials say, and the new open-systems core mission computers are expected to solve these issues. Upgraded computers are to obtain sufficient capability and capacity for future requirements, and offer greater reliability and simplified fleet-wide training.

The new distributed-architecture core mission computer will have a 100-megabit-per-second Ethernet interface over copper wire, and will have several sources of supply for components, such as MIL-STD-1553 interface chips, single-board computers, and I/O cards.

The core mission computers for the C-5 also will have commercial standard video interfaces with VGA as a minimum, at least one additional expansion data bus for federated systems or new line-replaceable units (LRUs) covering Ethernet, MIL-STD-1553, and ARINC 429 avionics databuses.

The computer will separate classified and non-classified data for at least one data bus type for proper isolation of classified information, Air Force officials say. It will support the weather radar, flight management system (FMS), and communication navigation surveillance (CNS) and air traffic management (ATM) subsystems, including automatic dependent surveillance-broadcast (ADS-B) Out, and identification friend or foe (IFF) Mode 5.

The new computers also will be able to accommodate future capability like the Joint Tactical Radio System into the communication system; memory expansion and processing necessary for the Joint Position Approach and Landing System algorithms; and memory and processing power necessary for new data links on the C-5M such as Link 16 or the conceptual Mobility Air Force Data Link.

Sensor fusion heads for the field

Researchers from military, corporate, and college laboratories are combining their skills to solve the problems of information overload and incomplete and missing information.

BY **J.R. Wilson**

More than 12 years of combat in Southwest Asia have seen the use, variety, and capabilities of military sensors grow by orders of magnitude, leading the U.S. Department of Defense (DOD) to adopt a term coined four decades earlier in a far different context—information overload—and a new one for the solution—sensor fusion.

"Algorithm development for sensor fusion is highly interdisciplinary," explains Vincent Velten, technology advisor in the electro/optical exploitation branch of the U.S. Air Force Research Laboratory (AFRL) Sensors Directorate at Wright-Patterson Air Force Base, Ohio. "We start with basic physics, which grounds us in what is possible, and work with the guys who build the physical devices," Velten says. "If you look at the science and technology priorities that come out of DOD, sensor fusion is a core part of three of those and secondary in others."

A 2013 white paper from SA Technologies in Marietta, Ga., entitled "Supporting Situation Awareness Under Data Overload in Command and Control Visualizations," describes the nature and impact of too much data on military operations and warfighters: "Overcoming information overload is a central challenge for supporting information-dense environments, such as military operations... We are living in the midst of a revolution of information technology. This increased information flow is provided to enhance decision-making and human-system performance, yet often, the high flow of data has a deleterious effect on the operator's understanding of the relevant aspects of the situation."

A Boeing artist's rendering depicts combining sensor information from spacecraft, ships, aircraft, and land sites.

"The problem in this environment is no longer lack of information, but finding, within the mass of data available, those precise bits of information that are needed to make an informed, reasoned decision," the

paper goes on. "A widening gap exists between the tons of data being produced and disseminated and the individual's ability to find the right, disparate bits and process them together to arrive at the actual information sought."

Global fusion

Although most U.S. researchers and military users say they believe the U.S. has an edge in sensor fusion over other nations—friend and foe—it is a significant effort worldwide.

For example, in November 2014, a special workshop during the 19th Iberoamerican Conference on Pattern Recognition (CIARP 2014) in Puerto Vallarta, Mexico, will bring together international researchers to share perspectives on computational advances in intelligent processing of multimode remote sensing imagery. "Due to the statistical diversity and extremely large dimensionality of the multi-scale sensor signal data and image sets provided by the latest generation of multimode/hyperspectral remote sensing instruments, there are many open problems related to the development of robust adaptive/collaborative intelligent signal/image processing architectures and techniques," say conference organizers. "Sensing in harsh environments is additionally complicated due to the operational scenario uncertainties attributed for random perturbations of the signals in the turbulent propagation medium, multiplicative noise, possible sensor calibration imprecisions, uncontrolled antenna vibrations, and carrier trajectory deviations in the case of [synthetic aperture radar]."

In January 2014, researchers at the Institute of Remote Sensing at Anna University in India reported on the difficulties of fusing SAR and multispectral sensor data into one high-resolution image while maintaining the original color and detail of sensor images. They say while the most-used current image fusion techniques (intensity hue saturation, wavelet transform, and principal component analysis) work well for single-sensor, single-date fusion, there are problems with more complex systems.

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data from different sensors or dates, these fusion methods create images of higher spatial resolution, but usually at the cost of the original color or spectral characteristics of the input images," researchers wrote in a white paper. "This is especially true if two completely different sensors are used. So new algorithms are required to overcome these problems and establish superiority over the standard fusion techniques." They also concluded that even successful fusion of multiple sensors will not achieve the desired result unless each sensor is fine-tuned to provide data best-suited for the algorithm being used, with real-time modification of how it provides end users—human and electronic—with better images and more informed useful information.

Military research labs

An extensive set of sensor fusion programs at the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., include the Pixel Network (PIXNET) for Dynamic Visualization, Adaptable Navigation Systems (ANS), Advanced Wide field-of-view Architectures for image Reconstruction and Exploitation (AWARE), All-Source Positioning and Navigation (ASPN), and Wide Area Network Detection (WAND).

Nibir Dhar, DARPA program manager for PIXNET and AWARE, says the latter, now in the last stages of technology transition to the services, focused on four primary goals: increasing field-of-view (FOV) without losing resolution; shrinking pixel size; making a focal plane array (FPA) that is sensitive across a broad band, from visible to midwave; and making the system multiband, with the ability to display specific wavelengths in different ways. A four-year program that began in late 2013, PIXNET evolved from the technologies developed under AWARE, looking at what can be done to increase the situational awareness (SA) of individual soldiers and squads using what Dhar calls "spectral fusion."

While not specific to radar and multispectral sensor fusion, researchers say every successful fusion algorithm may lead to breakthroughs in unrelated programs. Air Force researchers are trying to develop a fundamental theory of sensor fusion and a predictive theory for sensor algorithms based on understanding related phenomena, Velten explains. AFRL researchers also put a lot of effort into SWaP (size, weight, and power) in assessing potential applications for new technologies.

"If your platform has multiple sensors onboard, SWaP definitely becomes a consideration," Velten says. "But the real issue driving that is what kind of communications bandwidth do you have. Communications is the long pole in the tent; modern sensors can produce massive amounts of data, but you can't get that data off-board anywhere close to real time. That is a bad problem and latency is a major issue.

"You usually collect a lot more data than you need, because you're looking for what is new or unusual," Velten adds. "One of the big promises of sensor fusion is you can make much better use of your communications band. But probably the largest issue is pixels-to-pupils—you really

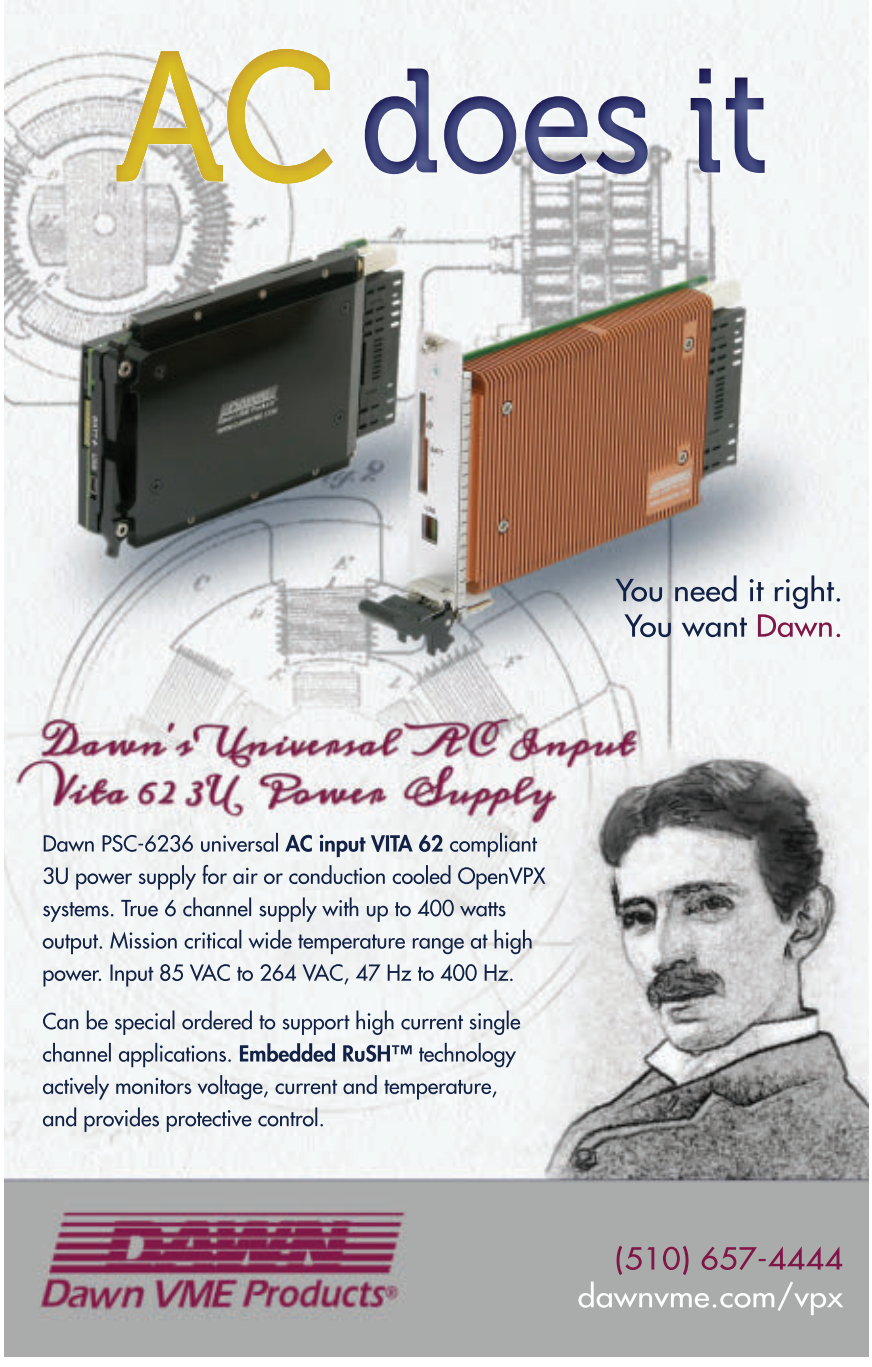
One of the first examples of sensor-fusion technology involves combining GPS satellite navigation signals with inertial navigation technology as shown above in a Honeywell integrated navigation system.

don't want to staff all the data channels. If you can do fusion, especially non-trivial issues, and instead can alert humans to the significant data, that is a very significant advantage." The trick is to understand which sensors to pick and tailor the package to serve the individual warfighter in-theater.

"Flexibility is the watchword, since it's really hard to predict what the user will need in different circumstances," Velten says. "A flare-up in the Pacific would be a different beast from one in the Horn of Africa. So we're trying to develop specialized algorithms and data collection resources. You want to collect everything you can, not just sensor data, with the fusion processes being very dependent on the layers you have—different elevations, angles, spectrum, etc.—and how you can fuse all that, with the customer always wanting to minimize personnel while getting cleaner, cheaper, faster data. It's almost easier to say what is not pertinent rather than what is."

Corporate and academic research

The DARPA All-Source Positioning and Navigation program is an example of the multiple disciplines and capabilities needed for sensor fusion, says Kevin Betts, position, navigation, and timing director for the advanced technology division of Leidos in Reston, Va. DARPA's goal is to develop a prototype sensor fusion system for land, sea, and airborne applications that can accept inputs from several kinds of navigation sensors so warfighters can maintain navigation capability with or without global positioning system (GPS) satellite navigation. "ASPN is focused on what technology advancements are needed for real-time, plug-and-play data fusion—processing elements to assess large amounts of data; on the filter side, it is going beyond the algorithms used in the past," Betts says.



The Northrop Grumman Sperry Marine Voyage Management System training center in Charlottesville, Va., blends several kinds of navigational sensors for enhanced shipboard navigation.

Fusing sensor data with light ranging and detection (LiDAR) sensors rather than radar represents a relatively new approach. Designers at Rockwell Collins in Cedar Rapids, Iowa, are working on the Degraded Visual Environment Pilotage System (DVEPS) for the U.S. Special Operations Command (SOCOM) at MacDill Air Force Base, Fla. The company began looking for solutions to degraded vision years ago, beginning with synthetic vision for helicopters, a database-driven system to provide a visual of the terrain and obstacles along the flight path, says Dan Toy, Rockwell Collins principal marketing manager for rotary-wing aircraft.

"We started looking at the types of sensors that were available or in development, the types of sensing technologies out there, and began constructing our ideas around how we would fuse various types of sensor information with the database information to provide a good image detection in the cockpit for the pilot," Toy says. "We began looking at radar and LiDAR sensors, the wavelengths, and radar bands appropriate for dust, snow, fog, rain and other obscurants pilots face. That narrowed us in on a few sensors where progress was being made. That's where we are—developing algorithms to do this."

Rockwell Collins completed a Multifunction Radio Frequencies (MFRF) DARPA program to develop a new onboard RF sensor to perform tasks that enhance the survivability of rotorcraft and provide lethality improvements for combat missions in zero-zero conditions. "The program has two elements: the radar sensor and a Synthetic Vision Avionics Backbook (SVAB)," Toy says. "They needed a visual capability to go with their radar, which is what the SVAB is, taking radar data and transforming it into something useable by the pilot. Part of that was to fuse radar and terrain database information and depict it to the pilot in an intuitive manner.

"DVEPS has many of the same challenges, but the attempt is to develop and qualify a system Army special ops can apply to Black Hawk and Chinook fleets," Toy adds. "As we started the DVEPS program, we realized [Army] requirements were more stringent [than DARPA's], so we decided to go with a different type of sensor—LiDAR—because of the higher resolution it can provide. In the SVAB program, we worked with a millimeter-wave radar that provides lower resolution than LiDAR. The SVAB was designed to work with either radar or LiDAR, so it was not a large stretch to take the technology developed for the DARPA program and apply it to the Army program."

That effort was competed in mid-2013. Rockwell Collins, Boeing, and Sierra Nevada were selected for a follow-on, three-phase program. The first phase, a ground demonstration of the system, is to be completed in late April. After a month or two of analyzing their reports, Toy says, the Army will down-select for Phase 2, a 12-to-18-month flight test phase.

"The program office running SVAB supports special ops aircraft, although I'm sure they would like to see this developed for other Army and DOD applications. Army program offices and NAVAIR are watching the program closely to understand the technology and how it might be adapted to other aircraft," Toy says.

Sensor fusion for UAVs

Critical requirements such as SWaP also apply to small to medium UAVs. "The big challenge is beyond the sensors and revolves around getting the capabilities needed and meeting

the SWaP challenge in doing something for a Black Hawk or even a Chinook," Toy says. "If we were packing it in the back of a C-130, 200 pounds wouldn't be a big deal, but for a Black Hawk, 10 or 20 pounds is a big deal, so getting the right algorithms, processing resources, and packaging that will live in a helicopter environment are really what will make the system work or not work well."

It requires a lot of different skills to do sensor fusion well and a broad analytical scope to do it right, says Betts. "You have to be able to ingest large amounts of data, especially with radar and multispectral sensors, and understand the underlying math. After you've done all that, you have to present it in a meaningful way to an operator or enable an autonomous platform to make a decision."

Hyperspectral sensors and LiDAR fusion are under consideration to help with target-detection applications. Alina Zare, an associate professor of electrical & computer engineering at the University of Missouri-Columbia College of Engineering, has been looking into this to detect specific vehicles or materials on the ground for Army Research Lab and the Office of Naval Research.

"I have been looking at automated scene understanding for different types of sensors—sonar, hyperspectral—and being able, given a data set, to describe what's at the scene, especially since much of the focus and understanding has been visual imagery. By moving those concepts to other types of sensors, you could get different viewpoints beyond what you could with even high-end cameras, and go into new areas using sensors such as sonar. Our results have been algorithm development. We used multispectral to cue [ground-penetrating radar], flying over an area with a multispectral sensor, then following up with ground radars. The final output will be something for a human to look at, but also to feed into other algorithms, so it really is for human operator and machine applications."

Future fusion factors

Another issue facing sensor fusion designers is the fast-changing and growing types of sensors available to the military and how to ensure future technology insertion and upgrades without needing a whole new fusion system.

"We are designing with the thought of upgrading the system, tuning the algorithms and adapting them to new and different sensors," Toy says. "Sensors are in their infancy in a lot of cases. LiDAR and radar are well known, but using LiDAR for helicopters is something that has not been done yet and will evolve a lot over the next 10 to 15 years; the algorithms will have to evolve with them.

"We are looking to ensure a scalable approach, because not every user is going to agree on what they need based on different SWaP requirements, platforms, and missions. A scalable system will adapt to different types and quantities of sensors. You might have to combine a couple multispectral sensors to get what the user wants, so we are trying to design it to accommodate changes as we go forward."

Already seen as a key enabler and top priority for sensor fusion is the evolving network-centric battlespace.

"When you look at trying to fuse different sets of data and the solutions now being worked, networking

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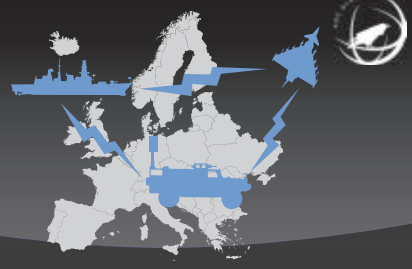

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CLARION EVENTS

disparate sensors is becoming central," notes George Yager, chief engineer for electronics & sensor solutions at Argon ST, a Boeing subsidiary in Fairfax, Va. "The days of single sensors or single data sets coming from a sensor are past us. Anytime you correctly integrate a new set of data, it becomes essential. You know you're doing it right when you don't have to look at two different displays and you can't tell it is coming from different sources. What fusion really brings to the user is more time to focus on something else, operationally, and not spend so much time managing data."

Sensor fusion relies heavily on what is happening outside DOD with commercial-off-the-shelf (COTS) components. Ironically, as fast as military sensors and requirements have grown, the commercial world continues to outpace even recently improved DOD acquisition and fielding schedules. "COTS can move so fast," Betts says. "Sometimes making radical developments, that if you only have a traditional, slow procurement process, by the time something gets to the field and you compare it to what then is available, it seems extremely limited in capability. And an adversary may be able to adopt it more quickly and so get an advantage. DARPA has had programs looking at that and how DOD can make use of COTS technologies, but shape it to be its own in terms of ruggedization, security, and so on.

"In terms of sensor fusion, one focus, as sensor technology advances in the commercial arena, is having plug-and-play algorithms that can take advantage of the latest and greatest COTS developments," Betts adds. "We have learned there may be commercial outlets for what has been developed for and by the military."

Today, sensor fusion is determined by a particular application driving which sensors are used, how data is brought together, and its intended use, says Zare. "In the future, algorithms will be sensor-agnostic—as long as you can get the data, the algorithms will deal with them. Knowing in certain situations how sensors should be fused for one result, but how to fuse the same sensors in different ways for different results will require improved algorithms.

"It can't be done by simply throwing the data together; there needs to be an intelligent approach," Zare says. "More data does not necessarily provide better information, and the more information you have, the larger the potential for error. It is application- and situation-dependent. There are a lot of advancements being made in a few very flexible algorithms, but we're still at the stage where there is not one way to solve all problems—no global fusion algorithm."

Fusion in the Future

"Sensor fusion is becoming more and more important," Betts says. Future platforms will take advantage of sensor fusion. Future sensors will be designed to function independently and in fusion with other data streams. Both will be designed for mission customization, including on-the-fly algorithm changes to meet the varying needs of an evolving situation.

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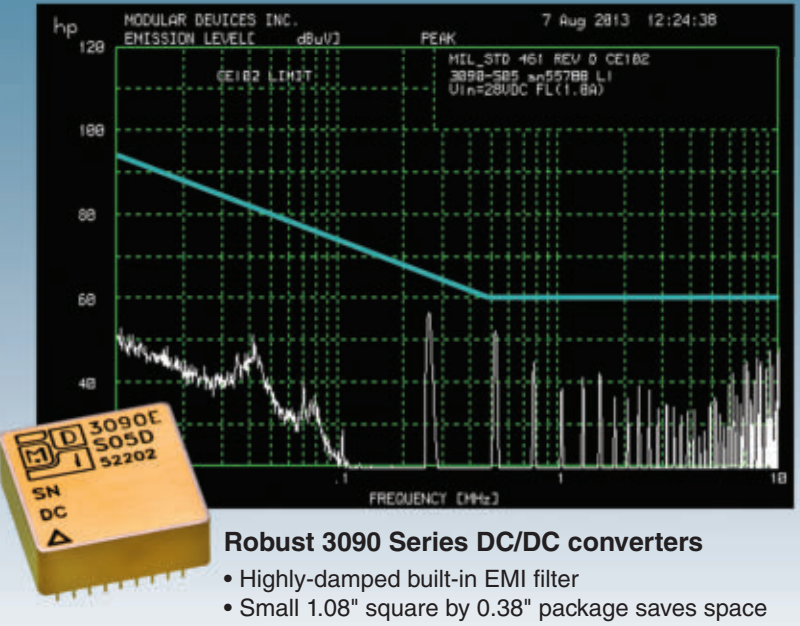

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Powering and cooling embedded electronics

Engineers tap the power of commercial processors while combating power and thermal challenges with modern electronics.

BY **Courtney E. Howard**

Aerospace and defense missions, today and for the foreseeable future, are driving the need for ever more advanced electronics. It is no longer sufficient to use solutions that simply are capable and efficient; rather, current and future electronic systems and subsystems also must be full-featured, multifunctional, and robust—not to mention affordable.

Industry engineers are meeting these demands with the help of commercial off-the-shelf (COTS) and custom aerospace and defense technologies. Increasingly, systems engineers are opting to implement the latest commercial computing components, including the hottest processors from Intel, AMD, NVIDIA, and others.

Though powerful, these chips often are power-hungry and produce copious amounts of heat; this trend is upping the need for innovative power electronics and thermal management, as well as prompting systems designers to partner with and seek the advice of aerospace and defense industry leaders.

SWaP-C considerations

The sheer size of aerospace and defense platforms—be they aircraft, satellites, ground vehicles, or unmanned systems—and the programs that fund them tend to be shrinking, whereas the amount of electronics being employed in each is growing by leaps and bounds. Current size, weight, power, and cost (SWaP-C) requirements are perhaps more strict than ever. Indeed, engineers often are faced with the need to deliver as many capabilities and as much functionality in as small size, weight, power, and cost as possible.

"As more and more electronic capability is packed into modern military and aerospace (mil/aero) systems, designers are faced with ever-increasing power system complexity, but under simultaneous pressure to reduce costs," says Steve Butler, director of advanced product development at VPT Inc. in Blacksburg, Va. "A steady stream of requirements for higher power, more voltages, and tighter specifications must be carefully managed to maintain high system reliability and minimize cost."

Engineers often are required to accept trade-offs, such as gaining processing power but suffering a power-consumption setback. "On the extremes, a design can be the most reliable but over budget, or it can be the lowest cost but take a lot of risk using commercial components," Butler affirms. "Most systems end up in the middle, balancing reliability with cost."

To help engineers optimize system designs within budget constraints, industry vendors provide a broad range of power electronics products. VPT, for example, offers multiple levels of power products, from radiation-hardened, space-grade products and hermetic military-qualified products to cost-effective, high-reliability (hi-rel) COTS products. "Choosing the right level of product for each application is key to maintaining high system reliability while minimizing cost," Butler adds.

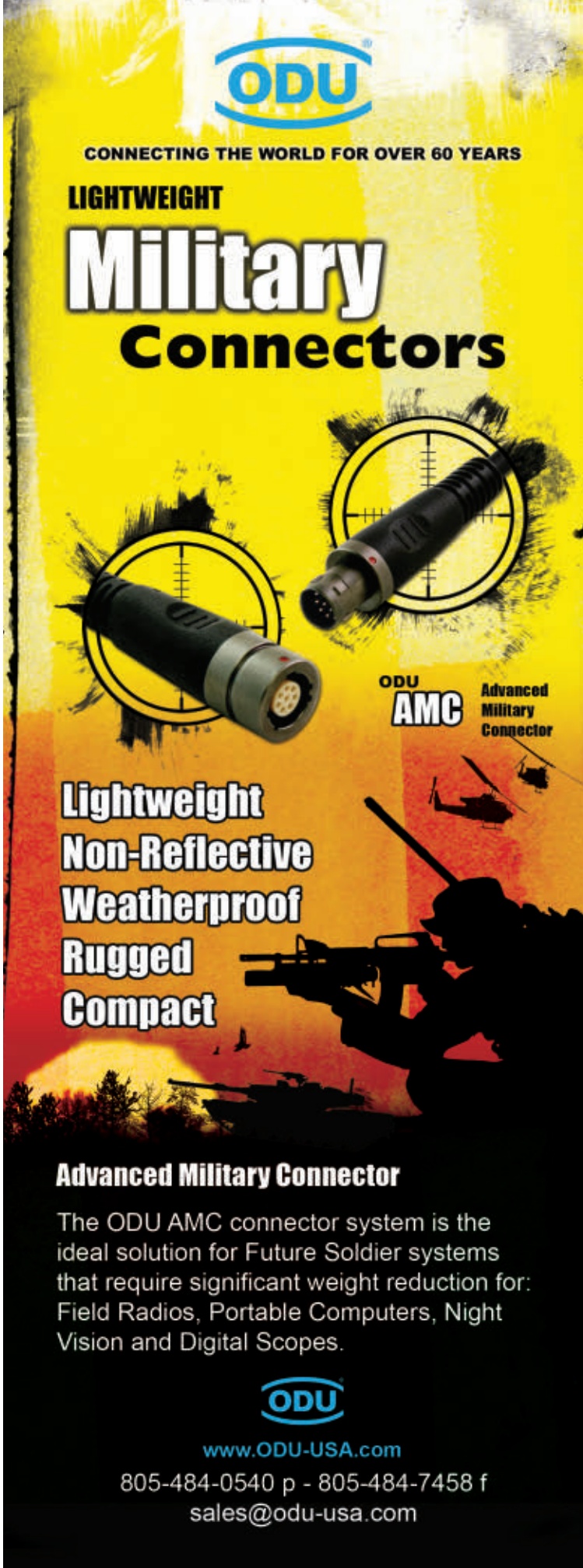
Behlman DMCA 4000 COTS power supplies support the operation of key electronics on the RC-135V Rivet Joint reconnaissance aircraft.

Life expectancy

As electronics are optimized for aerospace and defense applications, engineers must take into account time in the field and temperature—"typical factors which degrade or shorten the life of electronics," VPT's Butler admits. "As there is little one can do about the amount of time a device is powered, every effort should be made to reduce the operating temperature to maximize the life of the DC-DC converter."

VPT strives to increase efficiency, make the most of internal thermal conduction, and use the most conductive materials available, Butler says. Yet, "if a customer does not employ proper thermal management practices, all the thermal design benefit of the DC-DC converter is lost and long-term reliability is potentially reduced."

The company provides application notes and technical videos on thermal-management considerations for customer design applications, as well as offers thermal pads designed to work with its DC-DC converters to make the most of thermal interface between the converters and customers' thermal conductive surface. "Many of our customers appreciate the importance of thermal management," Butler says, "and to that extent, they will contact VPT directly either to gain further insight or ask VPT to review their thermal design



to ensure optimal thermal management as it applies to our products."

Custom-COTS combination

A continuing trend in aerospace and defense is "to move away from fully custom-designed power systems and move toward a combination of standard power converter modules and external custom circuitry," Butler explains. "By using standard off-the-shelf power modules, system design time, cost, and risk can all be reduced."

Mil/aero system designers should choose carefully the quality level of DC-DC converters for their application, recommends Butler and his colleagues at VPT. "Temperature range and input voltage range are two parameters which quickly differentiate Hi-Rel DC-DC converters from commercial or telecom products. A typical Hi-Rel temperature range is -55C to 100C or 125C. A typical input voltage range for 28-volt systems is 16 to 40 volts or the wider 15 to 40 volts," Butler says.

"Transient capability or the availability of transient protection and electromagnetic interference (EMI) filter modules is also important," Butler adds. "Power modules should be designed for harsh environments. Things to consider include Defense Logistics Agency (DLA) certification or a vendor's internal qualification plan, hermeticity, an EMI-shielded package, device screening, and a vendor's experience or reputation in the mil/aero market."

The NVIDIA Jetson TK1 Developer Kit is based on a mobile supercomputing technology.

Data deluge and the GPU

Aerospace and defense industry pundits recognize that missions are now achieved with bytes, rather than bullets. Information is king and compute power is key on the digital battlefield. For this reason, modern military and aerospace electronics harness the power of compute processing units (CPUs) and graphics processing units (GPUs) working in tandem.

NVIDIA GPUs have been adopted for myriad defense applications, from signal processing to digital forensics to image and video analytics of data captured by satellites and unmanned aircraft systems (UAS). "GPUs are used to perform local analytics, too, to do pre-analysis of the data and even collision avoidance in an unmanned aerial vehicle (UAV)," says Sumit Gupta, general manager of Tesla GPU accelerated computing business at NVIDIA in Santa Clara, Calif.

"The vision of the defense world is that every warfighter will have a handheld device and computing devices in every aircraft, Humvee, and tank," Gupta says. The vision of the U.S. Department of Defense (DOD), specifically, encompasses "hundreds of thousands of sensors sending data on the battlefield—including sensors

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on the ground, in the air, and on satellites, as well as analysis and data crunching done in the field without being connected to a back-end server."

Militaries "require very high computing capabilities but they are limited by power," Gupta adds. To fulfill this need, NVIDIA is bringing mobile chips into the defense embedded market to provide very high compute density, hundreds of gigaflops of performance within a few watts. NVIDIA CEO and co-founder Jen-Hsun Huang introduced the NVIDIA Jetson TK1 Developer Kit, being described as the first mobile supercomputer for embedded systems, during the NVIDIA GPU Technology Conference last month in San Jose, Calif.

The new Jetson TK1 DevKit harnesses Tegra K1 compute capabilities to usher in and enable new computer-vision, image processing, and real-time data processing applications in aerospace and defense, including robotics and avionics. Applications also exist in the automotive and medical markets, officials say. NVIDIA's embedded developer kit is "completely changing the compute capabilities; the use cases are unimaginable" and far-reaching, Gupta says.

The DOD and defense contractors already have shown interest, saying NVIDIA mobile chip technology delivers the exact computing density needed for the embedded defense market. "The mobile industry is driving innovation for compute which we can now use in military environments to meet the need for local computing," Gupta says.

"The NVIDIA Jetson TK1 Developer Kit provides developers with the tools to create systems and applications that can enable robots to seamlessly navigate [and] drones to avoid moving objects," according to a company spokesperson. The NVIDIA Jetson TK1 Development Kit,

CONTINUED ON PAGE 35 ➔

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Connector designers innovate to solve SWaP issues

BY **John Keller**

This photo shows a ruggedized, multiple protocol-enabled, electrically pluggable active optical cable from Zephyr Photonics.

Military systems designers today are obsessed with shrinking component size, weight, and power (SWaP). Connector and cable manufacturers—no small contributor to SWaP on military vehicles—are stepping up to the challenge in a variety of approaches.

The drive toward shrinking SWaP for unmanned vehicles, wearable computers and displays, networked weapon sights, and many other applications of embedded electronics is playing into the hands of companies that design small electronic parts called micro and nano connectors.

Not only does the shrinking voltages of modern microprocessors and other integrated circuits lend itself to small interconnects, but micro and nano connectors can be inherently rugged, explains Bob Stanton, director of technology at Omnetics Connector Corp. in Minneapolis.

"Everything has to be smaller and able to handle this new digital lower-voltage technology," Stanton says. "The rules of silicon run into the connectors, and that allows less voltage, smaller connectors, smaller

COMPANY INFO

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wires, and tighter spacing."

Small size, however, in itself is not a substitute for rugged connectors in today's military applications. "We have UAVs [unmanned aerial vehicles] that are two feet wide at most, and have to take lots of shock and vibration," Stanton says. "Sometimes they even have to crash land. We need high signal integrity through real rugged applications. At the same time, designers want smaller and lighter connectors to fit into this little vehicle or product."

One big advantage of smaller connectors in high shock-and-vibration environments is their physical mass. "The mass is lower, and it handles higher forces," Stanton says. There are other challenges, however. "The plating on the pins must be exceptionally good," he adds. Typically Omnetics engineers use a mix of nickel and gold—nickel for hardness and gold for electrical conductivity.

Other companies are taking a different approach to attack SWaP issues with cables and connectors. One approach involves substituting optical fiber for copper cable, which not only reduces weight and mass, but also resists the effects of electromagnetic interference (EMI).

From a design standpoint for military applications, fiber and fiber connectors have represented maintenance and reliability headaches. One bit of dirt in an optical connector can compromise performance. "You're in a dirty environment with people who don't know much about fiber," says Tim McAllister, vice president of business development at Zephyr Photonics Inc. in Zephyr Cove, Nev. So Zephyr's approach is to combine electrical connectors, with which military technicians and systems integrators are familiar, and run optical fiber between.

The result is a rugged electrically pluggable active optical cable.

The connectors are electrical and in familiar form factors. The cables convert the electrical signal to optical just behind the connector, and reconvert the signal back to electrical at the other end. An added benefit to using fiber is increased bandwidth.

"For the sensor folks, in particular, bandwidth over distance is a big application," McAllister says. "It will be the upgrade path for many sensors in the next five to seven years." ←

OPINION

More-than-Moore: the new era of microelectronics development for military applications

BY **Dave Anderson**

With the stakes for achieving superior systems integration continuing to rise, even as military budgets shrink, change is in the air for how military and aerospace companies will meet the need for ever-improving electronics.

While the demand for creation and extension of affordable—but undefeatable—weapons and defense systems remains a high priority, a historical shift toward much greater integration of materials is easing the challenge. This transformation is about to fuel an unprecedented range of applications that touches not only defense and its stake in such game-changing apps as infrared sensors, phased-array radars and missile guidance systems, but also nearly every other area of high relevance to society's future.

To make possible the reversal of big-ticket trends of the past, features for tomorrow's microelectronic components have shifted toward use and development of novel materials rather than just a myopic continual shrinkage of devices.

Reinforcing this global vision, the resulting new market applications benefit the mil-aero audiences by satisfying the rigorous size, weight, power, and cost (SWAP-C) requirements.

With fresh, broad integrations of materials driving widespread advancements for the defense industry, organizations and companies such as Raytheon, Northrop Grumman, Lockheed Martin, BAE Systems, L-3 Communications, DRS Technologies, DARPA, DTRA, and IARPA are among those who are exploring the wide range of new possibilities.

Why the change?

The rapidly emerging class of materials and technologies, known as More-Than-Moore (MTM), is being used strategically to integrate components that can yield a greater benefit than when they are positioned apart individually. As a result, MTM is fast becoming the de facto solution for defense and commercial applications. By extension, component integration will accelerate systems integration.

Those previously under-used elements are being used to create new materials and technologies for defense in critical areas that include silicon photonics, non-volatile memory, superconducting and quantum computing devices, GaN-on-Silicon power discretes, flexible semiconductors, and carbon nanotube microelectronics. Beginning to move into the markets now, the next generation of products can rely on novel means to prototype new devices and then can run the needed low-volume, higher-reliability upgrades for aerospace and defense systems.

Recent investments by the defense industry in wide bandgap (WBG) semiconductors are designed to take power electronics to another level with MTM technologies. They look to enhance GaN technology by heterogeneously integrating GaN on top of silicon wafers. High-power weapon systems, shipboard-power electronic systems, and phased-array radars are three applications for the new WBG technology. Integration of GaN technology onto larger silicon

DAVE ANDERSON is CEO of Novati Technologies Inc. in Austin, Texas, a nanofabrication center that provides prototyping for military, aerospace, and commercial business. Contact Novati Technologies online at www.novati-tech.com for more information.

wafer sizes and use of standard semiconductor manufacturing processing provides significant functionality and performance advantages at a much lower cost.

A further example of new benefits from materials integration is reflected in satellite manufacturers who are driving the use of new types of non-volatile memory for storage applications on spacecraft. These latest-generation memory devices are integrating non-traditional materials and technologies to make them able to operate in high-radiation space environments.

A few of the technologies being developed include ferroelectric RAM (FeRAM), magnetoresistive RAM (MRAM), phase change RAM (PCRAM) and resistive RAM (RRAM), all using MTM technologies.

With weakened capacity for advanced microelectronics from traditional contract defense manufacturers, a notable part of the trend toward using MTM is for industry to use third-party resources that more cleverly leverage current technologies into next-generation solutions.

Previously dismissed as being too exotic, thousands of new combinations of elements are being used to produce state-of-art micro-electro-mechanical systems (MEMS), microfluidics, novel transistors, and photovoltaics.

Playing a pivotal role in this evolution, a handful of nanofabs have begun to produce such high-demand apps as the next generation of higher-resolution microbolometers, using a backside illumination (BSI) technology and through-silicon vias (TSVs) for infrared sensing, that help to meet the needs of the warfighter.

The future fab

With a dwindling number of organizations able to afford to play the extremely expensive game of ever-smaller semiconductor device geometries dictated by Moore's Law, most device manufacturers are opting not to recapitalize to pursue next-generation semiconductor requirements. For instance, the existing fabs owned by many defense contractors have older technology and tools, limiting their ability to develop future generations of such

essential technologies as microbolometers and read-out integrated circuits (ROIC) for infrared and night-vision applications.

Many of the existing defense fabs are unable to support development of other advanced semiconductor device technologies, such as creation of ultra-thin, flexible transistors for high-performance optoelectronics used in high-speed photography, and high-performance antennae that are applied to the skin of aircraft and other vehicles.

It's important for the country's defense that photovoltaic cells be made even thinner and more flexible by nanofabrication, but rugged enough to be woven into everything from soldiers' uniforms to tents and backpacks. Development of novel chip-scale devices that combine electronic-photonic and mixed-signal integrated circuits on a common silicon substrate is a representative example of how the mil-aero community will benefit from a variety of optoelectronic microsystems, including coherent optical communications systems and coherent laser radar (LADAR) systems.

Other critical microelectronic advancements made possible by MTM include new ways of managing extremely complicated or open-ended tasks in short periods of time, as well as accelerated machine intelligence that can rapidly improve system capabilities. The potential is unlimited for the previously unimagined combinations to drive widespread changes in the defense industry.

To exploit this new pool of technology, defense communities are presented with an exponentially greater number of resources that offer a significant advantage over traditional silicon foundry technologies.

Historically, the majority of CMOS fabs have limited customers to working with no more than 25 elements from the periodic table. In stark contrast, the new class of nanofab targeted at MTM applications will offer 60 or more exotic materials. The break from the past limitations will be paved by the ability to safely engage an unprecedented number of elements to move innovative ideas and breakthrough designs into development and production.

Like the new markets they're helping to create, MTM-class nanofabs such as Novati enable defense companies to improve the performance of their systems through advanced packaging technology, stacking multiple chips in a single 3D system-in-a-package. This higher level of device integration provides the convergence of improved performance, power consumption, and functionality.

About-face for microelectronics

The business case for defense and aerospace developers to leverage an MTM development strategy has already begun. Working versions of all the devices cited here have been created and many are playing roles in improved systems integration.

Previously, microelectronics have subscribed to a relentless drive toward ever-smaller feature sizes with ever-greater wafer fabrication costs required to gain higher capabilities.

With physical limits looming and budgets shrinking, the viability of this march to the cadence of what's known as Moore's Law has reached a turning point, away from historical trends in the development of microelectronics. Moore's Law, named after Intel Corp. cofounder Gordon Moore, states that the number of transistors that can be placed on an integrated circuit doubles every two years.

> Latest-generation memory devices are integrating non-traditional materials and technologies to operate in high-radiation space environments.

Now, with an unprecedented focus on the reduction of SWAP-C and our ability to fabricate semiconductors with exotic materials at the nanoscale level dependable, the global transformation toward a greatly enriched portfolio of options for devices significantly improves the means for satisfying any mission.

Manufacturability for new innovations

With the rush to embrace the possibilities made affordable by newly combined elements, companies and organizations must consider that manufacturability continues to be a key technical risk-factor for MTM technologies. Proving manufacturability of breakthrough technologies requires a significant investment across a range of capabilities, not just electrical and industrial engineers, but using chemical engineers, device physicists, and material

scientists, processing equipment specialists, extraordinary materials, lab space, and other critical factors.

To demonstrate any new innovation, companies must fabricate complete cells, which require re-development and optimization of a number of standard process steps, unrelated to the innovation. The new generation of nanofabrication centers aims to reduce start-up time and provide access to a shared manufacturing knowledge-base and capabilities.

This evolution means not having to "reinvent the wheel" for standard technologies—previously a big challenge for both government and commercial interests. Ultimately, customers are able to reduce their development time by going through rapid cycles of learning, typically 3–5 times faster than at a traditional CMOS fab.

Defense technologists report that such services and capabilities aimed at significantly reducing the costs they incur to develop and demonstrate manufacturability will immediately become a huge advantage for the security community. Further, a notable enhancement provided by the most progressive nanofabs is the allowance of customers to work side-by-side with nanofab employees inside the cleanroom to develop their new technologies, a practice that's less common than one would imagine.

As a result of these improvements for device development, defense contractors, large corporations, small startup ventures, and university spin-offs that have influenced creation of such a strategic nanofabrication model will exploit designs and advantages that more traditional venues are simply not able to offer.

In summary, the fast-growing set of novel and extended capabilities for military microelectronics signals that MTM is the key to a future where nanofabrication facilities with multiple elements will lead the way. The result is an even larger set of options and opportunities for the defense and aerospace communities.

The era for enabling the most rapid, but affordable, product development and deployment has begun. ←

SRCTec to build ground-based radars to enable UAVs to sense and avoid other aircraft

U.S. Army surveillance experts are asking SRCTec Inc. in Syracuse, N.Y., to provide ground-based radar systems that enable military officials to operate unmanned aerial vehicles (UAVs) in controlled civil airspace without a chase plane or ground observer. Officials of the Army Contracting Command at Redstone Arsenal, Ala., awarded a $7.2 million contract to SRCTec to provide the Ground Based Sense-And-Avoid Lightweight Surveillance and Target Acquisition Radar (GBSAA LSTAR). The GBSAA radar system enables users to operate UAVs in the National Airspace System without a chase plane or ground observer. It uses the SRCTec Lightweight Surveillance and Target Acquisition Radar (LSTAR) ground sensors to detect airborne traffic and enable the UAV operator to maintain a safe distance between his UAV and other aircraft. The system is an alternate means to comply with the FAA see-and-avoid regulations and operates in bad weather and at night; provides an expanded operational area and increased operational time. By 2016, Army officials plan to install the GBSAA radar network at five installations to maintain separation of UAVs and civil aircraft.

Pentagon plans to spend $2.45 billion next year on UAVs for surveillance and attack

BY **John Keller**

The Northrop Grumman RQ-4 Global Hawk long-range unmanned aerial vehicle, shown above, will be a big winner in next year's DOD budget.

WASHINGTON—U.S. military leaders plan to spend $2.45 billion next year on unmanned aerial vehicle (UAV) procurement and research, with the RQ-4 Global Hawk, MQ-9 Reaper, and experimental U.S. Navy Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) system expected to be the biggest winners.

The Pentagon's proposed flying drone budget of $2.45 billion in fiscal 2015 is up 15.8 percent from this year's enacted UAV spending level of 2.1 billion, and up 3 percent from what the Pentagon requested for this year. The U.S. Department of Defense (DOD) released its proposed fiscal 2015 budget last month. Federal fiscal year 2015 begins next October 1.

Military leaders propose spending $855.79 million next year on procurement and research for the Northrop Grumman RQ-4 Global Hawk high-altitude long-endurance UAV and on the MQ-4 Triton, Northrop Grumman's maritime patrol version of the Global Hawk.

For the General Atomics MQ-9 Reaper hunter-killer UAV, DOD officials propose spending $607.1 million.

For 2015, officials propose to buy 12 Reaper aircraft and 12 fixed ground control stations, as well as modify MQ-9s to the extended-range configuration. Contractor: General Atomics–Aeronautical Systems Inc. in San Diego builds the Reaper.

MQ-1 Predator spending next year is proposed at $270.1 million. This includes spending for the MQ-1C Gray Eagle UAV.

Proposed spending for the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) in 2015 is $403 million. UCLASS is the next step in the Navy's integration of UAVs onto aircraft carriers.

Proposed spending next year for the RQ-7 shadow medium-sized UAV is $145.2 million; for the MQ-8 Fire Scout unmanned helicopter is $96.7 million; for the RQ-11 Raven hand-launched small UAV is $17.7 million; and for the combination small tactical UAS (STUAS) and Boeing Insitu RQ-21 Blackjack catapult-launched UAV is $14.5 million.

Other proposed UAV spending for fiscal 2015 includes $35.9 million for research and development on a future unmanned combat aerial vehicle (UCAV) prototype; and $2 million for miscellaneous UAV sensor and weapons payloads.

Northrop Grumman to supply Special Forces laser target designators

BY **John Keller**

CRANE, Ind.—Laser targeting experts at the Northrop Grumman Corp. Laser Systems segment in Apopka, Fla., will provide U.S. Special Forces with specialized laser target designator viewing devices under terms of a $12.3 million U.S. Navy contract.

The SOFLAM system, shown above, will help Special Forces warfighters put bombs and missiles on target.

Officials of the Naval Surface Warfare Center in Crane, Ind., are asking Northrop Grumman Laser Systems for Special Operating Force Laser Aiming Marker (SOFLAM) Ground Laser Target Designator (GLTD) electro-optical systems, as well as spare parts and repair services.

SOFLAM GLTD is a ruggedized laser designator designed for Special Forces that enables the user to designate targets with laser beams that guide precision-guided munitions to the targets. It provides the capability of combining two guidance choices: hand-off to aircraft or stand-alone terminal guidance.

The SOFLAM lightweight integrated laser designator and rangefinder provides Special Operations Forces with the ability to locate and designate critical enemy targets for destruction using laser-guided ordnance. It is capable of remote firing; supports mounting accessories such as pointers and night sights; can be carried by one person; and can be operated remotely during covert operations.

The SOFLAM enables Special Forces warfighters to remain undetected while they put accurate, precision-guided munitions on target, officials say. The system uses a neodymium-doped yttrium aluminum garnet (Nd:YAG) laser with a wavelength of 1064 nanometers, and pulse energy of 80 millijoules.

Company laser experts have developed an advanced version of the SOFLAM that is smaller and lighter, and operates from one BA-5590 battery by replacing a flashlamp-pumped laser with a diode-pumped laser with passive cooling. The SOFLAM PEQ-1C reduces the number of BA 5590 batteries necessary for operation from five to one, and provides the warfighter with a smaller, lighter, and more efficient rugged laser designator for the field, officials say. It has a range of 650 feet to 12 miles with one-meter accuracy.

Northrop Grumman will provide SOFLAM systems to U.S. military forces, as well as those of Romania and Lithuania. The company will do the work in Apoka, Fla., and should be finished by March 2018. ←

FOR MORE INFORMATION visit **Northrop Grumman Laser Systems** online at *www.northropgrumman.com*.

Army asks industry for 50-kilowatt laser

U.S. Army missile-defense experts are asking industry to supply an adjustable-power 50-kilowatt laser that with its cooling subsystem can fit on an 8-by-53-foot full-sized flatbed trailer. The Army Space and Missile Defense Command is sponsoring the High-Energy Laser Mobile Demonstrator (HEL MD) project to develop a truck-mounted laser weapon able to shoot down enemy rockets, artillery shells, mortars, and unmanned aerial vehicles. The Army wants a laser with a 200-micron fiber delivery system, with at least 75 meters of fiber length from the laser output to end of the fiber where the laser will link to a beam collimator via an HLC-16 connector. Army personnel should be able to operate and maintain the laser, which should be adjustable from 500 watts to at least 50 kilowatts, fire continuously at maximum power for as long as 60 seconds, and require no more than 10 minutes of regeneration between shots.

Raytheon to provide aircraft multispectral sensors

Electro-optics experts at Raytheon Co. Space and Airborne Systems in McKinney, Texas, won two contracts worth $22.9 million total to provide multispectral sensors for U.S. military aircraft. The Naval Surface Warfare Center Crane Division awarded contracts for the Raytheon Multi-Spectral Targeting System (MTS) for the U.S. Navy Sikorsky MH-60 helicopter and U.S. Air Force HC/MC-130J four-engine turboprop aircraft. ←

PRODUCT applications

POWER ELECTRONICS

Behlman to provide COTS power supplies for U.S. Navy airborne missions

Behlman Electronics Inc. in Hauppauge, N.Y., won a U.S. Navy order for its Model 00389 commercial off-the-shelf (COTS) power supplies. These power supplies have been used by the U.S. Navy since 1999, to support anti-submarine and anti-ship surveillance and targeting systems.

The Behlman 00389 power supply is a rugged, reliable unit designed and built for military and high-end industrial applications and to meet the requirements of MIL-STD-704A and RTCA-DO160, as well as MIL-Standards 901, 810C, 167, and 461C/D.

These power supplies have proven their reliability and performance in airborne naval systems, while similar Behlman COTS power supplies have proven themselves on shipboard and mobile applications, says a company spokesperson.

"The fact that our Model 00389 power supply has supported the Navy's program for 15 years, during which time we have received multiple follow-on orders, is clear evidence of its superb performance and high reliability," says Behlman President Ron Storm. "We are especially proud to be able to supply one of our COTS power supplies to meet the Navy's specific military requirements. This has saved taxpayers many millions of dollars that would otherwise have been required for custom designing, engineering and manufacturing."

Model 00389 power supplies operate from 115/200 volts AC (VAC) +/-20% at 360 to 440 hertz, and provide eight DC outputs of varying power. Other features include: superb specs for Load and Line Regulation; PARD-Ripple and Noise; Over-voltage Protection; Short-circuit Protection; Current Limit, Extreme Operating and Storage Temperatures; and High MTBF, in a very compact chassis, measuring 12 x 7 x 2.38 inches (30.48 cm x 17.78 cm x 6.04 cm).

The Behlman Model 00389 COTS Power Supply is designed and manufactured to withstand the rigors of airborne use, while meeting a wide range of MIL-STANDARDS. This unit has been selected for continuous use in U.S. Naval anti-submarine and anti-ship surveillance and targeting systems since 1999.

DATABUSES AND NETWORKING

Crystal Group to provide rugged network switches for AC-130U Special Operations aircraft gunship

U.S. Air Force avionics experts needed ruggedized Cisco network switches for the AC-130U Spooky gunship. They found their solution at Crystal Group Inc. in Hiawatha, Iowa.

Officials of the Air Force 1st Special Operations Contracting Squadron at Hurlburt Field, Fla., plan to award a contract to Crystal Group for the company's ruggedized Cisco switch for the AC-130 gunship, which is based on the Lockheed Martin C-130 four-engine turboprop aircraft.

The ruggedized Cisco switch from Crystal group is an integral part of the AC-130U SOF Air Mission Suite Enhanced Situational Awareness (SAMS ESA) system, which provides the gunship with improved display and utility of mapping and intelligence data inputs to the aircraft cockpit.

The switch has reached its end of life, and no other companies are available that ruggedize this version to withstand the military airborne environment, Air Force officials say. Choosing a different switch would require additional

re-engineering work, which would cost too much money. The switch provides the network connectivity necessary for the aircraft's SAMS-ESA system to operate.

Crystal is ruggedizing the switch to operate in harsh military aircraft environments. The Crystal switches will offer basic RIP and static routing; four SFP-based gigabit ports; stackability to enable as many as nine switches to operate in one unit with one IP address; and will packaged in 1U 19-inch air transport racks or transit case EIA form factors.

The switches also will have Delrin glides or fixed mounts; will operate in temperatures from -15 55 degrees Celsius per MIL-STD-810F; and will operate at altitudes to 40,000 feet. The unit measures 17.75 inches wide by 14.7 inches deep, by 1.75 inches high, Air Force officials say.

FOR MORE INFORMATION

visit **Crystal Group** online at *www.crystalrugged.com*, or the **1st Special Operations Contracting Squadron** at *www.hurlburt.af.mil*.

TECHNOLOGY FOCUS

CONTINUED FROM PAGE 25

priced at $192, is available for preorder now from NVIDIA and resellers in the U.S., Europe, and Japan.

"Having the level of performance and energy efficiency Jetson TK1 offers can potentially support the development of robots with real-time object recognition and compelling autonomous navigation capabilities. Our experience with the previous generation CUDA development kit has already enabled us to make great progress training robots to interact more intelligently with their environment," says Chris Jones, director of strategic technology development at iRobot Corp. in Bedford, Mass.

"Tegra K1 can change what's possible in the rugged and industrial embedded market," says Simon Collins, product manager at GE Intelligent Platforms in Charlottesville, Va. "We expect to be able to offer solutions in the sub-10 watt space that previously consumed 100 Watts or more."

Processing

The most challenging problem facing military/aerospace systems today is processing more data at higher speeds and with less weight, which requires higher data bandwidths and more power," says Jerry Hovdestad, director of COTS engineering at Behlman Electronics in Hauppauge, N.Y. "The problem is being addressed by VPX technology, which now enables evolutionary leaps in processing speed. All this technology requires power, and power means heat that needs to be removed from the system. High temperatures can damage electronic systems or, at best, the protective circuitry will shut them down."

Major defense contractors have selected Behlman VPXtra power supply cards for use in new, advanced VPX-based systems for their available power, efficiency, and thermal management, Hovdestad says. He credits the cards' performance to attention to detail in electrical and mechanical design, state-of-the-art heat pipes to optimize thermal performance, and "the judicious use of materials to address heat transfer vs. weight. For example, copper can transfer approximately twice the heat of aluminum yet weighs almost twice as much."

Behlman officials are actively involved in exploring new cooling technologies to enhance product performance. "We participate on national engineering committees responsible for writing the specifications to define new techniques for cooling systems," Hovdestad says. "The hottest trends in technology are those which are facilitating the goals described, increasing speed, decreasing weight, and improving thermal performance. VPX technology, optical backplanes, and advanced cooling are some of the areas that are addressing these issues. Efficient, high-power, and optimally cooled power supplies like Behlman's VPXtra are critical to this effort.

"Over temperature will damage or shut down critical electronic systems and, therefore, requires you pay careful attention to the actual thermal performance of the system and be aware of every aspect of the thermal cooling path. Chassis design and tolerances as well as all conductive elements are critical to system performance," Hovdestad advises.

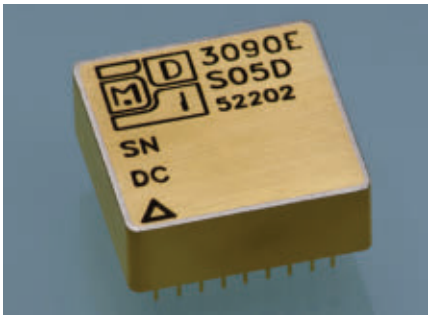
new PRODUCTS

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

POWER ELECTRONICS

DC-DC converter for military and civil aviation uses introduced by Modular Devices

Modular Devices Inc. (MDI) in Shirley, N.Y., is introducing the series 3090 compact DC-DC converter for aerospace, defense, and civil aviation airborne electronics applications. The



power electronics device meets MIL-STD-461 D, E and F without need for external EMI filtering, and enables efficient compliance with electromagnetic interference compatibility requirements for aerospace and defense applications. The series 3090 5-watt DC-DC converters operate from nominal 28-volt DC power sources. Models are available with single or dual outputs, and are packaged in a hermetic case that measures 1.08 inches square by 0.380 inches. The 3090 design can operate through MIL-STD-704A 80V/100mS power line transients.

FOR MORE INFORMATION visit **Modular Devices** online at *www.mdipower.com*.

COAX CONNECTORS

No-solder connector introduced by Times Microwave

Times Microwave Systems in Wallingford, Conn., is introducing the EZ-500-NMH-X type N no-solder male (plug) straight connector for LMR-500 low-loss coaxial cable in RF and microwave applications. The crimp-style connector neither requires soldering of the center conductor into the contact, nor braid trimming, making it suitable for field installations. The EZ-500-NMH-X is compatible with the CST-500 cable prep tool and the HX-4 (with Y151 dies) crimp tool. Other features include combination hex/knurl coupling nut; EZ spring finger contact; tri-metal plating instead of silver (eliminates tarnishing); chamfered cable entry hole for ease of termi-

nation; ridged landing area on the aft end for better grip and sealing of the heat shrink boot; and impedance matching for low VSWR.

FOR MORE INFORMATION visit **Times Microwave** online at *www.timesmicrowave.com*.

NETWORKING

Rugged COM Express Ethernet switch introduced by Diamond

Diamond Systems Corp. in Mountain View, Calif., is introducing the Epsilon-12G2 rugged managed Layer 2+ Ethernet switch COM Express module for rugged military, on-vehicle, and industrial applications. The

Ethernet COM Express module offers 12 10/100/1000-megabit-per-second copper twisted-pair ports and two-small-form-factor pluggable (SFP) sockets. The standalone switch does not require any host computer interface. A 480 MHz MIPS processor embedded into the switch manages all switch functions. The embedded computing processor is accessed via an in-band Web interface over one of the Ethernet ports or via an out-of-band command-line interface over an RS-232 serial port. The integrated Web interface provides an intuitive graphic user interface (GUI) for configuring and managing switch functionality.

FOR MORE INFORMATION visit **Diamond Systems** online at *www.diamondsystems.com*.

RF ICS

E-band MMIC power detector for communications, test, sensors, and RF detection introduced by Hittite

Hittite Microwave Corp. in Chelmsford, Mass., is introducing the HMC7447 E-band MMIC power detector for RF and microwave applications in communications systems, test equipment, sensors, and general-purpose RF detection over the 71 to 86 GHz frequency range. The HMC7447 power detector provides a linear output voltage over a -0.5 to +23.5 dBm input power range with insertion loss of 0.45 dB and typical input return loss of 19.5 dB.

For monitoring transmitter operation or enabling closed loop transmitter output power, the detector exhibits sensitivity and a frequency response of plus-or-minus 0.2 dB over the 71 to 86 GHz frequency band. Available in die format, the HMC7447 has I/Os that are internally matched to 50 Ohms and require no external matching components.

FOR MORE INFORMATION visit **Hittite** online at *www.hittite.com*.

THERMAL MANAGEMENT

TECA debuts thermoelectric air conditioners for space and energy savings

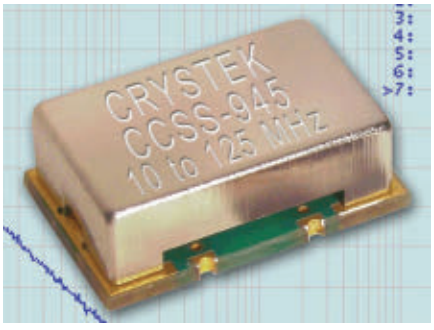
TECA Corp. in Chicago introduces a large, flush-mounted thermoelectric air conditioner for electronics enclosures with limited space. Flush-mounted air conditioners provide cooling without physical intrusion into the enclosure. TECA's new air conditioners mount flush against the enclosure without the aid of additional frames, flanges, or accessories. Environmental gasket and hardware are included to preserve the environmental integrity of the enclosure. TECA's newly expanded line allows for reliable thermoelectric cooling in larger applications. TECA's newest flush-mounted thermoelectric air conditioners are configured for environments, including NEMA-12, NEMA-4, and NEMA-4X.

FOR MORE INFORMATION visit **TECA** online at *www.thermoelectric.com*.

RF AND MICROWAVE

True sinewave clock oscillators for low-noise RF performance introduced by Crystek Crystals Corp.

Crystek Crystals Corp. in Fort Myers, Fla., is introducing the CCSS-945 true sinewave clock oscillator (XO) for RF and microwave applications requiring ultra-low-noise performance similar to more expensive OCXO crystal oscillators. The CCSS-945 provides -170 dBc/Hz noise floor at 1 MHz offset. The close-in phase noise performance is an -105 dBc/Hz typical at 10 Hz offset. The device is available in the industry standard 9-by-14-millimeter SMD package. The device is designed to MIL-STD-883 and MIL-STD-202 specifications. Versions for an extended-temperature operating range of -40 to 85 degrees Celsius and other custom specifications also are available. The CCSS-945 clock oscillator generates frequencies between 10 MHz and 125 MHz, with output level of +5 dBm min into 50 Ohms and harmonics lower than -25dBc. The CCSS-945 consumes 30 milliamps maximum current at 5 volts and has no sub-harmonics.



FOR MORE INFORMATION visit **Crystek Crystals Corp.** online at *www.crystek.com*.

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Michael Dowd

An executive discusses rad-hard microelectronics in aerospace projects.

For what platforms has Maxwell Technologies delivered solutions?

Maxwell has been providing components and computers to space projects for more than 20 years. Recent high-profile projects include: Gaia and Galileo (Europe), GLONASS (Russia), and Mars rovers Spirit, Opportunity, and Curiosity (U.S.).

What is unique about Gaia?

The European Space Agency's Gaia satellite will survey more than 1 billion stars and other celestial bodies during its five-year mission [helping] to create a 3D map of the Milky Way galaxy. Gaia was developed by European aerospace companies with Airbus Defense and Space's France-based unit (formerly Astrium) serving as the prime contractor and payload provider. Maxwell supplied SCS750 single-board computers to Airbus Defense and Space's United Kingdom-based unit, which provided Gaia's video processing units (VPUs).

What were the requirements, and what set your solution apart?

The SCS750 was the only single-board computer available combining the right levels of processing power, radiation performance, and technological maturity.

High-performance processing solutions in space typically rely on one-time programmable components, such as field-programmable gate arrays (FPGAs) or application-specific integrated circuits (ASICs). Both are extremely fast but cannot be changed once programmed. Gaia wanted the ability to change the VPUs' video-processing algorithm during ground-based development and flight thus making a system heavily dependent on FPGAs or ASICs undesirable.

On the other hand, traditional space-level computers, while flexible, did not provide enough computing horsepower for Gaia. Traditional space-level computers run anywhere from 40 to 300 million instructions per section (mips), which was not enough processing power to achieve Gaia's scientific goals.

Gaia's video processing algorithms were implemented in both hardware and software. Each VPU utilizes FPGAs to identify and select objects of interest on the focal plane array. A SCS750 running at 1,000 mips continues tracking and collecting data about an object as it continues moving across the focal plane array.

What are the challenges to engineering electronics for space?

The main challenge of fielding a space-qualified system is radiation performance—total ionizing dose, single-event upset, and single-event latch-up—which, in turn, leads to a host of other challenges. Unlike commercial designers who can pick any part they find on the Web, space designers must restrict component choices to a small subset of approved components. This subset is skewed toward older technologies leading to systems consuming more power and providing less performance compared to terrestrial equivalents. Maxwell's strategy is geared toward turning this paradigm on its head. ←

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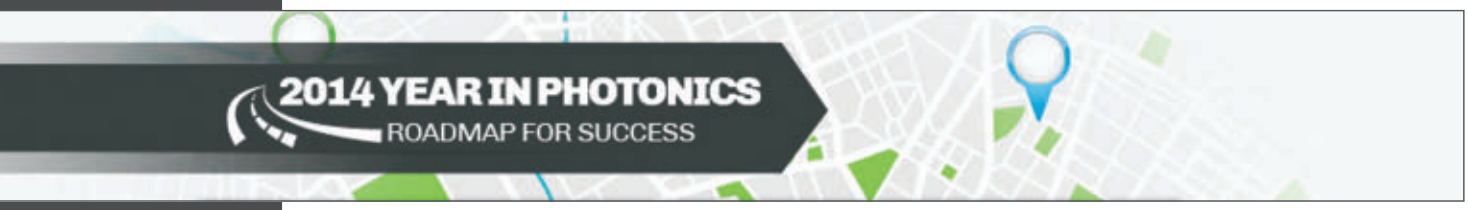

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