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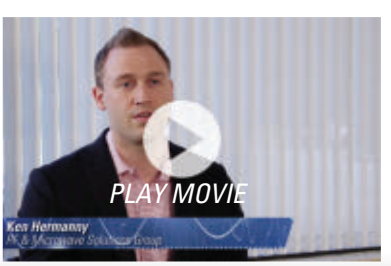

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Military & Aerospace Electronics

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ENABLING TECHNOLOGIES FOR NATIONAL DEFENSE

Laser weapons

Navy takes shipboard high-energy laser to sea. PAGE 4

Rugged embedded computing

Data and signal processing excel in tight spaces and harsh environments. PAGE 18

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Keeping an ear to the ocean

Sonar technology comes to grips with dangerous new era, as anti-submarine warfare (ASW) faces resurgent adversaries. PAGE 6

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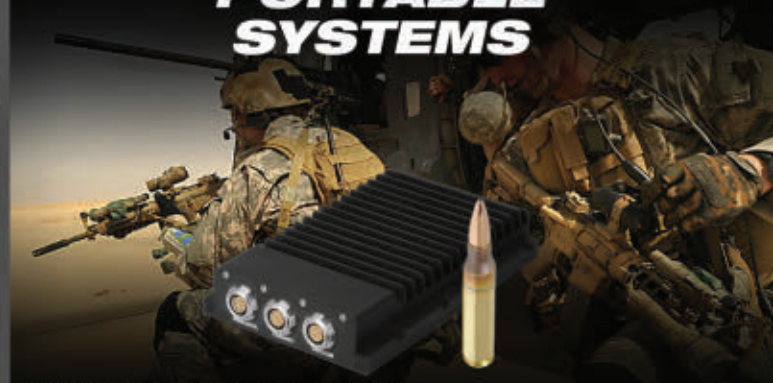

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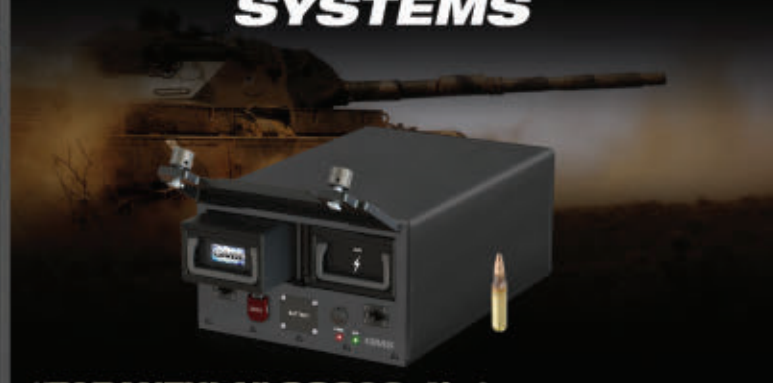

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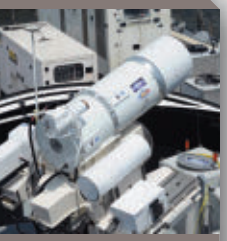
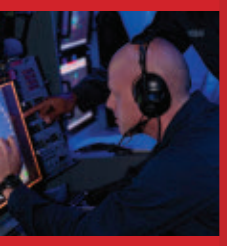
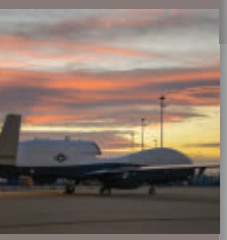
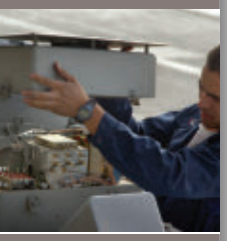




COVER STORY





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BY **JOHN KELLER**, EDITOR IN CHIEF

Plenty of changes as Mil & Aero celebrates 25 years

Welcome to *Military & Aerospace Electronics* 2015, as we celebrate our 25th year in publication. We've seen a lot of changes in our quarter-century at *Mil & Aero*, and this issue rings in a few more as we position ourselves for our next 25 years.

First, this is our inaugural issue containing the new RF and Microwave department that will bring you the latest news, analysis, features, contract awards, procurement opportunities, and standards related to military radio-frequency and microwave technology development and integration.

The RF and Microwave department in *Military & Aerospace Electronics*, as well as its companion RF and Microwave topic center on the *Mil & Aero* website (www.militaryaerospace.com) seek to be on the cutting edge of aerospace and defense RF and microwave technology coverage to keep you up to date in your busy careers.

Twenty-five years ago *Military & Aerospace Electronics* was much different from how it is today. Those were the days before the ubiquitous Internet. When we put volume 1, number 1 to bed in December 1989, we were a print magazine. Period.

Today we're a print magazine, and so much more. We have a vibrant *Military & Aerospace Electronics* website, along with our sister website *Intelligent Aerospace*, run by longtime *Mil & Aero* editor Courtney Howard.

In addition *Military & Aerospace Electronics* publishes 12 to 13 e-newsletters for subscribers each month, which includes two entirely new e-newsletters publishing for the first time this month.

We publish e-newsletters on each Wednesday and Friday of the week, as well as our Defense Executive business e-newsletter on the first Tuesday of each month, the Embedded Computing e-newsletter on the second Monday of each month, and our Unmanned Vehicles e-newsletter on the third Tuesday of each month.

Beginning this month, you can look for a quarterly e-newsletter on electronic warfare publishing on 27 Jan., 28 April, 25 Aug., and 27 Oct. To go with that, we will publish our first monthly Cyber Warfare e-newsletter on 29 Jan. and on each of the last Thursdays of the month thereafter.

When we published our first regular issue in January 1990, we were a tabloid magazine. I was the magazine's managing editor working with Chief Editor Tobias Naegele.

The big technologies then included VME embedded computing, sophisticated databuses in ring and linear topologies, gallium arsenide integrated circuits, supercomputers, and solid-state data storage.

Commercial off-the-shelf (COTS) as a term hadn't even been invented in 1990. At that time, there hadn't been a prolonged shooting war since the end of Vietnam, and we had no way of knowing that just a year later the nation would go to war for the first time in Iraq during Operation Desert Storm. Since then we've seen additional wars in Iraq and Afghanistan, as well as military operations in Bosnia and other places around the world. It's been an eventful 25 years to say the least.

When I started at *Military & Aerospace Electronics* in September 1989 I was just 30 years old and eight years out of college. Now I'm 55 and a grandfather.

Thank you to everyone I've been involved with over the years. The names include Tobias Naegele, the magazine's founder. Other names include Kick Kielb, Gene Pritchard, Lisa Burgess, Charlotte Adams, Bruce Rayner, Lisa Coleman, Kelly Sewell, Amy McAuliffe, John Miklosz, Ron Mastro, Phil Davis, Courtney Howard, John McHale, John Haystead, Ben Ames, Ernesto Burden, Jay Mendelson, Christine Shaw, Alan Bergstein, Bob Collopy, J.R. Wilson, and so many others to whom I apologize for not mentioning.

Here's to 25 years more.

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Navy laser weapon kills boats and UAVs during three-month at-sea tests

BY JOHN KELLER

ARLINGTON, Va.—U.S. Navy researchers have completed three months of at-sea testing of a shipboard high-energy laser weapon that could bring deck-mounted machine gun-like defensive capability to U.S. and allied surface warships at a fraction of the cost.

A new Navy shipboard laser weapon has shown promising results after three months of operational testing in the Persian Gulf.

Naval personnel deployed and operated the Laser Weapon System (LaWS) aboard the amphibious transport dock USS Ponce from September to November in the Persian Gulf, according to officials of the Office of Naval Research (ONR) in Arlington, Va. The LaWS operational demonstrations showed a laser weapon can work aboard a deployed U.S. Navy ship seamlessly with existing ship defense systems.

"We ran this particular weapon, a prototype, through some extremely tough paces, and it locked on and destroyed the targets we designated with near-instantaneous lethality," says Rear Adm. Matthew Klunder, chief of naval research. "Laser weapons are powerful, affordable, and will play a vital role in the future of naval combat operations."

During the tests, LaWS hit targets mounted aboard a speeding oncoming small boat, shot a Scan Eagle unmanned aerial vehicle (UAV) out of the sky, and destroyed other moving targets at sea. Sailors reported the weapon performed flawlessly in high winds, heat, and humidity.

Operated by a video-game-like controller, the system can address several different kinds of threats using options ranging from non-lethal measures like optical dazzling and disabling, to lethal destruction.

The LaWS demonstrations are expected to lead to solid-state laser weapons for vessels such as guided-missile destroyers and the Littoral Combat Ship in the early 2020s. LaWS-developed technologies also could be applied to airborne and ground-based laser weapons.

Shipboard laser weapons not only offer precision and speed, but are safer to operate than traditional deck-mounted weapons because lasers don't rely on dangerous propellants and gunpowder. Lasers run on electricity and can be fired as long as there is power. They also cost less to build, install, and fire than traditional kinetic weapons like expensive missiles, Navy officials say. ←

IN BRIEF

Trident moves to next-generation submarine

U.S. Navy submarine experts plan to equip future ballistic missile submarines with the UGM-133 Trident II nuclear missile, an advanced submarine-launched atomic missile. The Navy Strategic Systems Programs office in Washington is awarding a potential $99.2 million contract to Lockheed Martin to integrate the Trident II onto next-generation ballistic submarine designs of the U.S. and United Kingdom. Lockheed Martin will integrate the Trident II missile and reentry strategic weapon subsystems into the common missile compartment for Ohio replacement and U.K. successor submarine programs.

G/ATOR to switch from Windows to Linux OS

Officials of the Marine Corps Systems Command at Quantico Marine Base, Va., are switching the software operating system (OS) in the Ground/Air Task-Oriented Radar (G/ATOR), designed to protect Marines from rockets, artillery, mortars, cruise missiles, and unmanned aerial vehicles. Northrop Grumman Electronic Systems in Linthicum Heights, Md., will convert the G/ATOR operator command and control computer from Microsoft Windows XP to the Linux OS. ←

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Sonar technology comes to grips with dangerous new era

Sonar Technician 3rd Class Benjamin Obryan, bottom, and Operations Specialist 1st Class Lawrence Bedeau monitor the Anti-Submarine Warfare Module aboard the aircraft carrier USS George Washington.

Anti-submarine warfare (ASW) efforts face a militarily resurgent Russia, a strengthening China, and proliferating quiet diesel-electric submarines that could shift the global naval balance of power.

BY **J.R. Wilson**

During the last five days of October 1962, U.S. Navy warships, guided by surface, sub-surface, and airborne anti-submarine warfare (ASW) sensor data, launched numerous practice depth charges at Soviet submarines violating the Cuban Missile Crisis blockade. The actions were in accordance with the "Submarine Surfacing and Identification Procedures" released earlier that month.

ASW technology at the time included AN/SSQ-23 Julie, AN/SSQ-57B LOFAR (Low Frequency Acquisition and Ranging), and AN/SSQ-28 Jezebel sonobuoys, magnetic anomaly detection (MAD), radar, SQS-26 sonar, and SOSUS (Sound Surveillance System).

The Soviet submarines were seen as a threat to U.S. ships enforcing the blockade and as possible transports for nuclear warheads. The threat was considered so significant that Attorney General Robert Kennedy said "the President ordered the Navy to give highest priority to tracking the submarines and to put into effect the greatest possible safety measures to protect our own aircraft carriers and other vessels."

On the other side, Soviet Premier Nikita Khrushchev warned a visiting American businessman that Soviet submarines would attack any American ship that stopped a Soviet ship.

Despite having received a copy of U.S. naval orders limiting "signaling" to practice depth charges, many Soviet submariners believed they were under real attack. That misunderstanding was compounded by American military belief that all Soviet subs

in the area were armed only with conventional weapons. It was not known until decades later that Soviet submarine commanders were under orders to launch nuclear-tip-ped torpedoes against any U.S. warship trying to force them to surface—and two captains ordered those weapons assembled and prepared for launch before deciding to stand down.

It was the greatest exercise of ASW technologies and capabilities since the end of World War II and the last time the U.S. Navy used force (even if only practice depth charges) against a foreign submarine.

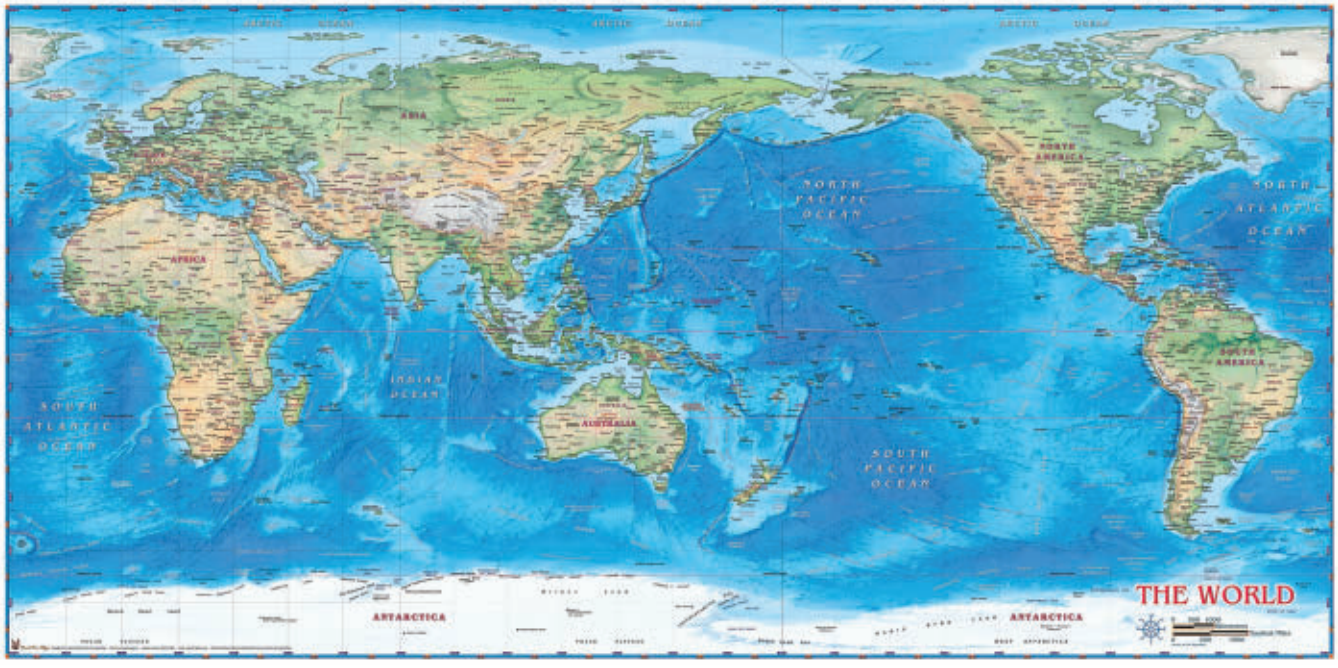
Cold War legacy

While ASW was a major element in the Cold War, other than the Cuban blockade, it was in the form of "hide-and-seek" engagements between the U.S. and Soviet navies. With the collapse of the Soviet Union and end of the Cold War three decades later, the U.S. became the world's only superpower, facing no adversarial blue-water navy.

That began to change in the 21st Century with dramatic increases in Chinese military spending (building a major submarine force as part of its evolving blue water fleet), the re-emergence of aggressive Russian military activity (building new submarines), hostile actions by the North Korean navy (and its small fleet of small subs), and even the broad use of "semi-submersibles" by Latin American drug cartels.

"There are competitors that are pursuing us. We know about China... but not as many people know what the Russians are up to," said Adm. Jon Greenert, Chief of Naval Operations, at the Naval Submarine League's symposium last October. "I can't go into detail, but they spend a lot of money. The Russians have been working on a sea-based strategic deterrence—and an SSN [nuclear-powered attack submarine]."

Next-generation submarines are key to the future evolution of the world's top naval forces. Next-generation unmanned underwater vessels (UUVs), performing many missions now conducted by manned surface and subsurface vessels, are expected to become a potent platform for ASW. Tracking small, fast, quiet UUVs will place even greater demands on ASW sensors and processing capability.



World map showing the overwhelming size of the Pacific and Indian Oceans, which cover half the Earth's surface.

U.S. Navy submarines

"With the collapse of the Soviet Union, the submarine threat diminished and the surface warfare community shifted focus from ASW to support other emerging mission areas... Our ASW proficiency suffered, as our ASW experience-based knowledge dwindled to the point where the Navy would have been challenged against a modern-day subsurface threat," says Capt. Charlie Williams, deputy for weapons & sensors, Navy Surface Warfare Directorate (N96).

"Today, with our renewed emphasis and shift to the Pacific, the surface Navy must reclaim the ASW battlespace if we are going to be successful in this new era... From the Surface ASW perspective, quieter submarines, emerging submarine tactics, and advanced weapons are potential challenges to our carrier strike group and expeditionary strike group operational concepts—and to the Surface force's ability to own the inner screen and defend the strike group. To meet this evolving threat and maintain our naval dominance, we must adapt."

Since 2007, the primary surface Navy ASW system has been the AN/SQQ-89A(V)15 undersea warfare combat system. "With the A(V)15, you have the base system, then a tech refresh every other year. Anything is easily upgradable aboard the ship, during a scheduled overhaul or in-port maintenance period," says Senior Chief Petty Officer Matthew Swanson, a Center for Surface Combat Systems sonar technician under the Naval Education & Training Command. "The whole suite comprises a multifunctional towed array [MFTA], sonobuoy capability, etc.

"It's currently on destroyers and some cruisers and works equally well detecting diesel- and nuclear-powered submarines," Swanson says. "When it comes to sonar and sound-travel, you have unlimited capability to exploit sounds from any depth. We are able to better exploit natural phenomenon in the ocean than was the case with older systems... which were built on hardware and limited by space on the ship. The new ones are more software-centric, making them easier to upgrade, faster, with better displays and capabilities."

Naval Sea Systems Command's (NAVSEA's) Program Executive Office-Integrated Warfare Systems develops common software for submarines, surface ships, and surveillance ships. Since 2011, the PEO-IWS5's Undersea Systems office has co-sponsored a series of Tactical Advancements for the Next Generation (TANG) workshops, alternating between senior and junior Navy submarine officers and sonar and fire-control technicians brought together to improve the capabilities of the fleet and its crews, with emphasis on ASW.

"A couple years ago, we realized we were pushing a lot of new technology onto submarines and overwhelming the operators. So we started a design thinking process: TANG.

Seen here being launched from the USS Roosevelt (DDG-80), the Mark 54 is an ASW torpedo that can be fired from surface ships and from most ASW aircraft.

We brought in E-5 and lieutenant-level people who had grown up using iPads and they realized the equipment we were giving them aboard ships was incredibly powerful, but not very intuitive," explains Capt. Steve Harrison, Undersea Systems Program Manager. "Through the TANG process, we have made some significant advances in that area. We've now expanded that beyond the sub side to the surface Navy and surveillance systems, so it has gained a lot of traction throughout the Navy, including how we do maintenance."

The current state-of-the-art in ASW relies on acoustic sensors which allow for distance detection, although other technologies are in place or under development. To improve the signal-to-noise ratio, most Navy development has been focused on signal enhancement and noise reduction.

"The larger the array, the more we can improve that resolution and reject the noise by getting the sensor as far away from the ship as possible, which is why towed array is the most common," Harrison explains. "We're still working to improve the size of sensors and get them away from the ships. In recent years, in addition to improving software processing, we've been restoring towed arrays on surface ships—MFTA. We're also putting new arrays on subs, such as the flank array, and generally doing lots of R&D."

MFTA went into production in 2008 as a replacement for the legacy submarine AN/SQR-19 Tactical Towed-Array Sonar (TACTAS). The dual active/passive AN/SQR-20 (aka TB-37U) MFTA is the surface ship version, the first U.S. Navy surface array to be built in 25 years. Able to listen silently or send out an active sonar ping in its search for enemy

The Zumwalt-class guided-missile destroyer DDG 1000 is floated out of dry dock at the General Dynamics Bath Iron Works shipyard.

submarines, it also provides better coverage, detection, and reliability.

MFTA is being installed as planned upgrades to Arleigh Burke-class guided missile destroyers and Ticonderoga-class missile cruisers, and is scheduled as part of the AN/SQQ-90, the first dual-frequency hull-mounted sonar, on the DDG-1000 Zumwalt-class guided missile destroyer, and as part of the ASW mission package aboard the LCS. Due to their light weight and streamlined shape, towed arrays are seen as significant additions to future unmanned anti-submarine surface vessels.

"Sensors to us are not just the interface with a hydrophone, transducer, etc., but also the human interface," explains Pete Scala, PEO-IWS5's director of advanced development undersea-sensors. "Improving sensors is the most expensive because you're building hardware. Larger arrays allow for narrower beams, which makes it more accurate to locate items and reject noise. In addition to towed arrays, we have to develop technologies that can help us separate the array on the ship from the ship's own noise.

"That is more difficult with a surface ship because they have a lot of noise associated with the air/water interface. Submarines are not easy," Scala says. "Because we are down deep, we're in the field with the energy a lot more than the surface guys and sub arrays are more sensitive than surface arrays. First, because we can be and, second, because we have built submarines for years and years to be as quiet as possible, while only in recent years they have tried to get surface ships quieter."

Diesel submarines are generally more difficult to detect than nuclear-powered boats because they spend most of their submerged operations running on batteries while nuclear reactors are noisy and always in operation. That is especially true of new-generation diesels that can stay submerged for as long as two weeks using fuel cells.

"In the last 15 years or so, we have completely revolutionized how we do signal processing on subs and surface ships. Since 1998, we also have used acoustic rapid COTS insertion rather than developing our own MIL-SPEC stuff. In addition, we develop a new hardware build every couple of years to manage obsolescence as a technology insertion," Scala adds. "On alternate years, we develop complementary software, which involves lots of tricks to reduce noise, make it more intuitive to operators and increase automation so the operator can spend more time analyzing what he's seeing. So automation and human interface are areas where we have made huge progress."

The U.S. fleet of nuclear-powered ballistic submarines has dropped from 41 at the height of the Cold War to only 14 today. At the same time, the subsurface Navy is facing a rising challenge from China, which is moving from regional power to Pacific (and potentially global) superpower status. At the same time, Russia announced plans to rebuild the naval capability once deployed by the Soviet Union, including a rebuilt submarine fleet based in the near-term around the Akula II-class of modern fast attack submarines, but moving into more advanced technologies and capabilities with the new Yasen-class.

With the growth of quieter, longer range new-generation submarines within the world's top navies, the growing development by potential adversaries—including Iran and North Korea—of anti-surface ship missiles and tactics and the expansion of undersea anti-access, area-denial (A2/AD) efforts, continuously improved ASW capabilities have become critical factors in U.S. military planning and deployment.

"We need to be ready for Russia, China, Iran, or whoever else who seeks to develop an A2/AD-like network underwater to match what many of them currently have on the surface and in the air. We know that is going to happen," warned Vice Adm. Michael J. Connor, triple-hatted as commander of U.S. Submarine Forces (COMSUBFOR), Submarine Forces Atlantic (COMSUBLANT) and the Allied Submarine Command.

The U.S. Navy plans to begin construction of a new-generation of Ohio-class, nuclear-armed ballistic missile submarines by 2021 called the Ohio Replacement program, Connor added. In addition,

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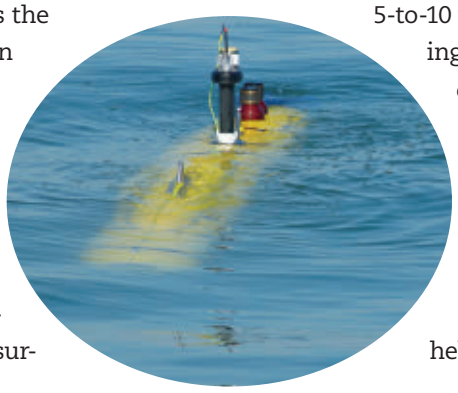
the Virginia-class and its anticipated mid-century replacement, the SSN(X), are scheduled to receive extremely long-range networked weapons, possibly including a prototype torpedo with a range of more than 200 nautical miles. The network interface would enable targeting data for a torpedo launched by the sub to come from another platform, including aircraft such as the Boeing P-8 Poseidon or UAVs.

"We have been making efforts to develop new sensors, but starting in the 1990s with submarines and now on surface ships we've been significantly improving processing," Harrison says. "That's called Advanced Processing Build on subs and Advanced Capability Build on surface ships. In 2009, on the surface side, in addition to MFTA, we lifted the processing capability developed for submarines, put it on surface ships and changed their old technology to state-of-the-art—a huge game-changer.

"We've seen several new developments in sensors, such as the large aperture bow array (which went to sea on its first sub, the USS North Dakota), MFTA on surface ships, a new towed array that has the same functionality but is more reliable (Compact Towed Array), and a high-frequency sonar; the higher the frequency, the smaller the sensors and array. That allows subs to see behind them, which is called the Low-Cost Conformal Array, with some of the processing embedded with the hundreds of sensors in the array."

Single crystal hydrophones and transducers have been in development for a number of years, providing greater efficiency with smaller size and less heat, but Harrison says they also are expensive and currently suffer from a high rejection rate due to flaws, "so that is probably 5-to-10 years from fielding." Another area of development is vector (directional) sensors, where the sensor only hears from a certain direction, which helps reduce noise. "Those will probably be in both surface and submarine towed and conformal arrays in another five years."



A prototype Submarine Hold at RisK (SHARK) unmanned underwater vehicle (UUV) conducts deep-sea testing for DARPA's Distributed Agile Submarine Hunting (DASH) program.

Scala adds that while the U.S. has an advantage over potential adversaries, "they are spending a lot of money to improve their submarines and ASW capabilities. There was a time when we were resting on our laurels. Today, we are working hard to maintain our competitive edge.

"A North Korean sub sank a South Korean warship a couple years ago, which pointed out the importance of ASW to Navy surface ships, so they can detect a torpedo in time to do something about it. We're not trying to look like a whale on subs—we're trying to not look like anything. On surface ships, DDG1000 is the major effort to reduce the signal profile."

The U.S. also is expanding ASW surface and aviation capabilities. In the 27 August 2014 issue of the U.S.

Naval Institute's *Proceedings* magazine, Lt. Cmdr. Jeff W. Benson of the Navy Surface Warfare Officer's School discussed those developments. "To meet expanded foreign submarine operations and UUV technological advancements, the U.S. surface naval force employs state-of-the-art ASW technology aboard numerous Arleigh Burke-class destroyers. The SQQ-89A(V)15 Combat System, which will be aboard 64 destroyers by 2020, and the new MFTA are game-changers in ASW operations. The combined capabilities alter how the surface Navy searches and tracks submarines. With enhanced sensor capability and data processing, the surface naval forces have an increased role in integrated ASW operations. ASW surface ships can remain longer on station in comparison to aircraft and provide real-time command and control capability beyond that of a submarine," he wrote. "In stride with the surface Navy's technological advancements, the aviation community has new platforms to meet the ASW mission. The MH-60R Sea Hawk helicopter and P-8A Poseidon aircraft are to be fully integrated in the fleet by 2020 [and] are already providing an improved ASW capability in fleet operations... The rotary aircraft has an enhanced active dipping sonar to increase detection ranges from three to seven times compared to legacy systems.

The littoral combat ship USS Freedom (LCS 1) is designed for surface warfare, anti-submarine warfare, or mine countermeasures.

"The P-8A adds an improved sensor search capability by utilizing a

multi-static active coherent (MAC) system, which comprises sonobuoys (source and receiver) and advanced processing. In addition to the new platforms and technological advancements, all ASW ships and aircraft in the future will employ the Mk 54 lightweight torpedo, which integrates several years of weapons technology. By 2020, these new improvements collectively in the surface and aviation communities will create a powerful ASW capability. The Navy must further improve requisite training to meet the new capabilities and foster a fleetwide culture that prioritizes the ASW mission."

Meanwhile, the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., has been pursuing two ASW programs: Distributed Agile Submarine Hunting (DASH) and ASW Continuous Trail Unmanned Vessel (ACTUV). DASH was designed to reverse the asymmetric advantage of the threat from quiet new submarines through the development of advanced standoff sensing from unmanned systems.

"The goal is not only to show we can address the most challenging problem in ASW, but that we can do so with systems that are scalable and affordable," DARPA Program Manager Andy Coon says. "A single deep-sea node provides a field-of-view with significant coverage, allowing a limited number of nodes to scale to large areas. Within the trade space of deep ocean sonar, we need to get creative to achieve affordable hardware and operations. We purposely have avoided increasing the size and complexity of arrays. This is a gamble, but the potential payoff will be high."

ACTUV involves development of an unmanned vessel optimized to track quiet diesel electric submarines. "Key features and technology for the vessel includes advanced software, robust autonomy for safe operations in accordance with maritime laws and innovative sensors to continuously track the quietest of submarine targets," says Scott Littlefield, DARPA program manager.

Sonar Technicians aboard the guided-missile destroyer USS The Sullivans (DDG 68) monitor sonar equipment during the Southeastern Anti-Submarine Warfare Integrated Training Initiative.

China ASW efforts

"China has centered its new-and-improved PLA Navy mainly on diesel-electric attack boats, importing some and building its own, while also experimenting with nukes," U.S. Naval War College professor of strategy James R. Holmes, a specialist in U.S., Chinese and Indian maritime strategy, wrote in the online magazine *The Diplomat* on 30 October 2014.

In the past quarter century, China has grown from a primarily littoral, regionally focused navy to a rapidly growing blue-water force, including Jin-class Type 094 ballistic submarines with JL-2 nuclear intercontinental ballistic missiles (ICBMs).

A February 2014 ONI assessment says the Chinese navy now has the ability to meet a wide range of missions, including being "increasingly capable of striking targets hundreds of miles from the Chinese mainland." They also are practicing operations off the shores of China's neighbors.

The JL-2 missile has a range of 4,000 nautical miles, enabling "the Jin to strike Hawaii, Alaska, and possibly western portions of the continental U.S. from East Asian waters, ONI reported, noting the Chinese underwater fleet comprises five nuclear attack submarines, four nuclear ballistic missile submarines, and 53 diesel attack submarines—and is growing.

"The type-095 guided missile attack submarine, which China will likely construct over the next decade, may be equipped with a land-attack capability," ONI continued—an enhanced ability to strike American bases throughout the Pacific.

All this has made China a growing target of ASW/USW (undersea warfare) development/deployment by a host of potential adversaries, from the U.S. to Vietnam. The sheer volume of the submarine challenge facing PLAN for the foreseeable future has led the Chinese to explore new, cheaper, more inclusive ASW technologies. An article in the April issue of *Proceedings* noted Chinese reports have indicated Beijing "has deployed fixed ocean-floor

A rare occurrence of a 5-country multinational fleet, during Operation Enduring Freedom in the Oman Sea, tasked with surface, air, submarine, information and anti-submarine warfare.

acoustic arrays off its coasts, presumably with the intent to monitor foreign submarine activities in the near seas."

China is following the path of the former Soviet Union's evolution from a littoral to blue-water navy with respect to ASW, which is considered more important to expeditionary than A2/AD deployments. As a U.S. Navy vice admiral told *Military & Aerospace Electronics*, "You don't build a blue-water navy to protect your own coasts, you build it to force someone else to protect theirs."

What is happening in the Asia/Pacific is an action-reaction-counteraction-repeat scenario, not unlike the land force armor/anti-armor history of technological one-upmanship. While ASW has risen in importance within PLAN, Chinese strategy—at least in the near-term—appears more focused on A2/AD.

"Both China and North Korea have a large underwater warfare capability with their submarine forces," Swanson says. "Our systems were not built specifically around a certain country or threat, but as an overall capability for both blue-water and littoral areas, so you have more flexibility."

The expanding numbers and capabilities of PLAN submarines and big ships are, in part, reflective of its concern about a potential future conflict in which American, Japanese, Australian, Indian, or other submarines might want to sink them. That has led to a growing commitment of Chinese money and R&D to developing ASW, which has been one of the biggest holes in Chinese military capability. In recent years, that has included deploying the Type 056 Corvette, Y-8 maritime patrol aircraft, and fixed underwater acoustic sensors.

According to reports on China's

U.S. Navy and Japan Maritime Self-Defense Force Sailors plot subsurface contacts in the combat direction center aboard the Arleigh Burke-class guided-missile destroyer USS Stethem (DDG 63) during a surface ship anti-submarine warfare exercise.

major maritime requirements, one near-term project may be a long-range ASW surface warship, intended to reduce the foreign threat to its growing fleet of aircraft carriers, cruisers, and amphibious warships—a concern shared by the U.S. and every other maritime nation.

Russian submarine work

Rear Adm. Dave Johnson, Naval Sea Systems Command's PEO-Submarines, keeps a model of the new Russian nuclear guided missile submarine (SSGN) Severodvinsk where he can see it every day at work.

"We'll be facing tough potential opponents; one only has to look at the Severodvinsk. I am so impressed with this ship that I had Carderock build a model from unclassified data," he admitted during the Navy Submarine League symposium, referring to NAVSEA's center of excellence for ships and ship systems. "The rest of the world's undersea capability never stands still."

Construction on the Yasen-class Severodvinsk began in 1993, leveraging Soviet technology from the previous two decades to build a successor to the Akula-class to compete with the U.S. Seawolf- and Virginia-class nuclear-powered subs. The post-Soviet Russian economy could not support sustained development of a new submarine, delaying its sea trials until late 2011 and becoming operational until early 2014.

Despite its fractured two-decade development, the highly automated 13,800-ton, 390-foot long vessel is considered Russia's most capable attack submarine. With a reduced crew size, it is by far the quietest of Russian subs, capable of "silent" speeds up to about 20 knots, although some reports suggest the Severodvinsk might have a maximum speed of 35 to 40 knots. Even with its advanced technology, the Yasen-class is still noisier than the U.S. Navy's newer Seawolf and Virginia classes.

Russia has two of seven more planned Yasen-class boats under construction, although when the full complement will become operational remains unknown. Russia is primarily an ASW/USW target with numerically, if not technologically, limited deployable ASW capabilities of its own.

Asia/Pacific ASW

In the coming decades, the U.S must deal with a rapid proliferation of new-technology submarines, USW capabilities, and ASW challenges in its new focus area: the vast land and ocean masses of the Asia/Pacific.

"To guard their interests—against China, in particular—smaller Asian powers have taken to constructing or importing undersea flotillas. Japan deploys some of the most impressive diesel boats in the world. Vietnam has taken delivery of Russian-built Kilos, while more are on the way," Holmes wrote. "Taiwan wants to build submarines at indigenous shipyards. Indonesia and Bangladesh voiced interest in purchasing boats abroad. India and Australia are trying to get their submarine programs on track. And on and on."

China has territorial and political conflicts with nearly all its neighbors, but the growing number of submarines and surface warships (Chinese, U.S., Japanese, etc.) crowding the waters of that region raise new issues for everyone's ASW effort. They must not only locate, identify, and track potential adversaries, but also be

Sonar Technician 3rd Class Kenneth Peer on the Ticonderoga-class guided-missile cruiser USS Vella Gulf monitors undersea contacts during an anti-submarine warfare drill.

sufficiently advanced to discriminate allied or non-adversarial vessels.

A major "passive" counter-ASW modality for the U.S. Navy is its submarine fleet patrolling two oceans (Pacific and Indian) that comprise half the surface of the Earth. According to the Navy, no nation has the resources to build enough ASW platforms to find those subs in the open ocean. Even within 200 miles of a foreign coast, America's new- and next-generation subs, built with stealth shaping, materials, and noise reduction, will be more difficult to detect.

The big picture

While the U.S. Navy develops the Undersea Dominance Campaign Plan, the competition for use of the undersea domain is critical as China, Russia, and many others invest heavily in undersea technology, diminishing the asymmetric advantage the U.S. has enjoyed since World War II.

"If you look at the sea and all its priorities, ASW is right at the top, so I would expect the Navy to continue putting an emphasis there, seeking better technologies and systems to exploit the underwater environment and improve training, which is a continual focus," Swanson says.

Maintaining a global leadership position is vital to U.S. naval superiority, Swanson adds. "ASW already is probably the most difficult warfare area with which the Navy must concern itself. You can't see it, put eyes on it, there are a lot of variables. It's a bit like playing chess, so you have to put yourself to the best advantage by putting your adversary to the greatest disadvantage. The ocean is a big medium and you have to have a way to track and localize unmanned vessels just as you do manned, which can be just as deadly to the fleet."

In a 22 April 2014 article for the Center for International Maritime Security, Williams called tactical ASW superiority "a critical enabler to maintain forward presence and sea control and support power projection and deterrence." He added: "The time is now for the Surface force to re-dedicate itself to this most central of missions. After all, the world's most lethal power projection Navy cannot do its job if the water it operates in is threatened from below."

Critical computing

Aerospace and defense missions call for rugged, high-performance embedded computing technologies.

BY **Courtney Howard**

Bits and bytes are as critical to an aerospace and defense mission as are bullets and bombs, if not more so. Advanced computer systems are now crucial to the handling of information, vehicles, and weapons.

"As the connected battlefield becomes a reality, the armed forces are looking to deploy substantial computing power out toward the battlefield edge. That means very small, lightweight platforms where minimizing size, weight, and power consumption while maximizing performance is crucial," says Chris Lever, general manager, embedded systems, GE Intelligent Platforms in Huntsville, Ala.

Size, weight, and power

The continued emphasis on reducing size, weight, and power (SWaP) also is being driven by "the growing focus on unmanned vehicles (ground, sea, and air) where the focus is on maximizing payload by minimizing the SWaP of each individual component and subsystem," Lever says.

The Northrop Grumman MQ-4C Triton maritime patrol unmanned aircraft system (UAS) uses two flight subsystems from Curtiss-Wright Defense Solutions in Ashburn, Va. Triton will provide the U.S. Navy with persistent maritime intelligence, surveillance, and reconnaissance (ISR) coverage to detect, track, and identify maritime and littoral targets. Curtiss-Wright supplies the integrated mission management computer (IMMC) that controls the aircraft's flight, and the advanced mission management system (AMMS) that communicates with onboard sensors and relays information to the ground station.

SWaP optimization is a key trend, to deploy as much processing as possible on the platform; it helps maximize the amount of computation done on the platform itself before downlinking. "We are seeing significant pull in the VPX world for 3U subsystems and modules; most new designs are looking at leveraging 3U VPX," says Mike Macpherson, vice president of strategic planning at Curtiss-Wright Defense Solutions.

SWaP on existing vehicles

SWaP also is of growing concern for larger platforms, particularly when upgrading older, space-constrained vehicles with modern, embedded computer systems. "What we're seeing is a real need to maximize onboard computing capability, but the size of the platform is finite, as is its ability to supply power, and its weight has an impact on its speed and agility," Lever says. "Subsystems with minimal SWaP are increasingly in demand for armored vehicles, for example. The phrase we hear over again is 'smaller, lighter, faster'."

SWaP is a significant priority for military deployments, driving the adoption of 3U VPX as the board architecture of choice, Lever adds. "With 3U VPX, it's possible to

Unmanned aircraft like the Triton (below) call for rugged, space-saving embedded computing systems and components.

architect a system capable of more than 2 TeraFLOPS with a thermal footprint of less than 200 watts."

BAE Systems called on Curtiss-Wright to design and develop a rugged embedded processor subsystem for use as the next-generation central processing unit (CPU) on the Bradley Infantry Fighting Vehicle. Curtiss-Wright Defense Solutions' Turret Processor Unit III (TPU III) subsystem, comprising its Fire Control Processor III single-board computer and commercial off-the-shelf (COTS) VPX3-671 Ethernet Switch, serves as the baseline for the CPU. The compact, lightweight, single-chassis solution features OpenVPX and the U.S. Army's Vehicular Integration for C4ISR/EW Interoperability (VICTORY) standard compliance. The TPU III subsystem provides high-density computing power to support processing for the Bradley's fire control system, and the VPX3-671 common processing capability supports additional functionality, such as VICTORY Databus Management Services and Condition Based Maintenance to meet the Bradley's future operational requirements.

To infuse the Bradley with in-vehicle training and simulation, engineers at BAE Systems Platforms and Services sought advanced, rugged high-performance embedded computing (HPEC) capabilities from GE Intelligent Platforms. GE is providing its 3U VPX COTS rugged systems as part of the U.S. Army's Common Embedded Training Unit (CETU).

"GE's solution is notable for its small SWaP characteristics; it can provide all the functionality required within the confined environment of the Bradley vehicle. It is particularly notable for a processor which can deliver 2 TeraFLOPS of performance in an enclosure that is about the size of a domestic toaster," Lever says.

The system includes a GE 3U VPX single-board computer with an Intel Core i7 processor and rugged graphics board that takes advantage of an NVIDIA 384-core Kepler graphics processing unit (GPU) in a rugged, 5-slot enclosure based on the GE CRS-D5I-3VC1 rugged COTS system.

"The graphics board is a result of GE's close working relationship with NVIDIA which has allowed GE to incorporate truly rugged technology rather than commercial/benign environment technology," Lever adds.

GPGPU for aerospace and defense

General-purpose GPU (GPGPU) technology is driving GE's response to SWaP constraints. It "allows significantly more processing power to be packed into small spaces, and with minimal power consumption," Lever says. "It can make a significant contribution to the armed forces' desire for greater situational awareness and autonomy of platforms.

"Take NVIDIA's Tegra K-1, technology, for example. A single processor can deliver over 300 GigaFLOPS of processing horsepower, yet consumes 10 watts or less of power," Lever adds. "It's possible to create a multiprocessor Tegra K-1 board that could deliver exponential increases in processing power in small spaces—with unbelievably low power consumption."

NVIDIA, a provider of GPGPU technology in Santa Clara, Calif., named GE as its preferred supplier of embedded GPGPU technology into harsh environments, such as those typical of military deployments, Lever says.

GE is delivering embedded computing subsystems to an as-yet-undisclosed defense customer to be deployed onboard an armored vehicle. The order includes Ethernet switches, gateway processors, data servers, and video servers that will allow the vehicle to be easily upgraded during its lifetime as new requirements and technologies emerge.

"These subsystems provide the backbone of the vehicle electronics architecture," Lever says. The Ethernet switch connects all the networked elements of the vehicle together; the gateway processor provides all the processing capability for the software to run the platform; and the data and video servers allow the vehicle to store and distribute vehicle and scenario data and video around the platform and on into the wider connected battlefield. "A strength of the GE proposal was that it was based exclusively on COTS products, minimizing program risk and cost and reducing time to first deliveries."

Consumer compute capabilities

Technology firms serving aerospace and defense customers are increasingly leveraging compact, high-performance commercial innovations.

Curtiss-Wright engineers are

leveraging server and micro-server technology. "Historically, we've been in the 'mobile' class of commercial processors, but some of the chip manufacturers are coming out with micro-server class devices that give you much more processing capability," Macpherson says.

GE is interested in processors used extensively in mobile devices, such as cell phones, Lever says. Not long ago, GE introduced the XMCM01 single-board computer in an XMC form factor and built around the ARM architecture, an industry standard in applications where high performance, small size, low weight, low power consumption, and low heat dissipation are important, such as cell phones and tablets, Lever says. "Tegra and ARM are truly consumer technologies and at the heart of true COTS products. GE is leveraging the latest in consumer technology—with everything that means in terms of leading-edge price/performance—to the benefit of the military."

Longevity and interoperability

Open standards are increasingly important to military rugged embedded computing over the years, and perhaps never more so than now.

Why is that? GE's Lever explains: "With reduced budgets comes greater focus on program longevity with superior value for money. Open standards help deliver those two vital attributes. Adhering to open standards means that a program reaching a premature 'dead end' is much less likely. Enhancements and upgrades can be almost guaranteed to be available over the long term. The armed forces are clear that open standards lead to 'future proofing'."

Interoperability, availability, and lower-priced, more-advanced options through competition also play a role. Open standards lend to "a broad choice of competing interoperable products, delivering greater flexibility in choosing the most appropriate solution, and minimizing cost," Lever says. "The plethora of development tools, knowledge, and expertise surrounding open standards mean that development times are faster, the process from design to deployment faces minimum risk, time-to-market is minimized, and competitive

advantage is increased.

"Adjacent to open standards are standards that the military is increasingly creating and mandating—standards such as VICTORY, to which GE is a contributor," Lever continues. "The initiative—implemented in an effort to resolve U.S. Army vehicle troubles created by 'bolt on' field equipment—reflects the U.S. Department of Defense's (DOD's) commitment to Modular Open Systems Architectures (MOSA) and looks to leverage COTS hardware and software and open standards to eliminate redundancy and deliver more in-vehicle space by reducing SWaP."

FACE of the future

Future Airborne Capability Environment (FACE) is another important standard. Formed in 2010 to define an open avionics environment for all military airborne platform types, it leverages industry standards to underpin open systems that are portable and robust, and that will lower implementation costs while bringing more capabilities to the warfighter more quickly, Lever explains.

Market demand also is growing for safety-certifiable solutions, especially in unmanned and manned systems where the products might be used in commercial airspace, Macpherson says. "With battlefields changing, the need can arise to cross into commercial airspace and to be able to do that we are seeing increased requirements for products to meet safety certifiability."

Northrop Grumman engineers needed embedded processor, network switch, and graphics controller modules for a cockpit digitization upgrade to the U.S. Army's UH-60V Black Hawk helicopter. They selected Curtiss-Wright Defense Solutions to supply its COTS-based, ruggedized single-board computer, network switch, and graphics display module technology to provide a digitized cockpit solution for use in the U.S. Army's UH-60V program.

The upgrade replaces the UH-60L cockpit with a scalable, integrated mission equipment package. Curtiss-Wright's DMV-186 SBC, SMS-652 network switch, and XMC-715 graphics

The BlackHawk cockpit digitization upgrade calls for rugged and compact equipment.

and video display products are being used to upgrade the avionics in the UH-60L aircraft's cockpit with digital electronic instrument displays.

"Our size, weight, power, and cost (SWaP-C)-optimized technology helps improve performance and reliability while reducing the aircraft's total life cycle cost. This success builds on our prior selection as a supplier of high-performance rugged modules in support of Northrop Grumman's FlightPro Gen II mission computer solution used on the U.S. Marine Corps UH-1Y and AH-1Z helicopters," says Lynn Bamford, senior vice president and general manager of Curtiss-Wright Defense Solutions.

The UH-60V's next-generation avionics system is aligned with the FACE standard and supports off-the-shelf software and hardware.

"Open system architecture is becoming much more prevalent in all military services, where we are seeing VICTORY standards for ground vehicles, Open Mission Systems (OMS) for the Air Force, and the Open Systems Architecture (OSA) Strategy for the Navy," Curtiss-Wright's Macpherson admits. "DOD modular system architecture mandates are becoming much more profound. With budget cuts, it is even more critical that open system architectures based on COTS technology are used as we develop systems."

Reliability and risk reduction

"Open Prime contractors, original equipment manufacturers (OEMs), and systems integrators find themselves in an increasingly difficult environment as budgets are cut and customers focus increasingly on value for money, GE's Lever says. "One outflow of that is a growing focus on minimizing risk."

Engineers at Sainsel Sistemas Navales of Madrid needed rugged embedded computing systems as part of a new mission system they are developing for an aeronautics program. They selected GE's 3U VPX SBC346 high-performance, single-board computer; ICS-8580 video capture, compression, streaming, and archiving XMC; ICS-7006a video capture XMC; PEX431 multi-fabric switch and XMC carrier card; GRA112 3U VPX high-performance graphics processor; and GBX410 3U VPX IPv6-capable, managed layer 2/3 Gigabit Ethernet switch. The initial value of the order is $1.5 million; the long term value is expected to be $7 million.

Lever calls it "a strategically

significant program for Sainsel; it was important to minimize risk in terms of potential incompatibilities, cost overrun, and time to market."

HPEC at the edge

With the proliferation of sensors of increasing resolution and capability, more and faster processing capability is being demanded to turn vast amounts of data into meaningful information that's actionable in real time, GE's Lever says.

"This demand led to the phenomenon of high-performance embedded computing, which takes the high-performance computing (HPC) architectures and hardware/software technologies deployed in the massive data centers of the likes of Google and Amazon and applies them to the needs of the world's military forces," Lever says. "Inevitably, multi-core, multi-processor computing is at the heart of HPEC, but that is supported by commercial-grade interconnects, such as InfiniBand."

Real-time data processing

There's the collection of data, via sensors, and then there's the processing of that information, Curtiss-Wright's Macpherson explains. "What our customers are trying to do is capture raw data from the sensors, distribute it, process it, and perform analytics on it as fast as possible."

Decisions are then made based on that actionable information. "Today, that whole process might take several minutes to hours; the goal now is for that process to happen in real time," Macpherson says. "In a lot of cases today, we are upgrading existing systems, where you don't necessarily get the luxury of adding new infrastructure.

"The flip side of the processing demand is the need to get the information from the sensor into the processor as fast as you can. The higher the performance of the various processing elements, the faster you need to feed the data to those processing elements," Macpherson says. "That's where high-speed interconnects and FabricX comes in." Curtiss-Wright's FabricX Initiative defines a set of interoperable modules, each utilizing the same data plane fabric, and are supported with a suite of software

tools, middleware, math libraries, and operating systems.

Compact and efficient

"The hottest trend in rugged computing today, not surprisingly, continues to be doing more with less," says Chad Hutchinson, senior engineering manager at Crystal Group in Hiawatha, Iowa. Reducing system SWaP continues to be one method to achieve customer requests for evolving military requirements. SWaP reduction helps not only meet budgetary constraints, but can also enhance operational mobility, product life, and duration of the mission.

"Closely related to SWaP is the idea of platform consolidation. The reduction of a device's footprint has become an increasingly viable option with multi-core support and processing power advancements used in rugged computing," Hutchinson says. "Not only does platform consolidation greatly improve SWaP, it also provides a base for future technology refreshes, something that is vitally important."

Hutchinson also sees the need for more real-time information gathering, processing, and communication from smaller devices. "This trend is pushing innovative design and engineering results for modularity, hot-swap functionality, higher-density compute capabilities, lower power consumption, and reduced weight."

Customization of current electronics technology is a strong trend, Hutchinson says. "Customers seek the highest performance possible in a more rugged or more reliable product than what is available through COTS. Lightweight products are becoming standard. Carbon fiber chassis are getting a lot of attention with customers who are interested in airborne solutions with rugged chassis made of lighter materials and contain more modern electronics."

Crystal Group has developed a line of ultra-lightweight carbon fiber chassis focused on meeting the needs of the commercial and military aerospace markets. The company's carbon fiber material has been "specifically engineered for superior shock/vibration performance while providing unprecedented electromagnetic compliance," Hutchinson says. The latest addition to Crystal Group's carbon fiber line is the RS2516PS18, a 2U, rack-mount unit designed to provide server-class computational capability, 24 removable hard drives, and environmental and electromagnetic compliance while weighing less than 25 pounds.

BAE Systems selected Curtiss-Wright and GE Intelligent Platforms to help infuse the Bradley Fighting Vehicle with greater compute power.

"Compute density is becoming more and more critical," Hutchinson says. "Requests asking for multiple computers, storage, and some sort of other data device in the size of what we put a single computer now has dramatically increased in the past 12 months." Rugged computer product requests also note the need for: extreme thermal performance for the both the compute part and the power part; extremely clean and efficient, electronically quiet power; extremely high data throughput recorders (greater than 1 terabyte per second, or 1TBps); and multifunction boxes that can adapt to different missions and can deploy on multiple platforms that either are or go into severe environments.

Crystal Group's rugged computers are onboard the B-2 Spirit Stealth Bomber as part of the Adaptable Communications Suite (ACS). Crystal Group's rugged servers and display hardware were selected for the program to enable B-2 aircrews to send and receive encrypted data while en route to targets—helping, Hutchinson says, "the U.S. Air Force increase the flexibility, lethality, and survivability of the crew and aircraft."

Performance provisions

Demand for increased capabilities, such as full-motion video and real-time processing, is driving the adoption of rugged embedded computing.

"The more the user community sees, the more it wants," Curtiss-Wright's Macpherson says. "They want higher-performance processing closer to the sensor—more processing on the platform. Applications and technology evolve, and as the user community gets exposed to these greater capabilities, they become aware of and more desirous of increasing their access to those capabilities."

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Crystek introduces VCO for SATCOM and base stations

Crystek Corp. in Fort Myers, Fla., is introducing the CVCO55FL-0183-0219 voltage controlled oscillator (VCO) for RF and microwave applications such as digital radio equipment, fixed wireless access, satellite communications (SATCOM) systems, and base stations. The VCO operates from 183 MHz to 219 MHz with a control voltage range of 0.5 to 4.5 volts. This VCO features a typical phase noise of -123 dBc/Hz at 10 KHz offset and output power typically of +8.5 dBm. Input voltage is 5 volts, with a typical current consumption of 25 milliamps.

Times offers lightning and surge protection

Times Microwave Systems in Wallingford, Conn., is introducing the Times-Protect LP-GTV-T series of DC pass RF lightning and surge protection products for applications requiring DC voltage and current to power tower top-mounted electronics. The Times-Protect LP-GTV-T RF and microwave series offers an extended frequency operating band from DC to 7000 MHz. This bidirectional design with TNC and Reverse TNC type female/female and female/male connectors handles as much as 150 watts of RF power and allows for up 72 volts of DC voltage on the center pin of the coaxial cable. The LP-GTV-T product family is IP67 rated. ←

Sierra Nevada to provide upgrade kits for carrier precision-approach landing systems

BY **John Keller**

A Navy technician services an AN/SPN-46 precision approach landing system during a deployment at sea.

JOINT BASE MCGUIRE-DIX-LAKEHURST, N.J.—U.S. Navy carrier aviation experts needed upgrade kits to improve the AN/SPN-46 automatic carrier landing system. They found their solution from Sierra Nevada Corp. in Sparks, Nev.

Officials of the Naval Air Warfare Center Aircraft Division, Lakehurst, at Joint Base McGuire-Dix-Lakehurst, N.J., announced an $8.2 million contract to Sierra Nevada to provide as many as 16 Block III receiver upgrade kits for the AN/SPN-46.

The Block III receivers are critical components on the AN/SPN-46 shipboard-based precision approach and landing system. The AN/SPN-46 precision approach landing systems from Textron Inc. in Providence, R.I., are installed on all U.S. Navy aircraft carriers.

The AN/SPN-46 employs low-probability-of-intercept technology to decrease the probability of passive detection by hostile forces. The AN/SPN-46 employs an X-band coherent transmitter and receiver using monopulse tracking and Doppler processing on received signals for clutter rejection and rain attenuation at an operating range of eight nautical miles.

The AN/SPN-46 precision approach landing system (PALS) includes the Textron SPN 46 (V)1 and (V)2 automatic landing systems for aircraft carriers and amphibious assault ships. The system provides final approach and landing guidance for aircraft during day/night operations and adverse weather conditions.

The precision approach landing system can control as many as two aircraft simultaneously in a leapfrog pattern; each approaching aircraft being assisted by the system lands, another can be acquired.

The AN/SPN-46 radar provides a Mode 1 approach. When engaged a PALS approach provides a hands-off landing for the pilot. Pilots reportedly do not use it often, preferring not to hand off much of the aircraft's controls to a computer but it is important for controller to be able to take control when all other systems fail.

On this contract, Sierra Nevada will do the work in Sparks, Nev., and should be finished by November 2018. ←

FOR MORE INFORMATION visit **Sierra Nevada Corp.** at *www.sncorp.com*, or the **Naval Air Warfare Center Aircraft Division, Lakehurst** at *www.navair.navy.mil/lakehurst*.

Pentagon explores countering UAVs carrying weapons

U.S. military researchers have approached industry for ideas on how to use small unmanned aerial vehicles (UAVs) to detect chemical and biological warfare agents, as well as how to counter enemy small UAVs carrying chemical and biological weapons payloads. The U.S. Office of the Secretary of Defense (OSD) Rapid Reaction Technology Office's Thunderstorm Technology Demonstration has two thrusts: demonstrating chemical and biological agent detection from UAVs; and countering commercially available UAVs carrying chemical and biological weapons payloads.

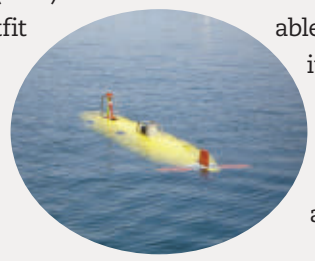
Woods Hole to outfit underwater drone for minehunting, ASW

Officials of the Naval Undersea Warfare Center in Newport, R.I., awarded a $35.5 million contract to the Woods Hole Oceanographic Institution in Woods Hole, Mass., to develop, assess, upgrade, and modernize underwater drones and other unmanned undersea technologies the Navy uses for undersea surveillance and undersea warfare. The contract calls for work on the Navy's PLUS and Acoms programs, REMUS UUV, REMUS launch and recovery systems, and related advanced ocean technologies.

Navy mulls arming large unmanned submersible with anti-submarine weaponry

BY **John Keller**

ARLINGTON, Va.—U.S. Navy researchers are sponsoring a plan to develop an anti-submarine warfare (ASW) mission package for the future Large Displacement Unmanned Undersea Vehicle (LDUUV). Officials of the U.S. Office of Naval Research (ONR) in Arlington, Va., plan to outfit a future large unmanned submersible with anti-submarine weapons. ONR officials plan to develop a working mission package for LDUUV underwater drones, integrate the mission package into a pre-selected surrogate LDUUV, and demonstrate the resulting ASW mission package during at-sea tests with relevant targets and in a relevant operating environment.



Navy researchers are considering arming future large unmanned underwater vehicles with anti-submarine warfare (ASW) capability.

The program will pursue technology development in mission autonomy, situational awareness, and undersea sensors, with emphases on software-in-the-loop and hardware-in-the-loop simulations, other ASW mission package components. Navy researchers want to integrate all components into a candidate LDUUV large unmanned submersible for at-sea testing and analysis.

The LDUUV project seeks to develop a large unmanned submarine able to operate in open ocean and coastal waters on missions lasting more than 70 days to gather intelligence, surveillance, and reconnaissance information. The program is developing autonomy and long-endurance propulsion systems for large UUVs.

The LDUUV also may evolve into a large UUV mothership that launches and recovers smaller surveillance UUVs when it reaches its mission areas. The future LDUUV must be able to avoid all vessels in its area of operations, including fishing boats. Development challenges include detecting and avoiding undersea stationary and moving obstacles, as well as path planning algorithms to minimize energy consumption while avoiding obstacles; detecting, locating, and identifying surface vessels; determining the intent of detected surface vessels; and detecting and avoiding all kinds of fishing nets and fishing gear. Outside the specified areas, human operators may intervene over satellite links.

Metron in Reston, Va., is developing experimental autonomy and mission planning software. Hydroid in Pocasset, Mass., is working on autonomy and control. Companies working on power and propulsion technologies are Fuelcell Energy in Danbury, Conn.; Sierra Lobo in Fremont, Ohio; Hamilton Sundstrand Sea Systems in Windsor Locks, Conn.; General Atomics in San Diego; Lynntech in College Station, Texas; and NexTech Materials in Lewis Center, Ohio.

Military electro-optical and infrared market to hit $16.35 billion by 2020

Global demand for military electro-optical and infrared sensors is expected to reach $16.35 billion by 2020, rising at a combined annual growth rate of 7.71 percent, predict analysts at market research MarketsandMarkets in Dallas. Electro-optic and infrared (EO/IR) systems are seen as critical force multipliers for military intelligence, surveillance, and reconnaissance (ISR) forces. In Naval platforms, electro-optic systems are finding increasing use in next-generation close-in weapon systems for target acquisition and engagement.

Sensors Unlimited viewer pinpoints battlefield lasers

Sensors Unlimited, a UTC Aerospace Systems business, is introducing a compact, modular shortwave infrared (SWIR) viewer called the Warrior handheld/weapon/helmet (HWH) to help view all battlefield lasers during day and night. The Warrior HWH infrared viewer is designed to decrease the time necessary to identify, acquire, and engage targets to reduce the risk of collateral damage. The electro-optical device can identify battlefield laser aim points to enable fast target engagement. The system also can produce images through haze, smoke, and dust to help enhance battle damage assessment. The rugged and modular viewer is available in handheld, weapon flip, or helmet-mounted configurations. ←

Northrop Grumman moves forward in defending planes and UAVs with laser weapons

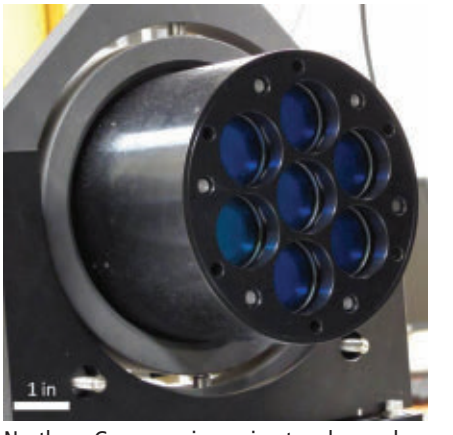
BY **John Keller**

ARLINGTON, Va.—Weapons experts at the Northrop Grumman Corp. Aerospace Systems segment in Redondo Beach, Calif., are moving forward with a military research program to use lasers for defending manned and unmanned military aircraft from heat-seeking missiles.

U.S. Defense Advanced Research Projects Agency (DARPA) officials in Arlington, Va., announced a $20.2 million contract to Northrop Grumman for the second phase of the DARPA Project Endurance to develop laser weapons to defend aircraft from electro-optical and infrared (EO/IR)-guided surface-to-air missiles. Late last year, DARPA awarded a $14.6 million contract to Northrop Grumman for the first phase of Project Endurance. Also receiving a phase-one contract for the program was the Lockheed Martin Mission Systems and Training segment in Akron, Ohio.

Project Endurance, previously part of the DARPA Excalibur program, focuses on miniaturizing component technologies, developing high-precision target tracking, identification, and lightweight agile beam control to support target engagement. The program also focuses on the phenomenology of laser-target interactions and related threat vulnerabilities, and seeks to develop pod-mounted lasers for manned and unmanned aircraft.

One goal is to design a miniaturized, flight-traceable, low-maintenance laser with an output beam strong enough to defeat incoming enemy missiles. The program also seeks to design a lightweight agile beam director and beam control technology to support coarse and fine tracking of moving targets. Also part of the program is the design of a high-precision coarse-to-fine-track and target identification subsystem, as well as laser effects testing. Ultimately, the program will design and test miniaturized airborne defense laser weapons, and estimate the vulnerabilities of enemy anti-air missiles to specific laser power levels.



Northrop Grumman is moving to advanced development of laser weapons small enough to defend unmanned aircraft from incoming missiles.

Northrop Grumman will do the work in Redondo Beach, Calif., and should be finished by March 2016. ←

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

PRODUCT applications

AVIONICS POWER

Crane to supply power modules for fly-by-wire system on COMAC C919 passenger aircraft

Avionics experts designing systems for the COMAC C919 family of narrow body aircraft needed power electronics modules for the aircraft's fly-by-wire systems. They found their solution at Crane Aerospace & Electronics in Lynnwood, Wash.

Designers at Honeywell Inc. who are providing the COMAC C919 flight-control electronics are asking the Crane Power Solutions segment to provide flight-critical and reliable power management and conversion. The Honeywell flight-control electronics are part of the C919 flight-control fly-by-wire system, which enable an electronic interface between the cockpit and the aircraft flight control surfaces.

The Crane power control module selects the proper source and conditions, and supplies uninterruptible power to the flight-control electronics. To ensure availability of power under all conditions, the power-control module can select from three independent power sources. The unit provides isolation between the aircraft power systems, removes transients, and provides reliable power for this critical equipment.

FOR MORE INFORMATION visit **Crane Aerospace & Electronics** online at *www.craneae.com* and *www.craneco.com*.

TEST AND MEASUREMENT

Navy looks to Hood Tech for engine blade vibration and monitoring

U.S. Navy flight-test experts needed a company that specializes in in-flight aircraft jet engine blade vibration and monitoring to help conduct flight tests on the U.S. Marine Corps AV-8B Harrier jump jet. They found their solution from Hood Tech Corp. in Hood River, Ore.

Officials of the Naval Air Warfare Center Weapons Division at China Lake Naval Weapons Station, Calif., are negotiating exclusively with Hood Tech for a one-year contract for AV-8B support. The AV-8B is a vertical- and short-takeoff fighter-bomber

designed to operate from aircraft carriers, amphibious assault ships, and undeveloped land bases.

Hood Tech, the Navy's sole supplier of in-flight blade vibration and monitoring, provides optical probe and laser sensors, facilities, and testing experience to characterize turbofan engine blade stress, dynamic behavior profiles, and lifecycle failure predictions in the laboratory and in flight. This capability is unique with no known competition, officials say. .

Hood Tech specializes in blade vibration and monitoring (BVM) for rotating machinery like gas turbine engines, turbochargers, steam turbines, and compressors. This discipline measures rotating machinery using sensors that do not make contact with the rotor blades. A BVM system acquires data for each blade, and is valuable for vibration characterization, risk mitigation, noise abatement, and failure prediction.

FOR MORE INFORMATION visit **Hood Tech** online at *www.hoodtech.com*.

RUGGED COMPUTERS

Navy taps General Micro for embedded computing on airborne electronic warfare

U.S. Navy avionics experts needed rugged general-purpose processors for a rapidly deployable electronic warfare system for U.S. Marine Corps

CONTINUED ON PAGE 31 ➔

CONTINUED FROM PAGE 29

fixed-wing aircraft and helicopters. They found their solution at General Micro Systems (GMS) in Rancho Cucamonga, Calif.

Officials of the Naval Air Warfare Center Weapons Division at Point Mugu, Calif., awarded a $3.6 million contract to GMS to provide S902R Golden-Eye III and S905R Raider III rugged processor and data-storage systems. The GMS Golden-Eye and Raider embedded computing equipment are for the AN/ALQ-231(V) Intrepid Tiger II reprogrammable communications jammer for Marine Corps fixed-wing aircraft and helicopters. GMS will provide 105 Golden-Eye and 145 Raider systems for the Intrepid Tiger II program.

Intrepid Tiger II provides airborne electronic warfare and electronic attack communications jamming capability for Marine Corps fixed-wing aircraft and helicopters, as well as unmanned aerial vehicles, ground-based systems, and laboratories. Navy officials designated the AN/ALQ-231(V) Intrepid Tiger II as a rapid deployment capability.

FOR MORE INFORMATION visit **General Micro Systems** online at *www.gms4sbc.com*.

ADVERTISERS INDEX

Military & Aerospace Electronics

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

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

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Phone: 847 763-9541 • Fax: 847 763-9607
E-mail: mae@halldata.com
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To submit new products for consideration, contact John Keller at jkeller@pennwell.com.

POWER ELECTRONICS

Rugged 3U CompactPCI power electronics module

North Atlantic Industries (NAI) in Bohemia, N.Y., is introducing the 75PS4 rugged 3U CompactPCI power electronics module for harsh-environment air, land, and sea applications. This PICMG-compliant power supply provides to 150 watts of power at to 90 percent efficiency, has four outputs (+5, +12, -12, and +3.3 volts). It meets MIL-STD-704A-F and MIL-STD-1275, including operation during 6-volt DC initial engagement surge. Other features include single-slot

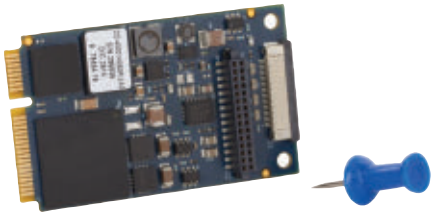
0.8-inch pitch; reverse polarity protection; built-in hold-up time to 50 milliseconds at 150 watts; integrated MIL-STD-461 EMI filtering; IPMB compatible; and user programming interface using supplied GUI via USB port on front.

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

AVIONICS DATABUSES

ARINC 429 and ARINC 717 Mini PCI Express board for avionics

Data Device Corp. in Bohemia, N.Y., is introducing the DD-40001H060 ARINC 429 and ARINC 717 Mini PCI Express avionics databus board for commercial aviation and business aviation avionics applications. The



DD-40001H060 offers the functionality of DDC's full-sized ARINC 429/717 embedded computing boards, and offers six ARINC 429/717 channels and DDC's ARINC 429 Multi-I/O AceXtreme architecture, with programmable transmission speeds and error injection. The first 2 ARINC 429 channels can be programmed to be ARINC 717, allowing flexibility to communicate with digital flight data acquisition units and digital flight data recorders. The board also offers two types of I/O connectors.

FOR MORE INFORMATION visit **DDC** online at *www.ddc-web.com*.

RUGGED COMPUTERS

Rugged small-form-factor mission computer for vetronics, C4ISR, and payloads

Acromag in Wixom, Mich., is introducing the ARCX rugged small-form-factor mission computer for military and aerospace deployable applications like vetronics, C4ISR, payload management, and command and control. The ARCX embedded computer comes with PMC, XMC, mini PCI Express, mSATA module slots, optional front I/O panel, and secondary connectors. This mission computer was engineered rugged with size, weight, and power (SWaP) to address space requirements of vehicle electronics, company officials say. The rugged computer is built to IP67, is tested to MIL-STD-810G for shock and vibration, and is available as one PMC/XMC slot or double PMC/XMC slot. The computer comes equipped with an Intel 4th generation Core i5/i7 CPU, built-in power supply and a

power filter. A rugged design includes thick circuit boards and SODIMM hold-down mechanism and heat sink plus it is cableless and fanless.

FOR MORE INFORMATION visit **Acromag** online at *www.acromag.com*.

POWER DEVICES

IGBT power electronics modules for high-power industrial applications

International Rectifier (IR) in El Segundo, Calif., is introducing a family of insulated-gate bipolar transistor modules for high-power applications including motor drive inverters, switch mode power supplies, uninterruptible power supplies, solar inverters and welding. The family uses

IR's NPT with planar-gate and field stop with trench-gate rugged IGBT technologies and diode technology in industry-standard packages.

FOR MORE INFORMATION visit **International Rectifier** at *www.irf.com*.

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KEYNOTE:
The Ultrafast Future
Ursula Keller, PhD
Ultrafast Laser Physics Group, ETH Zurich

Ultrafast--or ultra-short pulse--laser technology is dramatically impacting many areas of photonics, from basic science to industrial manufacturing and biomedicine. The design and performance of the lasers behind these applications will be critical for creating new applications and opening new market opportunities. Prof. Keller will provide a view of the ultrafast laser landscape and help the audience understand such important topics as power scaling of semiconductor lasers and diode-pumped solid-state lasers, and where such new capabilities might lead.

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Seeing What Others Can't

The Key to Unlocking New Insights

Mark Wallace
Vice President and General Manager
Keysight Technologies, Inc.

You've known us as Hewlett-Packard, Agilent Technologies and, now, Keysight Technologies. For more than 75 years we have been helping you unlock measurement insights.

There have always been two sides to the story. One is the work we do, creating innovative instrumentation and software. The other is the work you do: design, develop, debug, troubleshoot, manufacture, test, install and maintain components, devices and systems.

Those seemingly separate activities are connected by something profound: the "A-ha!" that comes with a moment of insight. When those happen for us, the results are innovations that enable breakthroughs for you.

Enabling the right idea at the right time

This is our legacy. Keysight is a company built on a history of firsts, dating back to the days when Bill Hewlett and Dave Packard worked in the garage on 367 Addison Avenue in Palo Alto, California. Our firsts began with U.S. patent number 2,268,872 for a "variable-frequency oscillation generator." Appropriately, the centerpiece of Bill's design was a light bulb, which is often used to symbolize a new idea.

Our future depends on your success, and our vision is simple: by helping engineers find the right idea at the right time, we enable them to bring next-generation technologies to their customers — faster.

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This is happening in aerospace and defense applications where increasingly realistic signal simulations are accelerating the development of advanced systems that protect those who go in harm's way. It's happening in research labs where our tools help turn scientific discovery into the discovery of new sciences. It's taking place with DDR memory, where our line of end-to-end solutions ranges from simulation software to protocol-analysis hardware. And in wireless communications we're providing leading-edge measurement tools and sophisticated, future-friendly software that support the development and deployment of LTE-Advanced.

Within those systems, there are more standards than a single engineer can keep up with. That's why so many of our engineers are involved in standards bodies around the world. We're helping shape those standards while creating the tools needed to meet the toughest performance goals.

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To help Keysight customers continue to open new doors, we're concentrating our effort and experience on what comes next in test and measurement. Our unique combination of hardware, software and people will help enable your next "A-ha!" moment, whether you're working on mobile devices, cloud computing, semiconductors, renewable energy, or the latest glimmer in your imagination. Keysight is here to help you see what others can't — and then make it reality.

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