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ENABLING TECHNOLOGIES FOR NATIONAL DEFENSE

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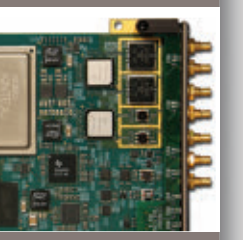
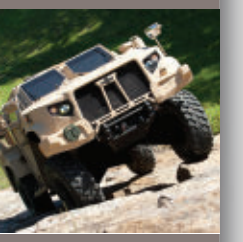
SEPTEMBER 2017
VOL. 28, NO. 9

Military & Aerospace Electronics

COVER STORY





Military & Aerospace Electronics® (ISSN 1046-9079), Volume 28, No. 9. Military & Aerospace Electronics is published 12 times a year, monthly by PennWell® Corporation, 1421 S. Sheridan, Tulsa, OK 74112. Periodicals postage paid at Tulsa, OK 74112 and at additional mailing offices. SUBSCRIPTION PRICES: USA $185 1yr., $327 2 yr., $466 3 yr.; Canada $280 1 yr., $479 2 yr., $618 3 yr.; International $335 1 yr., $638 2 yr., $834 3 yr. POSTMASTER: Send address corrections to Military & Aerospace Electronics, P.O. Box 47570, Plymouth, MN 55447. Military & Aerospace Electronics is a registered trademark.

BY **JOHN KELLER**, EDITOR IN CHIEF

Two collisions: What's going on in the Pacific?

One marine tragedy involving the collision of a naval surface warship with a commercial merchant vessel is a curiosity. Two such ocean collisions in a short time span is an amazement.

The U.S. Navy's Arleigh Burke-class guided missile destroyer is among the world's most modern warships. It's packed with sensors, advanced navigation equipment, and other technologies designed to keep the vessel safe even in the most difficult maritime conditions. Nevertheless, in the course of only nine weeks, two Burke-class destroyers operating in the Western Pacific have collided with big, lumbering cargo ships more than three times their size, leading to death and injury to U.S. military personnel.

On 17 June, the destroyer USS Fitzgerald (DDG 62) collided with the Philippine-flagged container ship MV ACX Crystal off the east coast of Japan. Then, on 21 Aug., the USS John S. McCain (DDG 56) collided with the oil and chemical tanker ALNIC MC in the Straits of Malacca near Singapore.

Each of the cargo vessels displaces about 30,000 tons of water and is longer than two football fields. They don't move quickly, and take a long time to turn. The Burke-class destroyer, on the other hand, displaces about 9,000 tons of water, is 509 feet long, and can move faster than 30 knots. It is maneuverable and can turn 180 degrees in a minute.

The big question is why did these collisions happen, and why should there be two similar accidents involving similar vessels in the same region of the world so closely together?

The answer is unclear, for now. A preliminary investigation of the June collision claims the accident was the Fitzgerald's fault. That mishap killed seven and injured as many as 300, including the captain, Cmdr. Bryce Benson. Benson and two others in the ship's senior leadership were relieved of duty, as were Executive Officer Cmdr. Sean Babbitt and Master Chief Petty Officer Brice Baldwin.

Suffice it to say that what happened aboard the Fitzgerald was really bad, with serious breakdowns in the chain of command and deficiencies of seamanship. Those relieved of duty likely are looking at the ends of their naval careers. Mistakes can and do happen, but twice in two months? Speculation for the accidents has ranged from intentional ramming to cyber attacks on the destroyers' navigation systems. Neither has been proven.

We're not sure yet what happened aboard the destroyer McCain. It's too soon for any kind of investigation, and the latest news reports list 10 of the McCain's crew as missing, with at least one of them dead.

The day after the McCain collision, Vice Adm. Joseph Aucoin was relieved of duty as commander of the U.S. 7th Fleet based in Yokosuka, Japan. The McCain's collision with the ALNIC MC in the Straits of Malacca near Singapore happened in some of the most congested waters on Earth. Virtually all the world's commercial ship traffic passing between the South China Sea and the Indian Ocean go through there. Still, naval surface warfare officers in command aboard the McCain are well trained in operating through congested and dangerous waters. What happened was far from routine.

Maritime accidents like these have big consequences; it doesn't involve just a bunch of big dents and scrapes.

The bulbous bows of the MV ACX Crystal and the ALNIC MC pierced the hulls of the Fitzgerald and McCain below the water line, causing massive flooding below decks; it's a testament to the skill of damage-control crews that the ships remained afloat. Damage below the water lines of these two destroyers was significant, and deaths came by drowning.

U.S. Chief of Naval Operations Adm. John Richardson ordered a pause in naval operations to review maritime practices in the Pacific. We'll see what the operational pause reveals. Let's hope the Navy can make some changes to prevent these accidents from happening again.

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news

Five companies to design power and thermal management for future jet fighters

BY JOHN KELLER

WRIGHT-PATTERSON AFB, Ohio — Military aircraft engine designers at the Boeing Co. are joining a major U.S. Air Force project to design next-generation aircraft power-control and thermal-management systems to enable future jet fighter aircraft to accommodate new technologies like laser weapons, powerful electronic warfare (EW), and low observability.

Officials of the U.S. Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, announced a seven-year contract to Boeing Defense, Space & Security in Hazelwood, Mo., for the Next Generation Thermal, Power, and Controls (NGT-PAC) program.

Boeing joins the General Electric Co. (GE) Aviation segment in Cincinnati; the Northrop Grumman Aerospace Systems segment in Redondo Beach, Calif.; the United Technologies Corp. Pratt & Whitney division in East Hartford, Conn.; and the Lockheed Martin Aeronautics segment in Fort Worth, Texas, for the NGT-PAC program.

Engineers from the five companies will share as much as $409 million in carrying out research to prove the technological feasibility of new kinds of thermal, power, and controls components and architectures using existing airframe and engine designs as test beds.

Next-generation fighter aircraft will require an unprecedented level of advanced capabilities for air superiority in contested environments. These capabilities will include advanced electronic attack, high-power laser, and future low-observability features. These advanced technologies are expected to require as much as 10 times the power levels of current tactical systems, Air Force experts say.

These power demands present electrical and thermal challenges aboard aircraft — especially in the presence of composite aircraft skins, high-efficiency engines, and embedded vehicle systems. Experts from the five companies will try to better understand the challenges and opportunities of and advance the state of the art in next-generation aircraft thermal, power, and controls.

Experts will focus on two areas: aircraft engines and airframes to develop revolutionary aircraft power, thermal, and controls technologies.

Five companies are investigating next-generation power and thermal-management technologies for future fighter aircraft.

On these contracts Boeing will do the work in Hazelwood, Mo.; GE in Cincinnati; Northrop Grumman in Redondo Beach, Calif.; Pratt & Whitney in East Hartford, Conn.; and Lockheed Martin in Fort Worth, Texas. All five companies should be finished by July 2024.

FOR MORE INFORMATION visit **Boeing Defense, Space & Security** online at *www.boeing.com*; **GE Aviation** at *www.geaviation.com*; **Northrop Grumman Aerospace Systems** at *www.northropgrumman.com*; **United Technologies Pratt & Whitney** at *www.pw.utc.com*; and **Lockheed Martin Aeronautics** at *www.lockheedmartin.com/us/aeronautics.html*.

Lockheed Martin eyes infantry squad situational awareness and communications

BY JOHN KELLER

ARLINGTON, Va. — Infantry technology experts at Lockheed Martin Corp. are designing system prototypes to enhance capabilities of the infantry squad in situational awareness, networked communications, and data sharing. An infantry rifle squad has nine to 13 warfighters.

Officials of the U.S. Army Contracting Command at Aberdeen Proving Ground, Md., announced a $12.9 million contract to the Lockheed Martin Missiles and Fire Control segment in Grand Prairie, Texas, for the Squad X Core Technologies (SXCT) program.

The Army Contracting Command is making the award on behalf of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va.

IN BRIEF

General Dynamics to upgrade Abrams main battle tanks and vetronics to new SEPv3 versions

Armored combat vehicle experts at General Dynamics Corp. will upgrade 45 M1 Abrams main battle tanks and vetronics to the most advanced M1A2 SEPv3 configuration under terms of a $270.2 million contract announced last month. The U.S. Army Contracting Command in Warren, Mich., is asking General Dynamics Land Systems in Sterling Heights, Mich., to install and integrate SEPv2 legacy unique components resulting in 45 M1A2 SEPv3 Abrams Main Battle tanks. The M1A2 SEPv3 main battle tank is the latest version of the M1 Abrams, and has increased power generation and distribution, better communications and networking, new vehicle health management system (VHMS), line replaceable modules (LRMs) for improved maintenance, and an ammunition datalink (ADL) to use airburst rounds. The contract also asks General Dynamics Land Systems to procure, stock and store 60 sets of SEPv2 legacy and SEPv3 unique components; procure integrated product support requirements of Lisa, special tooling and test equipment, and the systems support package.

The SXCT program seeks to make small units of Army and U.S. Marine Corps infantry warfighters more effective and deadly using existing weapons and unmanned systems.

This award moves the SXCT program to the prototyping phase. Lockheed Martin has been working on the program since fall 2015, and was involved in the first and second phases of the project.

Also working on the SXCT program's first phase were Helios Remote Sensing Systems in Utica, N.Y.; Kitware Inc. in Clifton Park, N.Y.; Leidos in Reston, Va.; the Lockheed Martin Advanced Technology Laboratories in Cherry Hill, N.J.; the Raytheon Co. Missile Systems segment in Tucson, Ariz.; Scientific Systems Co. Inc. in Woburn, Mass.; Six3 systems Inc. in McLean, Va.; SoarTech in Orlando, Fla.; and SRI International in Menlo Park, Calif.

U.S. infantry rifle squads today lack 21st century combat power, DARPA official explain. They do not have the ability to switch from offensive and defensive operations to stability operations and back again, which can produce a high number of casualties.

Lockheed Martin is designing prototypes to enhance infantry squad situational awareness, networked communications, and data sharing.

With these disadvantages, today's infantry warfighter faces an adversary that on its own terrain has ubiquitous communications, hides in the terrain or culture, and follows different rules of engagement. The result is that U.S. military squads have less situational awareness than their adversaries, with sensing limited by line of sight and narrow fields of view.

To rectify these problems, the DARPA SXCT program seeks to develop capabilities that enhance the dismounted rifle squad's situational awareness, as well as to build the rifle squad's combat power to adapt to a broad range of military operations.

The SXCT program has four technology thrusts: precision engagement, non-kinetic engagement, squad sensing, and squad autonomy. Precision engagement seeks to enable the rifle squad to engage threats precisely out to 1,000 meters while maintaining compatibility with infantry weapon systems and human factors limitations.

DARPA wants to develop technologies that help enable the rifle squad to engage known-but-unseen threats with new kinds of guided weapons that are compatible with current squad equipment like the M203/M320 grenade launchers or the Picatinny Rail system.

Researchers particularly are interested in a micro-missile or advanced 40-millimeter grenade that can engage unseen targets with precision using the networked squad, small unmanned vehicles, data-fusion-enabled shared situational awareness.

Non-kinetic engagement seeks to enable the rifle squad to disrupt enemy command, control, and communications with capabilities like electronic warfare,

cyber warfare, and optical warfare. This approach also seeks to use unmanned assets to ranges greater than 300 meters while maneuvering at a normal squad pace.

Squad sensing seeks to enable the rifle squad to detect and pinpoint hidden human threats out to 1,000 meters while maneuvering at a squad pace. DARPA particularly is interested in approaches that might involve acoustic sensor arrays, handheld radar, human heartbeat monitors, and infrared sensors.

Squad autonomy, finally, seeks to enable rifle squad members to keep track of each other and their unit's location to less than six meters in GPS-denied environments by collaborating with unmanned systems maneuvering in squad formations. It could involve the collaboration of squad members and unmanned systems, and to enable robots operating with the squad to maneuver as members of the squad formation.

A small unmanned aerial vehicle (UAV), for example, could operate 100 to 200 feet above and in front of the squad to track squad members and take cues from squad maneuvers. An unmanned ground vehicle (UGVs) might operate in front of the squad as an advance scout. Other UGVs could operate with the squad to carry supplies and communications gear.

DARPA particularly is interested in non-active sensors, or those with minimal signatures like spread-spectrum light detection and ranging (LIDAR). Sensors need to be small, lightweight, and power-efficient.

In the first phase of the SXCT program, Lockheed Martin and SRI International developed concepts in each of the four technological areas. In the second phase Lockheed Martin enhanced promising technologies from the first phase. Now Lockheed Martin will develop prototypes for field testing.

On this contract, Lockheed Martin will do the work in Grand Prairie, Texas; Rome, N.Y.; Menlo Park, Calif.; Woburn, Mass.; Ann Arbor, Mich.; and Cherry Hill, N.J., and should be finished by August 2019.

FOR MORE INFORMATION visit **Lockheed Martin Missiles and Fire Control** online at *www.lockheedmartin.com*.

DARPA seeks to improve machine autonomy for safety-critical aircraft

BY JOHN KELLER

ARLINGTON, Va. — U.S. military researchers are asking for industry's help in improving machine autonomy technology sufficiently to enable its use in safety-critical applications, such as unmanned aircraft operating side-by-side with passenger planes in controlled airspace.

This project will center on military autonomous vehicles. It will produce a set of publicly available software tools for use in commercial and defense sectors. DARPA

Military researchers are looking for machine autonomy that's good enough for unmanned aircraft operating in controlled airspace.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have issued a broad agency announcement (HR001117S0045) for the Assured Autonomy project to assure that systems will operate safely and perform as expected, which will promote trust in machine autonomy and speed its adoption.

The goal of the Assured Autonomy program is to develop rigorous design and analysis technologies to guarantee safety of autonomous machines that can learn on their own, based on experience.

seeks innovative techniques that render the learning algorithms inherently safe by incorporating safety constraints in the learning process, while meeting learning objectives.

Autonomous systems increasingly are critical to the military, and researchers have made tremendous advances in the last decade — particularly for unmanned vehicles that operate in the air, on the ground, and in the ocean.

Enabling these advances in machine autonomy have been innovations in sensor and actuator technologies; computing technologies; control theory; design methods and tools; and modeling and simulation technologies.

Despite these many advances in machine autonomy, however, adoption of such systems in safety-critical Department of Defense (DOD) applications remains to be both challenging and controversial. Designing in reliability to ensure trust is key to widespread use of machine autonomy.

The Assured Autonomy program has four technology areas (TAs): design for assurance; assurance monitoring and control; dynamic assurance; and integration and an experimentation platform. Proposers may address any of the four TAs.

Design for assurance involves a learning-enabled, cyber physical system (LE-CPS); assurance monitoring and control involves breakthroughs in operation-time techniques for assured and safe operation of LE-CPS for assurance monitoring and control; dynamic assurance involves new approaches in dynamic assurance that integrates design time assurance with operation time assurance; and the experimentation platform will provide challenge problems for evaluation and demonstration of the assurance technologies.

The program has three phases: an 18-month first phase for initial research and tool development; a 15-month second phase to focus on technology enhancement; and a 15-month third phase for technology maturation and demonstration on experimentation platforms.

Goals of the program are to increase scalability of design-time assurance; reduce overhead of operation-time assurance; scale up dynamic assurance; and reduce trials to assurance.

DARPA officials say they expect to make several contract awards for the Assured Autonomy program.

MORE INFORMATION IS online at *https://www.fbo.gov/spg/ODA/DARPA/CMO/HR001117S0045/listing.html*.

Focusing the military's weather eye

U.S. Air Force, Army, and Navy weather specialists are using enabling technologies like supercomputers to make detailed weather forecasts anywhere in the world to support deployed warfighters.

BY **J.R. Wilson**

The most powerful weapon of war, weather, has raised and toppled empires, destroyed invasion fleets, crushed armies, and changed world history, yet it neither was created nor controlled by generals, admirals, or governments.

There have been many failed attempts at weather modification — something China reportedly continues to pursue — but the best any military ever has been able to do, with limited success, is predict how weather will influence their forces.

Weather affects all types of military operations, but the specific needs of the U.S. Army, Navy, and Air Force differ substantially. While the Navy and Air Force have a growing need for accurate long-range global strategic weather forecasting — albeit emphasizing different domains of war — the Army is focused on accurate, real-time regional tactical weather forecasting. As a result, the three have developed separate and independent technologies and strategies, even as they share common elements.

Members of Air Force Special Operations weather teams participate in a training scenario on a CH-47 Chinook helicopter.

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Different weather aims

The Air Force provides all meteorological services to Army and Air Force operational forces; the Navy and Marine Corps have their own capabilities, although weather personnel from all four services attend the Air Force weather schoolhouse at Keesler Air Force Base, Miss.

Air Force and Navy personnel also man joint weather stations — one in Hawaii and another in Europe — providing warnings and advisories, hazardous weather bulletins, military weather forecasts for ground and air operations, and, when designated joint, naval operations as well.

Both stations are aligned to U.S. combatant commands. The European station covers European Command and Africa Command; the one in Hawaii covers Pacific Command. The Air Force also has a station at Shaw Air Force Base, S.C., covering Central Command; another at Davis-Monthan Air Force Base, Ariz., covers Southern Command.

"Our focus is on the Army, which means ground forces and very short time scales," says Pamela Clark, chief of the Army Research Laboratory Battlefield Environmental Division in Adelphi, Md. "So when we talk about global or regional, the Navy and Air Force work on a more global scale, and we use a lot of the products the Navy may produce in terms of models and long-term forecasting.

"We look more at nowcast, which is a short forecast, typically three to six hours," Clark continues. "We get global models from the Air Force and Navy as a starting point, but a lot can happen due to local effects; terrain areas can have a lot of influence on Army missions."

The Army's Battlefield Environment Division studies environmental impacts on Army systems, and develops new atmospheric models that will work at the fine scales the Army needs. "So we're different from NOAA [the U.S. National Oceanic and Atmospheric Administration] and other weather forecasters because we are looking at these short scales and may be in areas where we don't have a lot of observational data, so models have to run with sometimes limited input," Clark says.

The Navy has little interest in weather on land, other than its potential effect on global conditions, ports, and harbors, concentrating instead on maritime surface and subsurface conditions. Increasing the length of future weather forecasts is equally important, since it takes so long for ships to reach their destinations or escape extreme storms. Deployed Marines also depend on relatively long weather forecasts. The duration of accurate weather forecasting influences tactical sensor support, and system development.

"If the Navy doesn't fund that work, nobody else will," points out Ronald Ferek, program officer of marine meteorology and space research in the Office of Naval Research in Arlington, Va.

"Our biggest initiative right now is the Earth System Prediction Capability [ESPC] program," Ferek says. "For many years, the Navy has run global and metascale regional, forecasts. Global is good out to about 10 days. Within that global framework, we run about 100 regional models that provide the details in a particular location at a finer resolution. The Navy runs more metascale regions than anyone else in the world; more than half involve atmospheric forcing [the transfer of momentum and heat flux from the atmosphere into the ocean] on ocean surface and subsurface, driving detailed ocean forecasts.

"Rather than global and metascale grid technologies, we now are

Air Force and Navy forecasters take a global approach to tracking weather, while Army forecasters try to pinpoint conditions for troops deployed on the ground.

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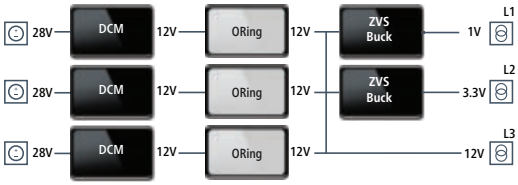

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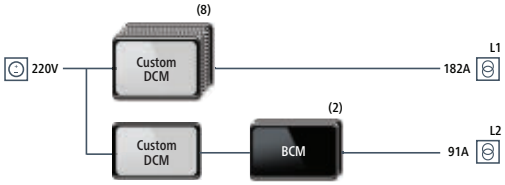

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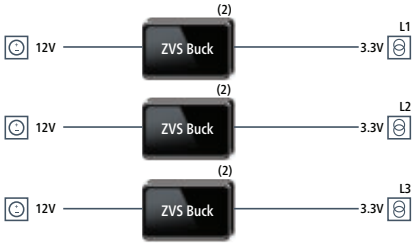

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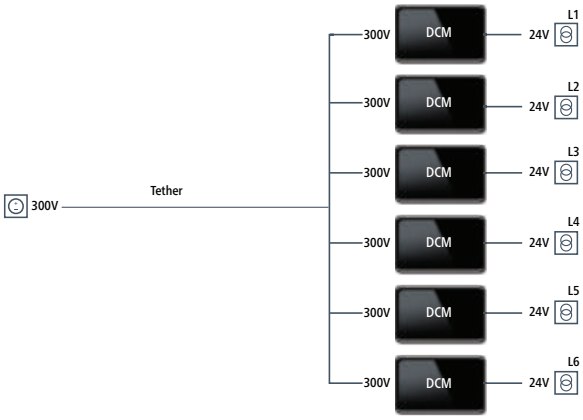

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working toward an ESPC, where the atmosphere, ocean, land, space and ice are coupled," Ferek continues. "Running separate models for each of those five subsystems is fairly inefficient because the physics interact. Coupling across the different domains and working toward variable or adaptive grid methods, instead of running global models to provide resolution to a regional model, is a more efficient way to do things."

Although also looking to increase range and accuracy, the Air Force's focus is on atmospheric conditions that impact air operations, from airbase takeoffs and landings to en-route, cruise-level to weather over the target, as well as support for some Army missions.

An Air Force senior airman monitors the air space and weather conditions around the Geronimo landing zone at the Joint Readiness Training Center, Fort Polk, La. (Air Force photo.)

"A strategic global model provides a unified global weather forecast for the combined Air Force and Army mission sets," explains Ralph Stoffler, the Air Force's director of weather. Air Force experts run global weather models out of the 557th Weather Wing at Offutt Air Force Base, Neb. The model comes in gridded format with machine-to-machine interfaces and post-process output for specific mission sets.

"We run our models and forecasts based on what's important to the military mission set," Stoffler says. "Where civilian forecasts tend to look at hazards, temperatures, and convective activity, we look at what temperature does to deployed airmen, dust to aircraft, etc. — the military impacts. We also focus on the entire globe, where most civilian forecasts look at local or national weather."

Looking to the future, however, Air Force weather experts want to change the paradigm.

Supercomputers and sensors

"The number-one thing that has driven weather forecasting forward is improved supercomputing capabilities," Stoffler says. "Our ability to run high-resolution models in a very short time has been essential to that. Thirty years ago, our global model had a 60-kilometer resolution; now it is 17 kilometers and by the end of next year, I expect it to go down to 10 kilometers," Stoffler says. "Miniaturization is going to give us increased data availability from various parts of the world, leveraging cubesats and placing miniaturized sensors on all kinds of satellites rather than just dedicated weather satellites.

"We're also building small sensors to put across the battlespace, mounted on vehicles and using Iridium [satellite phone] technology to bring that data back," Stoffler continues. "By putting sensors on almost every deployed vehicle, we can really increase the amount of data we have to use. The technology is not yet there for us to put sensors on individual warfighters, but sensor development is moving

Weather, war, and world history

Nearly 5,000 years ago, dramatic regional climate change turned the lush green expanse of North Africa into the Sahara Desert. That, in turn, forced the largely nomadic tribes of the area toward the only remaining source of food and fresh water — the Nile River. As their numbers grew, these weather-driven peoples eventually created the Egyptian Old Kingdom.

Half a millennium later, however, another major shift in the weather, which prevented the annual flooding of the Nile, brought the Egyptian Old Kingdom to an end. Another shift less than 150 years later gave rise to the Egyptian Middle Kingdom.

In the 13th Century, Mongol ruler Kubla Khan sent two massive fleets — the first in 1274 of 500 to 900 ships and 40,000 men, the second (seven years later) with 4,400 vessels and 140,000 men — to invade Japan. Both fleets were destroyed by massive typhoons. Although they created the largest contiguous land empire in history, the Mongols never again attempted to cross large bodies of water. The Japanese commemorated the 1281 typhoon as the "divine wind" — or Kamikaze.

In May 1588, a Spanish Armada of more than 130 ships carrying some 30,000 men set sail to invade England. It was Spain's second attempt, the first, a few weeks earlier, having been forced back by storms in the English Channel.

The second Spanish attack on England faced a valiant defense — including fire ships that caused more confusion than damage delayed the Armada and caused it to break formation and course. The final blow, however, came from what has been described as one of the worst storms in English history. As Spanish King Felipe II later told the survivors, "I sent you out to war with men, not with the wind and waves."

In late June 1812, French Emperor Napoleon Bonaparte sent an army of 610,000 men into Russia, expecting to force a quick Russian surrender. But Czar Alexander's army instead conducted a months-long "scorched Earth" retreat to Moscow, which they also abandoned — after setting it ablaze. By October, with their army reduced to only 100,000 by death, illness, and desertion, an unusually early and harsh Russian winter fell upon them, causing the French to begin a retreat that would destroy most of what was left of the Grande Armée.

Adolf Hitler's vaunted Wehrmacht met a similar fate 130 years later, when the severe Russian winter once again came to the defense of Moscow and the then-Soviet Union.

Two years later, on 6 June 1944, weather over the English Channel worked in favor of the largest amphibious invasion in history — some 5,000 vessels carrying more than 160,000 Allied troops to Normandy. Despite an estimated 10,000 casualties, the Allies seized a foothold in France that helped end the European half of the deadliest war in history 10 months later. The invasion had been postponed one day by bad weather, which threatened to stop what the Nazis could not. But clear weather the following day made success possible.

ahead quickly and the real challenges are communications and cybersecurity."

The impact of those technology advances on weather forecasting in the past two decades has been huge across all the services, says Benjamin MacCall, chief of Army Research Lab's Atmospheric Modeling Branch in Adelphi, Md.

"For the global perspective, the technologies that enable embedded computing lead to much more cost efficiency — cooling, energy, etc.," MacCall says. "That reduces the barrier to entry of other types of commercial technology, so the Air Force can do global forecasting at unprecedented levels of detail in a cost-effective manner. Embedded computing means you have to tailor your algorithms to what you're running them on. Using GPUs [graphics processing units] for general-purpose calculations requires a rethinking of how the physics are calculated in weather models.

"Going into the future, we see these kinds of embedded computational platforms being able to provide quick, maybe limited, area detail of the environments around buildings, for example, for quick decision making," MacCall says.

"They won't be doing full weather forecasting, but how weather is impacting a specific area," MacCall adds. "There also will be a significant growth in available sensor data, including many more carried by the soldiers themselves. All that has to be networked and optimized, having that capability on mobile phones and UAVs so the data can be reduced to important kernels of information that can be sent to where it can be used for future Army decision-making and execution."

SWaP and artificial intelligence

Despite miniaturization, size, weight, and power consumption (SWaP) remains a major problem for expanding the number and locations of weather sensors. As those issues are addressed, the volume of data gathered increases exponentially, making it necessary for many future platforms to perform onboard, real-time data analysis and fusion to alleviate a growing problem of information overload. One answer

gaining momentum as the enabling technologies advance is some degree of artificial intelligence (AI).

"In the old days, we could provide a limited amount of information, where today we can create thousands of products every day," says the Air Force's Stoffler. "Because we want to provide everything we can to the operations world, we're starting to overload them. The feedback is all they want to know is will weather be a problem or not. Eventually we will have to develop some sort of AI that will let the operator know just that."

The Navy's Ferek agrees, calling weather forecasting "one of the largest computational efforts in the world." He adds, however, that even the best forecasts possible with the most advanced technologies still will be subject to small variables that create uncertainty — and could result in vastly inaccurate weather predictions.

The sheer volume of weather data also means there is insufficient time to incorporate all of it in time for the next forecast. Assimilating that "lost" data to improve resolution and build more detail into weather models would require a 10-fold increase in computational resources. Anything more powerful, such as exoscale-computing, is still an open area of research.

"Weather covers scales from planetary to molecular, with one of the most important being the phase change of water in the atmosphere at the molecular scale," Ferek says. "It would be a little difficult to know the ideal resolution for capturing as many processes as possible, and at what scale. Typically, the more physics you capture, the more accurate your forecasts. We know exactly what to do with a 10-fold increase in computational capability; the real game is how many more processes do I need to represent and at what scale so our models can carry those parameters forward. At some point, you reach a limit of predictability, as chaos becomes part of the problem," he explains.

"We're also trying to develop ensemble systems, instead of single deterministic forecasts," Ferek continues. "You try to capture the uncertainty of the forecasts by running a whole bunch that are just

slightly different from each other. Sometimes the atmosphere is quite unpredictable and the sensitivity to the forecast can be a very small difference in one variable; you want to bracket the range of possibilities so you have an ensemble where the many members are all equally likely. In a situation where the forecast is uncertain, a single deterministic forecast can be very wrong, but a range of forecasts can capture how much uncertainty you have."

Little reliance on civilian technology

Unlike the vast majority of technology advances that have changed the face of warfare, military global strategic and tactical weather forecasting have only minimal reliance on civilian meteorology.

"The commercial data available actually is pretty limited. We are working with them to increase that, but we tend to rely on data produced by the U.S. Department of Defense (DOD) or national [agencies] and international governments that make it available through the World Meteorological Organization weather exchange," the Air Force's Stoffler explains.

"Under international rules of engagement, each country is to exchange a certain amount of weather data to all others. There also is a secondary set of data unique to those countries and not exchanged. DOD maintains our own data in some areas and has treaties to share it with some allies, but we also have methods in place to cut that data off, if necessary."

The Army Communications-Electronics RD&E Center (CERDEC) Space and Terrestrial Communications Directorate at Aberdeen Proving Ground, Md., performs modeling and simulation for the Army's tactical network. Starting with accurate and detailed models of what warfighters will be using in the battlefield, they look at the impact on the network of adding a new technology or removing an existing one, changing the location or distribution of certain network nodes and, where possible, incorporating weather impacts into the analysis.

"The more accurately we can describe the environment at a given

location, the higher-fidelity answer we can give to our analysis and provide a better functioning network," says Joshua Fischer, chief of the data collection, analysis, modeling and simulation branch at CERDEC. "It all boils down to accuracy and fidelity — the more accurate inputs we have, the more accurate outputs we will have.

"Today, we are using the Terrain Integrated Rough Earth Model (TIREM) to predict median propagation loss from 1 MHZ to 40 GHz for the network, items such as tropospheric scatter, atmospheric absorption, deflection, refraction, etc.," Fischer says. "MODESTA [Modeling Emulation, Simulation Tool for Analysis] is our system-of-systems network modeling framework. It provides a large-scale, tactical network analysis environment with a centralized framework so analysts can conduct realistic, operational scenarios with emulated and simulated systems, all while accessing centralized data models and data collection, reduction, and analysis tools."

Modern supercomputers are among the most powerful tools in the military weather forecaster's arsenal to run high-resolution weather models in a very short time.

Microscale weather models

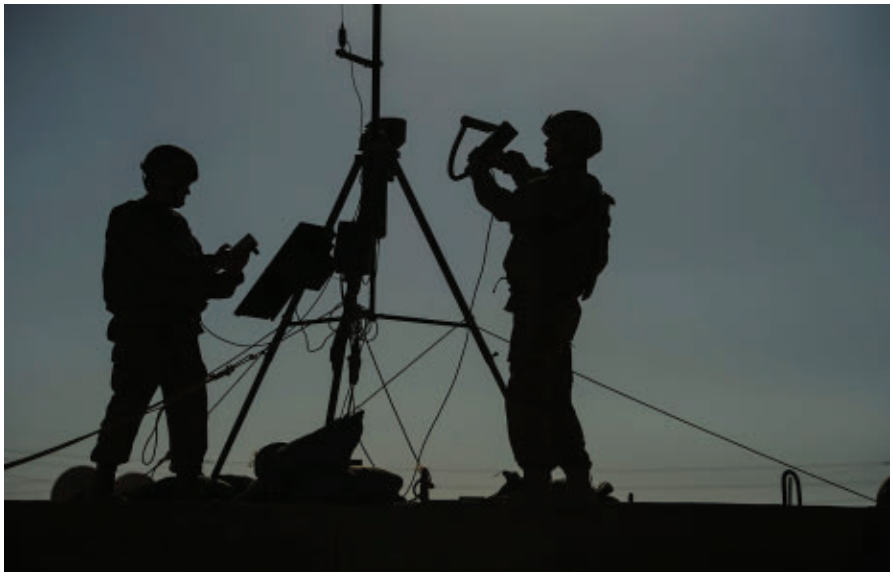
While the Navy and Air Force work on large models, the Army is focusing on the other end of the scale.

"We work on microscale model development, tailoring our program toward scales less than one kilometer and optimizing for urban environments, so we want to make sure we can detail flow fields within dense urban environments," the Army Research Lab's MacCall says. "We also look at mountainous terrain. Because of the high resolution, we don't do these models globally, but simulating over a smaller area, using coarser data to drive the boundary conditions, which we then use to figure out how the flow will be impacted by features such as buildings, mountains and hills. The main program is called the Atmospheric Boundary Layer Environment (ABLE) model development program. We began about four years ago, looking at complex terrain and urban areas."

ARL's in-house model developments are unique to the Army's short-scale time domain. The work MacCall's branch does at Adelphi is based in part on experimental data collected by ARL's Atmospheric Dynamics Branch (White Sands Missile Range, NM), looking at the lower two miles of the atmosphere.

"A program we began almost two years ago is the Meteorological Sensor Array," MacCall says. "There are at least 36 towers in our initial array that will become operational by the end of summer 2017."

The Meteorological Sensor Array is located at the Jornada



Air Force weather experts inspect a remote weather station to keep warfighters in the field up to date on the environmental conditions they will face.

Experimental Range in Las Cruces, N.M. Partners include the Naval Research Laboratory in Washington, New Mexico State University, and the U.S. Department of Agriculture.

"After we characterize the atmosphere and build more accurate models as a result, the model output then is used as input to our tactical decision aids for weather, where we have developed a number of tools that give the soldier and commander a color-coded, stoplight-type output — green for good, yellow for marginal, red for unacceptable. That gives anyone an instant way the see the impact of weather on his operations," says Dave Knapp, acting chief of the Army Research Lab's White Sands Branch in New Mexico.

The U.S. Air Force tracks global weather to predict conditions from airbase takeoffs and landings, to en-route cruise-level, to weather over the target.

Arctic weather

The Navy is responsible for forecasting some of the most powerful and unique weather conditions on the planet — Atlantic hurricanes, Pacific typhoons, and one of the least-understood environments, now becoming critical — the Arctic, where they have a major initiative

Members of the Air Force The 10th Combat Weather Squadron install a weather station near Salang Pass in the Hindu Kush mountain range in Asia to help predict avalanches. (Air Force photo.)

underway to improve forecasting. Ferek says current models miss half of the intense storms that are common to the region, and significantly misforecast the intensity level of those predicted.

While that makes U.S. Arctic weather forecasting the least accurate on the planet, he adds, all of the other Arctic nations also are deficient due to a combination of insufficient — or non-existent — observations and a lack of systematic study. A lot of Arctic modeling technologies are funded by the Navy, seeking to understand how wind waves and swell effect the state of the ice, for example.

"The physics are different up there; the resolution of the models is too coarse," Ferek says. "Imagine if half the tropical cyclones were unpredicted; it would be a disaster. The meteorological community has ignored the Arctic for too long. We've done fairly well at getting the tropics correct, but haven't spent anywhere near as much on the Arctic. A lot of errors in our global forecasts actually originate in the Arctic."

The Pacific also offers unique challenges for the Navy, which places a big emphasis on remote sensing. Similar in many ways to the National Hurricane Center for the Atlantic, the Joint Typhoon Warning Center covers the Western Pacific. Unlike the Atlantic, however, there is little to no reconnaissance in the vast open waters of the Pacific, forcing the Navy to rely on remote sensing and using all available sources — primarily commercial satellites — to get an idea of the size, extent, intensity, and track of storms.

Remote sensing

These large- and small-scale efforts are not entirely separate, but can be pulled together to create a more complete view of weather patterns across the globe, at all levels.

"A lot of global phenomenon start at small scales and graduate upscale," Ferek says. "If you start with a global model to provide interaction to the regional model, it only goes one way.

"Something with a unified global/regional variable grid technology can interact upscale and downscale, which is more accurate for some of the things we deal with," Ferek explains. "That means capturing the small scales and aggregating the effect up to large scale. That is mostly still in 6-2 applied research, although the basic framework is in 6-3 advanced technology development. The upscale effort is still in 6-1 [basic research].

The U.S. Navy takes a keen interest in global weather forecasting to help keep surface warships and deployed Marines out of harm's way.

"We hope to show it is feasible and can be operated within the restraints of the operating capability we have by 2020, showing we can link the systems and develop the models," Ferek says. "If we find our models can't capture reality, then we will have to go back to the drawing board to see what basic physics we're missing. One of the major technological problems is just building the framework where ocean, land, ice, atmosphere, and space models can all interact in a coupled system. That requires a lot of software engineering."

Demand for data drives embedded computing designs

The growing need for usable information in the field is influencing the selection of bus and board architectures for new and upgraded aerospace and defense system designs.

BY **Courtney E. Howard**

Aerospace and defense personnel, like most people today, depend on data. Information is integral to the success of a broad array of military and aerospace projects, missions, and battles. Even wars, it is said, are increasingly fought with bits and bytes.

Computer, electronics, and avionics system designs today, therefore, center on providing secure, reliable access to usable data. Yet, as engineers work to upgrade and modernize systems across domains — land, sea, air, space, cyber, and the electromagnetic spectrum — they are confronted with interoperability, connectivity, bandwidth, and security challenges.

Built-in security

"The military and aerospace world doesn't treat the Internet of Things (IoT) the same as typical commercial IoT applications because of security concerns," says Bob Judd, director of business development at United Electronic Industries (UEI) in Walpole, Mass. Nonetheless, he says, demand for smaller, localized IoT applications is on the rise. For example, a U.S. Navy ship design might not store data on an Internet-based Cloud, but may use a local Cloud host on-board from which data can be made available to computers and subsystems ship-wide.

"Even on captive, local networks on a ship, aircraft, or ground installation, the military is beginning to demand encryption. It's moving from a 'nice to have' feature to one that will soon be a firm requirement," Judd continues. "It has not risen to the level of biggest challenge yet, but data and system security issues may jump into first place in the not-too-distant future.

"In the military world, security aspects are rapidly becoming paramount; even in commercial aviation, system designers are very concerned about unauthorized access to data or, even worse, possible hacking of control systems," Judd adds. UEI is releasing a new version of its CPU modules with built-in hardware encryption to provide the security new systems will demand, but without the performance penalty of commonly used software-based encryption algorithms, he says.

For more on IoT technologies in aerospace and defense, visit http://bit.ly/2iXNfst.

Convergence conundrum

Aerospace and defense applications rely on data, often in real time or as near to it as possible, which puts a premium on robust, high-speed, connected systems and devices.

Mercury Systems 3U VPX enclosure

"The very high speed of the newest technologies makes signal integrity from end-to-end very important. One can no longer just plug things together and know they are going to work," says Michael Munroe, technical standards specialist at Elma Electronic Inc. in Horsham, Pa. In fact, "the biggest technical challenge we see is board interoperability, even when all are compliant to industry specifications."

Elma engineers are bringing the company's chassis and backplanes to bear on U.S. military system convergence challenges. "The effort is to combine what used to be multiple boxes of a total system (vehicle) into one box. This brings the former box-to-box communication onto the Elma backplane at the same time that data bus speeds are being increased," says Munroe, who finds it interesting and

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rewarding to help troubleshoot and sort out technical challenges.

Making the connection

The need for speed is influencing interconnect decisions throughout aerospace and defense designs, at the board, chassis, and system levels.

High-speed serial links are replacing virtually any bus, explains Rodger Hosking, vice president of Pentek Inc. in Upper Saddle River, N.J. "Gone are the parallel bus architectures previously used to interconnect virtually all embedded system elements. This not only applies to devices on the same boards but also between boards and systems.

"The benefits of fewer lines, less real estate, and smaller connectors are often well worth the added design challenges of higher bit rates and more sophisticated interfaces," says Hosking, who is witnessing a move from copper to optical connections.

"Spurred by the shift from parallel to serial links, optical interfaces are especially attractive for delivering high-bandwidth data over longer distances and where cable size, weight, and signal integrity are critical," Hosking continues. In fact, engineers are on the hunt for products capable of handling higher signal frequencies and bandwidths for their software radio communications and radar systems.

"Most new high-bandwidth A/D and D/A converters have abandoned simple parallel low-voltage differential signaling (LVDS) interfaces in favor of more complex JESD204B gigabit serial links, invariably implemented with custom field-programmable gate array (FPGA) engines," Hosking explains. "Not only must the FPGA accommodate the complexity of the JESD204B interface, but it must also handle data rates up to 9.6 gigabytes per second. As the sampling rates

Crystal Group RS363S15F Rugged 3U Server with a depth under 15 inches

Safety-certifiable COTS

The use of commercial off-the-shelf (COTS) technologies for aerospace and defense applications has moved into the safety-critical realm. Engineers are eager to leverage COTS modules to support safety-critical applications to RTCA DO-178 Software Considerations in Airborne Systems and Equipment Certification and DO-254 Design Assurance Guidance for Airborne Electronic Hardware Design Assurance Level (DAL) C and higher, and meet the need for mixed assurance graphics.

Interest in certifiable COTS modules continues to grow, says Greg Tiedemann, product line director of Mercury Mission Systems in Phoenix. Aerospace and defense engineers across a wide range of applications are interested in Mercury's safety-critical COTS product line, he says.

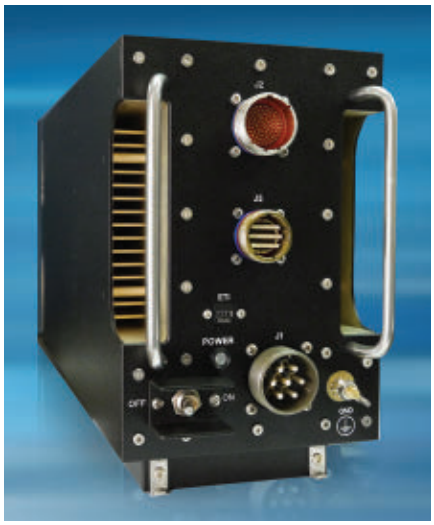
"The interest is fueled by the constraints on budget and schedule that doesn't allow for custom developments, as has been the case in the past," Tiedemann says. "We are seeing multiple applications for high-definition (HD) video streaming to cockpit displays and around the aircraft," Tiedemann explains. The trend toward glass upgrades in aircraft cockpits is driving the demand for mixed safety assurance graphics, and has generated some distinct challenges, he says.

Mercury was selected to provide safety-critical video server subsystems, which will perform encoding/decoding and switch multiple HD video streams, for a military airborne platform. "The challenge is always to provide a mix of boards at different safety-critical levels, within a single Modular Open Systems Architecture that can be easily configured for different sensors and upgraded for future capabilities," Tiedemann says.

Mercury engineers leverage a large portfolio of safety-certifiable processing and I/O building blocks and pre-integrate them into adaptable, pre-engineered avionics chassis, he says. For example, the company's ROCK pre-engineered, safety-certifiable chassis features multiple safety zones that support mixed assurance graphics and other applications requiring more than one level of safety certification.

Mercury personnel are also integrating safety-certifiable graphics libraries from Richland Technologies, an automotive and defense safety company it acquired, into the Mercury portfolio to expand its video server capabilities and safety-certifiable COTS offerings. Automotive electronics and software technologies are advancing rapidly in response to increased investment by top technology leaders, particularly in autonomous vehicles like self-driving or driverless cars. "Increased demand for automotive safety capabilities is influencing defense applications," Tiedemann explains. "The investment in Richland enables Mercury to integrate automotive technology for certifiable processing and graphics technologies into defense applications."

Technology transfer is growing among the automotive, Internet of Things (IoT), and aerospace/defense communities. Read more online about autonomous vehicle and IoT hardware and software innovations applicable to aerospace and defense applications from defense suppliers, such as Wind River, Crystal Group, and others at http://bit.ly/2eXAidS.



Elma Electronic StorSys-3000 Network Attached Storage (NAS) mission system

and operating modes change, these interfaces must adapt accordingly, further complicating the tasks."

Pentek's solution to the challenge lies it its Model 71141 6.4 gigasample-per-second A/D and D/A XMC module, the latest member of its Jade architecture for Xilinx Kintex UltraScale FPGAs. "By incorporating the required circuitry within the FPGA as an optimized and factory-installed intellectual property (IP) core, Model 71141 is ready to use, saving customers from tedious FPGA design tasks," Hosking says. Pentek's Navigator Design Suite offers libraries and drivers for application development, and an optional FPGA development kit for adding custom IP.

Interface with Ethernet

"We've seen an explosion in the number of military and aerospace systems that count on the Ethernet as the primary controlling interface between their central processing units (CPUs) and their input/output (I/O)," says Bob Judd, director of business development at United Electronic Industries (UEI) in Walpole, Mass. Judd cites a few reasons the Ethernet has become so popular, but perhaps the most powerful of is long operational lifespan.

"The Ethernet will be here for a long time. PC technology may change — e.g., Peripheral Component Interconnect (PCI) migrated to PCI Express — but the new revisions of Ethernet remain backward compatible," Judd explains. "That's critical in applications where the lifetime of a product needs to be measured in decades, not years or quarters.

"As PC technology changes and older CPUs become obsolete," Judd

says, "it's critical that new, modern CPUs can be brought on line that can use the existing infrastructure. The Ethernet provides this bridge between existing systems and the next generation of computers."

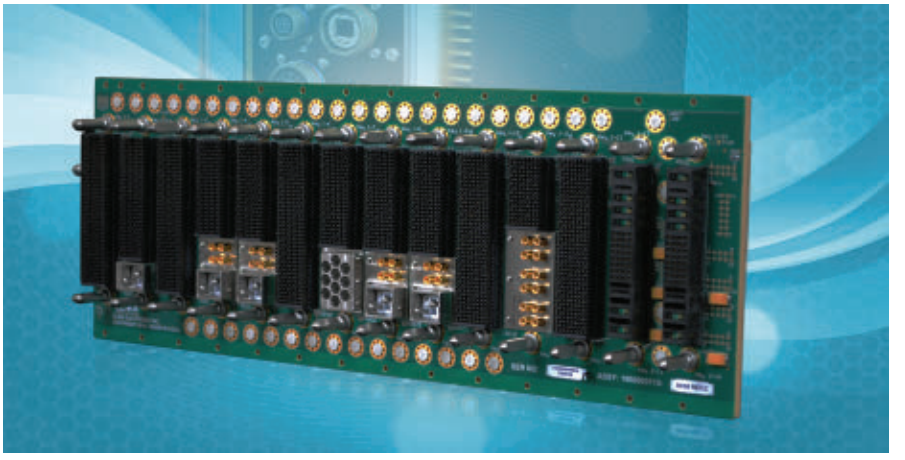
Open architecture adoption

Aerospace and defense applications are moving to open-architecture electronic designs for reasons of cost, interoperability, and simplified integration, upgrades, and maintenance.

VPX (VITA 46) is gaining design wins in many data-intensive applications where throughput and high-compute density (size) are critical factors, including signal and video processing, radar, communications, transportation, control, and management.

VPX adoption is rising rapidly for a wide range of systems, largely due to its dense, high-bandwidth backplane interconnects and its ruggedness, says Mark Littlefield, vertical product manager for defense at Kontron America Inc. in Poway, Calif. "The wide adoption of 10 Gigabit Ethernet is also a driving force making VPX a popular board architecture."

New applications sometimes also require additions to industry standards. "As new applications for VPX emerge, new requirements sometimes mean that new profiles must be defined to help guide the interoperability points necessary for integrating module to module, module to backplane, and chassis," says Jerry Gipper, executive director of the VITA open standards and open markets industry trade association in Oklahoma City. "OpenVPX will continue to evolve and incorporate new fabric, connector, and system technologies."



Elma Electronic high-speed 3U VPX backplane with 12 slots for integration of mixed payload modules, including COTS single-board computers, switches, c and RF payloads

"OpenVPX is by far the hottest architecture trend," Elma's Munroe says. Sensor Open Systems Architecture (SOSA), the new standards group effort started by Dr. Ilya Lipkin by the U.S. Air Force, ties in command, control, communications, computers, intelligence, surveillance, and reconnaissance/electronic warfare

United Electronic Industries DNA-MIL Cube advanced data acquisition and I/O platform

Speed time to market

Save time by buying one or more development systems before trying to build a deployable system, recommends Michael Munroe, technical standards specialist at Elma Electronic Inc. in Horsham, Pa. "A development system can prove feasibility, allow software work to start sooner, and be a critical support tool for deployable systems in the future."

Rodger Hosking, vice president of Pentek Inc. in Upper Saddle River, N.J., says he agrees, adding that "because the latest software radio technology means longer development cycles, growing complexity, and increased risks, defense contractors should try to find fully supported, standards based subsystems or boards, ready to install so that hardware and software integration systems of the larger system can begin as soon as possible. This cuts time to market, reduces development costs, and simplifies new technology insertion and upgrades."

"Keeping up with rapidly evolving technology, tight budgets, and constrained schedules — these challenges haven't changed in my years working in the defense and aerospace industries: They may actually be getting tougher," says Greg Tiedemann, product line director of Mercury Mission Systems in Phoenix.

Embrace COTS technologies wherever possible, advises Aaron Frank, senior product manager at Curtiss-Wright Defense Solutions. "COTS technology can reduce overall program cost, speed time to market, and eliminate technology risks associated with in-house bespoke designs."

modular open suite of standards (CMOSS) activities begun under the U.S. Army's Communications-Electronics Research, Development and Engineering Center (CERDEC). "SOSA defines the open hardware platforms for next-generation vehicle systems, and is based on the OpenVPX architecture."

"The VPX market has matured over the years and somewhat settled down with respect to architectures, largely due to VITA 65/OpenVPX," says Kontron's Littlefield. Yet, "there is still a lot of variability in VPX implementations, and both interoperability and interchangeability continue to be issues." Attacking those challenges are standards working groups for Modular Open Radio Frequency Architecture (MORA), Future Airborne Capability Environment (FACE), Sensor Open Systems Architecture (SOSA), and Hardware Open System Technology (HOST)/VITA 84, he says. "It's not simply a matter of pin grabs and slot profiles; it also involves things like system design approaches and software stacks."

Littlefield credits the industry working groups with driving things from a functional standpoint, "solving problems in determining what components best solve design issues/requirements and how these components are configured. The functionality is much more complex than in the '80s and '90s when VME (Versa Module Europa) ruled, and these groups are doing a great job defining these functional elements."

Standing the test of time

Computer on Module (COM) Express is gaining traction in a wide range of defense and avionics applications, and becoming a strong player, Littlefield says. "While one may not immediately think of COM Express as a reliable deployable form factor for aerospace and defense systems, we are seeing it applied to systems in ground vehicles, commercial and military fixed-wing aircraft, helicopters, and unmanned aerial vehicles (UAVs)," he says. "The only place I haven't seen it applied is spacecraft, but it's probably just a matter of time.

"Stick to industry standards and design practices; don't try to be too inventive in your system design

Autonomous airborne systems and SWaP

"We see a growing need for DO-254 safety-certifiable COTS modules," says Aaron Frank, senior product manager at Curtiss-Wright Defense Solutions. "This trend continues to find its way into systems which may not require safety certification today, but that need a path to safety certification in the future without requiring a future re-design. Just think of the growth in autonomous airborne systems that are increasingly making their way into commercial airspace. These systems are squarely in the sights of the aviation certification authorities."

In fact, "there is a growing demand for COTS-based single-board computers and graphics and I/O modules that are designed to be safety-certifiable, to DO-254, both for commercial aerospace and defense applications," adds Mike Slonosky, senior product manager of power architecture and ARM single-board computers at Curtiss-Wright in Ottawa, Ontario.

As the demand for safety-certifiable systems is increasing in the defense space, so is the decreased time to market (TTM) and requirement for lower non-recurring engineering (NRE), Slonosky says. COTS vendors like Curtiss-Wright are developing COTS products to fill this market space, amortizing the development cost and providing artifacts to support certification at a much lower cost than a custom development, he explains.

"In the safety certifiable market, customers are developing autonomous air taxis, which, when they come to market, will be the Ubers of the future," Slonosky predicts. "They are also driving the requirement for small, rugged form factors."

SWaP continues to drive many architectures from 6U to 3U and, without a doubt, 3U VPX is the overwhelming trend today, Frank says. "Add to this the constant push for more and more processing performance in the smallest space, and we find many customers re-architecting their legacy systems from 6U to 3U modules, using Intel processors. Also, with the incredible performance delivered by high core-count processors, such as the Intel Xeon D, a single 3U VPX module can replace a large number of legacy processing boards, shrinking overall system size, and/or significantly increasing capabilities in the smallest space possible."

approach," Littlefield recommends. "The more you stray from the norm, the harder and more expensive it will be to find the solution components that you need to build your deployable system.

Help with heat

For most designers, heat remains the toughest challenge, says Rodger Hosking, vice president of Pentek Inc. in Upper Saddle River, N.J. "As silicon features continue to shrink, increased functional density means more watts in a given space. Doing a better job of extracting that heat requires multi-disciplinary innovations in component packaging, materials engineering, mechanical design, and system standards."

"As the pressures of size and weight reduction as well as power performance increase, dealing with thermal management challenges is becoming increasingly important," adds Michael Munroe, technical standards specialist at Elma Electronic Inc. in Horsham, Pa., who recommends investing time in understanding thermal modeling tools.

"Sometimes in order to meet your mission requirements, you should approach a problem in an innovative way, which forces what might be seen as an unconventional system design," Littlefield continues "Even in these cases, it is best to try to employ common design patterns. Otherwise, you will end up with an expensive, custom solution and future tech refreshes will be all but impossible."

Think long term, UEI's Judd advises. "What you design today will probably still be running in 30 years. It may not be that you have to support it, but somebody will. A 10 or 20 percent savings in the development cost or delivery price of the system today is not cost-effective if the system becomes impossible to support or maintain in 10 years. The more you think about the long-term ramifications of the systems you develop, the better off your company and your customers will be."

Pentek Jade Model 71141 6.4 GS/sec A/D and D/A XMC module for wideband defense, radar, and communication applications

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SPY-6 radar for latest destroyers scores in missile-defense test

The radar bound for the Navy's new Flight III Arleigh Burke guided-missile destroyers tracked a complex ballistic missile target as part of a battery of tests to prove out the new system. The Raytheon-built AN/SPY-6(V) Air and Missile Defense Radar (AMDR), based at the Pacific Missile Range Facility at Kauai Hawaii, detected and tracked a medium-range ballistic missile target during the Vigilant Titan test, the second in a series of tests for the systems that will replace the Lockheed Martin AN/SPY-1D(V) volume search radar on the current Flight IIA. AMDR promises 30 times more sensitivity than current SPYs and is designed to find and track traditional air warfare and ballistic missile threats simultaneously.

BAE Systems launches iMOTR radar system for military test ranges

The BAE Systems Intelligence & Security segment in McLean, Va., has launched a new mobile multiple-object tracking radar (MOTR) for military test and evaluation ranges. The iMOTR system uses a C-band or X-band active electronically scanned array antenna and enhanced clutter suppression to provide high accuracy in tracking time, space, and position information for objects in flight.

RF jammers for the battle against IEDs go into full-rate production

BY **John Keller**

WASHINGTON — Electronic warfare (EW) experts at Northrop Grumman Corp. are moving to full-rate production of common open-architecture RF jammers for infantry, land vehicles, and fixed sites to protect U.S. and allied warfighters from radio-controlled improvised explosive devices (IEDs).

Officials of the U.S. Naval Sea Systems Command in Washington announced a $57.7 million contract to the Northrop Grumman Mission Systems segment in Herndon, Va., for full-rate production of the Joint Counter Radio-Controlled Improvised Explosive Device (RCIED) Electronic Warfare, Joint Crew (JCREW) Increment One Build One (I1B1). This contract has options that could increase its value to $505.3 million.

CREW systems provide combat troops protection against RCIEDs, and are designed to provide protection for foot soldiers, vehicles, and permanent structures. The JCREW I1B1, formerly known as JCREW 3.3, is the first-generation system that develops a common, open architecture across all three capabilities and provides protection for worldwide military operations, officials say.

This integrated design makes the most of commonality across all capabilities, reduces life-cycle costs, and provides increased protection against worldwide threats. It is for the U.S. Marine Corps, Navy, and Air Force, and is under supervision of Naval Sea Systems Command.

The Joint Counter Radio-Controlled Improvised Explosive Device (RCIED) Electronic Warfare, Joint Crew (JCREW) Increment One Build One (I1B1), shown above, is entering full-rate production.

Among the JCREW I1B1 systems is the Northrop Grumman Freedom 240 for Counter Radio-controlled IED Electronic Warfare Marine Expeditionary Unit Special Operation Capable (SOC), or CREW MEU. The system jams a wide range of IEDs and creates a protective barrier around Marine Corps infantry and their equipment while minimizing disruption to friendly communications systems.

On this contract, Northrop Grumman will do the work in San Diego and in Sierra Vista, Ariz., and should be finished by August 2022.

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

General Dynamics to upgrade Abrams main battle tanks and vetronics to SEPv3

BY **John Keller**

WARREN, Mich. — Armored combat vehicle experts at General Dynamics Corp. will upgrade 45 M1 Abrams main battle tanks and vetronics to the most advanced M1A2 system enhancement package version 3 (SEPv3) configuration under terms of a $270.2 million contract.

Officials of the U.S. Army Contracting Command in Warren, Mich., are asking General Dynamics Land Systems in Sterling Heights, Mich., to install and integrate SEPv2 legacy unique components resulting in 45 M1A2 SEPv3 Abrams Main Battle tanks.

The M1A2 SEPv3 main battle tank is the latest version of the M1 Abrams, and has increased power generation and distribution, better communications and networking, a new vehicle health management system (VHMS), line replaceable modules (LRMs) for improved maintenance, and an ammunition datalink (ADL) to use airburst rounds.

The contract also asks General Dynamics Land Systems to procure, stock, and store 60 sets of SEPv2 legacy and SEPv3 unique components, procure integrated product support requirements, special tooling and test equipment, and the systems support package.

This latest version of the M1A2 tank also offers an improved counter-improvised explosive device (IED) armor package, improved forward-looking infrared (FLIR) sensor using long- and mid-wave infrared, a low-profile Common Remotely Operated Weapon Station (CROWS), and an auxiliary power unit (APU) under armor to run electronics without the engine running.

General Dynamics will make technology upgrades involving several RF subsystems on the U.S. Army M1 Abrams main battle tank.

Prototypes of the M1A2 SEPv3 tank began testing in 2015, and should enter service this year. Improvements to the SEPv3 version focus on increasing the electrical power; improving survivability; integrating the new Army network; electronic component improvements; new auxiliary power unit; and an ammunition data link.

The M1A2 SEPv3 is the next-generation M1 tank version from the SEPv2, which focused on improved survivability, automotive power pack, computer systems, and night-vision capabilities. The SEPv2 also offered improvements in the CROWS and ballistic solution upgrades for the M829A3 kinetic and the M1028 canister rounds.

The M1A2 SEPv2 has improved microprocessors, color flat-panel displays, improved memory capacity, better soldier-machine interface, and a new open operating system designed to run the Common Operating Environment software.

The tank gunner's primary sight and the commander's independent thermal viewer include the improved thermal imaging capabilities of the new Block I 2nd generation FLIR technology.

Army leaders intend the M1A2 SEPv3 to defeat and suppress enemy tanks, reconnaissance vehicles, infantry fighting vehicles, armored personnel carriers, anti-tank guns, guided missile launchers, bunkers, infantry, and helicopters.

On this contract, General Dynamics will do the work in Lima, Ohio; Scranton, Pa.; Anniston, Ala.; and Tallahassee, Fla., and should be finished by August 2019.

FOR MORE INFORMATION visit **General Dynamics Land Systems** online at *www.gdls.com*, or the **Army Contracting Command** in Warren, Mich., at *acc.army.mil/contractingcenters/acc-wrn*.

New Army technology protects drones from enemy attacks

The U.S. Army and Textron are adding new computer processing power and cyber-hardening technology to the current inventory of ground control stations operating drones in combat, to better defend against enemy "hacking," "jamming" and "interference" with video feeds, service officials say. The Textron-built Universal Ground Control Station (UGCS), which currently operates the Army's Shadow and Grey Eagle drones, is being engineered with new performance-enhancing software to secure drone controls and drone video feeds from hacking, interference, and cyber-attacks. The upgrade, described as a software and hardware obsolescence project, will use an emerging Army software architecture called Future Airborne Capability Environment, or FACE. The re-architected software is designed to lower costs and accommodate new technologies and upgrades more efficiently — while strengthening cybersecurity. These semi-annual upgrades are part of a multipronged Army strategy to sustain and improve ground-control technology for drones now in combat as well as those planned for future years.

Raytheon to upgrade surveillance sensor in Global Hawk Block 30 UAV

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — U.S. Air Force surveillance and reconnaissance experts are asking the Raytheon Co. to upgrade an electro-optical sensor suite in the RQ-4 Global Hawk long-range unmanned aerial vehicle (UAV).

Officials of the Air Force Lifecycle Management Center at Wright-Patterson Air Force Base, Ohio, have announced a $25.9 million contract to the Raytheon Space and Airborne Systems segment in El Segundo, Calif., for the Global Hawk Block 30 Enhanced Integrated Sensor Suite (EISS) modification and for the Enhanced Electro-Optical Receiver Unit (EERU) retrofit.

Raytheon will upgrade a Global Hawk sensor suite to enable the long-range UAV to perform reconnaissance in all weather conditions.

The EISS provides reconnaissance imagery using an all-weather synthetic aperture radar and moving target indicator (SAR/MTI), a high-resolution electro-optical (EO) digital camera, and a third-generation infrared (IR) sensor, all operating through a common signal processor.

The Raytheon EISS enables the Global Hawk to survey vast geographic regions with image quality that can distinguish various types of vehicles, aircraft, people, and missiles, during the day, at night, and in bad weather.

The EISS transmits imagery and position information from altitudes as high as 60,000 feet with near real-time speed with night vision and radar detection capabilities.

The EERU is one of several line-replaceable units inside the EISS. To modify the EERU, Raytheon engineers also must modify hardware and software in the EISS's Enhanced Sensor Electronics Unit (ESEU) and Enhanced Integrated Sensor Processor (EISP).

Air Force leaders seek to demonstrate these upgrades to the Global Hawk Block 30's EISS, and then upgrade the service's entire Global Hawk Block 30 fleet with these enhancements.

The Global Hawk Block 30 is 47.6 feet long, has a wingspan of 130.9 feet, can fly as high as 60,000 feet, can carry payloads as heavy as 3,000 pounds, and can fly for as long as 32 hours on one load of fuel.

On this contract, Raytheon will do the work in El Segundo, Calif., and should be finished by February 2019.

FOR MORE INFORMATION visit **Raytheon Space and Airborne Systems** online at *www.raytheon.com/capabilities/sensors*, or the **Air Force Lifecycle Management Center** at *www.wpafb.af.mil/aflcmc*.

Navy asks Hydroid to upgrade MK 18 unmanned underwater vehicle

BY **John Keller**

INDIAN HEAD, Md. — Unmanned underwater vehicle (UUV) experts at Hydroid Inc. in Pocasset, Mass., will upgrade the company's MK 18 family of unmanned submersibles under terms of a $27.3 million contract.

Officials of the Naval Surface Warfare Center (NSWC) Indian Head Explosive Ordnance Disposal Technology Division in Indian Head, Md., are asking Hydroid for additional engineering to develop, test, and install preplanned product improvements for the MK 18 family of unmanned underwater vehicle (UUV) systems.

Preplanned product improvement, also called P3I, involve periodic systems and technology upgrades during development to enhance system performance or mitigate the effects of subsystem or component obsolescence.

The Navy Hydroid MK 18 UUV is a variant of the Hydroid REMUS 600, which Hydroid originally developed through funding from the Office of Naval Research (ONR) in Arlington, Va., to support the Navy's UUVs with extended endurance, increased payload capacity, and greater operating depth. REMUS is short for Remote Environmental Measuring Unit S.

The Mk 18 Mod 1 Swordfish UUV can perform low-visible exploration and reconnaissance in support of amphibious landing; mine countermeasures operations such as search, classification, mapping, reacquire, and identification; and hydrographic mapping at depths from 10 to 40 feet.

The UUV can navigate via acoustic transponders in long-baseline or ultra-short-baseline mode, or via P-coded GPS. Its upward- and downward-looking acoustic digital velocity log improves dead-reckoning accuracy.

The MK 18 Mod 1 Swordfish UUV achieved full operational capabilities in 2008. Follow-on block upgrades will combine two separate UUV programs into the MK 18 family of systems to deliver improved detection capability against buried mines in high clutter environments.

The REMUS 600, on which the MK 18 UUV is based, can dive to depths of nearly 2,000 feet, and can operate on one battery charge for as long as 24 hours. The UUV is for mine countermeasures; harbor security; debris field mapping; search and salvage; scientific sampling and mapping; hydrographic surveys; environmental monitoring; and fishery operations.

The torpedo-shaped REMUS 600 UUV is nearly 13 feet long and two feet in diameter. The unit weighs 622 pounds. It has dynamic focus side look sonar (SLS), a Neil Brown conductivity and temperature sensor (CT), WET Labs beam attenuation meter (BAM) optical sensor, Imagenex 852 pencil beam sonar for obstacle avoidance, and a WET Labs ECO fluorometer and turbidity measurement sensor.

Its communications suite consists of a long baseline acoustic communications, Wi-Fi, Iridium satellite communications, and radio modem via gateway buoy. The UUV navigates by up- and down-looking acoustic Doppler current profiler; Doppler velocity log; Kearfott inertial navigation unit; compass; and GPS.

Hydroid is upgrading the Navy MK 18 unmanned submersibles to enhance system performance and mitigate the effects of subsystem or component obsolescence.

The REMUS 600 has a modular design to meet a variety of payloads. The UUV has a series of hull sections that can be separated for vehicle reconfiguration, maintenance, and shipping. IT uses the Hydroid Vehicle Interface Program (VIP) for maintenance, checkout, mission planning, and data analysis.

Hydroid will do the work in Pocasset, Mass., and should be finished by November 2018.

Hydroid is a subsidiary of Kongsberg Maritime AS in Kongsberg, Norway.

FOR MORE INFORMATION visit **Hydroid** online at *www.km.kongsberg.com/hydroid*, and the **NSWC Indian Head Explosive Ordnance Disposal Technology Division** at *www.navy.mil/local/nswciheodtd*.

ELECTRO OPTICS watch

Lockheed Martin to upgrade electro-optical surveillance for Navy submarines

BY **John Keller**

WASHINGTON — Submarine combat systems experts at Lockheed Martin Corp. will provide systems upgrades and technology insertion for a U.S. Navy electro-optical surveillance system designed for several classes of submarines.

Officials of the Naval Sea Systems Command (NAVSEA) in Washington awarded an $119.7 million order to Lockheed Martin Mission Systems and Training in Manassas, Va., for technology insertion and refreshment for the AN/BVY-1 Integrated Submarine Imaging System (ISIS). Lockheed Martin will provide design, development, testing, reverse engineering, technology insertion and refreshment, engineering services, field engineering services, and system support for the ISIS system.

ISIS provides mission-critical, all-weather visual and electronic search, digital image management, indication, warning, and platform architecture interface capabilities for Los Angeles-, Ohio-, and Virginia-class submarines. An add-on system to integrate all imaging capabilities on existing Navy submarines, ISIS is part of the Navy's submarine Photonics Imaging System.

The ISIS program is replacing the optical light path of existing submarine periscopes with high-definition cameras and fiber-optic digital imagery. It uses infrared cameras for image enhancements; provides active and passive range finding control; installs image enhancement capabilities and analysis tools for real-time and recorded imagery; provides image recording, storage, and recall capabilities; and provides the ability to transmit imagery off the submarine to other naval and joint forces.

Lockheed Martin is upgrading the U.S. Navy ISIS electro-optical surveillance system designed for several classes of submarines.

In-Depth Engineering Corp. in Fairfax, Va., erves as the software development lead for AN/BVY-1 ISIS, a system that revolutionizes Navy submarine surveillance capabilities by integrating digital video and still images from devices on a submarine's exterior and presenting real-time imagery and analysis on existing control room tactical displays.

Lockheed Martin will do the work in Manassas, Virginia Beach, Arlington, and Fairfax, Va.; Syracuse, N.Y.; Northampton, Mass.; and Newport, R.I., and should be finished by September 2018.

FOR MORE INFORMATION visit **Lockheed Martin Rotary and Mission Systems** online at *www.lockheedmartin.com/us/rms.html*.

Army needs lidar long-wave infrared detectors

U.S. Army researchers are surveying industry to find advanced-prototype, long-wave infrared (LWIR) light detection and ranging (lidar) technologies for standoff detection of biological and chemical agents that could pose threats to military forces. Officials of the Edgewood Chemical Biological Center at Aberdeen Proving Ground, Md., issued a sources-sought notice (W911SR-17-R-LWIR) for the Long-wave Infrared Lidar project. Researchers seek advanced-prototype, commercial off-the-shelf or government off-the-shelf LWIR lidar technologies capable of detecting chemical vapors and biological aerosols to enable chemical and biological standoff detection. The goal is to provide a standoff detection capability in a mobile or fixed-site application at ranges as far as 1.3 miles.

Marine Corps enhancing targeting and fire control

Vetronics experts at the Raytheon Co. are upgrading the electro-optical, fire-control system in the U.S. Marine Corps General Dynamics M1A1 Abrams main battle tank to improve situational awareness. The Marine Corps announced a $10.2 million order to Raytheon Integrated Defense Systems in McKinney, Texas, for the Abrams Integrated Display and Targeting System (AIDATS). The upgrade to the Marine Corps's 400 M1A1 tank includes an upgraded thermal sight, color day camera, and single stationary display, and reduces target engagement times.

Navy needs electro-optical situational awareness aboard surface warships

BY **John Keller**

ARLINGTON, Va. — U.S. Navy researchers are surveying industry to find companies able to blend coarse-resolution and high-resolution electro-optical imaging technologies for enhanced wide-area situational awareness aboard Navy surface warships.

Officials of the Office of Naval Research in Arlington, Va., issued a sources-sought notice (N00014-17-RFI-0005) for the Panoramic Imaging for Situational Awareness and Target Recognition project. Researchers are trying to blend coarse- and high-resolution imagery from passive sensors such as long-, mid-, and short-wave infrared (SWIR) detectors, perhaps even passive millimeter wave technology, to help ship crews quickly detect, locate, and defend against surface and airborne threats such as fast-attack boats and anti-ship missiles.

Navy experts not only are interested in blending coarse- and high-resolution imagery, but also in blending data from different kinds of sensors to make the most of target detection in clouds, dust, fog, and rain.

For this project, Navy experts are focusing on a field of view measuring 20 degrees below the horizon of a surface ship, to 30 degrees above the ship's horizon. The object is to make the most efficient use possible of sensors and signal-processing, yet still meet the Navy's situational-awareness requirements for surface ships.

Today, the U.S. Navy uses two different approaches to shipboard situational awareness with electro-optical sensors: medium resolution and coarse resolution.

Medium resolution of around 80-microradian instantaneous field of view imaging sensors can see to 50 degrees above the horizon, and can provide 360-degree coverage. Coarse-resolution sensors of around 100 to 200 microradian instantaneous field of view can work quickly enough to detect fast-moving threats.

Cues from coast-resolution sensors can steer high-resolution sensors with narrow fields of view video-frame-rate imaging sensors to help recognize, identify, track, and gauge the intent of nearby threats.

Each has its drawbacks. Medium-resolution imaging sensors reduce the revisit rate for detected targets, can miss fast-moving targets, and generate too many false alarms.

Coarse-resolution sensors maintain situational awareness at frame rates fast enough to track fast-moving targets, deal with clutter, and reduce false-alarm rates, yet are not effective in the presence of targets numbering in the tens or hundreds. This approach also has latency issues as the high-resolution imager slews from one contact to another.

Instead, Navy researchers are asking industry for unconventional approaches, such as one that provides a coarse-resolution staring mode for situational awareness, while simultaneously under software control providing more than 100 regions that obtain high-resolution and video-frame-rate images. These regions also should be able to be steered dynamically without mechanical motion to follow objects of interest.

The Navy is trying to blend coarse-resolution and high-resolution imaging for enhanced wide-area situational awareness aboard Navy surface warships.

By providing high resolution only over regions of interest, such a system will minimize the data transfer bandwidth as well as size, weight, power consumption, and cost (SWaP-C) of the overall system.

This project also seeks to identify a family of imaging systems that could handle the situational-awareness needs of surface vessels ranging in size from a patrol craft, a frigate, a destroyer, and an aircraft carrier.

Navy researchers are looking for information from industry that is grounded in sound physical principles, and that is consistent with technology-development roadmaps in optics, focal plane arrays, and image processing hardware and algorithms.

E-mail responses in .pdf format no later than 6 Oct. 2017 to the Navy's Ravi Athale at ravindra.athale@navy.mil. Put "Panoramic Imaging for Situational Awareness" in the subject line. E-mail questions or concerns to Ravi Athale at ravindra.athale@navy.mil.

MORE INFORMATION IS online at *http://bit.ly/2gvId5S*.

PRODUCT applications

COMBAT VEHICLES

Oshkosh to build 748 new JLTV armored combat vehicles

Officials of the U.S. Army Contracting Command in Warren, Mich., are asking Oshkosh Defense LLC in Oshkosh, Wis., to build 748 new Joint Light Tactical Vehicle (JLTV) systems, as well as 2,359 installed and packaged kits, under terms of a $195.5 million order.

The order is a modification to a $114.7 million contract to Oshkosh in August 2015 for JLTV low-rate initial production (LRIP) and full-rate production. That contract has options that eventually could increase its value to $6.7 billion, and is expected to be one of the most lucrative military vehicle programs over the next decade.

The U.S. Department of Defense (DOD) wants to buy 54,599 JLTVs: 49,099 for the U.S. Army and 5,500 for the U.S. Marine Corps. The U.S. Government Accountability Office estimates that the DOD will spend more than $53.3 billion on the JLTV program: $1.1 billion for research and at least $52.3 billion for procurement.

The Oshkosh JLTV is a version of the company's Light Combat Tactical All-Terrain Vehicle (L-ATV). The JLTV light utility and combat multi-role vehicle is expected to deliver a level of protection similar to that of current, but far heavier and less maneuverable Mine Resistant Ambush Protected (MRAP) class designs, and much better than the latest armored HMMWVs. The JLTV has a two-seat and a four-seat variant, as well as a companion trailer (JLTV-T).

The Oshkosh vehicle offers Core1080 crew protection for survivability, turret-operated systems, remote weapons systems, and tube-launched missile system. The Oshkosh JLTV features the company's TAK-4i intelligent independent suspension system, and the digitally controlled General Motors Duramax V8 cylinder 6.6-liter diesel engine.

The contract was awarded on behalf of the Army Tank-automotive and Armaments Command and has eight options for Oshkosh to build the first 16,901 vehicles for the Army and Marine Corps.

Oshkosh will do the work in Oshkosh, Wis., and should be finished by November 2018.

FOR MORE INFORMATION visit **Oshkosh Defense** online at *https://oshkoshdefense.com*.

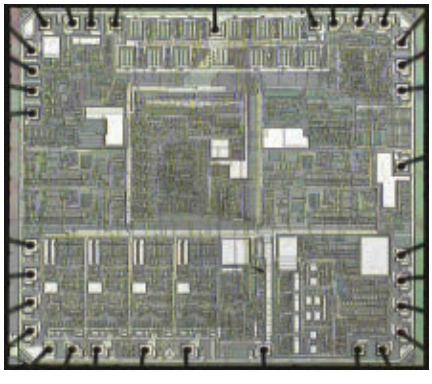
INTEGRATED CIRCUITS

USC, DARPA zero-in on high-end military IC custom design

U.S. military researchers are moving forward with a project to revolutionize high-end integrated circuit (IC) custom design for military and aerospace applications.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., announced an $8.2 million contract modification to USC Information Sciences Institute (ISI) in Los Angeles for phase-two options in the Circuit Realization at Faster Timescales (CRAFT) – FinFET Foundry/Design Aggregation Services military chips program.

The CRAFT FinFET program seeks to develop a custom IC design flow to



reduce the effort necessary to design high-performance custom ICs; help port IC designs to secondary IC foundries and more advanced technologies; and reuse of IC intellectual property.

USC ISI won an $11.8 million contract in December 2015 for the first phase of the CRAFT FinFET program.

USC ISI then won $3 million in CRAFT FinFET contract options in March 2016 — $1.2 million for phase 1, $890,524 for phase 2 option 1, and $840,335 for phase 3 option 2.

To maintain technology dominance, the U.S. military is developing next-generation systems that require high computational performance in a power-constrained environment. These technologies cannot be manufactured fast enough, causing systems designers today to choose between high performance and low power consumption. For the most crucial applications, systems designers must choose between high-performing, custom ICs that require years to design and fabricate, or settle for a 100X lower-performing, general-purpose processor that can be programmed in months.

The DARPA CRAFT program seeks to demonstrate a custom IC design flow and methodology in a leading-edge commercial 16- or 14-nanometer fab, port these designs to new foundry process flows, and increase design reuse by providing a repository for secure storage and distribution of design elements.

The CRAFT has three technical goals: reducing custom IC design and fab cycle time by 10X with new software tools; enabling a 50 percent reuse of critical military IC modules with an intellectual property (IP) repository system; and enabling flexible chip fabrication by porting a technology node from one foundry to another, or migrating from one design node to another design node at the same foundry.

To meet these goals, DARPA needs to build custom ICs using the FinFET leading-edge CMOS process node because of this technology's density, performance, and power advantages. To access this technology, the CRAFT program needs FinFET foundry access, and this is where USC Information Sciences Institute comes in.

In the program's first phase, USC experts will have demonstrated a 10X reduction in design efforts using a standard flow for a system-on-chip (SoC) with logic block size of more than 200,000 gates, several mixed signal blocks, SRAM memory blocks, and third-party intellectual property (IP) blocks. In the second phase, USC experts will demonstrate a 7X reduction in design efforts to create a DARPA-selected SoC design, document the design flow; test fabricated chip functionality across standard temperature ranges; characterize an initial suite of macros and generators; document a reference CAD flow; and design a suite of macro and generators.

USC is providing a design aggregation service for other CRAFT contractors as they perform dedicated and foundry-driven FinFET multi-project wafer shuttle runs. USC ISI will act as the primary interface between foundries and DARPA.

USC ISI will do the work in Marina Del Rey, Calif., and should be finished by August 2018.

FOR MORE INFORMATION visit the **USC Information Sciences Institute** online at *www.isi.edu*.

AIRBORNE SENSORS

Army chooses airborne electro-optical sensor payloads from L-3 Wescam

Electro-optical sensors experts at L-3 Communications will provide the U.S. Army with six Wescam MX-15D sensor turrets for reconnaissance and surveillance applications on helicopters and fixed-wing aircraft.

Officials of the Army Contracting Command at Redstone Arsenal, Ala., have announced a $7.4 million contract to the L-3 Sonoma EO segment in Santa Rosa, Calif., to provide the Wescam MX-15D sensor turrets and support equipment.

The MX-15 electro-optical sensor pod is for medium-altitude covert intelligence, surveillance, and reconnaissance (ISR); search-and-rescue;

and similar kinds of surveillance missions. It supports as many as six sensors simultaneously, including visible-light cameras, infrared sensors, and laser rangefinders.

The MX-15 has a zoom potter to enable the operator to balance magnification and field of view between moderately wide and ultra-narrow imagery. The system's high-resolution shortwave infrared (SWIR) camera provides imaging in haze and fog.

The MX-15's turret has a four-axis gimbal with internal inertial measurement unit, image stabilization, common operator interfaces and hand controllers, and a map-based sensor management package that enables operators to control sensors from an intuitive interface. In addition to helicopters and fixed-wing aircraft, the L-3 MX-15 electro-optical sensor pod also is for unmanned aerial vehicles (UAVs) and aerostats.

FOR MORE INFORMATION visit **L-3 Sonoma EO** at *www2.l3t.com/sonomaeo*.

DATA RECORDING

Rugged data recorder for military and aircraft introduced by Curtiss-Wright

The Curtiss-Wright Corp. Defense Solutions Division in Ashburn, Va., is introducing the CNS4-FC rugged computer data recorder for demanding military environments, such as those endured by transports, helicopters, unmanned platforms, and

mobile radar systems. The system is designed to support legacy sensor systems based on the Fiber Channel (FC) data communications protocol and to bridge that data to Ethernet networks, and ensure the integrity of critical data. For applications that require security for data-at-rest, the recorder also provides support for NSA Type 1 encryption. The CNS4-FC compact network storage subsystem combines four-channel data recording, encryption, and removable storage in a rugged chassis. It provides system designers with a modernized solution for high-speed data recording, cryptography, and removable storage while protecting their investment in previously qualified FC-based sensor and client system architectures. A Crypto Ignition Key (CIK) and DS-101 key fill port are mounted on the chassis' front panel when this IME is used. Additional encryption options are available.

FOR MORE INFORMATION visit **Curtiss-Wright Defense Solutions** online at *www.curtisswrightds.com.*

GRAPHICS PROCESSING

3U VPX embedded computing board for graphics processing introduced by Aitech

Aitech Defense Systems Inc. in Chatsworth, Calif., is introducing the CB912 VideoPaC 3U VPX embedded computing board to enhance graphics processing in dense computing applications like glass cockpit displays, mission computers, situational awareness, C4ISR, and electronic warfare (EW) systems. The CB912 combines two powerful processing boards and advanced software bundles into an integrated platform that provides graphics computing in a single-slot, SWaP-optimized,

rugged package. The PowerPC-based VideoPaC pairs a 3U VPX single-slot, single-board computer with a video and graphics XMC mezzanine that features the AMD E8860 Radeon graphics processing unit (GPU.) This combination offers a video imaging FPGA, which provides video input interfaces and additional output interfaces not natively supported by the GPU. Integrated software bundles include Wind River VxWorks and VxWorks A653, and Green Hills INTEGRITY and INTEGRITY-178 with tuMP (True Multi-Processing), coupled with CoreAVI's FACE-compliant, OpenGL SC (Safety Critical) or Richland Technologies VIPUR/RTGL certifiable graphics/video software drivers.

FOR MORE INFORMATION visit **Aitech** online at *www.rugged.com.*

INTERCONNECTS

Rugged spring-loaded connectors for wire-to applications introduced by Mill-Max

Mill-Max Manufacturing Co. in Oyster Bay, N.Y., is introducing the single-row 824-22-0XX-00-005000

and double-row 826-22-0XX-00-005000 solder cup spring-loaded connectors for rugged and discreet wire-to-board, cable-to-board, or cable-to-cable interconnect applications. The connectors provide a mid-stroke of .045 inches with a maximum stroke of .090 inches. The longer stroke helps compensate for tolerance stack-ups in assemblies and provides greater flexibility for unpredictable motion due to shock and vibration. The 824 and 826 series headers have the 0947-0-15-20-77-14-11-0 spring pin using 0.09-inch maximum stroke spring. Each pin in the connector provides a mid-stroke

force of 60 grams, a solder cup sized to accommodate as large as a 22 AWG wire, and a current rating of 2 amps continuous use (3 amps maximum). The high-retention force press-fit of the solder cup to the body of the spring pin ensures the reliability of the component during soldering and assembly. The connectors are made with high-temperature Nylon 46 insulators, have 0.1-inch pin spacing and are available from 1 to 64 positions in single-row, and 2 to 72 positions double-row.

FOR MORE INFORMATION visit **Mill-Max** online at *www.mill-max.com*.

RF AND MICROWAVE

Waveguide phase shifters test and measurement introduced by Pasternack

Pasternack Enterprises Inc. in Irvine, Calif., is introducing a line of RF and microwave waveguide phase shifters in sizes ranging from WR-42 to WR-10 for instrumentation, test and measurement, product development, and characterization in aerospace, defense, industrial, and other industries. Pasternack's waveguide phase shifters have seven models that operate in 18 GHz to 110 GHz and in seven waveguide bands from K to W band. They provide phase shift range from 0 to 180 degrees and 1 dB maximum insertion loss. These waveguide phase shifters are made from gold-plated brass waveguide material and feature UG flange-style per military standard. The micrometer allows for precision and repeatable phase settings. Pasternack's waveguide phase shifters are in stock and ready for shipment with no minimum order quantity.

FOR MORE INFORMATION visit **Pasternack** online at *www.pasternack.com*.

EMBEDDED SERVERS

Rugged embedded computing server for SIGINT, surveillance, and AI introduced by Themis

Themis Computer in Fremont, Calif., is introducing the XR6 Rugged Enterprise Servers (RES) with Intel Xeon Scalable (Skylake) processors for embedded computing applications

like signals intelligence (SIGINT), cryptography, artificial intelligence, surveillance, sensor fusion, analytics, communications, and video processing. The 1U RES-XR6 server with eight front-access drives has two Intel Xeon Gold Skylake processors with as many as 24 cores per socket, as much as 1.5 terabytes of ECC DDR4 2666 MHz memory, three PCI Express x16 slots, eight SAS3-capable 2.5-inch front-access drive slots for either SSD or HDD storage, and two onboard 1 gigabit Ethernet (optional 10 gigabit Ethernet) ports. Additionally, all XR6 RES servers come with IPMI v2.0, TPM 2.0 and are compatible with popular hypervisors and operating systems. Optimized for size, weight, and power (SWaP), the system weighs 22 pounds, is 20 inches deep, and meets MIL-STD environmental specifications.

FOR MORE INFORMATION visit **Themis Computer** online at *www.themis.com/res-xr6*.

BOARD PRODUCTS

Rugged 6U CompactPCI board for demanding environments offered by Kontron

Kontron in Augsburg, Germany, is introducing the rugged CP6006-SA new-generation 6U CompactPCI server-class embedded computing board for multi-CPU, server-class applications in demanding environments. The Kontron CP6006-SA is based on Intel Xeon D-1500 processors with 2 to 16 cores. It offers a scalable yet affordable high-performance option for servers and computing nodes providing virtualization support. The CP6006-SA boards will come with 8-core CPUs with 1.6 GHz at a thermal design power (TDP) of 35 watts and a more powerful variant with 2 GHz and a TDP

of 45 watts, respectively. As much as 64 gigabytes of DDR4 ECC memory allows for virtualization support, when many virtualized tasks require separated memory. The CP6006X-SA variant offers a significantly higher data throughput via PCI Express 3.0 and 2x 10 Gigabit Ethernet on the backplane, which lends the board to sonar, radar, and video stream analytics.

FOR MORE INFORMATION visit **Kontron** online at *www.kontron.com*.

SIGNAL PROCESSING

Rackmount rugged data recorder introduced by Pentek

Pentek Inc. in Upper Saddle River, N.J., is introducing the model RTR 2745 rugged rackmount data recorder to capture and reproduce signal bandwidths to 560 MHz for electronic surveillance, signals intelligence, and test and measurement applications. Optimized for rugged operating environments, the turnkey, wideband recording and playback system provides real-time capture of RF

and IF signals. With two 3 GHz 14-bit A/D converters and built-in digital down-converters, the system is for capturing the IF outputs of RF down-converters with bandwidths as high as 600 MHz. Selectable DDC tuning frequencies allow the RTR 2745 to accommodate a broad range of IF outputs. Two output channels with 2.8 GHz 16-bit D/As and matching digital upconverters provide a fixed interpolation of 4 to allow for precise signal reproduction of recorded signals. The 3 GHz A/Ds can operate without the digital downconverters to provide a wide baseband capture.

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

POWER ELECTRONICS

Industrial-grade AC-DC power supplies for test and measurement introduced by TDK

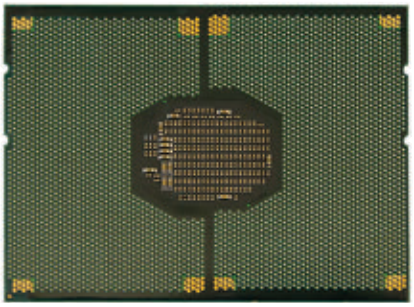
TDK-Lambda Americas Inc. in San Diego is introducing the RWS1000B and RWS1500B industrial AC-DC power supplies for industrial, test and measurement, and communications equipment. The RWS-B

series has seven power levels ranging from 50 to 1500 watts. These new 1000- and 1500-watt devices are available with 12-, 15-, 24-, 36-, and 48-volt outputs, adjustable from minus 15 to plus 10 percent of nominal. All models accept an 85-to-265-volt AC input and can operate at full load in temperatures from -20 to 50 degrees Celsius ambient temperatures, derating linearly to 60 percent load at 60 C. Efficiencies to 88 percent reduce internal waste heat and component temperatures, resulting in electrolytic capacitor service life predictions of at least 10 years. Output cable connections are made to screw terminal blocks with covers rather than bus bars. The RWS1000B measures 127 by 63 by 198 millimeters, and the RWS1500B measures 127 by 63 by 261 millimeters.

FOR MORE INFORMATION visit **TDK Lambda** online at *http://us.tdk-lambda.com*.

ELECTRONICS PACKAGING

Mercury uses BGA conversion to ruggedize Intel Xeon processor scalable



Mercury Systems Inc. in Andover, Mass., is using the company's ball grid array (BGA) packaging conversion technology to ruggedize the Intel Xeon processor scalable family for aerospace and defense embedded computing applications. The technology converts the land grid array (LGA) package on standard Intel Xeon server CPUs to the more rugged BGA package to create a rugged server-class processing option in an open-system architecture. Once converted to BGA, the Intel Xeon processors is suitable for deployed military applications on aircraft, surface vessels, and land vehicles that operate in harsh-temperature and -vibration conditions. Mercury's BGA conversion technology has been deployed on several systems that use previous-generation Xeon processors. Combined with using military-grade solder balls and underfill, this BGA conversion eliminates the risk of thermal expansion or contraction of the package.

FOR MORE INFORMATION visit **Mercury Systems** at *www.mrcy.com*.

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