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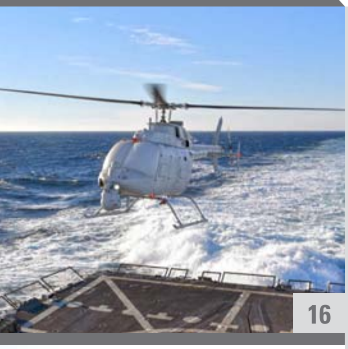

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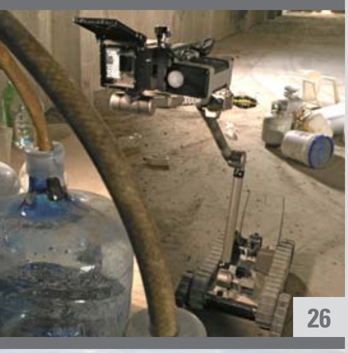

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ON THE COVER:

Top photo: The MQ-8 Fire Scout unmanned helicopter – roughly the size of a Bell 407 helicopter and weighing 3,150 pounds – is specifically designed to operate safely from any Navy ship with a helicopter deck at sea. Photo courtesy of Northrop Grumman.

Bottom photo: The 510 PackBot can enter hazardous environments to search for chemical, biological, radiological, nuclear (CBRN) threats. Photo courtesy of iRobot.

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Military investment in unmanned systems technology still strong

By John McHale, Editorial Director

Unmanned aircraft systems (UASs) get most of the headlines in the press, where they are often called killer drones, but U.S. military planners are also looking to expand capabilities for unmanned ground vehicles (UGVs), which have been instrumental in protecting soldiers from improvised explosive devices (IEDs). This commitment is evidenced in the Fiscal Year (FY) 2016 budget request from the Department of Defense (DoD), as the U.S. military increases funding for key autonomous platforms in the request.

UAS budget highlights

"The Air Force budget for FY16 includes 29 MQ-9 Reaper UAS, a plus up of seven over the previously planned procurement of 22 aircraft," said Chris Pehrson, Director of Strategic Development for General Atomics Aeronautical Systems, Inc. (GA-ASI) in an interview on page 20. "The Army budget includes 19 MQ-1C Gray Eagle UAS, which matches planned procurement for FY 2016. There is a plus up in the Army budget, however, to procure those 19 aircraft as Improved Gray Eagle. This is a more capable variant than the original Gray Eagle with over twice the payload capacity and almost twice the endurance."

According the DoD, the FY 2016 program for the U.S. Air Force (USAF) RQ-4 Global Hawk funds the development and modification efforts for the Block 30, Block 40, ground stations, and Multi-Platform Radar Technology Insertion programs. Block 40 includes multiplatform radar technology for synthetic aperture radar (SAR) imaging and moving target detection. Funding for the MQ-4C Triton continues engineering and manufacturing development efforts and procures three Low Rate Initial Production systems.

"I think funding for military unmanned aircraft will continue to increase both for initial procurement and recapitalization of legacy aircraft," Pehrson continued. "Unmanned aircraft are persistent, cost-effective platforms that will continue to be used for missions such as counterterrorism and counterinsurgency, as well as new surveillance applications and communications relays."

To read about smaller UAS platforms such as the Fire Scout, Raven, and Puma, see the Special Report by Sally Cole on page 16.

UGV outlook

Investment for robotic ground systems is definitely trending upward, according to officials at iRobot and the U.S. Army.

"There is evidence of increased funding [for unmanned ground systems] that we can see within the DoD and in major programs," said Tim Trainer, Vice President, Robotics Products International, iRobot Defense & Security business unit in an interview on page 26. "The military and Army have regrouped and taken a look at what they need for ground robotics. That vision had taken a pause and is now refocused. This is good news that has not been seen for the last couple years."

Autonomous and semi-autonomous systems are expected to be fielded between 2019 and 2025, said Scott Davis, Army program executive officer for Combat Support and Combat Service Support, at a session of the Ground Robotics Capabilities Conference and Exhibition held this spring, according to an Army release by David Vergun.

Davis touted the Robotics Enhancement Program (REP) as a key way to manage sustainment and technology development in autonomous ground systems, according to the Army release. According the REP website (http://www.peocscss.army.mil/REP.html), the REP mission is to "identify and evaluate commercial-off-the-shelf (COTS), government-off-the-shelf (GOTS), nondevelopmental items (NDI), robot systems, accessories, and/or robotic payloads that have the potential to enhance the overall combat effectiveness of the force."

Twice a year, a group of colonels will gather to review battle lab test results of the robotic ground systems to determine if capabilities of new systems or components pan out, Davis said. If approved, they may become requirements.

Davis says in the release that the Army is looking for "incremental hardware and software enhancements to existing systems/chassis; sensor and payload upgrades; modularity; open architecture in IOP, or in- and out-processing software; standardization; miniaturization and light weight; and intelligent behavior." Elaborating more on the intelligent behavior, Davis referred to a bird dog – "a small ground robot that can see, smell, hear, and fetch. It would also have to be simple enough for a soldier to use, as his cognitive focus would need to be on mission, not the tooling for that mission."

Programs now under evaluation by Davis and his team include the ManTransportable Robotics System Mark II (explosives ordnance disposal); the Husky Mounted Detection System, which has a deep detection system and a ground-penetrating radar; the Route Clearance and Interrogation System, which will be used by squads to transport gear and augment convoys in semi-autonomous mode; and the Common Robotic System-Individual (CRS-I), which will be carried by soldiers and not exceed 25 pounds (about 15 pounds for the platform, five for the controller, and five for the payload.)

Some new programs will be joint efforts "with the Army and Marine Corps generally, while some will go DoD-wide and involve the Navy and Air Force as well. Special Operations Forces (SOF) will also have unique opportunities that will often be more customized," said iRobot's Trainer in the interview.

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Embedded Success dSPACE

The promise of COM Express

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

Cost pressures continue to bedevil military programs. Years of fighting have taken a toll on equipment, while years of sequestration have made upgrading or replacing the equipment more difficult. Budget constraints require everyone involved to pay the utmost attention to life cycle costs at all levels of procurement.

Although commercial off-the-shelf (COTS) technologies yield savings by exploiting the economies of scale available in the consumer market, there is a major tradeoff. Consumer products – along with the electronic components inside them – are intended for benign environments, whereas military products operate in some of the world's most demanding environments.

Electronic systems in missiles, tanks, and airborne platforms must thrive amid high levels of shock and vibration and be able to withstand extreme temperature swings. Resistance to dust, sand, and salt spray also may be required.

In addition, military computers must provide high, and continually increasing, levels of performance as applications evolve; all of this must occur in small size, weight, and power (SWaP) packages. What's more, these systems must endure not simply for years, but for decades, as commercial technologies come and go. The implementation of concepts like network-centric warfare has only underscored the need for high-power, high-bandwidth, and easily upgradable electronics. The perennial question for designers of high-performance embedded computing (HPEC) systems then becomes: How to provide the best technologies from the commercial market in the bulletproof packages required by military applications?

COM Express – from commercial to military

A recent instance of this synergy is the ruggedization of computer-on-module (COM) Express technology. COM modules were developed to insulate computer boards from processor churn. Before their invention, designers of single-board computers had to rethink their layouts each time their processors went out of production. Adopting a new integrated circuit required designers to develop supporting silicon, as well as low-level software and firmware. This setup typically entailed board redesigns with the accompanying costs and delays.

Like most innovations in electronics, COM modules were introduced in proprietary packages but were eventually standardized in a range of sizes and pinouts. A popular set of COM module configurations, known as COM Express, was developed by the PCI Industrial Computer Manufacturers Group (PICMG). Today COM Express is widely used in commercial applications from gaming to health care.

"Above all, the ruggedizing of COM Express technology has made it attractive to applications such as missiles and unmanned vehicles."

The beauty of COM Express is that when a processor reaches end-of-life, it can be replaced with a new-generation, plug-in processor module without disturbing the underlying hardware. The carrier board can be a standard backplane module like VME or VPX or a customized format to support the particular size and input/output (I/O) demands of a military user. Furthermore, when upgrades become necessary, system downtime is minimal. The standard even specifies a module heat-spreading interface which can be combined with a designer's proprietary cooling approach.

Ruggedizing COM Express

COM Express was not developed for high-stress environments, however; after it became a commercial standard of potential interest to military users, there was still the task of ruggedizing the modules. This step has been achieved by measures such as screening components, developing specialized cooling technologies, and thoroughly

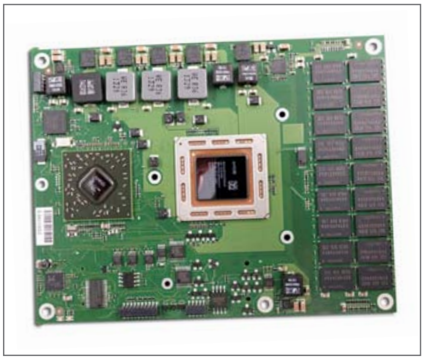

Figure 1 | The bCOM6-L1700 rugged COM Express module from GE features AMD's latest R-Series system-on-chip processor.

testing products to specifications such as MIL-STD-810 and VITA 47. Soldering rather than socketing components to modules further increases resistance to shock and vibration by reducing the number of mechanical connections.

One example of a recent rugged COM Express product is the GE Intelligent Platforms bCOM6-L1700 module, hosting AMD's latest R-Series system-on-chip processor and as much as 16 GB of soldered memory (Figure 1).

Rugged modules exist today using multiple IC types, while new developments in the manufacture of memory chips permit previously unheard-of module densities. Above all, the ruggedizing of COM Express technology has made it attractive to applications such as missiles and unmanned vehicles.

For military customers the benefits are compelling: When the time comes to upgrade a module, complex I/O cabling can be left in place. This configuration avoids the necessity of detaching wires and possibly misconnecting them, as well as the need to retest signal integrity after the configuration is restored. Wear and tear on board connectors is also reduced, extending system life on multiple fronts.

While COM Express technology is relatively new to the military world, the initial upfront investment promises to yield dividends by providing a low-risk path to incremental upgrades at acceptable lifecycle cost.

defense.ge-ip.com

For COTS, small is the next big thing

By Mike Southworth
An industry perspective from Curtiss-Wright Defense Solutions

Later this year, Marvel will release "Ant-Man," its latest film blockbuster, proving that superheroes can come in extremely small packages. Meanwhile, the aerospace and defense embedded commercial off-the-shelf (COTS) market are well ahead of the curve. We've already started to see whole new classes of small and ultra-small line-replaceable unit (LRU) offerings that are dramatically redefining the performance, power dissipation envelope, and cost savings that can be achieved with "shoebox" and even "pocket-sized" processors and Gigabit Ethernet switch and router LRUs.

Recently, market demand has intersected with previously unattainable higher levels of integration, enabling these new classes of technology miniaturization. First installed in smaller unmanned aircraft system (UAS) platforms, these new small and ultra-small LRUs are opening up entirely new market opportunities. These LRUs are equally adept at reducing size, weight, power, and cost (SWaP-C) on helicopters and ground vehicles as well. Users can rapidly migrate toward faster and faster sensor interfaces on their manned and unmanned airborne and ground vehicles, for example, from cameras collecting high-resolution data or from radars and other onboard sensors. In cases where 10/100 Ethernet used to suffice, platforms now require Gigabit Ethernet (GbE). At the same time, designers and users are seeking ways to eliminate space and weight in already burdened platforms, leading to efforts like the US Army's VICTORY standard, which aims to reduce hardware redundancy and foster interoperability.

In response, COTS vendors have begun to leverage technology advances to address these two market drivers. One recent approach is the use of multipurpose shoebox-sized stackable LRUs that combine Core i7 processing with Cisco IOS network routing software that runs as an application on Linux or on a VMware Hypervisor. This approach adds the capabilities of a secure Cisco router or virtual machine application without adding any additional weight to the processor system. With this setup, two or more standalone functions can be deployed in a single chassis, slashing required equipment space by 50 percent and cutting weight by four to five pounds.

An even more dramatic development is the emergence of a new class of function-specific ultra-small form factor (USFF) standalone LRU solutions, such as pocket-sized network routers, switches, and computers. These small subsystems take advantage of low-power processors, like ARM and Atom, developed for battery-powered or very power-sensitive applications, such as mobile phones and tablets. The smaller hardware on these diminutive boxes also tells a big story: The latest generation of silicon, from switches to CPUs, is shrinking the size of the die and reducing power consumption. In one great example, new Ethernet switch architectures feature low-power Gigabit Ethernet PHYs capable of turning off unused ports, putting them in a low-power or idle state. They are also intelligent enough to sense the length of the cable connection, limiting power for transmitting data, to say, 10 meters, rather than defaulting to the 100-meter Ethernet specification.

What's more, rather than using traditional connectors like DTL-38999s, USFF boxes often use new "micro-miniature 38999-like" connectors which deliver all of the performance benefits of their larger 38999 cousins but in smaller, lighter, and more dense configurations. On many platforms, just finding available space to add new hardware can be a real challenge. These small, low-power USFF boxes enable system integrators to easily install the solution they require without adding significant SWaP burdens. They are limited, either in processor performance or port count, compared to larger solutions, but for many applications they hit the sweet spot in ways that designers could previously only hope for. These tiny USFF solutions also open up whole new system upgrade architecture possibilities. For example, size-optimized USFF data bridge devices can be used to translate legacy data bus protocols from a platform's traditional data buses (i.e., CAN, RS422, MIL-STD-1553) and convert them to Ethernet for the improved situational awareness offered by an IP network. This approach provides a low-cost alternative to large and expensive one-size-fits-all data concentrator/conversion solutions, for which you'll likely end up paying for much more functionality than you'd ever use or need.

USFFs are also being deployed right now. In a recent example, a tactical UAS used for reconnaissance, surveillance, and targeting required upgrades for Ethernet switching capabilities for onboard communications and sensor payload equipment. The relatively small physical size of these platforms and the noisy electromagnetic interference (EMI) generated by their communications equipment presented a challenge to the manufacturer, who was seeking a COTS networking solution. Their USFF solution was Curtiss-Wright's "pocket-sized" miniature Parvus DuraNET 20-11 and 20-12 Ethernet switches. These LRUs are 10 percent of the size of a traditional small form factor GbE switch and only 25 percent of the weight of the next lightest Ethernet switch available in the company portfolio. Using microminiature MIL-circular connectors, this type of LRU can feature eight ports of GbE or, when fitted with a miniature rectangular Quadrax connector for enhanced signal integrity, it supports six ports of shielded 10/100 Ethernet.

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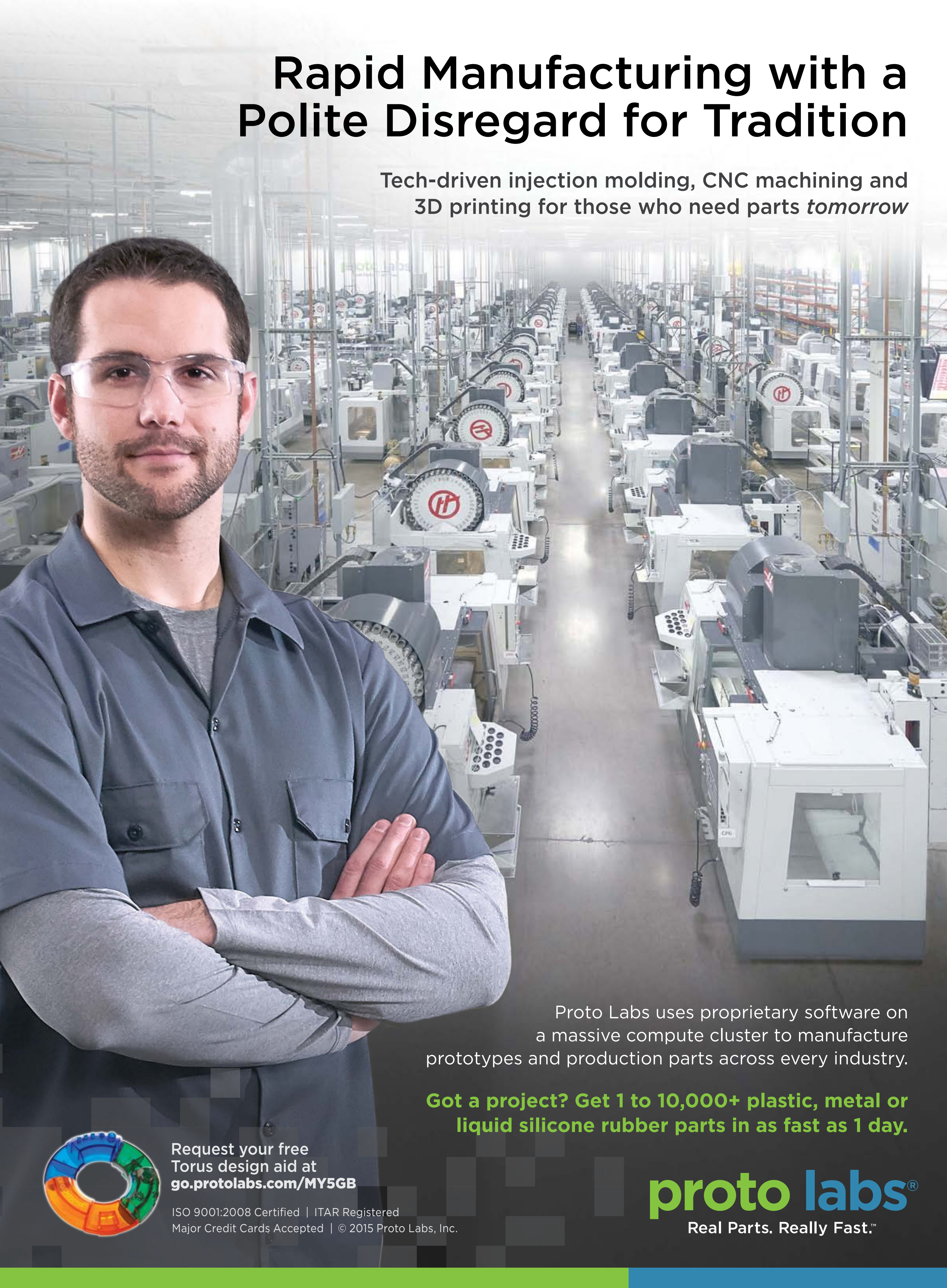
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By Mariana Iriarte, Associate Editor

NEWS

Laser stops truck in Lockheed Martin test

Engineers performing a field test of Lockheed Martin's Advanced Test High Energy Asset (ATHENA) – a 30-kW fiber laser weapons system – disabled the engine of a small truck and burned right through the engine manifold in only seconds. "This test represents the next step to providing lightweight and rugged laser weapon systems for military aircraft, helicopters, ships and trucks," says Keoki Jackson, chief technology officer at Lockheed Martin. ATHENA integrates the 30-kW Accelerated Laser Demonstration Initiative (ALADIN) fiber laser designed and developed by Lockheed Martin and is based on the Area Defense Anti-Munitions (ADAM) laser weapon system. The system uses a technique dubbed "spectral beam combining," in which multiple fiber laser modules create a single powerful beam for efficiency and lethality.

Figure 1 | The ATHENA laser weapon system disables the truck's engine. Photo courtesy of Lockheed Martin.

DARPA ALIAS tailored kit promises high levels of automation

The Defense Advanced Research Projects Agency (DARPA) has selected three companies for the Aircrew Labor In-Cockpit Automation System (ALIAS) contract to test out the system's initial capabilities. ALIAS aims to craft a tailored, drop-in, and removable kit that will enable high levels of automation, resulting in reduced pilot workload, increased mission performance, and improved aircraft safety. The three companies under contract are Aurora Flight Sciences, Lockheed Martin, and Sikorsky Aircraft. The companies will perform actual ground and flight demonstrations to test and develop the capabilities of ALIAS.

Phase one of the ALIAS testing will focus on three aspects of the technology: minimizing interfaces between the new automation system and the existing aircraft; aircraft operation knowledge to support the ALIAS toolkit; and a human-machine interface that reduces the need for constant pilot supervision.

Black Hawk cockpit avionics program to use VxWorks 653

Northrop Grumman Corp. chose the Wind River VxWorks 653 Platform to use in its digitization of an avionics mission-equipment package that will integrate into the Army Black Hawk UH-60V helicopter.

VxWorks 653 is a commercial off-the-shelf (COTS) platform for safety-critical, integrated modular avionics (IMA) applications. Recently released updates to VxWorks 653 support multicore silicon and partitioning for applications that provide multilevel RTCA DO-178C certification. The solutions also support the Safety Base Profile of Future Airborne Capability Environment (FACE) 2.1 Technical Standard. The use of VxWorks 653 will align with the FACE Technical Standard and meet DO-178C certification standards, says Ike Song, Northrop Grumman Electronic Systems' vice president for Situational Awareness Systems.

Army manpack radios to get updates from General Dynamics

The U.S. Army has awarded General Dynamics Mission Systems a contract to support upgrades to the company's Mobile User Objective System (MUOS) waveform that is already used in the Army's AN/PRC-155 two-channel MUOS-Manpack radios. The waveform is the digital "dial tone" necessary for connecting with the U.S. Navy's new MUOS satellite communications network; MUOS waveform upgrades will enhance voice clarity and cybersecurity of voice and data communications across the MUOS communications network. Other waveform enhancements include improved connectivity with other MUOS-Manpack radios, the MUOS ground system, and satellites. The MUOS communications network is expected to achieve global communications coverage in 2016.

Figure 2 | Army personnel using AN/PRC-155 two-channel manpack radios with upgraded MUOS waveform. Photo courtesy of General Dynamics.

SM-3 missiles get threat upgrade to their software from Raytheon

Raytheon engineers have started upgrading Standard Missile-3 Block 1Bs with what they call “threat upgrade” software, enabling the weapon’s kill vehicle to essentially hunt down more complicated, more lethal targets. Making improvements via software upgrades means combatant commanders can now get increased ballistic-missile defense capabilities without the time and cost typically associated with traditional disassembly or hardware replacement, company officials say. SM-3s destroy incoming ballistic missile threats in space through nothing more than sheer impact, which is about the equivalent of a 10-ton truck moving at 600 mph. The next-generation SM-3 Block 1B has an upgraded two-color infrared seeker and the Throttleable Divert and Attitude Control System, a mechanism that propels the missile toward incoming targets.

The U.S. Missile Defense Agency and the U.S. Navy are planning to test an SM-3 Block 1B upgraded with the new software this year.

Figure 3 | The Standard Missile-3 destroys short-to-intermediate range ballistic-missile threats. Photo courtesy of Raytheon.

New E-2D Hawkeyes deploy with enhanced radar, computer capability to USS Theodore Roosevelt

Five E-2D Advanced Hawkeye aircraft, built by Northrop Grumman, recently began their first deployment aboard the carrier USS Theodore Roosevelt (CVN 71), with new radar and enhanced computer-processing capabilities.

These new E-2Ds are assigned to Carrier Airborne Early Warning Squadron (VAW) 125 as part of the Carrier Air Wing (CVW) 1. The E-2D Hawkeye will replace the E-2C in its primary mission, which is to provide airborne early warning and command and control capabilities for all battle groups. The Advanced Hawkeye’s technology enables a multimission platform that has airborne strike, ground force support, and rescue operations. It can also manage a communication network that enables drug-interdiction operations.

Commercial unmanned aircraft to reach $1.27 billion by 2020, say market analysts

Research analysts at ASD Reports say in a new report that the commercial unmanned aircraft, or drone, market was valued at about $15.22 million in 2014 and that it is expected to grow to $1.27 billion by 2020. ASD Reports analysts say that this growth rate means an estimated CAGR of 109.31 percent between 2014 and 2020.

ASD Reports analysts say the increase in demand for unmanned aircraft is driven by technological advancements and increased use of these platforms in law enforcement applications. The report breaks down the category into products such as fixed-wing, rotary-blade, nano, and hybrid segments. The rotary-blade drone portion held the maximum share, at about 72 percent of the overall commercial drone market, as of 2014.

The report also covers the unmanned aircraft sectors of energy and power, law enforcement, manufacturing, infrastructure, agriculture, media and entertainment, and scientific research; the ASD report says that law enforcement is expected to be the largest user of commercial drones.

NATO AWACS fly with new avionics system from Rockwell Collins

NATO has completed flight tests on Airborne Warning and Control System (AWACS) aircraft flying with the Rockwell Collins Flight2 avionics system. Boeing’s upgrades to the flight deck replace the analog instruments with an avionics system that meets the U.S. government’s 2020 Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) directive.

Under contract, Rockwell Collins engineers are providing large displays and controls, a new flight-management system, and new communication and navigation equipment. Boeing is under contract to provide NATO with an additional 13 AWACS aircraft upgrades. The U.S. Air Force AWACS first flight with these upgrades is expected in 2016.

Figure 4 | NATO AWACS aircraft with Rockwell Collins Flight 2 Avionics Systems. Photo courtesy of Rockwell Collins.

Unmanned aircraft systems enable tactical ISR

By Sally Cole, Senior Editor

The U.S. Department of Defense's fleet of unmanned aircraft systems enables tactical intelligence, surveillance, and reconnaissance (ISR) – without endangering military personnel and at a lower cost than manned aircraft.

The MQ-8 Fire Scout unmanned helicopter – roughly the size of a Bell 407 helicopter and weighing 3,150 pounds – is specifically designed to operate safely from any Navy ship with a helicopter deck at sea. Photo courtesy of Northrop Grumman.

Unmanned aircraft systems (UASs) range from truly portable hand-launched systems to aircraft the size of helicopters or commercial airplanes. UASs are also much less expensive for the U.S. Department of Defense (DoD) to procure and operate than their manned counterparts.

As defined by the U.S. Federal Aviation Administration, a UAS is: "The aircraft itself and all of the associated support equipment, the control station, data links, telemetry, communications, and navigation equipment, etc., necessary to operate the unmanned aircraft."

The flying portion of the system, the unmanned aircraft (UA), is flown by a pilot via ground control system or autonomously by using an onboard computer, communication links, or any other equipment deemed essential for the UA to operate safely. Most military UASs carry some sort of payload that gathers information and transmits it – usually in real-time – to a user on the ground to provide enhanced situational awareness.

Small UAS development

When developing small UASs, designers must operate within narrow size, weight, and power (SWAP) constraints. Adding grams of weight to improve any given feature can reduce flight time, so "tradeoffs must be evaluated carefully with respect to customer requirements," says Chuck Strawbridge, program manager of Unmanned Aircraft Systems for AeroVironment Inc. (Monrovia, California; www.avinc.com).

In terms of footprint, AeroVironment's Raven unmanned aircraft has a wingspan of 4.5 feet, weighs 4.5 pounds, and can fly for 60 to 90 minutes. It's the most prolific small UAS within the U.S. fleet – supporting the Army, Marine Corps, Air Force, and Special Operations Command.

Among the hand-launched Raven's key benefits is that it's designed to "enable military units to conduct intelligence, surveillance, and reconnaissance over danger zones without committing soldiers," points out Strawbridge. "Task forces can use it to monitor an area with live video capabilities during day and night operations."

Operators can control the small UAS with handheld control stations that feature a color monitor to display imagery and data transmitted wirelessly from the air vehicle. Another option is to run it on autopilot; an operator simply determines what they would like to view and the autopilot manages the flight. "A standard ground station controls all AeroVironment's small UASs to ensure interoperability and operating efficiency," says Strawbridge.

Range capabilities vary by UAS. In AeroVironment's line of small UASs, for example, the Puma AE boasts a range of 15 km, while the Raven's is 10 km, with the Wasp AE and Shrike VTOL each having a range of 5 km. (See Figure 1.)

"We design all aspects of our UAS to operate effectively and reliably in real-world environments, with Puma AE and Wasp AE 'all environment' vehicles capable of landing in salt or fresh water, or on the ground. All operate in light rain and wind conditions, hot weather, and at high altitudes," Strawbridge adds.

AeroVironment's small UASs typically rely on electro-optical and infrared sensors, digital links for encrypted communications, autopilots, magnetometers, gyroscopes,

Figure 1 | The hand-thrown Puma AE has a range of 15 km. Photo courtesy of Aerovironment.

altimeters, and other technologies critical for reliability, performance, and reliability.

"COTS (commercial off-the-shelf) devices are used whenever available, and embedded processors and highly integrated programmable devices are used because of SWaP (size, weight, and power) limitations," notes Strawbridge.

All of AeroVironment's small UASs use electric-propulsion technology – making them quiet, clean, and powered by easily transportable and rechargeable electric batteries.

In terms of capabilities, small UASs are designed to help soldiers gain situational awareness easily. A squad advancing on a ridgeline, for example, needs to know what lies on the other side. Because squads typically don't possess or control their own larger aviation assets, small UASs represent a way to quickly gain

Future of small UAVs: Agility, advanced perception, autonomy

The U.S. Defense Advanced Research Projects Agency (DARPA) is working to equip small unmanned aerial vehicles (UAVs) of the future with advanced perception and the autonomy to rapidly search buildings or other cluttered environments – without teleoperation.

Military teams are often called upon to patrol dangerous urban environments overseas; they currently rely on remotely piloted UAVs to gain a clearer picture of the situation and to spot threats that aren't visible from the ground. However, the ability to know what's taking place inside an unstable or threatening indoor space frequently requires physical entry, which endangers troops.

Fast Lightweight Autonomy program

DARPA's Fast Lightweight Autonomy (FLA) program is addressing these challenges by creating a new class of algorithms designed to enable small UAVs to quickly navigate labyrinths of rooms, stairways, corridors, and other obstacle-filled environments without a remote pilot.

The goal of the program is to develop and demonstrate autonomous UAVs small enough to fly right through an open window and at speeds as fast as 45 mph, all while navigating complex indoor spaces independent of communication with outside operators or sensors and without reliance on GPS waypoints.

Birds of prey and flying insects are being studied because they possess the characteristics the military covets for its UAVs. "Goshawks can fly very fast through a dense forest without smacking into trees. Many insects can dart and hover with incredible speed and precision," says Mark Micire, DARPA program manager. "The goal of the FLA program is to explore nontraditional perception and autonomy methods that give small UAVs the capacity to perform in a similar way – including an ability to easily navigate tight spaces at high speed and quickly recognize if it has already been in a room before."

How can they make this happen? With algorithms designed specifically to enhance unmanned system capabilities by reducing the amount of processing power, communications, and human intervention needed for low-level tasks such as navigating around obstacles in a cluttered environment.

The program's initial focus is on UAVs, but advances made through the FLA program may turn out to be useful for ground, marine, and underwater systems, particularly within GPS-degraded or -denied environments.

While urban and disaster-relief operations will benefit from this technology, its "applications could extend to a wide variety of missions using small and large unmanned systems linked together with manned platforms as a system of systems," points out Stefanie Tompkins, director of DARPA's Defense Sciences Office. "Enabling unmanned systems to learn 'muscle memory' and perception for basic tasks like avoiding obstacles could relieve overload and stress on human operators so they can focus on supervising the systems and executing the larger mission."

Sidebar Figure 1 | Algorithms developed as part of DARPA's Fast Lightweight Autonomy program could enhance unmanned system capabilities by reducing the amount of processing power, communications, and human intervention needed for low-level tasks such as navigation in complex indoor spaces or cluttered environments. Photo credit: DARPA.

Tactical Exploited Reconnaissance Node program

DARPA is also working jointly with the U.S. Office of Naval Research on another program, Tactical Exploited Reconnaissance Node (TERN), to provide forward-deployed small ships with the ability to serve as mobile launch and recovery sites for medium-altitude, long-endurance unmanned aerial systems (UASs).

These systems will ideally enable long-range intelligence, surveillance, and reconnaissance (ISR), according to DARPA, as well as provide other capabilities over greater distances and longer durations than current assets. AeroVironment Inc. and Northrop Grumman Corp. were selected as the prime contractors for this program.

The two companies are tasked "with designing a new UAS intended to enable two previously unavailable capabilities: taking off and landing from very confined spaces in elevated sea states, and the ability to transition to efficient long-duration cruise missions," says Dan Patt, DARPA program manager.

TERN's ultimate goal is to "develop breakthrough technologies that the Navy can realistically integrate into the future fleet to make it much easier, quicker, and less expensive for the DoD to deploy persistent ISR and strike capabilities almost anywhere in the world," adds Patt.

To make this happen, AeroVironment and Northrop Grumman are working to develop UASs with persistent ISR capabilities for payloads of 600 pounds, while operating as far as 900 nautical miles away from a host vessel.

the situational insight that can mean the difference between safe passage and a dangerous firefight.

"Carried in a soldier's backpack, a Raven, Wasp AE, or Shrike VTOL system can be assembled, launched, and operated in fewer than five minutes, and provide the squad with an immediate aerial view of their surroundings," Strawbridge says. "Another example is using a small UAS to monitor the perimeter of a base or to investigate potential threats in a more rapid and accurate manner than through other means."

This enables the military – as well as law enforcement, environmental, commercial operators, and others – to "improve the effectiveness, efficiency, and safety of their operations," he adds.

It also helps to significantly reduce costs. More than 85 percent of the DoD's fleet of unmanned aircraft is comprised of AeroVironment's UAS – yet it represents less than 5 percent of the DoD's total spending on UASs.

Larger UASs can carry payload

Larger UASs such as Northrop Grumman Aerospace Systems' (Falls Church, Virginia; www.ngc.com) MQ-8 Fire Scout, which is roughly the size of a Bell 407 helicopter and weighs 3,150 pounds, are providing greater endurance and a lower cost of operation than their manned counterparts. The MQ-8 is specifically designed to operate safely from any Navy ship with a helicopter deck at sea. The autonomous aircraft is simply controlled with a mouse and keyboard from a ground station onboard the ship. Its advanced control stations use the U.S. Navy's Tactical Control System, Tactical Common Data Link, and communications, while a modular mission payload capability enables continued growth into new payloads.

By using a payload that includes electro-optical/infrared sensors with a laser rangefinder/illuminator and a maritime radar, the Fire Scout can locate and identify tactical targets, track and illuminate them, and accurately provide targeting data to strike platforms, as well as perform any necessary after-battle damage assessment.

Northrop Grumman "leverages software on our larger unmanned air vehicles, particularly when it comes to the vehicle management system," says Tom Twomey, business development manager for Northrop Grumman's Fire Scout program. MQ-8 has "a 12-hour endurance and can operate 150 nautical miles from the ground station," Twomey adds. "It's also designed to operate in the same harsh environments as manned helicopters."

The key benefits of larger UASs are similar to those of smaller UASs: the ability to operate within dangerous areas or hostile territories for maritime and overland ISR missions – without risking a manned aircraft.

"The U.S. Navy is now also combining unmanned aircraft with manned aircraft as a force multiplier – enabling coverage of more area at longer endurances, and at a lower cost to the DoD," notes Twomey. **MES**

Military UAS procurement outlook strong, counterterrorism and communication relays highlight future missions

By John McHale, Editorial Director

Chris Pehrson

General Atomics Aeronautical Systems, Inc. (GAASI) flight tested a preproduction Due Regard Radar (DRR), which marked the first functional air-to-air radar on an unmanned aerial vehicle (UAV) that meets the requirements for "Due Regard" operations in international airspace.

Unmanned aircraft systems (UASs) have been a game changer for the U.S military, providing persistent surveillance and lethality in the Gulf wars and the war on terrorism. In this Q&A with Chris Pehrson, Director of Strategic Development for General Atomics Aeronautical Systems, Inc. (GA-ASI), he discusses his outlook for unmanned aircraft procurement, the use of commercial off-the-shelf (COTS) in UAS payloads, UAS pilot training, and the potential for laser weapon capability in UAS platforms. Edited excerpts follow.

MIL-EMBEDDED: ***Please provide a brief description of your responsibility within GA-ASI and your group's role within the company.***

PEHRSON: I am Director of Strategic Development for all Department of Defense (DoD) business, which encompasses Army, Navy, Air Force, Marine Corps, and Special Operations customers. Products include GA-ASI's full range of unmanned aircraft, ground control stations, and sensor payloads.

MIL-EMBEDDED: ***The DoD released its FY 2016 budget request last month with an increase in overall funding, almost a reverse trend from the last few years. How do you see the funding outlook for military unmanned aircraft within the DoD such as the Gray Eagle and Reaper variants? Has the DoD clearly defined what missions it will need these platforms for over the next five years?***

PEHRSON: The Air Force budget for FY16 includes 29 MQ-9 Reaper UAS, a plus up of seven over the previously planned procurement of 22 aircraft. The Army budget includes 19 MQ-1C Gray Eagle UAS, which matches planned procurement for FY2016. There is a plus up in the Army budget, however, to procure those 19 aircraft as Improved Gray Eagle. This is a more capable variant than the original Gray Eagle, with over twice the payload capacity and almost twice the endurance.

I think funding for military unmanned aircraft will continue to increase both for initial procurement and recapitalization of legacy aircraft. Unmanned aircraft are persistent, cost-effective platforms that will continue to be used for missions such as counterterrorism and counterinsurgency, as well as new surveillance applications and communications relays. There is definitely increased interest in leveraging UAS to function as resilient nodes in airborne communication networks.

Unmanned aircraft are modular platforms that enable multiple mission

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configurations with varying capabilities, so their future is strong with the DoD.

MIL-EMBEDDED: *Please provide an example of current unmanned military platforms GA-ASI supplies to the U.S. and international countries.*

PEHRSON: For international markets, we redesigned the original MQ-1 and developed the Predator XP with modifications to make it export-compliant. It is not weaponized and is intelligence, surveillance, and reconnaissance (ISR)-capable-only in compliance with International Traffic in Arms Regulations (ITAR) and Missile Technology Control Regime (MTCR) guidelines. We designed it more efficiently than the original Predator, enabling us improve its endurance. Currently the Predator XP is rated at 35 hours, but in testing it has flown as long as 46 hours.

Domestically, the Predator C Avenger is our most advanced UAS platform. It can reach altitudes as high as 50,000 feet, can fly for as long as 18 hours, and can carry over 4,000 pounds of munitions or sensor payloads. The Predator C is currently in an extended test program with the Air Force. We also used it to develop our offering – the Sea Avenger – for the Navy UCLASS competition.

MIL-EMBEDDED: *There is an insatiable need for ISR data from sensor payloads, which often means heavy signal processing demands and use of commercial processing technology. In your payload designs, what is your approach to using COTS embedded computing technology and open architectures? How do you manage the obsolescence challenges?*

PEHRSON: From a payload perspective, we often work with third-party providers via the government or as a system integrator. That said, we also leverage open architecture designs, COTS solutions such as avionics components, IP-based components, etc. If platforms and payloads are built to open standards, integration is much easier and faster. COTS solutions shorten the procurement cycle and make rapid integration of enhanced capabilities possible.

However, there are exceptions. Some applications, such as Gorgon Stare on the MQ-9, require unique cabling and components, which require more than just plug-and-play changes to avionics boxes or simple software updates.

There are multiple approaches to obsolescence management, some more aggressive than others. For example, we had an engine supplier with an obsolescence issue for the Gray Eagle, so we are now building those engines in-house. That is a pretty aggressive approach to diminished manufacturing sources (DMS). We also manage obsolescence through software upgrade cycles and open architecture designs. We work with the government program offices to ensure there is a plan for dealing with DMS challenges on all platforms and products. We have to pay attention to every avionics, mechanical, payload, and software component when it comes to managing DMS.

MIL-EMBEDDED: *Reduced size, weight, and power (SWaP) requirements are hitting all applications in defense electronics. How are they impacting your unmanned payloads and the overall platforms? What are the tradeoffs with smaller tech?*

PEHRSON: We build larger UAS with payload capacities as much as 2,000 pounds, so it's not always optimal to try to be as small as possible. With smaller platforms, such as Scan Eagle or Shadow, it is necessary for electronics to be small. We have a little more wiggle room. That being said, miniaturizing components enables multi-INT solutions, such as multiple sensors to do signals intelligence, EO/IR, radar, etc., all on a single platform. The other advantage with smaller payload components is fuel savings, which increases endurance.

However, when miniaturizing components, one must obey the laws of physics. For example, a camera aperture and telescope lens needs to be of a certain size to take effective imagery.

MIL-EMBEDDED: *How are you adapting your current and future ground control stations to comply with the DoD's UAS Control Segment (UCS) architecture?*

PEHRSON: There are two architectures we comply with in ground control stations (GCS) – the UCS and the UCI [Unmanned Aircraft Systems (UAS) Command and Control (C2) Standard Initiative]. UCS comes out of the Office of the Secretary of Defense and is a top-down concept. It is a more modular standard and our Block 50 GCS is built to comply with it. We are building to the hardware specifications and design. We also sit on UCS working groups to engage in dialogue and help with standards development.

In addition to UCS, the Air Force has UCI, which is more of a bottom-up approach, with messaging between different modules. UCI and UCS are both compatible in the same system with enough forethought early in the design.

MIL-EMBEDDED: ***What feedback do you get from military operators of your unmanned aircraft and how does that affect designs? Are they all certified pilots as on manned aircraft?***

PEHRSON: For our Block 50 GCS upgrade we worked with the Human Factors Laboratory at Wright-Patterson Air Force Base to design the cockpit and make pilot task loads easier. Efficiency and flight safety were paramount in the legacy GCS, but the user interface and similar human factor aspects needed enhancements.

For example, we improved how classified and unclassified information is integrated and displayed, improved menu scroll functionality, consolidated multiple intel feeds onto one screen, and provided hands-on-throttle-and-stick (HOTAS) flight controls. The result is a more elegant solution that enables the pilot to focus on the mission rather than the demands of just flying the aircraft. The improved human factor functionality is also more intuitive and reduces the training burden. Human factors are a primary consideration in modern aircraft design, particularly combat aircraft, since it enables the pilot to focus on activities outside the aircraft, such as mission execution and avoiding threats.

In the Air Force, unmanned aircraft pilots have to be rated pilots. There is a separate UAS career field where they have to be instrument-rated, but it is not full pilot training so they can enter a GCS career field earlier. The Army has UAS operators – warrant officers and senior enlisted – but they are not trained as rigorously as Air Force pilots.

The difference is more cultural, as the Air Force likes rated pilots flying the UAS and making decisions regarding mission execution. However, automation will continue to perform more and more pilot functions, and the pilot or UAS operator will become more of a mission manager or mission commander, possibly directing multiple aircraft in the battlespace.

MIL-EMBEDDED: ***GA-ASI recently announced the validation of its Due Regard Radar (DRR) for sense and avoid capability. Does this give your unmanned aircraft the ability to fly in civilian airspace without a manned aircraft escort? If not, then how far are you away from developing that capability?***


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PEHRSON: We validated the engineering concept for our DRR, a system that can detect noncooperative traffic and recommend maneuvers to avoid such traffic. It provides safe separation and collision avoidance inside a certain range or bubble of airspace around the airframe, enabling maneuvers to prevent a collision.

We've tested the MQ-9 with the DRR and we are working with the FAA to get it certified. We think the DRR will satisfy sense and avoid requirements in national airspace, but it will be a long process to get it certified as it takes time for policy to catch up with technology.

MIL-EMBEDDED: ***The DoD community loves its acronyms, but there seem to be competing acronyms when it comes to describing unmanned aircraft – UAV (unmanned aerial vehicle), UAS (unmanned aircraft system), and lately GA-ASI has been using RPA (remotely piloted aircraft). Why the switch to RPA? Was it more to assure the public that these vehicles have human control?***

PEHRSON: First, let me say that RPA is an Air Force term, not a GA-ASI creation. UAV was the original terminology, then UAS became the acronym of choice as it covered not just the aircraft, but the GCS and other components as well. The Air Force chose RPA to make a statement – that they are keeping the pilot in the loop. With RPA they can say to the public and those inside the Air Force that these aircraft are not autonomous flying robots and that a person is still in the loop and in control.

While the Air Force prefers RPA, the Army likes UAS. In the public domain, drone, which can have a negative connotation, has become popular. Drone is the widely adopted terminology, but I prefer UAS since it covers all components of the platform.

MIL-EMBEDDED: ***Looking forward, what disruptive technology/innovation will be a game changer for unmanned aircraft designs and/or payloads? Predict the future.***

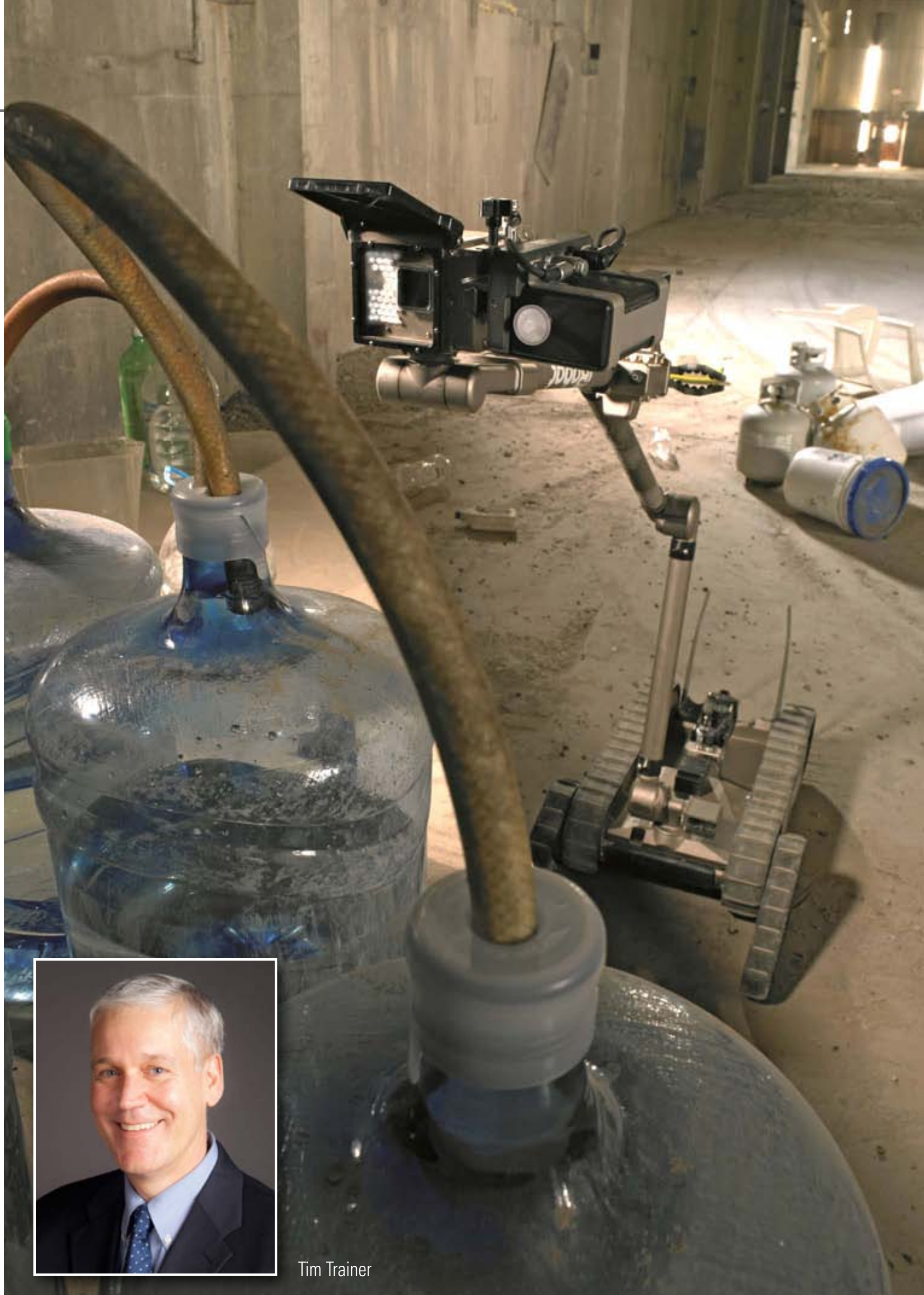
PEHRSON: I believe the next game changer – and this does not just apply to unmanned aircraft but to air combat in general – will be directed-energy laser weapon systems. GA-ASI is designing a laser weapon module to fit in the Predator C Avenger, and we plan to fly an Avenger with this laser weapon in 2018. **MES**

***Chris Pehrson** is Director of Strategic Development for GA-ASI. Prior to joining the firm in 2010, Pehrson served in the U.S. Air Force, where he commanded an operations group and two squadrons. He holds ratings as a command pilot and electronic warfare officer; his military decorations include the Defense Superior Service Medal, Legion of Merit, Distinguished Flying Cross, and Bronze Star. Pehrson holds a bachelor's degree in computer science from the University of Michigan, a master's in computer information systems from Boston University, and a master's in logistics from the Air Force Institute of Technology. He is also a graduate of the U.S. Army Command and General Staff College and the Air War College.*

Military robotic systems funding steady as the systems continue to save lives

By John McHale, Editorial Director

U.S. warfighters often sing the praises of unmanned ground vehicles (UGVs) like iRobot's 510 PackBot because it saves lives in areas such as improvised explosive device (IED) detection. In this Q&A with Tim Trainer, Vice President, Robotics Products International, iRobot Defense & Security business unit in Bedford, Massachusetts, he discusses how UGVs have impacted the warfighter from a safety and efficiency standpoint and covers the outlook for robotics technology in the military. Edited excerpts follow.



Tim Trainer

The 510 PackBot can enter hazardous environments to search for chemical, biological, radiological, and nuclear (CBRN) threats. Photo courtesy iRobot.

MIL-EMBEDDED: ***Please provide a brief description of your responsibility within iRobot and your group's role within the company.***

TRAINER: I am Vice President of Robotic Products International at iRobot. I cover everything outside North America including the Asia/Pacific and European regions. My legacy is from the defense side, as a retired U.S. Navy Captain. My early years at iRobot were in the defense market and it has been a nice transition to the international business as that market focuses on what is successful and working in the U.S. market.

MIL-EMBEDDED: ***The Department of Defense (DoD) released its FY 2016 budget request in February with an increase in overall funding, almost a reverse trend from the last few years. How do you see the funding outlook for unmanned ground vehicles? Has the DoD clearly defined what missions it will need these platforms for over the next five years?***

TRAINER: There is evidence of increased funding that we can see within the DoD and in major programs. The military and Army have regrouped and taken a look at what they need for ground robotics. That vision had taken a pause and is now refocused. This is good news that has not been seen for the last couple years.

The major programs focused on ground robotics include Common Robotic Systems- Individual (CRS-I), a 20-pound vehicle that is getting research and development funding; the Man Transportable System (MTRS) Increment 2, which has funding; and the Squad Multipurpose Equipment Transport (SMET). New mission requirements for ground robotics will drive industry and government investment. Some will be joint programs with the Army and Marine Corps generally, while some will go DoD-wide and involve the Navy and Air Force as well. Special Operations Forces (SOF) will also have unique opportunities that will often be more customized.

The budget reductions and troop drawdowns aside, all folks see that and understand that the Army and other services will need to sustain current systems, which also makes us feel fairly good about where the market is going.

Internationally, it's a dangerous world out there that can benefit from robotic systems. Aside from the military, we've also deployed our platforms to help secure major events in Brazil, including the papal visit, World Cup, and the upcoming summer Olympics. Growth has been very good internationally.

MIL-EMBEDDED: ***Please provide an example of current unmanned ground platforms iRobot supplies to the U.S. and international countries.***

TRAINER: Our most popular military platform is the 510 PackBot, of which 4,500 are deployed to U.S. military and domestic customers around the world. We also have a new HAZMAT configuration kit for the multimission PackBot system.

iRobot also provides robotic solutions to state and local first responders, nuclear facilities, industrial applications, and for the expanding chemical, biological, radiological, and nuclear (CBRN) mission set. Counter-improvised explosive device (IED) work also continues, especially with the risk of chemical weapons attached to an IED. We are always looking at new sensors to enhance mission effectiveness.

MIL-EMBEDDED: ***What types of payloads do iRobot's unmanned ground vehicles carry? Intelligence, surveillance, and reconnaissance (ISR) sensors? Have any been weaponized?***

TRAINER: We have not weaponized any of our robots, but do have a payload we call a disruptor, and that some call a water cannon. It is essentially a shotgun barrel attached to the robot that can fire a water charge at high velocity and at short range to separate an IED initiation device from its explosive charge, rendering it safe. It can also discharge clay and steel rounds.

From there we also have thermal cameras for ISR capability, two-way audio, and GPS for mapping and to allow operators to understand where the robot is to map out suspected hazards. Recently the Canadian Department of National Defense, for their Recce system requirement, competitively selected our new PackBot CBRN HazMat suite.

MIL-EMBEDDED: ***What is your approach to using commercial off-the-shelf (COTS) embedded computing technology and open architectures in your payload and control systems?***

TRAINER: For payloads, we prefer to buy those from the market then integrate them onto the robot so we can focus on what we do best, which is robotics.

We have leveraged commercial computing technology for our new uPoint Multi-Robot Control (MRC) system – a universal control system for all the company's defense and security robotic platforms (Figure 1). It incorporates a touchscreen tablet that runs on the Android operating system. Prior control stations leveraged a laptop with a joystick for control. The MRC uses an Android app that has a touchscreen control virtual joystick that enables operators to touch and drag anywhere on the main video feed to control the robot. It also enables users to share data with other team members. Through networking technology it can tie into the cloud to offload some computational requirements to provide even greater processing capability.

The Army has also looked at Android tablets and the CRS-I system is also expected to leverage the Android technology.

MIL-EMBEDDED: ***Reduced size, weight, and power (SWaP) requirements are hitting all applications in defense electronics. How are they impacting your unmanned ground vehicles and their payloads?***

TRAINER: Historically, operators want something that weighs nothing, costs nothing, and does everything. In other words, SWaP has always been an important consideration, especially in dismounted missions. Our five-pound 110 FirstLook was designed with SWaP in mind. It is so light an infantry soldier can carry it with him and actually throw it into a target area.

Extending the endurance of these systems and increasing computational capability are also critical design factors. More and more things are driving autonomy in these systems. As we shrink the platforms, we are also enabling more computational power with each generation of processing chips in the same footprint. An example of this would be the uPoint MRC mentioned above, which while smaller has more computational capability than previous control stations.

Figure 1 | The iRobot uPoint Multi-Robot Control (MRC) system uses a touchscreen tablet that runs on the Android operating system. Photo courtesy iRobot.

MIL-EMBEDDED: ***What type of training is involved for using your ground robots on missions?***

TRAINER: Ideally we wouldn't have to provide much training. An example of a platform with minimal training requirements is the 110 FirstLook system. If an operator has to deploy the system into a village or an unknown situation, we want the task of remembering how to operate the device to be intuitive and easy so they can focus on the mission. This is also an issue with first responders and police, who are not always training with their robots, often only using it once a month. Therefore ease of use is paramount.

MIL-EMBEDDED: ***What feedback do you get from military operators of your unmanned ground vehicles?***

TRAINER: What we hear from them is that they are getting tasked with increased mission sets and are asking us to help them prosecute those different missions with robots. Our robots came into the world as a counter-IED system and now they are used for checkpoint operations, SOF support, CBRN support, etc. The growth of the systems happens with new capabilities and the addition of new missions.

MIL-EMBEDDED: ***What impact do you think robotic technology has had on the warfighter?***

TRAINER: It really brings safety and standoff to the U.S. service person. For example, from an aviation perspective in Vietnam to attack a target we would send a whole squadron, in the first Gulf War, we would send a flight of aircraft, now we are sending one drone aircraft to attack multiple targets. Similarly, unmanned vehicles allow standoff and reduce the risk to the individual warfighter. The same thing is happening with unmanned ground systems, where we are separating warfighters from hazards and helping them perform these dangerous tasks more effectively and safely.

UGV mission sets will continue to grow as capabilities expand. We will see the same progression on the ground that we've seen in the air, though the ground-based terrain environment poses a significantly more difficult physics problem than that faced by airborne vehicle.

"OUR ROBOTS CAME INTO THE WORLD AS A COUNTER-IED SYSTEM AND NOW THEY ARE USED FOR CHECKPOINT OPERATIONS, SOF SUPPORT, CBRN SUPPORT, ETC."

MIL-EMBEDDED: ***Looking forward, what disruptive technology/innovation will be a game changer for UGV designs and/or payloads? Predict the future.***

TRAINER: The holy grail is autonomous operations. We won't get there in five years, but maybe in 10. This will reduce the workload on operators, allowing them to control multiple robots. Robots might be sent into hostile environments as a squad, entering a village or building to identify suspect packages and or people and then report back to central command.

What will help enable this is leveraging what works from the commercial side of our business and using it for defense platforms and vice versa. This trend has increased since we reorganized our engineering operations by merging the government and consumer divisions together. We married the higher tech from our lower volume markets with the expertise from our high volume markets. It provides an opportunity for cross-pollination and the germination of revolutionary ideas.

An example would be how we developed our Ava remote-presence platform, where the robot moves about an office space providing high-definition video, teleconference capability with sensors that enable obstacle avoidance – all things that were originally developed on defense side of our house that has found a home in our remote-presence business. Interestingly, some of that technology is now finding its way back to the defense side. **MES**

__Tim Trainer__ is vice president, robotics products international for iRobot's Defense & Security business unit. Prior to this appointment, he served as interim general manager and vice president of operations, where he was responsible for all manufacturing, contracting, and program management. Prior to that role, Trainer was vice president, programs and vice president, engineering. He joined iRobot after a 30-year career in the U.S. Navy, including positions as commanding officer of the Naval Aviation Depot (NADEP), North Island, California; head of Naval Air Systems Command's Air Vehicle Engineering Department; and various program positions. Trainer holds a bachelor's degree in mechanical engineering from Marquette University, has a master's degree in aeronautical engineering from the Naval Postgraduate School in Monterey, California, and is a graduate of the U.S. Naval Test Pilot School in Patuxent River, Maryland.

Architecting unmanned systems: How suppliers can adapt to disruptive requirements changes

By David Barnett

An RQ-4 Global Hawk unmanned aircraft system (UAS) like the one pictured is being used to assist Japan in disaster relief and recovery efforts. (U.S. Air Force photo/Senior Airman Nichelle Anderson.)

Unmanned aircraft systems (UASs) are relatively new additions to the arsenal of weapons available to the military, and the technology is evolving rapidly. Beyond the normal course of advancing technology, additional factors are driving change in UAS development such as budget realities that necessitate the adoption of open architectures and increased UAS operation in civilian airspace that requires support of commercial safety standards. Also, software developers who wish to supply the military (or commercial clients) with UAS technology must quickly respond by adopting a new approach to the way they develop systems for unmanned aircraft. Not heeding these disruptive forces may leave suppliers out in the cold.

Technology embedded in unmanned aircraft systems includes many components such as processors, operating systems, communications infrastructure, and application software. These components are designed to enable unmanned air vehicles (UAVs), the airborne component of a UAS, to efficiently carry out a specific mission. Traditionally, each UAV design also requires a special-purpose ground control station (GCS). Components are typically redesigned for each new vehicle, and building UAVs that are readily adaptable to different mission objectives and parameters has proven to be difficult.

Winds of change

This will not be the case in next-generation UAS, which will include many-to-many relationships between GCSs and UAVs capable of supporting multiple mission objectives. The systems needed to deliver this multimission capability will include self-coordinating UAVs controlled by multiple GCSs, with UAVs and manned aircraft as well as space systems, all cooperating to meet a continuously changing set of mission criteria.

Visionary research papers from the Department of Defense (DoD) in the U.S., the Ministry of Defence (MOD) in the U.K., and government-industry consortia such as Future Airborne Capability Environment (FACE), UAS Control Segment (UCS), and Open Mission Systems (OMS) endeavor to define these requirements for UAS developers, including designing for a net-centric environment. Designers of UAVs and GCSs will have to ensure that every element of their capability is accessible to every other relevant participant in the net-centric environment.

Recognizing this new reality, the DoD laid out its plan for the evolution of the underlying technology needed for next-generation UAS in its "Unmanned Systems Roadmap 2007-2032." The DoD vision has also been echoed in NATO forums and country-specific UAS initiatives. The Unmanned Systems Roadmap defined six goals, two of which are particularly relevant here:

- Emphasize commonality to achieve greater interoperability among system controls, communications, data products, and data links on unmanned systems.

- Foster the development of policies, standards, and procedures that enable safe and timely operations and the effective integration of manned and unmanned vehicles.

These are the disruptive forces transforming UAS development. Software developers and system designers will very soon, if not immediately, need to first support open architecture requirements, and also meet heightened safety-certification requirements for unmanned aircraft in commercial airspace.

Procurement strategy and the push to an open architecture model

By mandating, managing, and verifying interoperability and safety certification, the DoD is more closely aligning the defense market with the operation of open commercial markets. The most important commercial market benefit sought is market competition for subsystem supply. Defense procurement seeks to foster investment ahead of specified requirements, building agility into the procurement process to enable shorter update cycles and stay at the front of the technology race. Moreover, because military budgets have tightened, the DoD wants to drive down cost by encouraging design innovation and competition.

This approach represents a fundamental shift in procurement strategy. Existing DoD systems have typically been developed for a unique set of requirements by a single lead integrator with long lead times, resulting in platform-unique design limitations as well as barriers to competition within and across platforms. An interoperable open-architecture approach will mandate system integration and eliminate the traditional model of siloed development.

To be meaningfully interoperable within an open architecture, different systems built at different times, with different hardware, different software architectures, different technologies, and different uses of data must be readily and meaningfully integratable. The DoD has determined that the key to achieving this goal is to specify a common semantic data model. All data to be exchanged is rigorously defined, described, and documented.

The safety-certification imperative

In addition to meeting open architecture requirements, the DoD says, UAS developers must "enable safe and timely operations and the effective integration of manned and unmanned vehicles." This requirement has broad implications beyond the military UAS.

The Federal Aviation Administration (FAA) is moving toward integration of UAVs, colloquially referred to as "drones," into U.S. commercial airspace. International counterparts are considering similar steps. This integration of drones into national airspace presents new opportunities for UAS developers. A company that develops UAS for the military will certainly want to leverage its research and development investment to create similar products for the commercial market. To accomplish this, a company must address requirements for both military and commercial clients.

Safety has been a primary concern for the FAA, which follows the RTCA/DO-178C standard for software safety certification. These guidelines affect UAS developers by adding complexities and costs directly related to safety certification. DO-178C objectives dictate that code be developed with extraordinary attention paid to testability (Table 1). Code must be deterministic to enable repeatable test results.

Additionally, certification is expensive. For DO-178C, costs can range to as much as $100 per executable line of code (ELOC), depending on the certification level. These are only the costs for creating the certification evidence and do not include the costs for designing and writing the code. Since safety certification is costly and developing safety-certifiable software comes with its own unique challenges, mission-critical components must be developed with minimum line count, testability, and determinism as top-line requirements.

Leveraging DDS to achieve interoperability and safety certification

Fortunately, there is a proven approach to systems design that enables developers to achieve the requirements of open architecture and safety certifications for military and commercial UAS, while reducing development time, cost, and risk. That approach involves building components on DDS-compliant middleware.

DDS, or Data Distribution Service for Real-Time Systems, is a set of specifications standardized by the Object Management Group (OMG). At its core, DDS implements a real-time software data bus (Figure 1) based on a connectionless architecture. This architecture overcomes problems associated with point-to-point system integration, such as the inability to scale, interoperate, or evolve the architecture.

DDS uses the publish-subscribe communications model to enable data producers to publish data to the infrastructure and allow data consumers to subscribe to data from this data

Level	Failure Condition	Process Objectives	Code Coverage
A	Catastrophic	71	100% modified condition/ decision coverage
B	Hazardous/Severe	69	100% decision coverage
C	Major	62	100% statement coverage
D	Minor	26	100% of requirements
E	No effect	0	None

Table 1 | DO-178C safety levels and certification requirements.

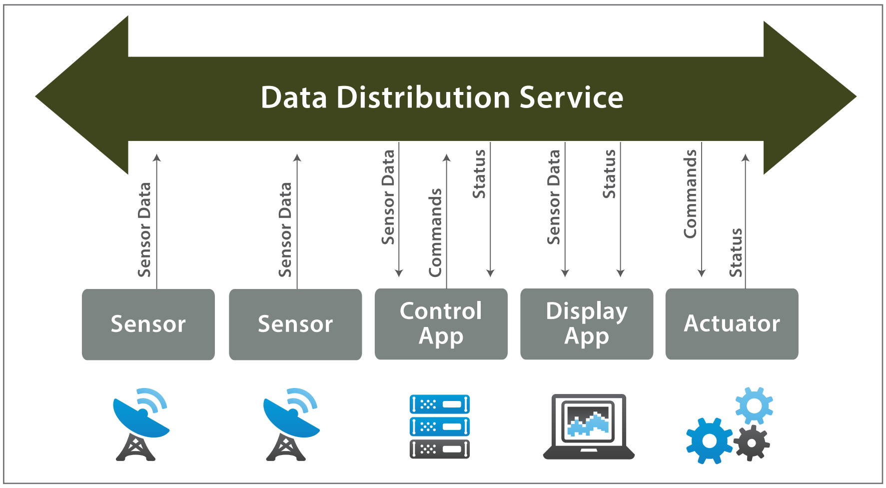


Figure 1 | Data Distribution Service for Real-Time Systems (DDS) enables data producers to publish data to the infrastructure and allows data consumers to subscribe to data from the infrastructure.

infrastructure. In a DDS implementation, the data is abstracted away from the physical source and destination and made accessible to any application that subscribes to it, independent of the source's location and the specific link technology that transports the data.

DDS is used in thousands of mission-critical applications and systems across many industries including aerospace, defense, healthcare, energy, automotive, and air traffic control. Since these systems tend to process high-volume and highly frequent updates, such as sensor information, accurate transmissions are critical. The implications of system failure are often severe, potentially leading to loss of property or even loss of life. The proven success of DDS makes it an excellent starting point for safety-critical applications such as UAS.

Use of DDS in UAS is standardized by open architecture guidance including FACE, UCS, and OMS. DDS implementations, including RTI Connext DDS Cert, are certifiable up to DO-178C Level A and include the process and testing artifacts required by the certification authority. This approach can save millions of dollars of certification cost by greatly reducing the amount of custom code that must be evaluated. **MES**

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Themis high-density computing Q & A

What is behind the growing demand for high-density server solutions in the defense industry?

Function consolidation, virtualization, and big data analytics are driving more compute capability in a smaller footprint. The DoD requires feature-rich systems that interoperate in multiple applications and allow information sharing between applications. Demand is also driven by "Common Operating Environment" requirements, the use of common components, and "right-sizing" systems to deploy solutions in as many places as possible. To support big data analytics, the DoD utilizes the Map/Reduce function initially developed by Google for search purposes and provided by Apache in Hadoop clusters. The DoD utilizes Hadoop for mining sensor data in the DCGS-A program. The DoD is constrained by size, weight, power consumption, and heat. Themis HD/HDS systems provide robust thermal management and double compute density with a weight savings of nearly 50 percent when compared to a 1U server stack.

How does HD enable enterprise RAS features for embedded mission-critical systems?

Themis HD servers utilize the latest RAS features provided by Intel, including data and address path protection through parity and ECC for CPU and memory. These units incorporate built-in out-of-band management features for accessing system health. Through the KVM function, any network-connected client can access the console for BIOS setup, system boot, or software installation. The fans in each server module are managed locally and are over-provisioned. In the event of fan failure, remaining fans manage the required cooling load until the failed fan is replaced. Server, storage, and power modules are hot-pluggable. Front-mounted air filters protect electronic components and can be easily cleaned or replaced. The Resource Management HD module puts system management at the fingertips of the IT user.

How do Themis HD solutions address DoD requirements?

Themis HD servers deliver increased capability while allowing systems to be built up of standard, modular, lightweight, rack-mount components. Combined with a network switch and a transit case, a complete server solution can be deployed to any service region required. Available in a 2RU (four bay) or 3RU (six bay) chassis, RES-HD servers provide maximum system configuration flexibility and functionality with hot pluggable processor, storage, high-speed switch, and system management module options. Combining leading-edge components that include Intel® Xeon® E5-2600 v3 Series processors and SuperMicro motherboards, up to 256 GB of memory, dual GbE ports, and a single PCIe slot, RES HD modules feature expansion slots, extensive high-speed front or rear I/O, storage, and enhanced reliability options. Themis HD systems are modular. A 2RU Chassis can host up to one HDS8 module plus two HDS8 Storage Expansion modules (2.5 inch SSD or HDD drives) for a total of 24 drives (including eight drives in HDS8 Storage module) or 48 TB. A 3RU Chassis can host one HDS8 module plus four HDS8 Storage Expansion modules for a total of 40 drives (including eight drives in HDS8 Storage module) or 80 TB.

Themis 3RU Chassis populated with one HDS8 module plus four HDS8 Storage Expansion modules provides a total of 40 drives (including eight drives in HDS8 Storage module) or 80 TB.

Themis 2RU RES-HD System

What are the Themis server's primary size, weight, and power-cost (SWaP-C) characteristics?

Themis HD systems offer a four-bay 2RU (3.5 inches) or six-bay 3RU chassis (5.25 inches) height. System depth is 20 inches. The 2RU HD system typically weighs 40 pounds, and the 3RU system typically weighs 55 pounds when fully populated, the HD system power consumption is -1,300 W and the HDS power consumption is -750 W. HD systems enable customers to double compute density, enable a 50 percent rack space savings with system module weights as low as six pounds. Depending on the configuration, total system weight is reduced by nearly 50 percent.

Do HD designs enable regular technology refresh or technology insertion?

Yes. Themis follows the Intel road map. HD systems are refreshed at the same interval. These systems enable individual module upgrades with the main chassis in place, in the rack.

Where can Themis HD servers be used in applications outside of defense?

HD systems can be used in any application where high compute density and large, local storage are needed. Add in the robust environmental capability and they can easily be deployed in industrial or energy-exploration applications.

THEMIS

Themis Computer
www.themis.com/hd

Benefits of Using Safety Certified Software Components

The relentless growth of safety regulations has resulted in an ever-increasing number of products requiring certification. There are examples of mature products now requiring certification for the first time, while other products may require product certification in the future. The challenge for software engineers is how to bring these products quickly and cost effectively to the market, while balancing the need to meet the rigorous requirements demanded by international safety standards.

One method of achieving this is to purchase Safety Certified Software Components for the basic building blocks of the software architecture.

Navigating Certification

Safety Certified Software Components are software modules that provide specific and well defined functionality, developed according to a recognized design standard such as IEC 61508 or DO-178C. These software components can be integrated into safety projects with minimum effort while maintaining their safety rating, resulting in a highly reliable software product requiring little additional certification effort.

A good example of a safety certified software component is SAFE**RTOS** from WITTENSTEIN high integrity systems. SAFE**RTOS** is a safety certified RTOS that consists of a pre-emptive, embedded, real time operating system developed to comply with IEC61508-3 SIL 3 and a Design Assurance Pack (DAP) containing all the design and verification artefacts generated during the development of SAFE**RTOS**. Contained within the DAP is the all-important Safety Manual. The Safety Manual explains exactly how to install and integrate SAFE**RTOS** into the development environment. Following the concise instructions will also generate the evidence required to confirm the process has been followed correctly at any subsequent audit.

Some Safety Certified Software Components, like SAFE**RTOS**, are available pre-certified to a specific standard, but it is not always possible to pre-certify software against all standards. For example, IEC 61508 (Industrial) allows certification of software only components up to Safety Integrity Level (SIL) 3, whereas IEC 62304 (Medical) only allows certification of the final product. Within these markets, Safety Certified Software Components can only be sold as certifiable. It's also important that the certification of the Safety Certified Software Module is issued by a recognized body independent from the developer of the component, such as TÜV SÜD.

One of the major advantages of using Safety Certified Software Components is that they allow developers to purchase certification in advance for core components of the system, removing the considerable time, effort and resources needed to design, verify and certify the components themselves.

Lowering Risk

Safety Certified Software Components can lower project risks. Technically, they are very robust, deterministic and stable, which significantly lowers the probability of finding problems within the code during development or once the product has been released. When it comes to program management risk, developers can be confident that any problems during the product certification process will not be caused by the purchased Safety Certified Software Component, (providing the installation and integration instructions are followed correctly). Therefore, no nasty surprises occur late in the development cycle, and no unexpected and lengthy re-work phases are required to resolve certification issues.

Greater Value

In today's engineering world, software development is normally the most expensive element of any new design, and safety critical development significantly more so. Naturally, this is reflected in the price – Safety Certified Software Components tend to be much more expensive than the commercial grade alternatives. This price difference leads some companies to consider purchasing the commercial version, and certifying in-house.

However, there are two significant advantages to buying safety certified software components. First, commercial versions are often missing key safety functions, or specific safety features. Secondly, it can often be more cost effective – companies that specialize in the development of specific safety critical software components will have the processes and experience in place to generate these products efficiently. Economies of scale come into play, as the components will be available on the open market, hence, the cost of developing this product will be distributed across many customers resulting in a purchase price that should be lower than developing and certifying the software module in-house.

In conclusion, Safety Certified Software Components are highly robust, reliable and deterministic software modules that are easy to integrate into safety critical development projects while maintaining their safety ratings. They normally lower technical and program risks, leading to shorter development schedules. However, typically, the cost is significantly higher than the commercial grade alternatives, therefore Safety Certified Software Components offer best value when used in systems that require actual certification.

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WITTENSTEIN

OpenRFM: A proposed open architecture to support EW and SIGINT applications

By Lorne Graves

OpenRFM is an affordable, modular open systems architecture that standardizes the electromechanical interfaces and control planes to drive affordability, ease of integration, and interoperability within the radio frequency (RF)/microwave domain and is ideally suited to electronic warfare (EW) applications. Its modular approach and leverage of commercial technology enables scalability, adaptability, high channel density, and exportable features.

Within the defense industrial base, adherence to standards such as IEEE and ISO is nothing new. However, there has been little standards-based activity born purely out of the defense sector; nearly all standards activity emanates from the commercial sector. This situation is not surprising, since much of the work within defense electronics is centered on platforms designed to meet very specific applications, where standards-based solutions are difficult to design, engineer, and develop. This fact is especially true within RF and microwave-based defense applications where, to date, little to no progress has been made in developing open systems architectures that support EW applications.

This void of homegrown standards completely contradicts the Department of Defense (DoD) mandate that all systems move toward open architectures in order to lower costs and facilitate ongoing upgrades to essential electronic systems so they remain on the cutting edge of technology. The DoD open systems initiative dates back to November 1994, when the Office of the Secretary of Defense directed that all DoD agencies use open systems and standards for acquisition of weapon systems and programs. The Open Systems Joint Task Force was established to promote open systems and standards around the Open Systems Architecture (OSA). In June 2013, the DoD published the OSA "Contract Guidebook for Program Managers," which provided the first prescriptive approach on how open architectures should be developed and rolled out for key defense programs. This guide defined an open architecture as "a technical architecture that adopts open standards supporting a modular, loosely coupled and highly cohesive system structure that includes publishing of key interfaces within the system and full design disclosure. A key enabler for open architecture is the adoption of an open business model, which requires doing business transparently to leverage the collaborative innovation of numerous participants across the enterprise, permitting shared risk, maximizing asset reuse, and reducing total ownership costs. The combination of open architecture and an open business model permits the acquisition of open systems architectures that yield modular, interoperable systems allowing components to be added, modified, replaced, removed and/or supported by different vendors throughout the life cycle in order to drive opportunities for enhanced competition and innovation."

The OSA guidebook specifically defines expectations around OSA for commercial organizations supporting the defense industrial base, while leaving the development of standards to industry participants. Today, throughout the DoD, there is a push toward commonality – using the same equipment, hardware, and software across multiple platforms to reduce operational and training costs, improve efficiency, and combat obsolescence. This push for commonality requires a standardized OSA.

Yet despite the fact that RF and microwave technologies have been part of the underlying fabric of critical defense applications for generations, proprietary systems and technologies prevail, making upgrades challenging at best. RF and microwave components – mixers, filters, capacitors, limiters, oscillators, and digital receivers, among other technologies – have been part of the lexicon for decades. Today, as EW and signals intelligence (SIGINT) applications are ramped up to meet emerging threats around the globe, advanced Digital Radio Frequency Memory (DRFM) jammers and Integrated Microwave Assemblies (IMA) use these technologies in ways that had never been imagined. An IMA, for example, often offers customized designs for mission-specific applications, which combine the integration of switches and switch matrices, amplifiers, attenuators, filters, oscillators, and other RF and microwave functions.

An open standard for embedded defense electronics

The bottom line is that today's technologies, while advanced, have not kept pace with the DoD's OSA directives or the need to provide a standardized way of building, integrating, testing, reusing, and upgrading these systems. In other words, the world of open systems and open architectures has not been introduced to RF and microwave solutions.

Working with the VME International Trade Association (VITA), Mercury helped to form the OpenVPX working group, which built a true open standard for embedded processing within defense electronics in 18 months. The emergence and adoption of the OpenVPX standard means added interoperability, cost certainty, risk mitigation, affordability, and technology innovation.

"OPENRFM ENABLES EXISTING EW AND SIGINT APPLICATIONS TO BE DEPLOYED MORE EFFECTIVELY AND AFFORDABLY."

The difference today is that OpenRFM is not an idea waiting to be developed. Mercury is already building modular, standardized solutions that can be applied to

EW and SIGINT applications, and is developing OpenRFM-based products in 3U and 6U VME, VXS (VITA 41), and OpenVPX (VITA 65) form factors. These products are protocol-agnostic and use a common test bed, which reduces development time. (Figure 1.) Currently, Mercury is using OpenRFM on three unique missions with three key customers.

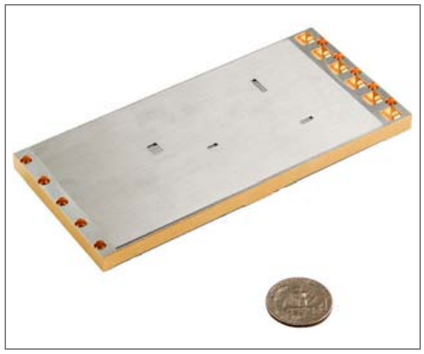
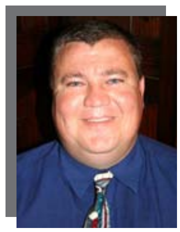


Figure 1 | Mercury Systems' OpenRFM wideband IF module with cover.

OpenRFM a tool to counter evolving threats

OpenRFM's modular, standardized, scalable approach allows prime contractors and the DoD to develop or augment existing applications to counter evolving threats in EW and SIGINT. It enables faster deployment of applications and classified techniques that are the lifeblood of rapidly evolving EW-related programs, which continue to grow in importance as the complexion of our defense base and the missions it serves continues to change. OpenRFM enables existing EW and SIGINT applications to be deployed more effectively and affordably. It can accelerate the deployment of techniques such as "cloaking" the outgoing signal with random noise, and make deploying EW applications more predictable and affordable.

OpenRFM will become a key part of the industry landscape, as it is the best option for meeting today's EW and SIGINT challenges. OpenRFM combines digital signal processing and advanced RF and microwave into a single system. Most importantly, it aligns with the DoD directives to lower costs and increase the ability to rapidly and continuously upgrade critical defense electronics systems, thereby keeping pace with emerging threats. **MES**



***A. Lorne Graves** is Chief Technologist at Mercury Systems. With more than 20 years of experience designing mixed-signal circuitry and FPGAs as well as expertise in mixed-signal and RF technology, he has served as the business development lead on several key radar, SIGINT, and electronic warfare programs working directly with various defense prime contractors. Before joining Mercury in 2003, he was a senior engineer for a major networking company; prior to that, he served as a Field Applications Engineer for two electronic-component manufacturers. Graves earned his bachelor's degree in Electrical Engineering from the University of Alabama, Huntsville. Readers can reach him at agraves@mrcy.com.*

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www.mrcy.com

ISR PAYLOAD DESIGNS FOR UAVS & UGVS

Multicore processor-based 3U architectures reduce SWaP for UAS ISR platforms

By Aaron Frank and Jacob Sealander

The MQ-43 Triton unmanned aerial system (UAS). [Northrop Grumman photo/Alan Radecki.]

There is a never-ending pursuit of reduced size, weight, and power (SWaP) in intelligence, surveillance, and reconnaissance (ISR) processing. Traditionally, what's been seen in the ISR application space: Complex, specialty-built systems which tended to be very large, very high-powered, and difficult to cool. Many of these systems were ground-based; over time, a larger number have moved into the air and into a variety of different platforms such as unmanned aircraft systems (UASs). Today's systems need to be deployed on smaller and smaller platforms, making it even more challenging to meet the SWaP targets of traditional ISR platforms.

Another emerging trend is that technical requirements for ISR systems continue to grow and get increasingly complex even as the platforms get smaller. For example, UAS-based imaging systems require higher resolutions and a higher level of processing than in the past, demanding higher throughputs to ingest and analyze data, then store and relay information. The same trend is true for other ISR applications. Combine these factors with ever-shrinking defense budgets and issues such as sequestration, and the result is increased pressure to find ways of cost-effectively reusing and developing IP to leverage existing technologies and architectures.

Today's higher levels of integration and improved performance are helping to address these requirements. Yesterday's ISR systems typically contained many different 6U processing boards, each with one or more single-core processor. In the past, the main processing workhorses found in these systems were Power Architecture processors supported with Altivec math libraries, as well as custom DSP-based and FPGA-based systems. Recently the industry has seen a move toward using a common computing platform to provide many of these functions.

These earlier 6U-based multiprocessing ISR systems also tended to use a number of fabrics to tie them together, such as Ethernet, Serial RapidIO (SRIO), VMEbus, PCI, and others. On the software side, a variety of different operating environments have been used, including VxWorks and Linux, with many different application programming interfaces (APIs) for application development. In addition, custom libraries were often tailored to the specific hardware. For these earlier systems, thermal management was a challenge: The more boards and hardware required to get the job done, the more power was required, the more heat generated, and the heavier the solution.

Today, looking at the latest generation of processors from leading vendors such as Intel, Freescale, and AMD, the industry sees the integration of multiple processing cores into a single piece of silicon. Today the "sweet spot" tends to be two-core and four-core processors that are driven by today's desktop and

"THE RESULT IS THAT THE PROCESSING POWER IN JUST ONE 3U SINGLE-BOARD COMPUTER IS NOW EQUIVALENT TO MANY PREVIOUS GENERATION 6U BOARDS."

laptop computing world, but we also see the emergence of processors with many more cores, such as the eight-core hyper-threading Xeon processors from Intel, or Freescale's 12-core dual-thread processors (with 24 "virtual" core processors) integrated onto a single piece of silicon. The core-to-core interconnect fabric is typically a high-speed bus with multiple levels of processor cache to ensure that the processors are not starved when they share common memory interfaces. With multiple memory channels, the processors are able to access massive amounts of data and feed the processing cores.

Today's processing cores also have specialized accelerators that can be used for math-intensive processes. For example, Power Architecture processors again feature Altivec processing engines, whereas Intel's Core i7s feature vector-processing engines using AVX or AVX2 instructions. Even better, current-generation devices also have onboard graphics accelerators, which can also be used as general-purpose GPU (GPGPU) processors offering in excess of 350 GFLOPS of floating-point performance, and upwards of 20 or more GPGPU engines, all on a single piece of silicon. Common to all of these modern processors is the use of PCIe to provide connectivity to the outside world.

A 3U processing board based on today's leading processing architectures can deliver performance in the range of 173,000 Dhrystone MIPS. This is compared to a previous generation common 6U processor, which might deliver approximately 3,000 MIPS, representing a huge leap in performance. Today's Core i7 3U boards, for example, also feature built-in Altivec2 processing engines that provide roughly 300 GFLOPS. Their on-chip graphics processing GPU also adds another 350 GFLOPS. The result is that the processing power in just one 3U single-board computer (SBC) is now equivalent to many previous generation 6U boards. What's more, for board-to-board data communication, the built-in PCIe connectivity on today's silicon benefits SWaP reduction by providing 8 or 16 Gigabytes/s connectivity using a fabric already built into the device. This eliminates the need for extra fabric interface chips that would otherwise need to fit onto the 3U board.

Example of a small ISR system

An example of a small ISR system based on today's multicore processor-based 3U boards consists of three 3U VPX3-1258 SBCs powered with the latest fourth-generation Intel Core i7 processors. Using XMC mezzanine modules, two of these boards are used to acquire and digitize sensor inputs, while the third SBC is used to further process the data for analysis, display, and storage. This three-board combination delivers close to 2 TFLOPS of floating-point performance, and because the boards are based on the standard VPX form factor the entire signal-acquisition and processing core occupies an area of only 75 square inches. Thermal management is also much simpler compared to an earlier-generation 6U ISR solution. The power of this example system is less than 200 W, quite manageable in a 3U form factor.

One of the reasons that thermal design of 3U deployable systems is easier compared to 6U-based systems is the proximity of the circuitry to each of the two side cooling walls in the 3U chassis. By using multiple SBCs, each with its own multicore processor, the heat can be better managed across multiple modules in the chassis. By using high-performance fabrics that are already built into the processors (such as PCIe) and optimized software middleware (such as shared memory drivers, OFED, and VISPL libraries for optimized vector processing) it's now possible to achieve the performance and the ease of development and affordability needed to rapidly develop and deploy today's demanding ISR applications.

Speeding development to deployment of 3U VPX ISR systems

After selecting the 3U COTS boards to use in an ISR system, one of the biggest challenges that system integrators face in getting their solution from development to deployment is ensuring that the boards will work as intended in a specific design configuration. As a result, integrators must typically focus significant time and effort on developing and executing test software and processes to properly integrate any commercial off-the-shelf (COTS) board into their ISR system.

A better solution is provided by preconfigured, prepackaged, and pretested 3U VPX ISR solutions. (Figure 1.) Curtiss-Wright Defense Solutions has developed integrated, pretested reference designs that are backed by test support tools and data items and that can be used in existing development programs for a variety of computer-intensive applications, including ISR. Its 3U VPX subsystems have already been deployed on UAVs, including Northrop Grumman's Global Hawk and Triton. These reference designs are engineered to meet specific key performance parameters (KPPs) and benchmarks and are supported with a suite of software tools for performance testing of the reference designs against program requirements. The key features of this embedded software infrastructure also include a system-level built-in test (BIT) solution, a configurable stress test suite, hardware-based background BIT, and a common test set infrastructure. **MES**

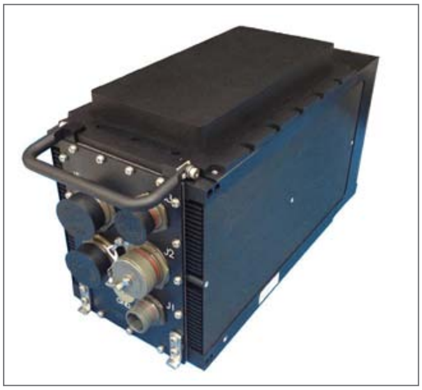

Figure 1 | The Curtiss-Wright MPMC-9351 integrated system, designed for harsh military environments, accommodates high-power 3U cards within a five-slot forced-air enclosure.

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Aaron Frank, *who joined Curtiss-Wright in January 2010, is the Senior Product Manager for the Intel Single Board Computer product line. His focus includes product development and marketing strategies, technology roadmaps, and serving as a subject matter expert within the sales team. Previous to this role, Frank held the Product Manager role for networking products. He has a bachelor's of science degree in Electrical Engineering from the University of Waterloo. Readers can reach him at aaron.frank@curtisswright.com.*

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An MQ-1B Predator unmanned aerial system (UAS) [left] and an MQ-9 Reaper UAS taxi to the runway in preparation for takeoff from Creech Air Force Base in Nevada. U.S. Air Force photo/Airman First Class Christian Clausen.

Smaller form factors benefit electronic warfare applications

By Lance Brown and Ching Hu

Small form factor (SFF) requirements continue to drive higher-performance computing platforms in electronic warfare (EW) and other signal-processing intensive applications year after year as there is an insatiable need for intelligence, surveillance, and reconnaissance (ISR). Airborne EW is a critical component of the military's overall EW strategy and almost all approaches desire more computational performance while reducing size, weight, power, and cost (SWaP-C) as more capabilities are added.

Smaller unmanned aerial system (UAS) platforms (for example, the Boeing Insitu ScanEagle or MH-6 Mission Enhanced Little Bird or the Northrop Grumman MQ-8 Fire Scout) are now performing EW missions alongside larger platforms like the General Atomics MQ-9 Reaper, the Northrop Grumman RQ-4 Global Hawk, and manned fixed-wing and rotary aircraft. Some platforms are not able to carry onboard the payloads of current processing technologies, so these smaller craft must download the data for ground-based processing.

(For more on these small platforms, see the Special Report by Sally Cole on page 16.)

Applications such as signals intelligence (SIGINT), digital radio frequency memory (DRFM), and radar processing for all aspects of EW (attack, support, and protection) are requiring more digital signal processing to achieve their goals, especially when they need to be adaptive with increasing bandwidth or are distributed.

This trend is unlikely to change even if the U.S. reduces its military footprint worldwide. Fewer boots on the ground means an even greater dependence on actionable intelligence from persistent ISR and EW systems.

Moore's Law provides a basis for increased processing capabilities, but this does not imply that power consumption drops accordingly or that memory bottlenecks can be opened up. In some sense, a technological leap is necessary to allow the desired processing capabilities to fly on SWaP-constrained platforms.

Smaller boards for EW purposes

Algorithms that traditionally required a large, heavy box or ground-based system can now be performed on a small form factor board. In addition to the EW-centric applications mentioned previously, synthetic aperture radar (SAR), space-time adaptive processing (STAP), real-time spectrum monitoring and SIGINT, multispectral (MSI) and hyperspectral (HSI) image processing, communications link encryption, multiple channels of H.264/H.265 video compression, software-defined radio, and many other defense/intelligence-critical functions can be considered for onboard processing within small SWaP envelopes.

PC/104 answers the call

For meeting the magic sub-one-pound payload SWaP-C requirements of smaller platforms, PC/104 is an attractive and robust commercial off-the-shelf (COTS) standard with a rich assortment of existing I/O modules like Intel Core i7s and analog-to-digital/digital-to-analog converters (ADCs/DACs). The PC/104 form factor is just large enough for an FPGA plus one or two hybrid memory cube (HMC) memory chips, currently two or four GB each, and a variety of I/O interfaces.

Interface	Connector	Max. data rate
DisplayPort Source	Mini-DisplayPort	17.28 Gbps (effective)
DisplayPort Sink	Mini-DisplayPort	17.28 Gbps (effective)
Ethernet	RJ45	1 Gbps (raw)
USB 2.0 Host	USB-A	480 Mbps (raw)
USB 2.0 Device	µUSB-B	480 Mbps (raw)
PCI-Express (top)	PC/104 (top)	126 Gbps (effective, in each direction)
PCI-Express (bottom)	PC/104 (bottom)	126 Gbps (effective, in each direction)
LVDS (top)	Custom I/O	17 Gbps (raw)
LVDS (bottom)	Custom I/O	17 Gbps (raw)
XCVR (top)	Custom I/O	128 Gbps (raw, both directions)
XCVR (bottom)	Custom I/O	128 Gbps (raw, both directions)
HMC Interface	N/A	1280 Gbps (effective, both directions)

Table 1 | ACE-PCIE-104 interface data rates

FPGAs have become a game changer for signal processing systems such as EW and radar as they handle the front end, where the signals are received by the embedded computing system whether PC/104 or larger systems such as 6U VPX. The components are better connected to I/O than general-purpose processors and handle real-time processing more efficiently as well. In the end FPGAs essentially provide integrators with more control in their systems, enabling them with the flexibility pivot and modify their applications based on mission requirements.

For smaller form factors they are ideal. Add to that support for IEEE 754 Floating Point Unit (FPU) via Hard IP blocks and for OpenCL integration into the tool chain and the value of such a solution increases. The FPU is also a key enabler for OpenCL, which enables scientists, engineers, and researchers to program using the C language to massively parallelize their applications.

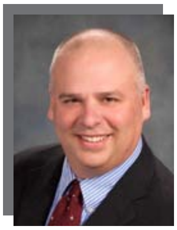
In addition to the standard PC/104 connector, a similar type of connector with custom I/O can be located on the opposite side to provide more I/O bandwidth if connecting to boards with mating connectors. Adding two peripheral boards containing high-speed ADCs and DACs can realize a full DRFM or general active sensor back end enclosed in a low-volume box.

Given the effective x16 PCIe Gen 3 bandwidth of 15.754 GBps in each direction, the data converter modules can transfer over 120 Gbps (e.g., 12-bit resolution at 10 GSamples/s [Gsps] or 16-bit resolution at 7.8 Gsps) and even more if a custom module can utilize the connector.

One recent example of a small form factor board comes from Colorado Engineering, the Arria Common Element PCI/104 (ACE-PCIE-104). The ACE-PCIE-104 features the 10AX066 with two to eight GB of HMC memory.

With the introduction of the some of the new powerful high-end field programmable gate arrays (FPGAs), such as the Altera Arria 10 and Arria 10 system-on-chip (SoC), many of these missions can be executed within smaller and lighter payloads. In case of this particular FPGA, it can provide as much as 1.5 TFLOPS and as much as a 65 percent drop in power consumption compared to a previous generation Stratix V, even with the embedded dual ARM cores of the SoC variant. When this increased performance per watt is married with HMC technology that provides 1.2 Tbps or 160 GB/s data rate, the possibilities expand. (See Table 1.)

Other applications that could benefit from the ACE PCIE-104-CL SBC are scalable distributed aperture systems (DAS), situational-awareness 360 (SA360) systems, scalable ultra-wide band receivers, and small form factor EW threat generators. **MES**



Lance Brown *is the director of High Performance Computing (HPC) at Colorado Engineering Inc. (CEI). Lance's current work focuses on HPC for radar, electronic warfare, and cybersecurity systems along with smaller platform using FPGAs and GPUs for smart cities.*

Ching Hu *is a senior strategic and technical marketing manager in the Military, Aerospace, and Government Business Unit at Altera. Hu has been employed in the military and aerospace industry for more than ten years with roles in software and firmware engineering, program and engineering management, and military marketing. Hu earned his bachelor's degree in optics at the University of Rochester, Rochester, New York.*

Colorado Engineering • coloradoengineering.com
Altera • www.altera.com

Ethernet: The connectivity platform of choice for UAVs

By Ronen Isaac

Ethernet has become the connectivity platform of choice for military unmanned aerial vehicle (UAV) system designers.

Pictured is a U.S. Air Force Global Hawk unmanned aerial vehicle built by Northrop Grumman. (U.S. Air Force photo/Bobbi Zapka)

Fixed- and rotary-wing unmanned aerial vehicles (UAVs) are employed extensively by the military for reconnaissance, search and rescue, counterterrorism, and combat. UAVs function in missions where it is too dangerous, too difficult, or too demanding to send a pilot, whether the mission is in inaccessable terrain or a war zone, whether the objective is covert surveillance, a long-haul flight, or continuous extended observation.

Unmanned aircraft require the use of onboard computers and mission-critical equipment in order to support mission profiles. They use multiple sensors, including visual, infrared, near-infrared, radiation, biological, and chemical. The equipment uses multiple visual cameras to provide 180-degree forward and downward views for remote pilots and recording of mission data. Also on board a UAV may be short-range radios, satellite links, radar, and other tactical communications devices to communicate back to centralized command. All of these devices demand dependable, flexible, and fast connectivity to produce an onboard system that works in harmony and keeps the mission on track.

Ethernet – the well-established standard for wired connectivity technologies in government and commercial applications – is now rapidly becoming the standard for military and other rugged applications due to its proven interoperability, reliability, and speed. Dedicated bus architectures have been traditionally used in military applications, including UAVs, but have in the past resulted in heavier, proprietary, and inflexible systems.

Why Ethernet for UAVs?

Ethernet has been shown as a viable alternative for military UAV applications for a number of reasons:

- Ethernet and IP technologies are ubiquitous
- Ethernet devices are inherently interoperable, encouraging modularity
- Rugged commercial off-the-shelf (COTS) components are readily available
- Ethernet continues to receive large technology investments
- Ethernet operates over world-spanning distances using established infrastructures

"UAVS CAN BE BUILT FOR MORE THAN ONE FUNCTION BECAUSE OF THE FLEXIBILITY OF ETHERNET COMPONENTS, AND UAVS IN THE FIELD CAN BE MODIFIED ON-SITE AND OUTFITTED TO FIT SPECIFIC NEEDS."

An increasing number of components in UAVs used by the military are now being modularized and connected via Ethernet.

The benefits of Ethernet connectivity in UAVs

First off, Ethernet is robust. Previous generations of connectivity were vulnerable to the elements that a UAV faced under normal conditions. Dirt, moisture, temperature deviations, and vibration can all reduce the efficacy and efficiency of standard bus architecture connectivity. Ethernet is a more solid and dependable connectivity platform; moreover, interconnectivity between switches can make these connections even more reliable. For example, multiple switches can be used in UAVs to provide redundancy and to eliminate the possibility of a single point of network failure. Switches are interconnected so that the failure of a switch or link between switches can be avoided by routing around the failure.

Ethernet also offers a diagnostic feature. Managed Ethernet switches can increase the resiliency of the internal communication of the UAV. The system can be set to self-detect and self-manage modules, thereby adding to the UAV's uptime.

In some bus architectures, modules that communicate with each other via direct electrical connections can crash the entire system if one module fails. In Ethernet architecture, however, modules are electrically isolated so that if one module fails, the loss is limited to the loss of that module.

The modularity of Ethernet components also allows UAVs to have design and implementation flexibility. UAVs can be built for more than one function because of the flexibility of Ethernet components, and UAVs in the field can be modified on-site and outfitted to fit specific needs.

Ethernet can also help with size, weight, power, and cost (SWaP-C) concerns. Every ounce of decreased weight means more flight time for UAVs, so every ounce of component weight must provide and maintain optimal system performance. Each square inch must carry as much functionality as possible. Power management is also a challenge, and finding a balance for a deployed UAV is critical. Lightweight, rugged Ethernet switches are an excellent combination to make the most of SWaP-C pressures and constraints, as they save real estate room on a UAV for other devices.

Power over Ethernet

The power part of SWaP can be enabled by a concept called Power over Ethernet, or POE. It is a technology that enables a single cable to provide both data connection and electrical power to networked pieces of equipment such as sensors, IP video cameras, and even wireless mesh nodes. POE works across standard network cabling (i.e. CAT5) to supply power directly from the data ports to which networked devices are connected.

In traditional enterprise networking, POE has been implemented for years to help simplify the wiring of network devices – especially where running both electrical and CAT5 cables can be cumbersome and costly. In battlefield and avionics communications networks, using POE switches can provides both data connectivity and power on a single device to drastically reduce space requirements and wiring complexity on these mobile platforms. By eliminating power sources and associated wiring within a single mobile platform, these space-constrained platforms can use that much-needed space to support new devices to enhance communication and battlefield effectiveness.

Today the IEEE has two common standards for POE that support two levels of power classification. These two standards assure that all devices that use POE are compatible and will interoperate with each other. The original 802.3af POE standard provides up to 15.4 W of DC power to each device using 48 V. In most cases only 12.95 W is assured to be available at the powered device, as some power is dissipated in the cable. Examples of devices that only require this lower wattage power include standard IP cameras, most WLAN access points, and IP phones.

As remote devices became more complex and more compute power was required at the device, the electrical power needed to run them increased as well. Some of these devices include pan tilt zoom (PTZ) cameras and high-power wireless communications devices. More recently, the IEEE updated the standard to the 802.3at-2009 POE standard, also known as POE+ or POE plus, which provides as much as 25.5 W of power for these increased power requirements. Powering devices must support 30 W of DC power to compensate for dissipation in the cable.

When evaluating POE switches, one needs to evaluate the true power available in those switches. Although a switch may have, for instance, eight ports on the switch, the overall POE power budget for that switch may not be enough to support POE+ on every port. A full evaluation of what type of devices and their power draws need to be calculated and planned.

Long life

Finally, Ethernet boasts long design life: The Ethernet standard has been around for a long time – more than 40 years – which means that UAV designers can mitigate design obsolescence. The systems that employ it can enjoy a long life cycle.

UAVs are extending mission potential, mitigating risk, and increasing efficiency, enabling the modern military to undertake operations never before possible, in ways never before possible. As the desired functions for UAVs grow, UAV technology constantly faces new requirements and tasks, which calls for changing approaches to design and systems. Onboard Ethernet connectivity facilitates much of the design flexibility to meet the ever-changing demands for UAVs.

Progress in standards and speed

To keep up with the exponential demand for and sharing of data, Ethernet has taken some huge leaps in speed over the last five years. In 2010, the IEEE took an unprecedented step and ratified two Ethernet standards at once – the 40 GbE standard for local server applications and the 100 GbE rate for Internet backbones. Together these standards are known as Higher Speed Ethernet; 40 GbE consolidates four lanes of 10 GbE and 100 GbE consolidates four lanes of 25 GbE (a totally new technology). The 40 GbE implementation is gaining momentum in connecting

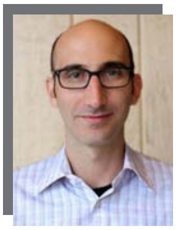
"AS ETHERNET BECOMES MORE AND MORE PERVASIVE AS THE TECHNOLOGY OF CHOICE TO CONNECT DEVICES AND DATA TRANSMISSION FROM PERSON TO HOME TO DESKTOP TO CARS OVER WIRED AND WIRELESS NETWORKS, IT WILL CONTINUE TO EVOLVE."

servers and routers to each other within a data center (east/west traffic), while service providers are implementing 100 GbE in their network backbones (north/south traffic). Both standards require higher-speed optical fibers to make the connections.

Earlier last year, the IEEE started forming working group task forces to create standards to implement both 25 GbE (a single lane of the four 25-GbE lanes developed to support 100 GbE) and 400 GbE (the consolidation of four 100-GbE links).

As Ethernet becomes more and more pervasive as the technology of choice to connect devices and data transmission from person to desktop to home to cars over wired and wireless networks, it will continue to evolve. The beauty of Ethernet is that, as a standard, no matter what speed a device supports, all speeds are backward-compatible through switches and routers; moreover, devices that use Ethernet as a standard connection will always be able to communicate with each other.

It's an exciting time for military embedded and non-embedded systems. Government mandates for COTS and standardization bring us one step closer to delivering the same commercial applications adoption rate to military applications that will enable us to protect and save lives. **MES**



Ronen Isaac *is the general manager for Milsource. He has been designing and implementing corporate and government connectivity and video security solutions for the last 15 years. His newest company, MilSource, serves the U.S. market for ultra-compact, military-grade Ethernet connectivity for manned/unmanned aerial vehicles built from the ground up for SWaP-constrained environments. Readers may reach him at ri@milsource.com.*

Milsource • www.militaryethernet.com

Ultra-small rugged NAS for harsh environments

Harsh-environment military applications such as those experienced by unmanned systems and combat aircraft that generate intelligence, surveillance, and reconnaissance (ISR) data benefit from storage servers rugged enough to operate in those conditions. For these situations Galleon Embedded Computing has a range of ultra-small rugged network attached storage (NAS) servers that are built on the same hardware platform as its small rugged data recorders.

Despite its physical dimensions (from 156 mm by 220 mm by 113 mm), the Galleon Rugged NAS has a capacity of as much as 8 TB of removable storage. Each cartridge can hold as much as 4 TB single-level cell (SLC) or 8 TB multilevel cell (MLC) NAND flash using standard 2.5-inch serial ATA solid-state drives. The removable data cartridges can be exchanged without tools, even when the operator is wearing gloves. Front ends include up to five 1000Base-T Gb Ethernet, and/or dual 10 Gb optical Ethernet connections. An optional AES 256-bit hardware encryption module handles the data-security side, with flexible key loading options including physical key tokens through a front-panel key loading port and remote loading over a secure network connection.

Galleon Embedded Computing | www.galleonembedded.com | www.mil-embedded.com/p372650

Rugged Gigabit Ethernet switch with Cisco IOS router

Unmanned system payloads, radar, and signal processing-heavy military applications require fast Ethernet switches that also reduce size, weight, and power (SWaP). The XPand6206 20-Port Gigabit Ethernet switch and Cisco IOS router from Extreme Engineering Solutions (X-ES) does all those things. A small form factor (SFF) system, it weighs less than 10 pounds and is based on two commercial-off-the-shelf (COTS) XChange3013 3U VPX Gigabit Ethernet switches. The XPedite5205 Cisco IOS Router XMC may also be installed on the XChange3013 to enable secure data, voice, and video communications for stationary and mobile network nodes. The full Cisco IOS is familiar to about 99 percent of those who would use it in a military environment, thereby significantly reducing training costs, company officials say.

The X-ES XPedite5205 completed its Common Criteria Certification (NDPP 1.1 AND VPN GW EP 1.1) and is now officially posted on the NIAP Website as CCEVS-VR-VID10576-2014: https://www.niap-ccevs.org/st/Compliant.cfm?pid=10576. FIPS 140-2 Certification tests for the ESR 5900 series routers, including the XES XPedite5205, have been officially approved and posted on the FIPS NIST website as #2242 at http://csrc.nist.gov/groups/STM/cmvp/documents/140-1/140val-all.htm#2242. The system, which has an integrated 27 VDC power supply, also meets MIL-STD-810 and DO-160 requirements, and has MIL-STD-461 EMI filtering. The product also provides convection or conduction cooling, depending on customer requirements.

Extreme Engineering Solutions (X-ES) | www.xes-inc.com | www.mil-embedded.com/p372654

Tool crafts embedded display for avionics projects

The VAPS XT-178 Version 4.0.1 from Presagis is a safety-critical software package for creating embedded display graphics for avionics projects that are intended for RTCA DO-178 B certification. The object-oriented, XML-based human-machine interface (HMI) tool enables the user to create custom widgets, save them, and reuse them from project to project. VAPS XT-178 can be used to certify both ARINC 661 and non-ARINC 661 applications. The end user may use the documents and test cases provided with the product in order to obtain credit for the tool qualification as part of the total system certification.

VAPS XT-178 can be used for such applications as ARINC 661-compliant avionics, RTCA DO-178-compliant/certified avionics, unmanned aerial system (UAS) ground-station control graphics, and projects that require HMI tool and graphics driver pre-integration. The software also has qualifiable CODE nGEN (C++ code generator) and certifiable runtime libraries. The updated software tool – which runs in Windows 7 / Visual Studio 2010 development environment – has enhanced graphical canvas drawing for precise modeling and design; text improvements with multiline text object, haloing on vector fonts, and a text string pop-up editor; and upgraded CODE nGEN usability.

Presagis | www.presagis.com | www.mil-embedded.com/p372651

Suite offers flexible video, data configurations

The HOTLink II suite of products from Great River Technology can set up military and civilian aerospace designers with flexible tools for point-to-point uncompressed digital video transmission. One component is the frame grabber and camera-emulator video card, which comes in five form factors that support video formats at data rates from 160 Mb/s to 1.5 Gb/s. It is aimed at IR sensor development and flight testing. The suite's HOTLink II data cards are an off-the-shelf solution for high-speed point-to-point data transfer using HOTLink II Fibre Channel. The video record and playback systems enables users to configure the system to play back to a GUI or play out through the hardware, creating synchronized HOTLink II video playout to cockpit displays or simulators.

Also available is a serial link analyzer, which uses PCI 64-bit/66-MHz technology to capture and analyze raw Hotlink II data, while the device's HL2View software analyzes and debugs the HOTLink II interfaces. Users also can choose the HOTLink II video card in five form factors, supporting a range of video formats at data rates from 160 Mb/s to 1.5 Gb/s. A portable, standalone software module dubbed the HS SAMView II can handle ARINC 818 testing. Great River's optional software-development kit (SDK) enables designers to integrate HOTLink II equipment into test environments.

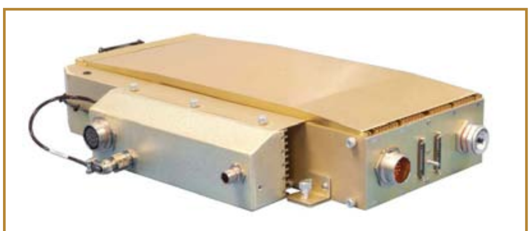
Great River Technology | www.greatrivertech.com | www.mil-embedded.com/p372653

Mission computer for day or night views

The TacView Portable Mission Display (PMD) from Esterline is a compact, self-contained mission computer designed to enhance situational awareness for military, paramilitary, law-enforcement, and civil aircrews. Its high-contrast display allows viewing in both day and night lighting conditions, and is fully dimmable from 800 to 0.5 nits (a unit of brightness also called candela per square meter). TacView also has a rugged design and can withstand high vibration and temperature extremes associated with demanding airborne operations. A removable minimum 64 GB solid-state memory ensures continuous operation and enables immediate declassification of important data when necessary. The computer, say Esterline officials, links crews to those on a networked battlefield and eases mission planning in the paperless cockpit.

The computer's user interface offers single- or dual-touch input capability, while its multifunction bezel buttons are designed to accommodate gloved-hand tactile feedback. TacView also comes equipped with an Intel Core i7 processor with integrated video-processing capability, which allows multiple applications to run simultaneously. The PMD's software environment is supported by a Windows 7 operating system, which enables the air crew to select applications best suited to their conditions. The applications include flight planning software, target imagery data, live-feed video, and two digital voice channels. Additional applications are available that provide note-taking, image sharing, post-flight maintenance debrief, mission rehearsal/review, charting, and embedded training.

Esterline | www.esterline.com | www.mil-embedded.com/p372652



Ultra-high-density data storage for heavy users

Military big data needs require high density and Mercury meets that requirement with a modular solution. Mercury's storage architecture leverages commodity solid-state disks (SSDs), providing tailored capacity with an upgrade path for future requirements. Its configurable design meets different data interface, redundancy, and security needs, while also fulfilling size, weight, and power (SWaP) needs.

The data interface can accommodate SATA, 10 GbE, SFPDP, Fibre Channel, or other high-bandwidth interconnects. Technologies such as Protocol Offload Engine Technology (POET) add networking and video-compression capabilities. Users may also look for redundancy using technologies such as RAID, and can then add encryption for security and deep-packet inspection for protection against intrusions, noncompliant data, and viruses. The data-storage units may be adapted for users' specific vibration or pressurization requirements; a conformal coating protects the unit against moisture, dust, chemical contaminants, and temperature extremes. Next-generation versions will address ways to store analog signals.

Mercury | www.mrcy.com | www.mil-embedded.com/p372655

National Collegiate Cyber Defense Competition highlights cybersecurity skills and opportunities

By Sally Cole, Senior Editor

The U.S. military says that it wants 6,000 new "cyberwarriors" by 2016; the Pentagon has requested a $5.5 billion cybersecurity budget for FY2016, and the Obama administration is seeking $14 billion. Cybersecurity has clearly emerged as a national imperative.

The escalating onslaught and sophistication of cyberattacks – especially ones sponsored by nation-states – targeting U.S. military and defense contractors, the U.S. government, as well as both public and private industries, has clearly demonstrated an urgent need to improve cybersecurity.

Although the U.S. Department of Defense (DoD) seeks to add 6,000 new cyberwarriors by 2016, it has run up against a severe shortage of information security (infosec) talent.

One program that's helping highlight cybersecurity skills and careers at the collegiate level is the annual National Collegiate Cyber Defense Competition (NCCDC), most recently held April 24-26, 2015 in San Antonio, Texas.

Once a year, NCCDC brings together 2,000 students who compete in qualifying and regional events to earn a spot on the 10 regional teams that move on to compete for the national title. To win, teams must keep a mock business running while fending off a constant barrage of attacks.

"This is a defensive-only competition from the students' perspective," explains Dwayne Williams, director of the NCCDC. "The mock business networks involved are typically modeled around a commercial endeavor – including things like an online pharmacy, electrical utility company, or a hospital clinic."

The networks are operational, but not secure, so the students must secure and defend them. What does this entail? "Maintaining critical services at all times," says Williams. "Teams are scored based on their ability to keep services up and respond to typical business tasks like setting up a new service, doing risk assessments, or management tasks like adding or deleting users."

Live "red" teams comprised of infosec experts attack the students to give them a concentrated taste of what real attackers might do, providing real-world experience.

"The sorts of things the red team is allowed to do here goes well beyond what's allowed in commercial or government penetration tests – like locking out user accounts or wiping systems during certain points in the competition," points out Williams.

Raytheon, a sponsor of NCCDC, works across a broad spectrum of cybersecurity and is actively searching for a "cyber workforce" with skills in three key areas: engineering, operations, and infrastructure.

"Raytheon needs security architects who can design advanced security solutions," says Jeffery Jacoby, Raytheon's program engineering director for Cybersecurity and Special Missions. "Cyberengineers who are experts at mission resiliency are critical if you're representing the military community. These individuals understand how the systems we design and develop will operate in and around cyberspace, how they're potentially vulnerable to attack, and, ultimately, how they provide mission or operational continuity in spite of an attack."

Within the cyberengineering realm, Raytheon is also searching for computer scientists with a deep knowledge of computer science at the firmware, operating system, and binary levels. "Vulnerability researchers – experts at assessing vulnerabilities and identifying risks across a wide variety of platforms, processors, and operational environments – are also critical," notes Jacoby.

For operations, Raytheon is on the lookout for talent with security operations center (SOC) experience. "These folks monitor and respond to threats, as well as maintain operational continuity, including intrusion detection and prevention," Jacoby says. "This includes threat operations, which is similar to security operations, except that we anticipate and prepare for future threats. We also look for malware and forensics analysts to dissect and diagnose malicious software and operational anomalies, including traffic analysis."

While the initial goal of NCCDC was to attract more talent and help get them into the workforce, another important goal is to improve the state of education by pushing universities to stay current by embracing new technologies and programming languages. "Teaching only theory to students doesn't prepare them for a career in the military or anywhere else," says Williams. "They need a more relevant, real-world technical education to be immediately useful when hired."

Knowing that someone has gone through NCCDC sits well with Jacoby. He's seen the pressure the students face and is quick to point out that they're doing this on their own time, outside their regular curriculum. "This says a lot about their motivation," he adds.

Mentoring opportunities – particularly from a military or industrial perspective – abound with local community schools and colleges. "Making a personal connection with a mentor working within the field truly helps to build that next generation of talent," the NCCDC's Williams says.

E-CAST

Where is COTS technology today?

*Presented by GE Intelligent Platforms,
North Atlantic Industries, Pentek,
United Electronic Industries*

It's been more than 20 years since then-U.S. Defense Secretary William Perry issued his famous "COTS memo," which ordered the Department of Defense (DoD) to buy commercial-off-the-shelf (COTS) technology wherever and whenever possible. Many people in the industry equated COTS with cheap products bought at retail stores.

Just over two decades later, the COTS industry is flourishing, with many mil-spec products being offered as COTS, already coming with strong track records of use in mission-critical applications. However, the dark side of COTS – obsolescence – still lurks and is unlikely to change as commercial component suppliers answer to large-volume consumer markets. In this e-cast, the panel of industry experts will discuss the state of COTS today, how it is defined, and how it fits into today's procurement environment.

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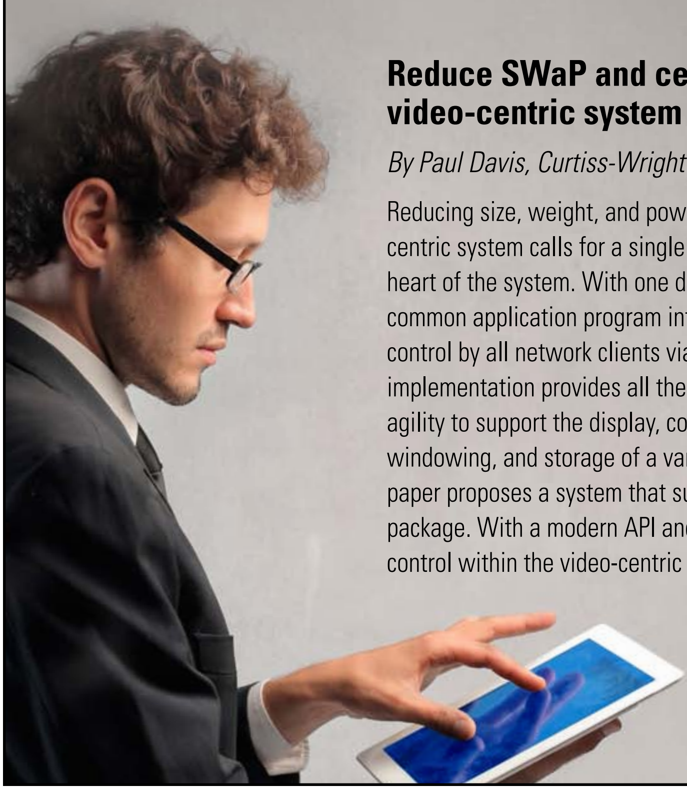

Reduce SWaP and centralize control in a video-centric system

By Paul Davis, Curtiss-Wright Defense Solutions

Reducing size, weight, and power (SWaP) in a mobile video-centric system calls for a single multifunction device at the heart of the system. With one device for all video functions, a common application program interface (API) can be used for control by all network clients via Ethernet. The all-in-one video implementation provides all the needed functions, with the agility to support the display, conversion, distribution, scaling, windowing, and storage of a variety of video formats. This white paper proposes a system that supports all the necessary video functions in a SWaP-optimized package. With a modern API and network connectivity, this device provides a single point of control within the video-centric system and a bridge to the network-centric system.

Check out our white papers.
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CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

BOB WOODRUFF FOUNDATION

Bob Woodruff Foundation

Each month in this section the editorial staff of *Military Embedded Electronics* will highlight a different charity that benefits military veterans and their families. We are honored to cover the technology that protects those who protect us every day. To back that up, our parent company – OpenSystems Media – will make a donation to each charity we showcase on this page.

This month we're featuring the Bob Woodruff Foundation (BWF), a nonprofit dedicated to ensuring that post-9/11 injured service members, veterans, and their families thrive long after they return home. A national organization with local reach, the Bob Woodruff Foundation aims to help people navigate through the more than 40,000 nonprofits that provide services to veterans; the foundation's purpose is to find, fund, and shape innovative programs and hold the nonprofits accountable for results. To date, BWF has invested more than $20 million in such programs and has reached more than one million service members, support personnel, veterans, and their families. According to the foundation, 87 cents of every dollar received goes directly to programs.

Among the programs that have been funded and sponsored by the BWF are The Telling Project, in which veterans recount their experiences to their communities; United Through Reading, which brings together service members and their children through storytelling; the Red Sox Foundation/Mass. General Hospital Home Base Program, which is working to develop a multilevel training institute in New England to serve veterans and military families; and Veterans Inc., which aims to relieve homelessness in Massachusetts veterans.

The Bob Woodruff Foundation was cofounded in 2006 by ABC news anchor Bob Woodruff and his family after Woodruff was severely injured by a roadside bomb while reporting from Iraq. His experiences during his recovery inspired the Woodruff family to help make sure the nation's heroes have access to the highest level of support and resources available.

For more information, visit www.bobwoodrufffoundation.org.

WHITE PAPER

Computer system design for critical applications

By Earle Foster, Sealevel Systems

"Industrial computer" is a widely used term that unfortunately can be quite ambiguous, as it is often applied to computers that have little real advantage over commercial PCs but may outwardly appear "rugged."

This white paper will consider the factors that affect system performance, reliability, and longevity. Building a system to a higher standard where uptime is paramount requires eliminating the most common causes of failure and obsolescence in the design: mechanical parts wearing out; vibration, shock, and unexpected power loss resulting in an unplanned shutdown of the operating system; and corruption of the hard drive.

Read about how paying close attention to heat management, component selection, testing, and other factors will greatly increase the success of your next project.

Read the white paper: http://mil-embedded.com/white-papers/white-system-design-critical-applications-2/

More white papers: http://whitepapers.opensystemsmedia.com/