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Top photo: The Avenger Tail 2 Unmanned Aerial System (UAS) will be able to carry large payloads of sensors for Intelligence, Surveillance, and Reconnaissance (ISR) operations. Photo courtesy of GA-ASI

Bottom photo: TerraMax Unmanned Ground Vehicle (UGV) kits will transform Army trucks into UGVs to help protect convoys by removing some manned vehicles and detecting Improvised Expolsive Devices (IEDs), through Light Detection And Ranging (LIDAR) cameras and radar. Photo courtesy of Oshkosh Defense

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Unmanned aircraft are coming to a sky near you

By John McHale, Editorial Director

Unmanned Aircraft Systems (UASs) are no longer just for the military and hunting down terrorists. The way is being cleared for them to fly in civilian airspace. Law enforcement agencies are already making use of UASs, and pretty soon businesses and even individuals will be putting up their own private drones.

Are we close to seeing a hand-thrown UAS hanging in suburban garages above the lawn mower? Probably not. Many homes already have an Unmanned Ground System (UGS) – the Roomba vacuum cleaner by iRobot (which also provides UGSs to the military) – but vacuum cleaners don't pose a major safety risk to the public.

The FAA is coming out with new rules and setting up organizations and processes for dealing with getting UASs into the national airspace, but technology, as always, moves much faster than bureaucracy. (For more on UAS safety certification, see the Mil Tech Trends article on page 26.)

"The horse is out of the stable already, and things are really moving fast," says George Romanski, President and CEO of Verocel. "People are now setting up companies to help customers build UASs at home, and there is more sophisticated free software available online to help them experiment with unmanned technology. Small UASs exist now that are easy to use and carry video cameras that can be controlled via an iPad where the user can also watch – via the video feed – where the tiny aircraft is going. They are great toys that can take and record video."

"There are many challenges ahead that must be solved before autonomous commercial jets ferry us across the country. First and foremost, we must guarantee that the UASs can be just as safe as a manned aircraft."

"I think we'll see uses we aren't even thinking of, and not just from law enforcement," says Bobby Sturgell, Vice President at Rockwell Collins and former Administrator of the FAA. "Academics and researchers are using them for weather prediction and forecasting, and they are being looked at for agriculture, oil pipelines, monitoring forest fires, and other search and rescue operations. Military UAS use is increasing, especially with small aircraft that assist the warfighter in the war on terror and larger aircraft that provide persistent surveillance and ISR capabilities. (For more, see the Special Report on page 16.)

There are many challenges ahead that must be solved before autonomous commercial jets ferry us across the country. First and foremost, we must guarantee that the UASs can be just as safe as a manned aircraft.

"The rules of the road are if you are flying small aircraft on visual flight rules, the pilot has an obligation to avoid somebody else; so what the pilots say [is], 'If we are doing that, we need the unmanned aircraft to do that as well,'" Romanski says. In case of engine failure, the military has light unmanned aircraft that can glide for miles with preprogrammed routes and landing spots in case of trouble, he says. "This will work pretty well, but like with everything else in programming, you must be specific. There is a famous story of a UAS that suffered a lost link and flew home as preprogrammed, but home in this case was Belgium where the UAS was produced, not where it originally launched."

"The robustness of the data link and sense and avoid capability are some of the most important technological issues for UASs as they enter civilian airspace," Sturgell says. "Other than that, we don't see a lot of technological hurdles that need to be overcome. The technology is out there, and it is just a matter of incorporating it into the platforms that need it."

Last year Rockwell Collins demonstrated damage tolerance by landing a UAS that had one of its wings blown off. They also are working with NASA Glenn on certifying a data link for use in a NASA UAS – the Control and Non Payload Communications (CNPC) data link program. The collaborative research project focuses on defining the CNPC waveform, seeing how it survives in an RF intensive environment, such as in an urban canyon, says Robert Hughes, Principal Marketing Manager at Rockwell Collins. People get anxious when they hear "forecasts about the skies being filled with all types of unmanned aircraft in the near future," he continues. "We can combat the fear by educating them on unmanned technology and its benefits and by demonstrating that a UAS can operate reliably and safely."

"Unmanned aircraft are the next big thing in aviation, and we don't know what we don't know when it comes to the different ways unmanned aircraft can benefit the public," Sturgell says. "The U.S. is a leader in unmanned vehicles and needs to stay a leader in this area and nurture it and let it expand just as the nation did with satellite technology."

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Not your dad's LCDs

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

When Liquid Crystal Displays (LCDs) began to replace Cathode Ray Tube (CRT) displays, the newcomers seemed revolutionary. Despite some drawbacks, LCDs were much smaller, lighter, and more power efficient than the older TV tubes that they were clearly the way of the future. But that was then. Much more is expected now of LCDs in a world of inter- and intra-connected platforms and asymmetrical warfare.

In its 2012 modernization plan, the U.S. Army stresses connectivity and situational awareness as key goals. It also emphasizes the need to upgrade its tracked and wheeled fleets and develop a new ground combat vehicle to support land operations. As a key convergence point for situational awareness technologies, displays will play an important role in these programs.

High bar

Tomorrow's vehicles will be far more networked than before, and their visual systems will need to exploit this advantage. That means, for example, the ability to receive, present, and, if necessary, integrate multiple, simultaneous video feeds from vehicle and external sensors and to update target data in real time. Yet all this must be done within tight Size, Weight, and Power (SWaP) constraints and ever-present budget limitations.

Modern architectures call for sensors around the vehicles, typically feeding data to the displays via 1 GbE links. Other architectures employ 10 GbE backbones to move video around the vehicle. Ethernet-equipped displays can tap into either data stream, and ideally displays will support both data rates. Both architectures eliminate the need for a separate box to drive the signals to the display head. This consolidation also reduces the noise, jitter, and attenuation that can be induced by the older technology.

Commanders want to maximize visual awareness by stitching together sensor inputs into a full-circle view of the vehicle's surroundings. Additionally, they need to run motion detection and facial recognition applications in order to identify potential threats. The displays must also support the latest battle management software and have the sharpness and 3D realism necessary for embedded training exercises for troops on long deployments. And they must be easily integrated into existing architectures yet bridge to meet future needs.

How can they do that? The answer is smart displays, LCDs packaged in small enclosures with their own computing resources – high-speed, multicore, multifunctional processors and data communication interfaces. Figure 1 shows an example of this new breed of intelligent displays, the GE Intelligent Platforms 10.4-inch IVD2010 with Intel CPU and NVIDIA General Purpose Graphics Processing Unit (GPGPU). These widely used COTS components are backed by suppliers' long-term commitments and solid software support.

Figure 1 | The IVD2010 from GE Intelligent Platforms combines significant processing capability within a rugged exterior.

Tough cookie

Land vehicle displays are subject to a very bouncy ride as their host platforms bulldoze their way across broken, hostile, and harsh terrain in unpredictable areas of the world. Hence, the displays need to withstand high levels of shock and vibration, as well as temperature and humidity extremes. Laminating together the layers of the display also prevents distortions caused by moisture ingress and holds the layers in vertical alignment.

Because interiors are cramped, displays also must be protected against accidental damage. Toughened glass guards against occasional encounters with the guns and other equipment of the soldiers inside.

Operating the display while on the move is also a challenge. Yet it is essential to push the right key and not the wrong one by mistake. Engineering helps to make sure that the user can operate the display under adverse conditions. Thus, some displays use resistive technology that requires a positive touch force to activate.

The variables of combat further dictate that the displays be usable under all visibility conditions, from bright sunlight to the dark of night. Thus, the glass needs to be both sunlight-readable, dimmable, and compatible with night vision goggles.

Smart approach

The U.S. Army plans to spend billions of dollars in its ground movement and maneuver portfolio. While not all of the vehicles will need the most sophisticated displays, it's safe to say that the military will not be using your dad's LCDs. Rather, they will want intelligent displays that integrate glass, touch screens, and coatings with processing and data communications in affordable, evolvable products.

Contact Charlotte at cburtonadams@yahoo.com.

3U VPX poised to serve small UAVS

By Steve Edwards
An industry perspective from Curtiss-Wright Controls Defense Solutions

Thanks to significant advances in performance and Size, Weight, and Power (SWaP) efficiency delivered by the newest generation of CPUs, General Purpose Graphics Processing Units (GPGPUs), and FPGAs, the military is increasingly turning to smaller, lower-cost Unmanned Vehicles (UVs) as platforms for compute-intensive ISR applications.

As a result, the use of 3U VPX modules in smaller UVs is also gaining traction. Until recently, 3U modules were ill suited for performance-hungry ISR applications; however, today's latest-generation CPUs such as Intel's third-gen Core i7, NVIDIA's 240-core Fermi Architecture GPGPUs, and Xilinx's Kintex-7 FPGAs have significantly improved processing performance per watt to create small, power-efficient ISR platforms. Add data storage for recording and 3U systems comprise a powerful solution for UV ISR.

Newest-generation technology supports ISR applications

As thermal management techniques have advanced, open architecture systems are now better able to optimally leverage the full potential of the latest multicore, low-power processors such as the Core i7 without having to derate performance in deference to heat dissipation. The use of ruggedized MXM modules enables the deployment of the latest, highest-performance NVIDIA GPGPUs in small form factor embedded systems. Xilinx's new Kintex-7 family of FPGAs is especially well-suited for ISR applications, enabling the design of XMC FPGA modules that boast ~3x the performance of earlier-generation modules while keeping power dissipation almost the same.

As data storage moves from heavier, less reliable spinning-disk media to large-density, solid-state designs, small form factor system designs receive the benefit. Thanks to OpenVPX, there is an architecture that enables integrators to leverage these advanced technologies into systems and scale them. Curtiss-Wright Controls Defense Solutions' VPX3-491 features an NVIDIA Fermi architecture GPU device on a 3U VPX board ideal for small unmanned vehicle ISR applications (Figure 1).

Figure 1 | The VPX3-491 from Curtiss-Wright Controls Defense Solutions

Taking 3U processing to the next level

Making these compact, small form factor systems even more suitable for UVs will require new 3U VPX backplane topologies that are being proposed for the next revision of the standard. Today's 3U topologies cannot take full advantage of the high-performance bandwidth supported by the most advanced CPUs, GPGPUs, and FPGAs.

At its inception, the designers of OpenVPX envisioned that 3U would predominately serve as a replacement for moderate-performance 3U CompactPCI or AdvancedMC cards. The ability to deploy 500 Gigaflops or more in a five-slot 3U chassis was not envisioned. But it is now becoming clear that five-slot 3U VPX systems that combine storage, GPGPU, SBC, and I/O functionality have the potential to be a disruptive force in the smaller UV market. These units will range from 10 to 20 lbs. and 50 to 250 W in a mailbox-sized platform. What is anticipated, essentially, is the shrinking of Global Hawk-level capabilities down to a UAV the size of a desk.

Embedded COTS suppliers have most of the pieces today to make this vision a reality. But what will really accelerate this technology shift is a dialogue between the sensor-engineering community and the embedded processing system community. While there is a lot of legacy I/O in the field, there has been no organized initiative to standardize the interfaces and interconnects used by leading ISR sensor vendors. Today interfaces used in ISR sensors vary from system integrator to system integrator. It is not uncommon to find one vendor using 10 GbE, while another uses 1 GbE, while yet another uses 1553 and a variety of video interfaces.

The plethora of interfaces used in the ISR sensor market has impeded the ability of COTS embedded system designers to support all of the I/O types on a single box, especially considering the SWaP-constrained nature of the technology. What might help encourage the development of standards in the sensor I/O arena would be the creation of a consortium in the OpenVPX community that reaches out to sensor providers to explore the definition of three to five common I/O types for airframe communications, uplink/downlink communications, and sensor interfaces. By defining a common suite of interfaces, system designers will get both the benefits of leading-edge COTS system designs and the cost and time-to-market benefits of COTS upgradability.

To learn more, e-mail Steve at Steve.Edwards@curtisswright.com.

FPGA migration strategies: IP development tools ease Xilinx Virtex-6 to Virtex-7 migration challenges

By Robert Sgandurra

Migrating to a new FPGA platform is not for the faint of heart, but the challenges can be eased, thanks to modern IP development tools.

When FPGA vendors announce next-generation devices, engineers seek to exploit new features and performance levels. The first step in migrating to a new platform is deciding if the benefits outweigh the effort and possible risks. Key to a Virtex-6 to Virtex-7 migration strategy is the consideration of IP development tools available to ease the process.

Virtex-7 FPGAs

Xilinx presents compelling reasons to migrate to their new low-power 28 nm process technology – twice the performance and half the power. This implies that a Virtex-7 silicon device of a given dimension will deliver twice the system-level performance, and a given FPGA function will consume 50 percent less power, compared to a Virtex-6 device.

Many system designers are realizing that even the largest Virtex-6 devices are too small for their application requirements. The prospect of dividing the processing across two FPGAs and the associated power makes the larger Virtex-7 an attractive option. However, this might not be an easy feat; thus, designers must consider the maximum FPGA resources, speeds, and power dissipation for the largest members of the Virtex-6 and Virtex-7 families. Once the decision is made to move forward with migration, IP development tools are integral to simplifying the process.

IP development tools

IP is a general term to describe the logic design that is loaded into the FPGA and ultimately performs the processing task. For more than 10 years, the Xilinx ISE design tools have been the environment of choice for FPGA engineers to create IP. The latest release, ISE Design Suite (version 14), supports FPGA IP development for both Virtex-6 and Virtex-7. Much of the logic and peripheral architecture is similar between the Virtex-6 and -7 silicon families, allowing the majority of IP to be compatible across both platforms. IP typically must chase when new features have been added to the FPGA.

"Where peripherals have changed, like the PCIe interface now supporting Gen 3, designers will need to integrate new IP to support the new capability. "

A designer moving or "retargeting" his IP from Virtex-6 to -7 will find the ISE handles much of the migration transparently. Where peripherals have changed, like the PCIe interface now supporting Gen 3, designers will need to integrate new IP to support the new capability. In places where the internal logic structures have been improved such as the new Look Up Table (LUT) architecture, engineers might find hand tuning their IP could be the best way to exploit the new feature and achieve the highest performance. As new FPGA functions are added like integrated analog-to-digital converters, the designer can choose to add a new system level feature to the product by adding new IP to support the converter.

IP development tools moving forward

As FPGA logic densities increase and more functionality is offered in the form of integrated high-speed gigabit serial interfaces and high-performance DSP engines, the FPGA is moving from its role as a processing component in the system to an integrated system-on-chip solution. With this shift comes the requirement for more sophisticated design tools. Xilinx recently announced the Vivado Design Suite to address this exact requirement and provide a path for developers to migrate from the ISE as their application requirements. Vivado offers the FPGA design engineer a tool that handles both programmable logic and programmable system integration.

The core of any FPGA development suite is the synthesis, place, and route tools. A new analytical approach in Vivado enables the designer to balance the design constraints that govern how effectively the tools create deployable FPGA IP. Specifically, parameters like routing congestion, trace length, and overall signal timing can be controlled to produce better results more quickly and reliably. Overall design integration and implementation times can see up to a 4X speed-up over previous approaches. This accelerated development is crucial as FPGA parts become larger and require more development time.

Manage complex FPGA designs

While much of the Virtex-6 IP will port to Virtex-7 using IP development tools, resulting in overall performance increases by nature of the new silicon, the engineer can always choose to further push performance and features by targeting specific attributes of the new architecture. As FPGA devices become larger, designers have the option to use new tools like Vivado to speed development time and manage complex FPGA designs.

***Robert Sgandurra** is the Director of Product Management at Pentek, Inc., where he is responsible for new product definition, technology development, and strategic alliances. He can be contacted at bob@pentek.com.*

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By Sharon Hess, Managing Editor

NEWS | TRENDS | DoD SPENDS

SAIC gives more support to USMC's CREW

Everyone needs some support sometimes, and the USMC's Counter Radio Controlled Improvised Explosive Device Electronic Warfare (CREW) program is no exception. Having received product-integration support from Science Applications International Corp. (SAIC) under an existing CREW contract, the USMC recently issued a contract modification, raising the IDIQ contract's cumulative total to $500 million and extending SAIC's integration-support duties. The contract renders maintenance technicians and program management for CREW systems located both outside and within the continental U.S. (Figure 1). Contract work is slated for Afghanistan (77.7 percent), Twentynine Palms, CA (5.5 percent), and Charleston, SC (16.8 percent) and is anticipated for completion in August 2014. The contracting activity is the Marine Corps Systems Command in Quantico, VA.

Figure 1 | A recent contract mod has SAIC continuing CREW product-integration support services to the USMC. Pictured: A briefing on the CREW setup on an M1A1 Delta tank. U.S. Navy photo by Senior Chief Mass Communication Specialist Jon E. McMillan

Combat Operations Center (COC) gets modern

Following the DoD modernization trend, the U.S. Navy recently issued a $64 million Combat Operations Center (COC) hardware modernization contract to iGov Technologies, Inc. Under the contract, iGov Technologies will replace servers and routers and transform the COC into a more SWAP-savvy, single baseline. The mobile COC command and control center comprises processing systems, cabling, power, shelter, and trailers. Contract options are included and could raise the contract's total to nearly $1 billion if exercised. Work commences in Tampa, FL and is slated for completion by June next year. The contracting activity is the Marine Corps Systems Command in Quantico, VA.

Boeing's Silent Eagle F-15 variant passes its test

So is that an F-15? Not exactly, but it's close. The Silent Eagle aircraft, an F-15 derivative, recently underwent successful wind tunnel testing of its Conformal Weapons Bay (CWB). The testing featured a Silent Eagle scale model and examined the effects of myriad flight angles and airspeeds on CWB. Specifically, the tests analyzed CWB design enhancements, and more testing is planned for this year to assess multiple weapons loads' aerodynamics in addition to the closing and opening of CWB's doors. What makes the CWB unique is that it is able to be reconfigured as a Conformal Fuel Tank (CFT) for enhanced flexibility, increased weapons loading, and longer-range aircraft optimization. Meanwhile, the aircraft can still deliver air-to-surface and air-to-air functionality. Pairing with Korea Aerospace Industries in CWB design and production, the aircraft is Boeing's entry in the Republic of Korea's F-X competition for a multirole fighter aircraft.

12 companies are better than 1 for USAF vehicle

Apparently the USAF was serious about collaboration when it issued a nearly $1 billion IDIQ contract for a whopping 12 companies to come up with a support vehicle that will enable customer access to services including integration, migration, sustainment, help desk support, training, operational support, and testing (Figure 2). The contract's fulfillment locale is unknown for the time being, and the companies specified in the contract span quite a geographic range: ActioNet, Inc., Vienna, VA; Array Information Technology, Inc., Greenbelt, MD; SI Systems Technologies, Folsom, CA; Segue Technologies, Arlington, VA; IndraSoft, Reston, VA; Excellus Solutions, LLC, McLean, VA; Exeter Government Services, LLC, Gaithersburg, MD; Diversified Technical Services, Inc., El Paso, TX; DSD Laboratories, Inc., Sudbury, MA; Diligent Consulting, Inc., San Antonio, TX; Digital Management, Inc., Bethesda, MD; and, finally, Datum Software, Inc., John Creeks, GA. Contract work (after copious coordination indeed) is expected to be done by January of 2022.

Figure 2 | The USAF recently issued a nearly $1 billion contract to 12 companies to develop a vehicle for supporting customer access to services including testing, operational support, integration, migration, and much more. Stock photo

Northrop Grumman doubleheader

Both a contract and a separate contract modification were awarded in one day to Northrop Grumman Space & Mission Systems Corp. in San Diego, CA, courtesy of the USAF: 1) a $106 million "contract for modification to extend the deployment and operation of three Battlefield Airborne Communications Node payloads installed in Global Express BD-700 and three Global Hawk unmanned Aerial vehicles," according to the DoD website (Figure 3). Work will occur worldwide in the locations where the relevant technology is already deployed, and will be finished by June of next year; 2) a $50.5 million modification to the contract known as the Battlefield Airborne Communications Node contract. The modification calls for E-11A platform maintenance support for eight months for 9001, 9358, and 9355 aircraft. Work will be completed at the Kandahar Air Field in Afghanistan by next February.

Figure 3 | Northrop Grumman Space & Mission Systems Corp. received a contract and a separate contract modification from the USAF, both on the same day. Pictured: Global Hawk UAV, photo courtesy of Northrop Grumman

Figure 4 | The Multi-Service Execution Team Office issued a contract to Lockheed Martin to update the DIB for $2.6 million. Photo by Christian Marquardt (USAREUR)

Lockheed Martin upgrades DIB

The Distributed Common Ground System (DCGS) and its software infrastructure dubbed the "DCGS Integration Backbone" or "DIB" serve as a critical vehicle for intelligence sharing among coalition partners, national agencies, and the military services (Figure 4). Thus, it's not a huge surprise that the DCGS Multi-Service Execution Team Office wants the DIB in top form. Accordingly, the Office issued a $2.6 million DIB upgrade contract to Lockheed Martin, including a new open source software Distributed Data Framework (DDF); the update also provides "increased security filtering capabilities, an enhanced data ingest framework, and orders of magnitude increases in ingest and query capability," Lockheed Martin reports. Meanwhile, the DCGS continues to gather and combine data from myriad systems and sensors (unmanned or manned) and transform it all into a user-friendly, easily understood picture.

Smarter sensor processing for UAS payloads

By John McHale, Editorial Director

UAS payload designers are packing more and more processing capability behind the sensor, enabling more data filtering at the sensor level so only the most important information gets to the commanders in the field, cutting down on communication bottlenecks.

The Avenger Tail 2 Unmanned Aircraft System (UAS) will be able to carry large payloads of sensors for Intelligence, Surveillance, and Reconnaissance (ISR) operations. Photo courtesy of GA-ASI

Unmanned Aircraft Systems (UASs) are still a bright spot for U.S. defense technology, even in light of the shrinking Department of Defense (DoD) budget. Despite the economic pressure, the U.S. still needs Intelligence, Surveillance, and Reconnaissance (ISR) capability operating around the globe night and day to keep an eye on threats and, where necessary, to remove those threats. UASs are their best tool for doing so today – from small, hand-thrown aircraft to large systems such as the Predator C Avenger and Global Hawk.

While these programs are facing budget pressures, it is milder than some other platforms due to their cost effectiveness and mission necessity. Integrators of these systems are taking advantage of Commercial Off-the-Shelf (COTS) computing technology to help alleviate some cost issues while leveraging the COTS performance capability to enhance UAS ISR payloads.

"The goal is to support a smarter sensor for sophisticated ISR payloads in tactical UASs," says Tom Roberts, Solutions Marketing Manager at Mercury Computer Systems in Chelmsford, MA. "With new graphics processors such as those from NVIDIA and AMD, we are putting as much processing power as possible behind the sensor, enabling it to mine a sea of information, so that the 99 percent of data that is not needed is not transmitted to ground – just the needles in the haystack they want to find."

"The primary goal of a UAS is to provide real-time imagery and intelligence, but if the radio link is weak they sometimes end up making a compromise with compression and even distribution," says Robert Kubis, Product Marketing Manager at FLIR in Wilsonville, OR. In many cases, a direct line of sight downlink is necessary to get the highest-quality imagery, he continues. Beyond line of sight can be limited when it comes to image detail and fidelity. "They are trying to extract the intelligence before its loss due to the radio link."

"It has become a recurring customer mantra: 'We want more capability than we had previously – but using less Size, Weight, and Power (SWaP) than the older systems used to,'" says Peter Thompson, System Architect, Military and Aerospace, GE Intelligent Platforms. "For ISR systems, this is driven by increasing focal plane array size, faster frame rates, and more sensors of different modalities. We see demand for taking existing functionality – say a target tracker or a video compression unit – and dramatically reducing the SWaP of the hardware to fulfill that need." GE offers an automatic video tracking solution called the ADEPT3000.

"A lot of UAS folks use cost-effective, lightweight sensors and camera cores for the smaller aircraft, whereas the bigger platforms can be more complicated," FLIR's Kubis says. "Even in manned aircraft, customers want to do more with their payloads – such as through imaging exploitation techniques to capture more data with cameras. FLIR makes use of many different high-end electronics components in their payloads to meet these performance demands such as FPGAs, DSPs, image processing techniques, and focal plane technology. We also push the envelope and talk about lowering SWaP and how can we do more in the product to manage thermal issues." FLIR's Star SAFIRE 380HD system flies on larger UAS platforms, and its BRITE STAR II currently is on the Fire Scout UAS from Northrop Grumman. FLIR cameras are also on numerous small UASs such as the Raven.

High-performance computing in the payload

"The big trend is to get as much processing power into the payload as possible, which creates tougher size, weight, and power challenges for the designer," says Dinesh Jain, Senior Product Manager at Mercury Computer Systems. "They need to figure out how to extract the maximum performance at the lowest power. This can be done through delivering heterogeneous computing and dividing up tasks among the devices best suited for particular applications – such as DSPs, FPGAs, and GPGPUs.

"Heterogeneous computing is where you have very specific processors assigned specific tasks," says Scott Thieret, Technical Director at Mercury Computer Systems. Mercury's StreamDirect technology helps enable this process. The technology allows "users to transfer data from the sensor via Serial RapidIO and bypass the processor, transferring directly to the GPU. This improves overall efficiency and also cuts down on the design footprint, which cuts down on power consumption."

"Heterogeneous computing also can help with multisensor payload designs,"

Sidebar Figure 1 | Payloads onboard NASA Global Hawks will analyze how hurricanes are formed under the NASA Hurricane and Severe Storm Sentinel (HS3) program.

Hurricane research payloads in NASA Global Hawks use high-speed processing

Engineers at NASA Dryden Flight Research Center in Edwards, CA, are working on a hurricane research project and using high-performance sensors in payloads on NASA Global Hawks (Sidebar Figure 1). Their next mission – Hurricane and Severe Storm Sentinel (HS3) – will last five years and investigates causes of hurricane formation and intensity changes in the Atlantic Ocean basin. Hurricanes are as hazardous an environment as there is on the Earth, requiring the NASA Global Hawk payloads to be rugged and signal-processing-intensive payloads much like military UAS missions.

"Hurricanes present an extreme environment that is difficult to sample," says Dr. Paul Newman, NASA Goddard Space Flight Center, Greenbelt, MD, Deputy Principal Investigator for the Hurricane and Severe Storm Sentinel mission. "They cover thousands of square miles in area, and can also extend up to 50,000 feet in altitude. Second, they involve very high winds, turbulence, and heavy precipitation. Third, ground conditions (high winds that create heavy seas or blowing material) make surface observations difficult. HS3 will use two Global Hawks with separate payloads."

"The Global Hawk is a challenging platform [on which] to install an instrument," says Dr. Gerry Heymsfield, NASA Goddard, Instrument Principal Investigator for High-Altitude Imaging Wind & Radar Airborne Profiler (HIWRAP). "While the Global Hawk can hold 1,500 lbs., the instruments have to be rebuilt to squeeze into the irregularly sized available payload bays. At takeoff and landing, surface pressure, temperature, and humidity are usually high. At 65,000 feet in the stratosphere, the pressure is 1/20th of the surface, temperatures are between -100 °F and -50 °F, and the air is drier than Saharan air. The instruments must operate over this huge dynamic range and still take science-quality data. Both heating and cooling of instruments is very challenging on the Global Hawk."

Sensors on the payloads require a great deal of processing horsepower, none more so than the HIWRAP from NASA Goddard Space Flight Center. "HIWRAP is similar to a ground radar system but pointed downward and measures cloud structure and winds," Heymsfield says. "It uses a combination of custom processing boards for the digital receiver and signal processing, and COTS solutions for the overall data system. This approach was required to reduce the size, weight, and cooling required for this part of the system. A fully COTS system would have been much larger and would not have met its signal processing requirement.

Just as with military UAS downlinks, transmitting high volume can result in a bottleneck issue. "The payload is communicated back to the ground using satellite telephone links (Iridium) and a satellite antenna (Ku dish)," Heymsfield says. The telephone links pass only a small amount of data back to the ground, while the Ku antenna can return a large volume of data – including imagery from the HD cameras onboard the Global Hawk. "However, the rate at which HS3 data is recorded exceeds our ability to directly download back to the Wallops ground station. The HIWRAP radar produces huge volumes of observations, and significantly more processing is done near the sensor to both compress data volumes for storage and to extract products for future real-time downlink."

Sidebar 1 | The Hurricane and Severe Storm Sentinel (HS3) program tracks hurricane formation, thanks to information gathered by NASA Global Hawk payloads.

Roberts says. "Military payload designers more and more are looking to fuse the data coming in from multiple sensors such as cameras, radar, etc., into one image that enables the ground analysts to get a better understanding of what is happening in theater."

"When designing sensor payloads today, we need to think in terms of a network of sensors that [has] a hardware architecture and a software architecture," says Eran Strod, Systems Architect at Curtiss-Wright Controls Defense Solutions. "Today ISR sensor architectures take advantage of the intensive DSP computing capability of Intel GPUs and other processors." For more on Curtiss-Wright High Performance Embedded Computers, visit www.cwcdefense.com/products/subsystems/program-specific-subsystems/hpec-software-platform.html.

"However, the software architecture is just as important and must be able to have all the applications talk to each other," Strod continues. "The software/hardware collaboration increases the flexibility of being able to talk to other entities or people on ground or other applications or the continental U.S. All of that stuff requires middleware, and Intel is the best platform from an enterprise software perspective. Intel has the most ubiquitous software story as it unlocks openness and functionality. The benefit of having more openness than ever on the software architecture side combined with high-performance number-crunching engines is really exciting from a design standpoint."

Open architectures also enable rapid deployment of new payloads. Along those lines, engineers at General Atomics Aeronautical Systems, Inc. (GA-ASI) in San Diego and SELEX Galileo have developed an open payload architecture concept for Predator B unmanned aircraft that enables payload suppliers and mission systems integrators to design their own payload control software, then integrate their own payloads, according to a GA-ASI release. GA-ASI engineers handled the hardware and software modifications to the Predator B system, and SELEX Galileo provided the radar during a recent demonstration of the concept.

"We continue to see new opportunities for COTS products, primarily because the defense contractors and system integrators don't have the resources to develop their own hardware and/or they want to focus their engineering resources on their value-add rather than reinventing the wheel," says Rob Scidmore, President and CEO, Extreme Engineering Solutions (X-ES) in Middleton, WI. The COTS XPand6000 Series from X-ES uses existing rugged COTS COM Express modules for the processing subsystem and rugged COTS PMCs or XMCs for the application I/O, he adds.

Small UASs and small form factors

"The smaller payloads do obviously have lower size, weight, and power requirements," says Michele Evans, Vice President, Lockheed Martin MS2 Business Development. "Power efficiency is important with the smaller

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aircraft, as you have to weigh extra battery power versus the speed and altitude requirements. If a particular mission requires greater speed and altitude, the payload will have to be less weight and lower power."

"Payloads for small, hand-thrown UASs such as the Lockheed Martin Desert Hawk (Figure 1) – produced for the United Kingdom – can basically be interchanged by the warfighters themselves, Evans says. "The payloads are fairly small, and installing them is a pretty simple procedure where the warfighter just unscrews four bolts, then swaps in the next payload. The small UAS uses a typical Electro-Optical Infrared (EOIR) payload that uses basic cameras, so ground troops can see what is ahead of them in night or day. Future sensor payloads may also include a miniature synthetic aperture radar.

Keeping it cool on a UAS

"The lower SWaP requirements present design challenges in UAS environments because of the cooling constraints in unpressurized high-altitude environments," says Andy Mason, MilAero Products Business Manager at Kontron in San Diego. "Designs also are trending more toward reduced SWaP COTS system solutions. We have some small form factor products in use on UASs. One is the small form factor embedded Cobalt computer, which takes advantage of high-speed processors in a small conduction-cooled box."

"For some unmanned applications, the size and cooling requirements are pretty tight, so solutions such as 3U VPX in a conduction-cooled half ATR box can be used with or without fans, depending on the mission requirements," Mason says. "There are some challenges in cooling small form factor designs. One is the desire designers have to avoid fans for increased reliability and reductions in cost and size. Some are going with a natural convection approach that limits the amount of thermal energy you can dissipate. Effective systems making use of the heat sink can cool up to 50 to 100 watts, but beyond that will need help such as adding a cold plate for additional cooling." **MES**

Figure 1 | The Desert Hawk hand-thrown UAS has a payload that warfighters can swap out just by removing a few bolts.

UGV technology transforms manned vehicles into unmanned, beefs up autonomous operation while maintaining original payload

Q&A with John Bryant, Vice President and General Manager of Joint and Marine Corps Programs, and John Beck, Chief Engineer of Unmanned Systems for Advanced Products, Oshkosh Defense


John Bryant


John Beck

INTERVIEW

Editor's note: *With IEDs and other threats historically pervasive on the front lines now endangering the more reclusive resupply convoys (think: Jessica Lynch), Oshkosh Defense is developing its TerraMax Unmanned Ground Vehicle (UGV) technology, which aims to remove some of the drivers within a convoy, while providing situational awareness via an advanced "perception" system comprising Light Detection And Ranging (LIDAR) cameras and radar. Meanwhile, the Marines have been assessing and performing live force experiments on this machine-learning-enabled technology. The next stop: A live force experiment at Fort Pickett, including veteran Marines training this July. Managing Editor Sharon Hess recently interviewed John Bryant and John Beck to get an insider's perspective of both TerraMax and the UGV market. Edited excerpts follow.*

Tell me briefly about your company – where it's located, number of employees, markets you serve, and what you're supplying to the military.

BRYANT: Oshkosh Defense is located in Oshkosh, Wisconsin and has more than 4,000 employees. Oshkosh started in 1917 as a pioneer in four-wheel drive technology and off-road vehicles. Our technology focus is rugged, off-road tactical wheeled vehicles. We provide the lion's share of heavy, medium, and MRAP All-Terrain Vehicles for the Army, Marine Corps, and our joint customer. We have provided over 8,500 MRAP All-Terrain Vehicles through the Joint Program Office. We also provide to tactical wheeled customers worldwide.

To whom are you supplying unmanned vehicle technologies, and of which types?

BRYANT: Our TerraMax Unmanned Ground Vehicle (UGV) technology can help protect warfighters from threats like IEDs by actually removing certain drivers from a vehicle entirely within a convoy. Right now on today's battlefield, IEDs are one of the greatest threats to military personnel. And in Afghanistan, for example, the front lines have blurred and troops carrying out logistics missions – particularly troops in convoys – are exposed to dangers that were previously contained only in active battle zones amongst frontline combatant forces. So we have worked closely with the government since 2003 to demonstrate fieldable, state-of-the-art autonomous kit systems [to enable unmanned vehicle operation] and to [thereby] develop the tactics, techniques, and procedures to provide a less perilous means for DoD to support and resupply troops in theater.

TerraMax is designed for use on any fielded tactical wheeled vehicle, Oshkosh or otherwise, and can operate for extended periods of time; they don't get tired, they don't lose situational awareness – the types of things that can afflict human operators.

Tell me about the government programs you've worked on.

BRYANT: So as DoD and its research strategic defense review call for continued reliance on new technologies including unmanned systems, the Cargo UGV [program] supports that. It is sponsored by the Marine Corps Warfighting Lab and the Joint Ground Robotics Enterprise Robotics Technology Consortium. That was a program that began in 2010 to demonstrate the ability to integrate the TerraMax autonomous system into an MTVR – a tactical vehicle capable of hauling a 7-ton payload cross-country.

What was the goal of the program?

BRYANT: The goal was really to determine the feasibility of reducing the exposure of Marines to lethal attacks by replacing some of the manned vehicles in logistics convoys with unmanned vehicles and to assess the feasibility of having our vehicles act as a resupply multiplier through one-to-many operator control. We've tested this by participating in experiments to assess the feasibility to assimilate our TerraMax UGVs into a supply distribution system in the tactical environment. In 2011 we conducted our first-ever training for Marines on the system. They found it to be very user friendly; they support its further development and provided valuable feedback, and that program is ongoing right now. It completed its first limited technical assessment in May 2011 and a second limited assessment again in August 2011.

What kind of system is it though? Is it just a remote control system, or is it a sensor system?

BECK: It has transformed over the years. It started off in the DARPA Challenge days; the TerraMax kit is basically the computing hardware, sensing hardware, and interfaces to the vehicle to allow unmanned operation, along with a lot of sophisticated software. Basically you provide a map it can drive on. Within that map exist checkpoints that the vehicle needs to achieve. It then drives autonomously to those checkpoints and stops at the last checkpoint, while avoiding obstacles and obeying traffic laws.

You said your system is for situational awareness, to spot IEDs. How does it do that?

BECK: It itself does not determine whether something is a threat or not. We have a very advanced perception system on it that consists of sensors like LIDAR (Light Detection And Ranging), radar, and cameras. We bring all of those sensors' outputs into specific software modules that then process that data and fuse it together to get a good understanding of the environment that the robot is operating in. It understands where the road ends; it understands what vegetation is versus what's a rock, what's dust, and so on.

Dust is a particular challenge for sensing and can show up in two different ways: first, as an obstacle if you get returns from the LIDAR, but dust can also absorb the LIDAR energy, indicating that there is nothing there. By fusing the radar information with the LIDAR information, we are able to reduce those false positives and false negatives and maintain safe operation.

So is whatever the LIDAR and radar are sending being viewed by human operators in real-time then, remotely?

BECK: The operator gets a condensed version of that. Most of the perception system is used for guidance of the robot and robotics operation, and that amount of data is really too much information to send over a wireless link to an operator control station. So we condense that down into what we call a *cost map* that presents hazards for the vehicle to an operator. So trees, for instance, are a hazard, as are other vehicles. Some potholes and small bumps and rocks aren't necessarily costly, but at the same time if you can avoid them and do it safely, then the vehicle will tend to do that. Same with pedestrians, which are, of course, the highest cost.

For situational awareness … additional cameras are used by the operator. So the operator (who can be up to a kilometer away) can view through the windshield of the vehicle or around the sides of the vehicle to understand the situation that the vehicle is in or gather additional intel.

BRYANT: So if you could get a picture, the picture would be a convoy operating whereby a number of the vehicles in the convoy don't have operators at all [because] the TerraMax UGV system allows unmanned vehicles to operate in the convoy. So the vehicles can drive along a route but at the same time an operator can monitor how they are operating and he can intercede as he sees fit.

BECK: For instance, if there is a situation where all of a sudden the terrain turns from dusty hard-pack sort of soil into deep mud, the operator has the ability to set the drive line locks, and adjust the central tire inflation system just like [a Marine or soldier] would normally do if he was driving the vehicle by himself. Also, if it's known that there is an area that's rocky terrain or another area that is sandy terrain, [the operator] can lay down these specific zones on the map ahead of time while he is planning the mission, and the vehicle will automatically change into those different modes.

Are these to carry supplies basically and to give a false impression of military soldier presence as they're providing situational awareness?

BRYANT: TerraMax isn't trying to create a false convoy; it's actually to remove operators from a significant number of vehicles within the convoy, particularly those vehicles that are in, I might say, historically dangerous positions.

BECK: [Another advantage] is the ability to have one operator control multiple assets, which reduces the force. And so what we are working on with the

Marine Corps Warfighting Lab and Joint Ground Robotics Enterprise Robotics Technology Consortium is to understand what is the right ratio of unmanned assets to manned assets in these convoy scenarios. These convoys aren't going to run unprotected, so you're always going to have somebody in a protected vehicle like an M-ATV to protect the convoy. But at the same time we want to mitigate any injuries or casualties due to attack and to take advantage of the ability to have one-to-many control.

"One-to-many control" was mentioned earlier, too. What does that mean?

BECK: One operator can supervise more than one unmanned vehicle. Last July we trained six veteran Marines on the operation of the TerraMax system over the period of about eight days and ran through many different scenarios. After two days of classroom training and practice applications on the vehicles, they were convinced that they could control three to five vehicles.

Since that time, we have built one more Cargo Unmanned Ground Vehicle, so we now have two operating from a single operator control unit in a separate MTVR. And the experiment [at Fort Pickett] that [happens in] July will be a much larger experiment. We will again train a veteran group of Marines on the use of the system over a two- to three-day period and then they will be using this system in live force experiments performing logistics missions.

What kind of hardware or software exactly does your UGV system have?

BECK: All the hardware that we use is mil-grade hardware. We do use some automotive-grade sensors, radars, and those types of things. The software is application specific.

There aren't any off-the-shelf types of software used? The automotive is off-the-shelf?

BRYANT: Many of the key technologies within [our] system are off-the-shelf sensor technologies, but the entire system has to be able to operate in military profiles; therefore, we have integrated off-the-shelf sensor technologies with a hardware and software control solution and hardened it so that the entire system provides that autonomous capability. So it's not as simple as simply taking off-the-shelf technology and hanging it on a vehicle; it's an integration and a hardening process that has produced a very robust system that can handle the demands and environments required by our military customer.

You mentioned earlier that TerraMax operates for extended periods of time?

BECK: Yes, currently the system is designed to run for at least six hours. The limitation is the amount of [full-motion] video storage that we have onboard. In reality, the operation could run for a full tank of fuel, which could be any amount of time, depending on the mission profile.

Are the cameras hidden or on the exterior of the vehicles?

BECK: All of the proprioceptive sensors are mounted external to the vehicle. We go to lengths to make sure that the kit is hidden into the vehicle bodywork as much as possible because we don't want these vehicles to look any different from any other military vehicle.

Let's talk about payload issues. What is the biggest payload issue? Is it the size, weight, and power? Is it the radar? Ruggedization? Cargo?

BRYANT: [We're in] a different situation than is faced by UGV developers of very small systems. Where size, weight, and power are significant challenges in the very small systems, our TerraMax technology has no significant impact whatsoever on the payload of a vehicle that is designed to carry a 7-ton payload, which still carries a 7-ton payload in addition to [our] integrated capabilities.

How much room does the TerraMax system take up though? Is it a big system?

BRYANT: In terms of the space, really just think about small sensors at different points on the vehicle that are pretty well hidden into the body and cab of the vehicle, and a computer. That's basically what we have claiming space.

What are the challenges in the unmanned systems market?

BRYANT: We're continually watching the evolution of technology, watching the changes in the threat and rapid development cycles to be able to quickly field a mature robust solution for the next increment of capability.

BECK: Also, one of the challenges is testing these autonomous systems. Our systems use advanced machine learning, and it is very common for a [testing agency] to design specific, repeatable tests, and that is a challenge on the community side … when you [develop] a machine that can decide to do something. It's hard to have a hard-and-fast test for every possible scenario, in all-weather conditions, and every possible terrain or environment.

You said "machine learning"? How does that work?

BECK: On the perception side of things, [when] we drive this vehicle around – whether manually or in autonomous mode – [we] are gathering information on different types of vegetation, different types of ground surface, different types of dust, for instance. All of these data are logged in digital format. We are able to examine these logs and hand-label different feature classes. We can extend this to any number of feature classes, limited only by computing power, and [we] can teach the robot how to interpret its environment.

What changes are coming to the unmanned market within the next five years?

BRYANT: I think two factors will work in conjunction to define the market over the next five years. One of them will be that the actual evolution of the battlefield itself will change requirements for unmanned systems in ways that are somewhat difficult to predict. And the other main factor is the rapid evolution of technology. As sensor technology improves over very quick development cycles and microprocessor technology develops over very rapid development cycles, the capabilities for unmanned systems will blossom significantly over the next five years.

What are the hardware and software trends right now in unmanned systems?

BECK: On the perception side, it's really still where we have gone from fairly simple automotive-type sensors to more specialized sensors that provide a very rich 3-D point cloud of the environment. They are active sensors and right now you can detect one of these things from a distance; you [can] detect LIDAR painting the environment. You can also detect a radar-emitting signal; at this point, stealth isn't terribly important, but in the future it will be. So in the future there are going to be sensing capabilities that don't require active emission, or if they do require active emission, it is in a more stealth manner that is more difficult to be detected. **MES**

John Bryant *is the Vice President and General Manager of Joint and Marine Corps Programs for Oshkosh Defense. He is responsible for the development, production, and sustainment of Oshkosh's programs with the U.S. Marine Corps, as well as programs that span multiple branches of the U.S. military. A retired colonel, he brings a 28-year history of service with the Marine Corps to his role at Oshkosh. As a program manager, he led several acquisition programs, including Tank Systems, Light Armored Vehicles, and Expeditionary Fighting Vehicles.*

John Beck *is Chief Engineer of Unmanned Systems for Advanced Products for Oshkosh Defense. He has responsibility for the company's autonomous vehicle developments and technology partners. He has led Oshkosh's efforts to develop its TerraMax Unmanned Ground Vehicle System, working with technology partners and organizations such as the Defense Advanced Research Projects Agency, Naval Surface Warfare Center, Robotics Technology Consortium, Joint Ground Robotics Enterprise, and Marine Corps Warfighting Lab.*

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Unmanned aircraft such as the Global Hawk from Northrop Grumman can fly in the national airspace under certain conditions.

Certifying and securing UASs for civilian airspace is more about rules than technology

By John McHale, Editorial Director

Federal Aviation Administration (FAA) officials have started clearing the way for UASs to enter national airspace, causing a stir about how to assure they are just as safe and secure as manned aircraft.

Military Unmanned Aircraft System (UAS) designers for the most part have been able to design their aircraft free of Federal Aviation Administration (FAA) regulations for safety certification and other design regulations.

The FAA has become more open to UASs flying in the national airspace. The agency requires that "federal, state, and local government entities must obtain an FAA Certificate of Waiver or Authorization (COA) before flying a UAS in the national airspace. The FAA is also required to streamline that process. Meanwhile, some law enforcement and military aircraft already are flying in civilian space.

"At the FAA we required a chase plane when a UAS was flying in controlled airspace," says Bobby Sturgell, Senior Vice President of Washington Operations at Rockwell Collins in Cedar Rapids, Iowa and former Administrator of the FAA. "Once the UAS entered restricted space – typically military controlled – the chase plane was not required while it flew in restricted airspace. What the FAA also will do is dedicate an air traffic controller to watch that UAS while it flies over civilian airspace."

"There also are specific rules for smaller UASs – dubbed Class 1 – such as the tiny robotic helicopters that weigh only a pound or two or three," says George Romanski, President and CEO of Verocel in Westford, MA. These are just starting to enter service for applications such as law enforcement and users "have to ask FAA permission and comply with various other rules such as they can only fly less than 400 feet high and have to maintain a line of sight and be more than 5 miles from the nearest airports."

"The concern with UASs in the national airspace revolves around what happens when something goes wrong in the aircraft or its resident airspace and there are no pilots onboard to handle the situation," says Chip Downing, Senior Director, Business Development, Aerospace & Defense at Wind River Systems in Alameda, CA. "If you have just one person, i.e., a military pilot, in an aircraft, he can avoid danger by manually flying the aircraft away from populated areas. With unmanned aircraft, it is more critical to have autonomous systems in place based upon a reliable safety and security foundation, which will enable the aircraft to react safely when things go wrong. Unmanned aircraft will need to have higher levels of response in emergency situations."

Later this year FAA officials are expected to release a proposed rule that will establish procedures, policies, and standards for UAS users, according to the FAA website. In the meantime, there is still concern about how to get UASs to be equal with manned aircraft when it comes to operating safely in civilian airspace.

Safety certification for UASs

Rules are also the biggest question mark when it comes to safety certification of UAS flight software. The expertise is out there, but how, when, and where UASs need to comply is still murky.

"The biggest challenge to work out is what the rules are," Romanski says. "Today they are not clear. We know the rules for manned aircraft so we want equivalent safety for unmanned aircraft. However, what does that mean? We still need to work out the rules."

"The certification issues regarding DO-178B, DO-254, etc., will play out in different ways for different classes of aircraft," Sturgell says. "The transport category will have the highest levels of certification requirements, while the ultra-light and experimental aircraft have a lot fewer layers of certification. Operational requirements are what will drive certification levels in the long run. For example, if an experimental UAS is flying over populated areas, it will need to have higher levels of certification than one that does not.

"When you get to bigger and more sophisticated UASs such as the Predator, their communication and electrical systems have much redundancy built in for reliability and safety," Sturgell continues. "In that way, they kind of mirror business and air transport aircraft. The certification efforts in these vehicles are consistent with the way manned aircraft go about ensuring certification and reliability."

Economics are also an issue. "Budgets are an issue for Office of the Secretary of Defense (OSD) personnel when it comes to adding safety and security certification for UASs," says David Sequino, Vice President and General Manager of the INTEGRITY Security Services business unit at Green Hills Software in Santa Barbara, CA. "They go through their budgets and know that everybody wants it, but also know that there is no money to spend on it right now."

"Eventually every component will undergo safety analysis with a category level worked out for each component," Romanski says. "If a failure could cause a catastrophic event, some components will need to be certified to Level A, while others may be able to be certified to lower levels as they are in manned aircraft, where every component is certified to its prescribed level. To get where we want to go, we need to make sure we have a safe and secure platform where we can compose a system made up of certified components. Even though we don't know all the components, we do know that the platform will have to have a safe and secure foundation."

"We have a lot of experience with DO-178B, and no deaths have been attributed to software using this guidance document," Romanski continues. "The FAA mandates that you do safety analysis and work out [the] level and certify to that level. The problem with UASs is that many currently flying were produced quickly to serve a purpose in theater and not required to meet DO-178B-type processes. Now if they are flying in national airspace, they will have to follow the same rules as the rest and government [will] take the time to make sure the software and hardware meets the proper safety certification levels. For UASs, the Ground Control Station (GCS) is an extension of the cockpit and must have equivalent levels of safety; in other words, a UAS flown on a Windows operating system probably won't be compliant. A fault in GCS software could quite easily send bad data into the aircraft, which could result in catastrophic failure."

"Most commercial aircraft already have very sophisticated autopilot controls, so the next steps for UASs are gaining public trust and having a reliable safety and security record for the software and hardware flying the aircraft," Downing says.

Security

"In addition to safety, security is also paramount for military UAS operations and for when UASs enter civilian airspace," Sequino says. "The data links need to be encrypted to and from the ground control station to the UAS so there are not more security and reliability problems. They need to get 99.999 percent reliability with the data links. A lot of ground stations today are not secure."

"The National Security Agency (NSA) typically recommends that Suite B security standards be applied for defining the cryptography used in all government classified communications," Sequino continues. The Green Hills ISS business unit offers an embedded cryptographic product – ISS Security Solutions – which consists of Suite B-Compliant Security Protocol Toolkits and a Device Lifecycle Management (DLM) system. (For more information, visit www.ghs.com.) "We've got some customers implementing the solution and are working on an ISS solution for the Army for UAS programs."

Security is also a key part of the DoD's effort to create a universal control station architecture for UASs – the UAS Control Segment (UCS) (www.ucsarchitecture.org/page/home).

"They are still in negotiations on what types of security levels and other standards will be used, but the Multiple Independent Levels of Security (MILS) approach is one being looked at," Romanski says. "One of the objectives of UCS is to have the ability to provide mixed levels of security and to make it also dynamic. Video feeds coming through to the analyst observing video at the ground station most of the time

are benign. However, once he sees something that is important, it now becomes secure information. So he presses a button to tag the data as top secret, then he distributes it around the proper channels where it can only be decrypted by those with the proper clearance. There is a fair amount of work still to be done in this area."

FACE can help

Compliance with safety and security regulations could go more smoothly and cost effectively by getting the UAS community to adopt common standards. They could take a hint from the military avionics community, which is doing just that within the Future Airborne Capability Environment (FACE) Consortium.

"I'm seeing crossing over between FACE and the UAS community in the military," Sequino says. "FACE is classic avionics, and now the FACE Consortium really has its act together and [is] telling the UAS community to just adopt FACE. It is a matter of changing the culture and a little bit like herding cats to get the different vendors, OSD, and various program offices to move away from using competing standards and get everyone on the same page. They are beginning to converge, but it is a long process."

UCS is also being built along a similar philosophy to FACE. "With UCS, the government is trying to encourage an ecosystem of suppliers as these services are published and find what interfaces exist that you can get from different suppliers," Romanski says. "If there is not a service available, the government can pay someone to supply one and get it put into the repository. These services then can be sold and plugged in the new type of model the government wants. It is a different type of business model, an open business model that fosters innovation and grows the market so people can supply components to the UCS architecture."

FACE, with more than "40 members from both industry and government, has developed safety and security operating system profiles for military avionics systems," Downing says. "The FACE technical standard is an open, modular, multivendor software environment enabling portability and reuse of software components across multiple programs and platforms. Next-generation military avionics platforms will require a common compute platform based upon open industry architectures to enable portability across aircraft types. Because these platforms will be sharing a common infrastructure, FACE systems should be able to lower the cost and risk of achieving safety and security objectives."

"Common core platforms such as those based upon ARINC 653 have been very effective in Integrated Modular Avionics (IMA) in commercial aircraft, but these advancements have simply not occurred in military avionics systems," Downing says. Wind River's ARINC 653 product, VxWorks 653, has enabled IMAs on 55 different aircraft. (For more information visit, www.windriver.com.) **MES**

"Googlizing" military intelligence searches: The next frontier for sifting through all that UAV (and other) data

Interview with Tony Barrett, Sr. Manager, ISR Technology Integration, and Mark Wallace, Principal Engineer for Semantic Applications at Modus Operandi


Tony Barrett


Mark Wallace

INTERVIEW

Editor's note: *Saying that military intelligence analysts have their work cut out for them these days is really an understatement. Sure, the explosion of new UAV sensors and other information-gathering technologies is guaranteed to enable capture of exponentially more Intelligence, Surveillance, and Reconnaissance (ISR) data, but someone – or something – needs to make heads or tails of the resulting avalanche of data, whether it's full-motion video, Intelligence Information Reports (IIRs), or myriad other structured or unstructured data.*

However, instead of a human analyst slogging through (maybe) 10 three-page documents in an hour, Modus Operandi has developed its military intelligence "Googlizing" system, which has been "trained" via machine learning and enabled by a semantic analysis engine to provide the military intelligence community a way to quickly conduct military intelligence searches – as simply as one would do an ordinary Google search on a home computer. The difference (besides the content and data sources, of course) is the interfacing with the military's DCGS Integration Backbone (DIB). Managing Editor Sharon Hess recently caught up with Tony Barrett and Mark Wallace of Modus Operandi to get a behind-the-scenes look at this technology. Edited excerpts follow.

Tell me briefly about Modus Operandi – number of employees, location(s), technology focus, markets served.

BARRETT: Modus Operandi is a software technology company focused on rapidly solving complex intelligence information discovery, integration, and fusion problems for defense and intelligence customers. Modus Operandi has offices in Melbourne, Florida, and Aberdeen, Maryland, and employs fewer than 100 employees.

I received some information from Modus Operandi about a technology described as "Googlizing military intelligence." So what is this program or technology, and what is it called?

BARRETT: Internally I think we're calling it Blade, but a generic technology description is: a Wiki-based semantic engine that handles intelligence data, in the interest of shortening the intelligence analyst research track.

The background says the "Googlizing" capability is enabled by a semantic engine, as you mentioned, and machine learning.

BARRETT: Yes. We are adding semantics to structured and unstructured data. That makes the data smarter as it enters the intelligence flow, so to speak. We come up with dictionaries and vocabularies that train the computer how to recognize words, ideas, and concepts that people intuitively know, so that as intelligence data is fed into the system, it automatically either correlates or corroborates intelligence to help the analyst figure out what's important and what's not important.

WALLACE: Also, Googlizing involves going through lots and lots of intelligence data, making a model of what [the semantics engine] has seen. Then when people search with it, they can get to that data quickly. We can crawl through lots of data in advance; people can be sending [Blade] video data saying, "Here is what we have found." They are crawling video data and giving their results to [our system]. Other systems or our own software might be crawling through documents and figuring out what we're storing and understanding, what we need to put in our model. Then when someone comes to the Wiki or does a search on the DIB [DCGS Integration Backbone] for something – those are two ways to get at the information. And then once they click on a link, they are in a model like you would see in Wikipedia, where you have a page on something and you have links to other pages.

How does the semantic analysis differ from the machine learning?

WALLACE: The semantic analysis involves how you go through and identify what the different words are in the text, for example, and what they mean and whether they are of interest: "Is this representing an event that we care about or a person we care about?" Machine learning is a little different from that; it's really just feeding back if it turns out [the system] missed something – maybe we missed the fact that this is an alternative name for this person. Then when a human reviews the document later, they'll say, "Yeah this is an event about this guy that was missed." It's a way that the machine learns, "Oh, well this is maybe an alias of that guy" or "This is another way to describe an IED emplacement event," for example.

Why is this military intelligence technology needed? How many hours of intelligence are there to power through?

BARRETT: The bottom line is most intelligence analysts are drowning under a wave of data. Over the past 10, 15 years, the intelligence community has done just an absolutely magnificent job of acquiring new sensors, which has created an onslaught of data that is crushing intelligence analysts. So what we are trying to do is take that data being fed to them from all of these sensors – whether it's full-motion video or text, whether it's structured or unstructured – [and make it accessible to operators]. For a human brain to be able to read, internalize, and then make decisions off of all of that data is extremely challenging, especially when, for example, 90 percent of what you read might be chaff and you are trying to find the golden nuggets.

WALLACE: Yeah, how many three-page documents can an analyst go through in an hour? Five to 10 maybe. With the automation, you're talking hundreds or thousands of documents per hour, so that's where applying the computer helps the analyst avoid overload.

Does a lot of the data that your technology uses come from UAVs?

BARRETT: Yeah. We have partnered through the Office of Naval Research with a company called Defense Analytics Corporation or DAC. They have produced a technology that has the ability to stare at full-motion video that comes out of UAVs and be able to identify those things that are most important to the analyst. Say, for example, [their technology was] looking for a white pickup truck and they've got their machine staring at a full-motion video feed coming from a UAV and it notices a white pickup truck. What that will do is identify that portion of the video where the white pickup truck is visible, tag it with an indicator, send it to our system, and provide an alert to the analyst as well as a link to the source video in facilitating that analyst's ability to go straight back to that video and take a look at it.

With which types of sensors or data does your system work?

BARRETT: Whichever sensors are out there. So if you want to talk Predator, you want to talk Rover, Raven, we want to have the ability to ingest that intelligence into the system. That is also ground-station agnostic, which is important because we don't want to get tied up with whatever particular proprietary technology the ground station is. We're more interested in the data and how that feeds into the overall intelligence enterprise, rather than just specific data types.

However, our system loves structured data, like images that come in, pretagged with metadata off the sensor; it loves that because it is pretagged, it's got very good data, it's got very structured information that is coming into the system. But the true power behind our system is in the unstructured data and being able to correlate that structured data with the unstructured stuff. And when I say "unstructured stuff," I am talking about open-source intelligence.

The other thing is, human intelligence reported in Intelligence Information Reports (IIRs) is highly unstructured, yet it describes a meeting that someone had. We would want to be able to ingest that and make the machine understand not just the spirit but also the intent behind the report, what it was saying, and how valuable that information could be. So what we're trying to do is cover "270 degrees of the intelligence cycle," if you will. The only thing we are not doing is directing collection assets and what they are doing.

How fast does this system work?

BARRETT: That's what is being born out right now through the program [we're working on with] the Office of Naval Research. The problem is that there is a trade-off among time, storage capability, and currency of data. And what we're trying to do is figure out where the trade-offs are because the bottom line is that most searches are returned in milliseconds, no matter what you're doing.

How does intelligence information feed into your system?

WALLACE: As I mentioned earlier, our technology builds a model, so that is based on the work that is happening in advance of the operator doing a search, as long as we have the pipes, so to speak, to get that data in. We can get the data in by watching a folder, by having other Services feed us data through a network connection. Then when an operator wants to find something, typing in some keywords might get them to their starting point. Once they get that initial hit, then it is kind of like a Wikipedia.

Is the "model" relative to a certain topic or individual, or is it a display mechanism for any search?

BARRETT: If they are hunting a person, for example, they have a very concrete idea of what information they need going into that problem set and what they should produce coming out of that problem set in order to allow the prosecution of that mission. What we are doing is integrating that into the very fabric of the product that we are building, so that the algorithm and the technology that we build reflect precisely what they have told us they need in order to produce intelligence products.

Your original press release says the system displays the results in some kind of a Google Earth format?

WALLACE: Yes. The idea is that a lot of map capabilities use common formats, which means the same data can be rendered on Google Earth and can be rendered in a Yahoo map or certain other military open-source mapping capabilities. So in the Wiki, there's a little area of the page where you could

"... The true power behind our system is in the unstructured data and being able to correlate that structured data with the unstructured stuff."

show different events related to a person in a table or plot them on a map.

You mentioned DCGS earlier. How does your system interface with that?

BARRETT: Our focus right now is getting it into the DCGS Enterprise in the interest of wider federation across all Services. Modus Operandi is a Small Business Innovative Research (SBIR) company, and what we are doing right now is transitioning this technology from the research lab into the hands of the operator.

Are any of the Services using this system right now?

BARRETT: No. We are in the middle of testing right now. We are working very heavily with the Marine Corps. The Marine Corps work out of something called a MAGTF or Marine Air-Ground Task Force. What that means is that they have all of the pieces and parts required to execute a battle, all within their own control. That means they have the air, the ground, the command structure, the logistics support. So what we're doing is working on transitioning this technology to a Marine unit, which would allow them to correlate and corroborate all of their intelligence that they are receiving from both the national level as well as their organic assets in order to prosecute a mission they have been assigned.

Is there a date for when testing of your system is going to be done?

BARRETT: The decision-making process for that is ongoing. I can't give you a solid answer because I know target dates and not exact dates at this point, but it looks like 2013.

[As an aside], we have been talking about the full system package [Blade]. However, one of the pieces of technology that feeds into [Blade] is something called a Virtual MetaData Catalog [VMDC], which allows users to hook into the DCGS Enterprise and share data across all Services as well as the intelligence community. So that [component of Blade] is being used by one of our customers at Fort Meade. What we're trying to do is make that part and parcel to the full [Blade package], which includes the Wiki front end, the wave semantic engine that underlies that, as well as the VMDC.

So in essence, there are multiple parts to the full system technology we've been describing, i.e., what we're working on right now is taking the full package and putting that together within the concept of operations of how the Marine Corps sees their tactical operations running. That's what we are trying to get into the hands of the operator right now.

Referring to the full package system we have discussed during this interview, what are the limits or challenges of this technology?

BARRETT: I think a lot of the challenges pertain to predictive analysis. What you want to be able to do – the whole point behind intelligence – is to make a guess or determination what the enemy is going to do. I think the next stage beyond getting the relevant information to the analyst is to then be able to determine "What does that mean" and "What does that predict that the enemy is going to be able to do?" So I think predictive analysis is the next frontier.

You mentioned the Office of Naval Research earlier. I assume they are providing funding for Blade?

BARRETT: Everything that we produce is GOTS – Government Off-the-Shelf – technology. They are paying for it. The contract vehicles that we use to develop this technology mean that the technology is government owned.

Do you have any commercial customers, or would you ever expand this to a commercial realm?

BARRETT: That is not in our vision right now. Right now, considering the challenging time that this country is in, we're trying to be able to provide the best product to the government based on their R&D investment. **MES**

Tony Barrett, *a retired U.S. Marine Intelligence Officer, is the Senior Manager of Intelligence, Surveillance, and Reconnaissance (ISR) Technology Integration for Modus Operandi. He has more than 23 years of experience in the Defense Department as an intelligence professional and received numerous awards for activities both deployed in combat as well as garrison environments. He is a recognized expert in U.S. intelligence operations and ISR data handling protocols and procedures.*

Mark Wallace *is the Principal Engineer for Semantic Applications at Modus Operandi. He has more than 25 years of experience in software development and 15 years of experience as lead architect on software projects for the DoD and private industry. Prior to rejoining Modus Operandi in 2009, Mark served as chief architect and ontologist at 3 Sigma Research. He also served previously at Modus Operandi as Director of Product Development for the Wave product.*

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Transitioning to DO-178C and ARP4754A for UAV software development using model-based design

By Tom Erkkinen

With the FAA and EASA adopting aviation standards such as DO-178C and ARP4754A, UAV software developers should familiarize themselves with these standards, particularly when transitioning to model-based design.

U.S. Air Force photo by Senior Airman Nadine Y. Barclay

Few applications place more importance on verification, or prescribe more process guidance, than aviation. The FAA and its European equivalent, EASA, provide guidance using standards such as ARP4754 for aircraft systems and DO-178B for flight software. These standards are often used outside of civil aviation, in whole or in part, for applications including military aircraft and land vehicles. Adoption for UAV programs is rapidly growing because of the FAA's recent decision to require UAS and OPA certification via FAA Order 8130.34A. UAV systems are heterogeneous, and not restricted just to flight software. Therefore, other standards are used such as DO-254 for hardware and DO-278 for ground and space software.

However, these standards are more than a decade old and are showing their age. For example, they lacked guidance on modern development and verification practices such as model-based design, object-oriented technologies, and formal methods, at least until the nascent DO-178C standard was developed. So the FAA and EASA have worked with aircraft manufacturers, suppliers, and tool vendors to update standards based on modern technologies (Table 1). Rather than significantly modify the standards, they created technology supplement documents.

The impact of the new standards to UAV developers using model-based design is especially significant. Before describing this, an introduction to model-based design is appropriate.

Introduction to model-based design

With model-based design, UAV engineers develop and simulate system models comprised of hardware and software using block diagrams and state charts, as shown in Figures 1 and 2. They then automatically generate, deploy, and verify code on their embedded systems. With textual computation languages and block diagram model tools, one can generate code in C, C++, Verilog, and VHDL languages, enabling

Document	Release date	Prior release	Focus
SAE ARP4754A	12/01/2010	11/01/1996	Aircraft Systems
RTCA DO-178C	12/13/2011	12/01/1992	Airborne Software
RTCA DO-254	04/19/2000	n/a	Airborne Electronic Hardware
RTCA DO-278A	12/13/2011	03/05/2002	Ground and Space Software
RTCA DO-330	12/13/2011	n/a	Software Tool Qualification Supplement
RTCA DO-331	12/13/2011	n/a	Model-Based Design Supplement
RTCA DO-332	12/13/2011	n/a	Object-Oriented Supplement
RTCA DO-333	12/13/2011	n/a	Formal Methods Supplement

Table 1 | Aircraft certification documents and recent updates

implementation on MCU, DSP, FPGA, and ASIC hardware. This lets system, software, and hardware engineers collaborate using the same tools and environment to develop, implement, and verify systems. Given their autonomous nature, UAV systems heavily employ closed-loop controls, making system modeling and closed-loop simulation, as shown in Figures 1 and 2, a natural fit.

Testing actual UAV systems via ground-controlled flight tests is expensive. A better way is to test early in the design process using desktop simulation and lab test benches. With model-based design, verification starts as soon as models are created and simulated for the first time. Tests cases based on high-level requirements formalize simulation testing. A common verification workflow is to reuse the simulation tests throughout model-based design as the model transitions from system model to software model to source code to executable object code using code generators and cross-compilers.

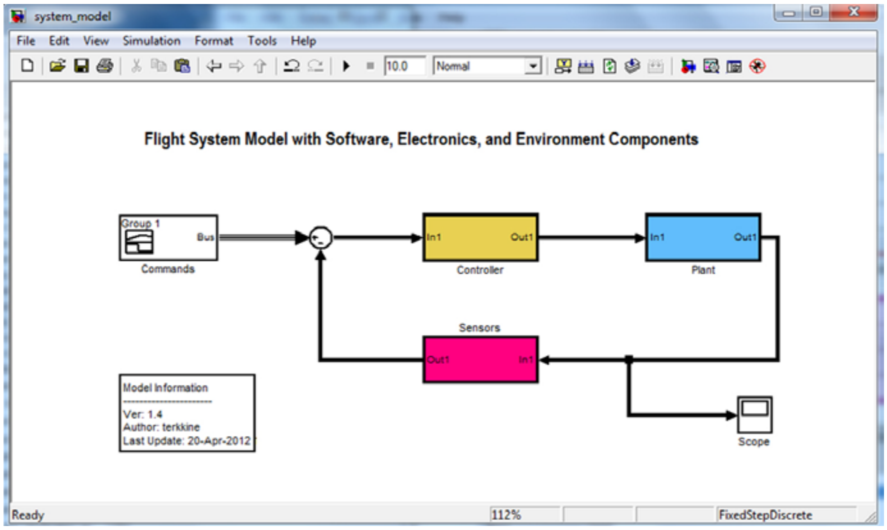

Figure 1 | Example system model used for UAVs with controller and plant

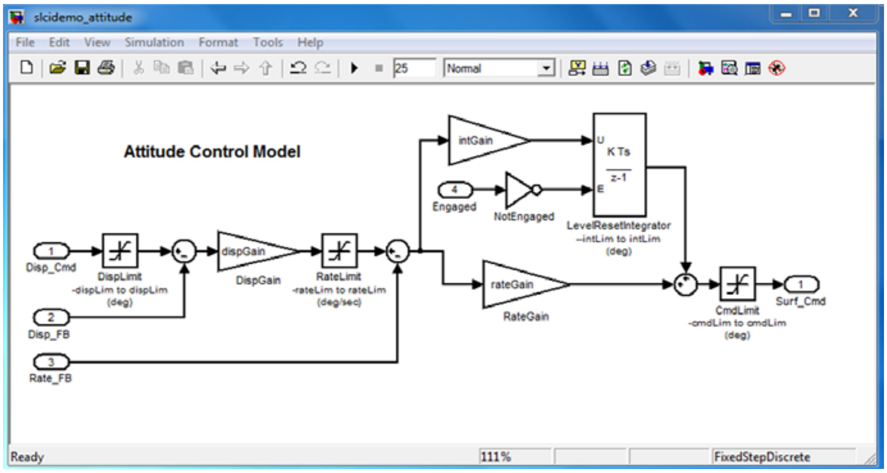

Figure 2 | Example software model used for UAV control laws

Test	Device under test	Device execution platform	Focus
MIL	Design model	Simulink	Verify design
SIL	Source code	Host computer	Verify source code
PIL	Executable code	Embedded processor or instruction set simulator	Verify object code
FIL	Hardware implementation	FPGA or HDL simulator	Verify hardware implementation
HIL	Embedded system (LRU)	Embedded system connected to real-time simulator	Verify system

Table 2 | Simulation-based test summary

An in-the-loop testing strategy is often used as itemized below and summarized in Table 2:

1. Simulation test cases are derived and run on the model using Model-In-the-Loop (MIL) testing.
2. Source code is verified by compiling and executing it on a host computer using Software-In-the-Loop (SIL) testing.
3. Executable object code is verified by cross-compiling and executing it on the embedded processor or an instruction set simulator using Processor-In-the-Loop (PIL) testing.

4. Hardware implementation is verified by synthesizing HDL and executing it on an FPGA using FPGA-In-the-Loop (FIL) testing.
5. The embedded system is verified and validated using the original plant model using Hardware-In-the-Loop (HIL) testing.

A requirements-based test approach with test reuse for models and code is explicitly described in ARP4754A, DO-178C, and DO-331, the model-based design supplement to DO-178C.

Transitioning to new standards using model-based design

ARP4754A

ARP4754A addresses the complete aircraft development cycle from requirements to integration through verification for three levels of abstraction: aircraft, systems, and item. An item is defined as a hardware or software element having bounded and well defined interfaces. According to the standard, aircraft requirements are allocated to system requirements, which are then allocated to item requirements.

The fact that ARP4754A addresses allocation of system requirements to hardware and software components is significant to UAV developers, especially suppliers. Some suppliers might have claimed that UAV subsystem development was beyond the scope of the original ARP4754, even for complex subsystems containing hardware and software, but not anymore. ARP4754A also more clearly refers to DO-178 and DO-254 for item design. In fact, the introductory notes for ARP4754A acknowledge that its working groups coordinated with RTCA special committees *to ensure that the terminology and approach being used are consistent with those being developed for the DO-178B update [DO-178C].*

Given the high coupling among systems, hardware, and software for UAVs, it is helpful that the governing standards now clarify relationships between systems and hardware/software subsystems.

“ Some suppliers might have claimed that UAV subsystem development was beyond the scope of the original ARP4754, even for complex subsystems containing hardware and software, but not anymore. ”

ARP4754A recommends the use of modeling and simulation for several process-integral activities involving requirements capture and requirements validation.

ARP4754A Table 6 recommends (R) analysis, modeling and simulation (tests) for validating requirements at the highest Development Assurance Levels

(A and B). For Level C, modeling is listed as one of several recommendations. While ARP4754 made similar recommendations, ARP4754A provides more insight and states that a representative environment model, such as the plant model shown in Figure 1, is an essential part of a system model.

Also noted in ARP4754A is that a graphical representation or model can be used to capture system requirements. The standard now notes that a model can be reused for software and hardware design.

If engineers use models to capture requirements, ARP4754A recommends engineers consider the following:

1. *Identify the use of models/modeling*
2. *Identify the intended tools and their usage during development*
3. *Define modeling standards and libraries*

When using model-based design with ARP4754A and DO-178C, additional verification capabilities are often needed beyond in-the-loop testing described in Table 2. These including requirement tracing, model standard checking, model-to-code structural equivalence checking, and robustness analysis using formal methods. For UAVs, rigorous verification that includes multiple verification technologies is paramount given their autonomous nature and system complexity.

DO-178C

Not surprisingly, one of the first changes new in DO-178C is an explicit mention of ARP4754A in Section 2: *System life-cycle processes can be found in other industry documents (for example, SAE ARP4754A).*

Clarification updates aside, such as the one noted earlier, DO-178C does not differ significantly from DO-178B, at least at first glance. In fact, a casual reader might miss an item mentioned in Section 1.4: *How to Use this Document: One or more supplements to this document exist and extend the guidance in this document to a specific technique… if a supplement exists for a specific technique, the supplement should be used …*

In other words, the standard's big changes are captured in the supplemental documents, such as RTCA DO-331, Model-Based Development and Verification Supplement to DO-178C and DO-278A.

Pertinent to this discussion, a long-standing issue with DO-178B for practitioners of model-based design is the uncertainty in mapping DO-178B objectives to model-based design artifacts. Addressing this mapping was a main goal of the DO-178C Sub-Group (SG-4) focused on model-based design. No single mapping sufficed, so several mappings are provided in DO-331. Some include the concept of a Specification model, which is a model separate from that of the one used for design and code generation. The other concept is a Design model, which serves as the detailed requirements used to generate code.

The essence of a Design model is the following:

1. A model can be used for design (system and/or software) and should be developed using requirements external to the model (for example, a textual document or requirements database).
2. Source code can be generated directly from the design model (by hand or automatically).

Of course, with 125 pages, DO-331 has a lot more to offer than described here. One approach noted in the standard is that a model used initially for system design can be elaborated on and reused for software design and code generation. This ties ARP 4754A and DO-178C together quite nicely for UAV system and software developers using model-based design.

For example, the controller shown as a component in the system model in Figure 1 and by itself as a software model in Figure 2 is:

- Used during system design
- Reused as an entry point for software design
- Elaborated on during detailed software design (for example, by discretizing continuous time blocks and changing double-precision data to single-precision or fixed-point)
- Used as input for embedded code generation

The test cases for system requirement validation likewise are reused on the model, source code, and executable object code to perform functional testing and collect coverage metrics.

While not advocating for any particular mapping, the use and reuse of models for systems and software design along with code generation have long provided UAV system developers using MathWorks products of Simulink and Embedded Coder with streamlined processes. It is nice to see that this same approach is now clearly acknowledged as an acceptable means to certification by the governing standards. MathWorks provides verification tool qualification kits and workflow guidance regarding the use of model-based design for DO-178. **MES**

Tom Erkkinen is the Embedded Application and Certification Manager at MathWorks. He is leading a corporate initiative to foster industry adoption of code generation technologies. His team participated in the DO-178C SG-4 working group focused on model-based design. Contact him at tom.erkkinen@mathworks.com.

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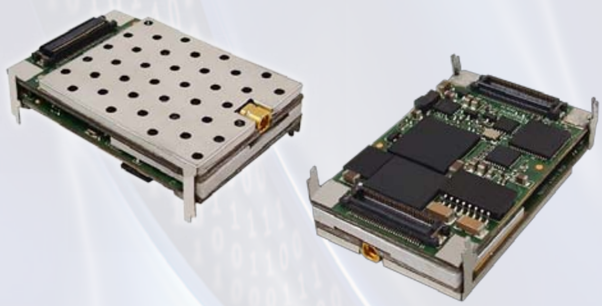

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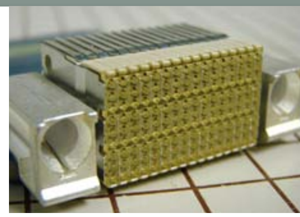

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Rugged UAV connectors meet the end-to-end challenge for speed and space savings

By Gregory Powers

The increasing capabilities of UAVs mean heavier demands on signal processing. Embedded computers are evolving to provide high data rates while becoming smaller and lighter, demanding new I/O connectors to prevent bottlenecks in communication.

U.S. Air Force photo by Lt. Col. Leslie Pratt

UAVs have become an important offensive and defensive tool, combining sophisticated surveillance with precision targeting. Since some UAVs are expected to remain aloft for upwards of 36 hours, Size, Weight, and Power (SWaP) are critical issues that affect component selection. At the same time, the signal processing load is steadily increasing to keep pace with advanced imaging, targeting, and controls. These two factors – SWaP and high-performance computing needs – are leading designers to create systems with both higher bandwidth and smaller form factors. This evolved concept in system design has implications for the entire connectivity chain, inside the box and box-to-box.

While VITA 46 (VPX) is probably the most widely used state-of-the-art computing platform for defense and aerospace applications, industry is looking to the next generation of Small Form Factor (SFF) systems. 6U systems are giving way to 3U systems – and even smaller form factors are under investigation by VITA 73, 74, and 75 committees.

The challenge isn't simply size and speed, but robust connector designs capable of withstanding shock, vibration, temperature extremes, and potential exposure to fuels and other environmental challenges found in aerospace applications such as UAVs.

For example, a commercial backplane connector is typically designed to withstand random vibration of 3 *g*s over a vibration frequency of 20 to 500 Hz. The military counterpart is tested to higher levels of vibration over a wider frequency range – 11 or 12 *g*s at 20 to 2,000 Hz. In other testing areas to determine mechanical and environmental ruggedness – such as mechanical or thermal shock or mating cycles – connectors for UAVs and other military applications must withstand much more severe conditions. A closer look inside the box, in an effort to break the I/O bottleneck and design for signal integrity, is important.

Inside the box: Bandwidth, size, ruggedness

As designers look toward next-generation SFF systems, they are also looking for backplane connectors with higher speeds and signal densities than previously available to support the SWaP needs of UAVs. New generations of backplane connectors are providing designers with a smaller footprint at the backplane/daughtercard interface, while supporting 12+ Gbps operation in rugged environments. Such connectors are modular, scalable, and typically compatible with a wide variety of existing optic, RF, and power connectors, thereby expanding the designer's "in-the-box" arsenal. Thus, they help enable SFF systems.

Breaking the I/O bottleneck

As speeds increase, the input/output connection becomes the bottleneck. Designing connector systems for controlled impedance to maintain signal integrity becomes essential. Since there are many sources of impedance mismatch in a connector – caused by geometric nonuniformity and changes in the dielectric constant – connector interfaces must be designed to minimize crosstalk and reflections from impedance discontinuities that contribute significantly to signal degradations.

Quadrax systems, for example, have supported 100 Mbps and 1 Gbps quite well. But UAV designers today are looking for rugged impedance matched I/O to support 10 GbE, IEEE 1394, USB 3.0, and other fast protocols.

Two common solutions to enable these protocols are to selectively pin an existing 38999 connector in a pattern that minimizes crosstalk between pairs directly by isolation or indirectly by symmetry cancellation or to integrate a commercially available RJ45 modular plug or jack into a rugged Size 19 38999 connector shell. Neither solution is optimal. Military circular connectors such as 38999 were not designed for the match impedance required for high-speed operation, leading to several limitations that include wasted space in selective loading. Proposed approaches use a Size 17 or 10 shell with selective contact loading. While these approaches allow increases in I/O speed, they do not fully meet the return loss requirements of a Cat 6A connector – the industry-standard measure for 10 GbE. Category 6A twisted-pair cable is the

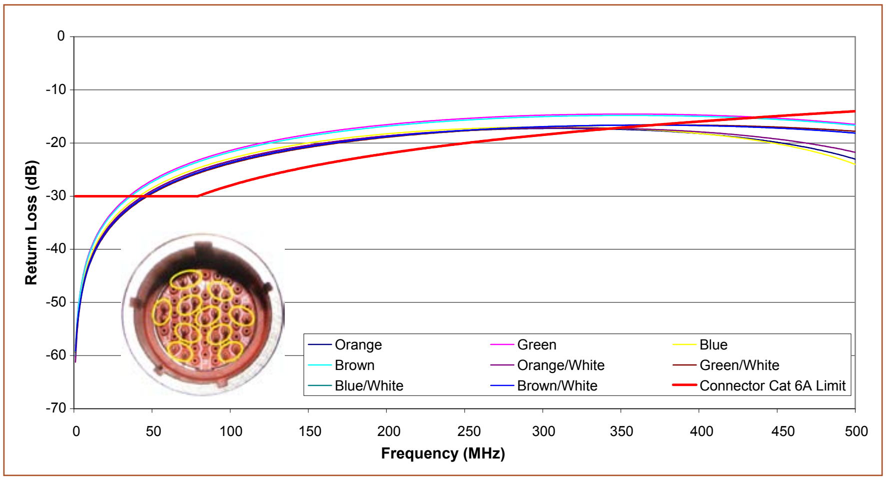

Figure 1 | Return loss results for a selectively pinned 38999 connector show that the connector fails to meet Cat 6A requirements at high frequencies.

industry-standard cable for 10 GbE, and the connector must also meet the ANSI/TIA-568C.2 requirements for Cat 6A hardware. Today's high-speed requirements in military UAV applications demand connectors with smart signal integrity configurations.

Figure 1 shows return loss measurements for a Size 17 shell tested up to

500 MHz with Cat 6A cable. The pinout pattern is based on an ARINC 664 proposal for 1 Gbps operation and illustrates that, while the pinout can be configured to operate satisfactorily for 1 GbE, it does not meet the return loss requirements for a Cat 6A connector at 10 Gbps.

Return loss is a handy metric for comparing connectors for high-speed use since it directly or indirectly indicates the quality of impedance matching and crosstalk cancellation.

Designing for signal integrity

Rather than "force fit" an existing design for 10 Gbps operation, TE Connectivity's new CeeLok FAS-T connector is an example of how designing a connector for signal integrity can yield both a smaller size and faster speeds up to 10 GbE operation.

Figure 2 | The T-shaped contact pattern of a new compact connector supports signal integrity at high speeds.

Achieving both smaller size and faster speeds is critical in UAVs.

To minimize the effects of crosstalk within the interface, a symmetrical contact pair pattern provides better noise cancellation than parallel or asymmetrical configurations and reduces the required spacing between contacts (Figure 2). A "T" pattern was determined to be the optimal way to achieve crosstalk cancellation. This pattern was based on an existing TE Connectivity commercial connector interface that had met 10 GbE data transmission through signal integrity modeling, analysis, and physical testing.

Once the pattern was established, contact density was optimized adjusting the dielectric constant of the insert material. Thermoplastics used in high-temperature connector applications typically have relatively high dielectric strengths to prevent arcing between adjacent contacts at the required operating voltages, but have a negative effect on electromagnetic coupling – crosstalk – between contacts. Strategically placed air pockets within the interface reduce crosstalk coupling and allow a higher contact density.

The connector fits in a Size 8 shell, giving users the familiarity of the 38999 interface while providing significant size and weight reductions: 50 percent smaller and 75 percent lighter than the traditional I/O Size 17 38999 Series connector. As shown in Figure 3, return loss

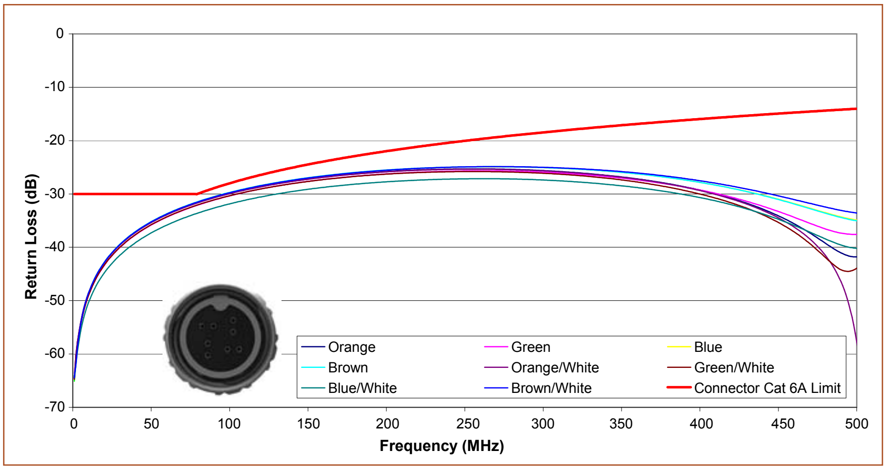

Figure 3 | The CeeLok FAS-T connectors meet Cat 6A requirements.

performance is well within performance requirements for Cat 6A cable assemblies and even improves at higher frequencies.

Higher speeds inside and outside the box

Achieving high-speed systems begins inside the box where the intensive processing takes place. End-to-end connectivity means optimizing the signal path at every step – from the backplane through cables and connectors – to ensure signal integrity. Impedance matching becomes mandatory to avoid reflections, crosstalk, and other sources of signal impairment. As UAV designs drive the push for smaller, lighter-weight solutions, compact connectors are being introduced to meet the needs of rugged performance and high-speed signal transmission. **MES**

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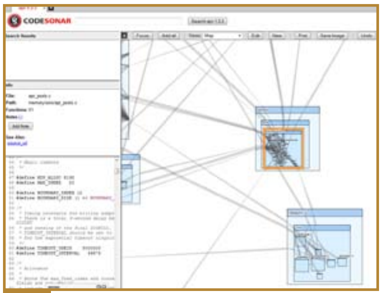

New GrammaTech code analysis tool works with millions of lines of code

Engineers at GrammaTech designed a new tool for code analysis that includes a Google Earth-like zooming feature that enables users to zoom in on individual lines of code in systems that contain as much as 20 million lines of code. The new CodeSonar visualization tool (which works with GrammaTech's CodeSonar static analysis tool) enables developers to visualize data sets at different levels of abstraction. Designed for a customer program that contained 20 million lines of code, GrammaTech officials say there is no reason the tool cannot analyze larger amounts of code. Users can also overlay the CodeSonar defect analysis capability.

GrammaTech designers originally based the tool on Google Earth, but found that model inefficient and then created their own visualization tool that still has the same "zooming" effect that you see with Google Earth. Users can actually scroll via the mouse all the way out so that the program is just a dot, then shoot all the way down to individual lines of code.

CodeSonar visualization displays the program's call graph, so it is organized according to the program module structure. Graph layouts can be changed in real time and present data in tree, circuit, map, cluster, radial, flow, and other layouts. With CodeSonar visualization, developers can begin at individual functions to gain insight from a bottom-up perspective, annotate nodes and edges with additional information, and overlay the visualization with data on defects and source-code metrics such as complexity. CodeSonar visualization runs through a standard Web client such as Microsoft Internet Explorer, Chrome, or Firefox browsers.

GrammaTech | www.grammatech.com | www.mil-embedded.com/p367800

Rugged AdvancedTCA for C4ISR applications

Engineers at SANBlaze Technology's Defense Solutions Group have come up with a rugged AdvancedTCA solution for C4ISR applications such as shipboard, ground, and airborne battle management and communications systems. They have dubbed it the Rugged Compute Platform for Tactical Ops, or RCP-Tactical Ops. The Commercial Off-the-Shelf (COTS) available AdvancedTCA device enables military users to process data collected via various reconnaissance methods in a rugged, lightweight, low-power system.

The RCP-Tactical Ops can be used for frontline field or fixed-mount deployments. The AdvancedTCA platform also supports SIPRNet and NIPRNet. The SANBlaze system is modular with building blocks comprised of storage, networked computing elements, and switch and payload blades that comply with the AdvancedTCA standard. It has payload blades that are multicore 64-bit SMP, with as much as 192 GB. The storage blades are 6 TB per slot and RAID 01, 5, 6. The switch blades are multiport and 10 Gb. The RCP-Tactical Ops works with a variety of rear I/O modules that can work with SPARC and x86 processor blades. I/O options include Fibre Channel, SVGA video, USB, RS-232C 9-pin serial full modem control, networking, and storage drive options.

Each platform features 10 GbE connections that can be used for pipelined packet processing in virtualized operating system environments. It also has AC (120/240 V) and DC (-48/60 V) power supply options cooling capabilities. Other military applications for the AdvancedTCA device include network-centric converged voice, video, and data solutions.

SANBlaze Technology, Inc. | www.sanblaze.com | www.mil-embedded.com/p368771

RF signal analysis products from D-TA leverage 10 GbE for SIGINT applications

Two new software radio solutions from engineers at D-TA Systems Inc., called RFvision-1 and RFvision-2, help enable sensor-independent processing for SIGnals INTelligence (SIGINT), RF spectrum monitoring; ELectronic INTelligence (ELINT); COMmunications INTelligence (COMINT), RF test and measurements; and arbitrary waveform generation applications.

The products' real-time recording and playback of almost 2 GBps is possible due to D-TA's 10 Gigabit sensor processing technology. Company engineers adapted the 10 Gigabit network technology for sensor processing. Additionally, the design has been implemented using FPGA technology. It is faster than most computer buses and is free of the digital noise associated with a computer bus. The technology also uses optical fibers to transfer data over long distances if required. The D-TA product's throughput rate can be increased by adding more fibers; multiple fibers also can be synchronized. This processing architecture is also sensor independent, remaining the same no matter which type of sensor is being processed.

The RFvision-1 has frequency coverage from 20 MHz to 6 GHz with a bandwidth of 40 MHz. The RFvision-2 delivers frequency coverage from 500 MHz to 26.5 GHz with a bandwidth of 500 MHz. Each product offers real-time recording and playback of the selected signal. Either one can be controlled from a user's PC that uses a D-TA-supplied GUI. The D-TA devices also can be quickly deployed with little customization. For 90 percent of the solutions, all the user has to do is write the application code – the server can be dropped right into the network – making sensor-to-network a reality.

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