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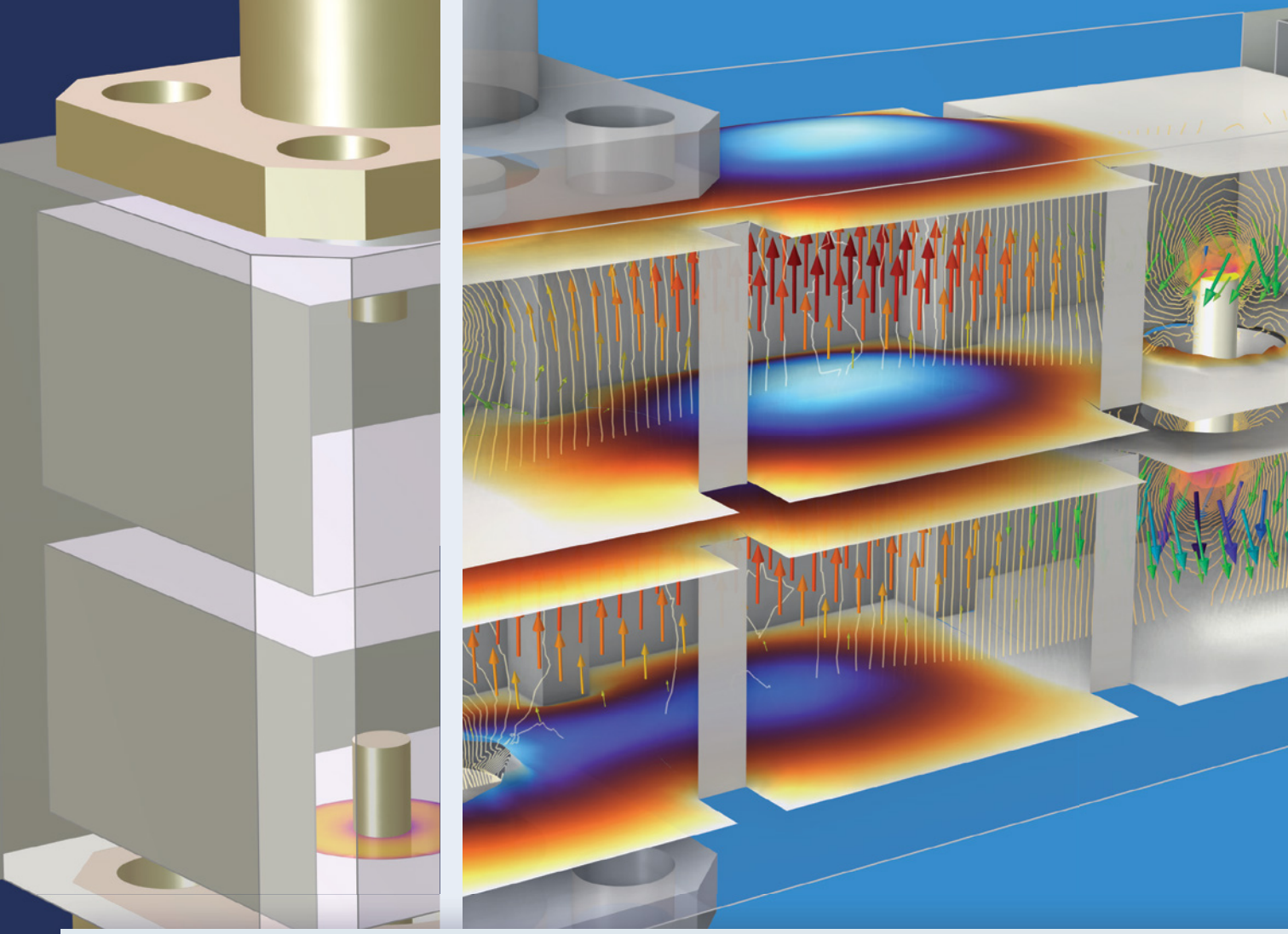

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December 2022

AEROSPACE & DEFENSE™ TECHNOLOGY

The Engineer's Guide to Design & Manufacturing Advances

SAE INTERNATIONAL®

Solving Military Satellite, Radar and 5G Communications Challenges with GaN-on-SiC MMIC Power Amplifiers

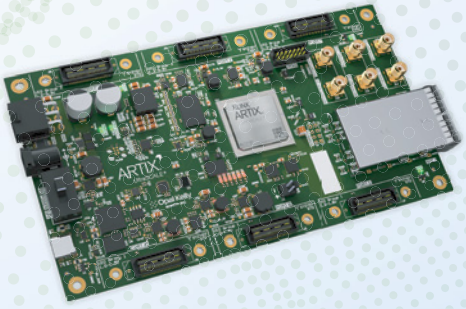
The Role of DevSecOps in Modern Edge Systems

Designing Multi-Channel Microwave Radio Systems Using Optical Interconnects

Making Machines Curious

From the Publishers of TECH BRIEFS

Your **Xilinx Artix® UltraScale+™** FPGA Development Begins with Opal Kelly



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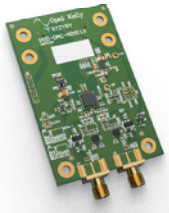
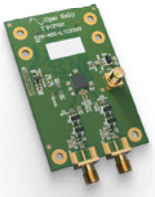


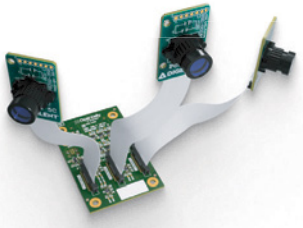
Dual 125 MSPS DAC



Dual 40-125 MSPS ADC

3.4 Mpx Image Sensor

4x PMOD Adapter



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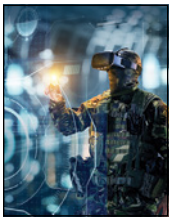

mmWave is enabling 5G-based systems such as augmented reality displays to enhance situational awareness on the battlefield. A new generation of power amplifiers based on Gallium Nitride (GaN) Monolithic Microwave Integrated Circuits (MMIC) technology could solve many of the challenges involved in bringing 5G networking to both on-battlefield and off-battlefield applications in the unused millimeter wave (mmWave) band. To learn more, read the applications brief on page 24.

(Image: K_E_N/Shutterstock.com)

Errata: In the September issue, the tech brief titled *Design, Demonstration, and Simulation of the Diode-Pumped Thulium/Holmium (Tm/Ho) Composite Fiber 2.1-μm Laser*, attributed to the Army Research Laboratory, should have been titled *Coherent, Efficient and Practical Polariton Lasers Using a Designable Cavity* and attributed to the Air Force Research Laboratory. We apologize for the error.

Time to Ride

Regular readers of *Aerospace & Defense Technology* will be surprised to see this page. In all the years I've edited this magazine, this is the first time I've written an editor's column. It will also be the last. Like Clint Eastwood in one of those old westerns that made him famous, at the end of this year I will saddle up and ride off into the sunset.

A lot of people have asked me "Why?" To be honest, I've asked myself that question several times since deciding to retire. I still love making magazines and getting to make them with some of the most talented editorial and art professionals in the business for the last 15 years has been one of my life's greatest blessings. That may sound like a cliche but consider this – we came through a pandemic together, continued producing top-notch issues, and never missed a deadline. That's dedication.

There's a lot about this business I'm going to miss. First and foremost are the people who create the cutting-edge technology we cover in A&DT. I've had the privilege to meet more bona fide geniuses than Albert Einstein, and I certainly don't have his credentials. But they always made me feel like I did.

The PR and marketing communications people have been equally amazing. When your lifeblood is high-quality contributed content, those folks can make or break an editor. I've been fortunate to work with some of the best in the business and it shows in the articles we've published.

For me, one of the most pleasurable aspects of creating magazines is making them visually appealing. That's not always easy with technical content, but I've been lucky enough to work alongside some of the most talented art and production people on Earth. It shows in every issue.

I've also enjoyed working with our sales team. The relationship between sales and editorial has always been tricky because the revenue they generate pays everybody's salaries, but editorial must maintain an objective, arm's-length relationship or the publication's credibility will suffer. Not once have our salespeople ever put me in a compromising position, and I will always be grateful for that.

Finally, I'm going to miss collaborating with our publisher, Joe Pramberger. I've worked with a lot of publishers in my career, but I've never met one who cares as much about the readers as he does. It's a publisher's job to ensure the magazine is profitable and to do that, most adhere to strict guidelines regarding the ratio of editorial to advertising. Joe never enforced those rules. If I needed more pages to educate our readers, he gave them to me. I thank him for that...and you should too.

So, getting back to the original question: Why am I retiring?

I've been married to the same wonderful woman for 47 years and she has selflessly been my rock throughout this amazing journey. I'd like to spend more time with her. Maybe travel together instead of me jetting off all the time. I've got three great kids and their partners who, for some strange reason, still think dad is cool and enjoy hanging out and going on vacations with me. I'd be a fool not to take advantage of that. And I've got three beautiful grandchildren that I adore and who adore me. I'd like to be a bigger part of their lives while we're all still young enough to appreciate it.

That's it in a nutshell. It's been an amazing run, but as I said earlier, it's time to saddle up. And if you'll tolerate just one more Clint Eastwood reference, my favorite line of his is the all-time classic: "You've got to ask yourself one question: 'Do I feel lucky?' Well, do you, punk?"

Actually, I do, Clint. Very lucky.

Bruce A. Bennett

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Why are **Aerospace & Defense Companies** *Embracing* **Additive Manufacturing?**

It's no longer a question of when metal additive manufacturing (AM)—and particularly metal laser powder-bed fusion (LPBF)—will become an accepted, reliable production technology, particularly in aerospace and defense. This is already the case now. Over the past 18 months a host of aerospace leaders, OEMs, startups, and contract manufacturers (CMs) alike have purchased, or begun outsourcing work to, advanced AM systems. They're confidently producing end-use, 3D-printed parts—and sometimes entire rocket engines.

In a quarterly study of revenue growth of leading AM system-makers, published in the summer of 2022, the industrial sector was reported to have grown 19 percent compared to the same period in 2021. This was cited as proof that companies and users are looking to invest in the larger, more powerful industrial AM solutions that offer greater efficiency and productivity.

Pratt & Whitney, Lockheed Martin, SpaceX, Honeywell, and others, for example, have clearly come to the realization that the technology is capable of delivering mission-critical products. SpaceX in particular is on a fast track with additive, with more than 10 systems installed.

And it's not just the biggest names buying into AM; "New Space" startups like Launcher and Aerojet Rocketdyne are finding that they can purchase a machine or two, develop proprietary designs, and deliver competitive rocketry in astoundingly short periods of time. What's more, many CMs that serve aerospace and defense customers—including Wagner Machine, Vertex, Hartech Group, and Knust-Godwin—have also been actively integrating AM systems into their machine shops in response to customer demands for highly sophisticated parts that can't be made any other way.

Many items on the wish-lists of the aerospace and defense industry are now being particularly well-served by advanced additive systems: Lightweighting through part consolidation using an ever-widening selection of superalloy powders qualified for 3D printing. The

Makveev Aleksandr/Shutterstock.com

ability to not only print exactly what's desired without compromising on design, but improved performance metrics provided by complex internal passageways; low-angle, support-free blading and tubing; and "impossible" geometries not previously imaginable.

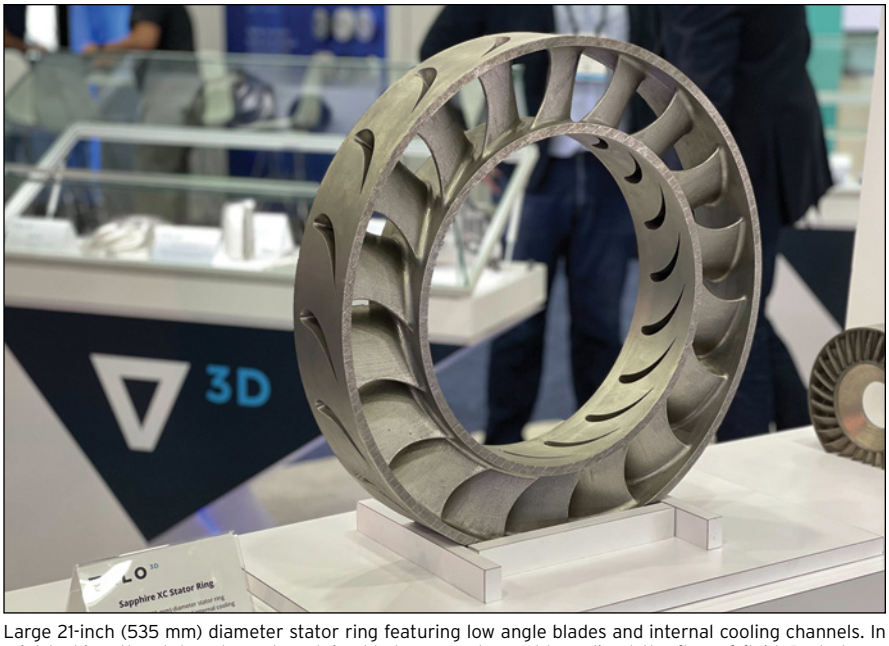
A cross-sectioned thrust chamber printed in GRCop-42, a copper/chromium/niobium alloy designed for high-strength dispersion and high conductivity. The chamber walls contain internal channels for regenerative cooling. This material was developed by NASA for use in regenerative rocket engines. It is shown here as-printed (L) and polished (R).

AM in Commercial Aviation

An understandable abundance of caution related to human flight has resulted in a regulatory environment that has slowed commercial aviation's move towards adoption of AM to some extent. Although a variety of 3D-printed parts have been certified by major players in that industry—GE aircraft engine components are the best-known example—this has involved many years of proprietary development time and considerable expense (FAA 14 CFR 21.1 permits airframe, engine, and propeller manufacturers to make AM parts, with exacting certification requirements).

However, last year's announcement of an MMPDS (Metallic Materials Properties Development & Standardization) materials spec, for Alloy 718, an Inconel™, is a step toward levelling the field for aviation-related companies of all sizes. MMPDS is an industry-based source for design allowables recognized by the FAA, DoD and NASA. Inconel is the first of several materials (aluminum and titanium are next) being evaluated for use with 3D-printed parts and repairs.

This, in turn, is increasing the value of AM to commercial aviation for supply chain "fixes," i.e., when a casting shop no-quotes a legacy part, or lead times for a replacement are astronomical. LPBF technology can help offset the high costs of low-volume, direct-part replacement of conventionally produced parts when demand and long-term forecasting are uncertain. This significantly impacts the economics of future Maintenance, Repair & Operations (MRO) projects.

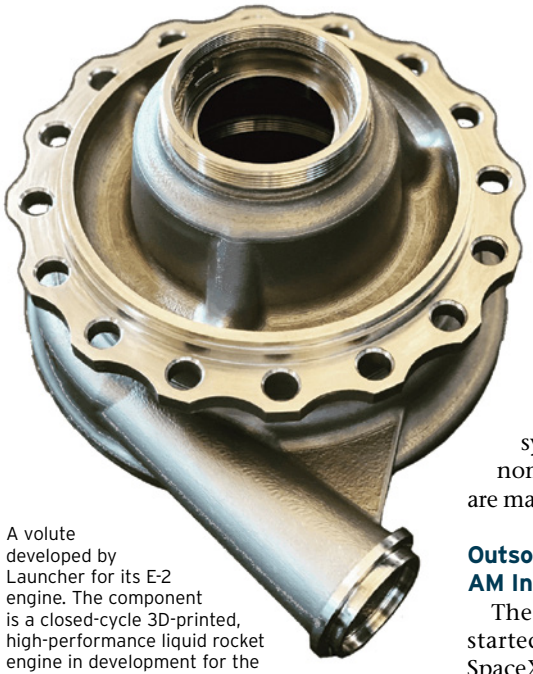


Large 21-inch (535 mm) diameter stator ring featuring low angle blades and internal cooling channels. In a jet turbine, the stator element contains blades or ports used to redirect the flow of fluid. Part shown as-printed. This part was printed on a Velo3D Sapphire XC machine, which is capable of printing parts 600 mm in diameter and 550 mm in height.

3D-printed parts must provide inherent value because they are 3D-printed. For example, with complex gas turbine combustor components with optimized interior geometries—that will have limited aftermarket availability or high replacement cost—AM can enable a CM to produce hardware for its customers on-demand, negating the high NPI (new product introduction) tooling costs and lead-times of other methods.

AM in Aerospace and Defense

On a faster pace than commercial aviation, unmanned space flight, satellite launch, hypersonics R&D, and drone production have been leaping ahead with metal AM in the past few years. Applications include monolithic, nozzle/combustion chamber combinations that consolidate large assemblies of parts into one, as well as impellers, stators, fuel tanks, pump housings, complex tubing, and lightweight microturbines.



A volute developed by Launcher for its E-2 engine. The component is a closed-cycle 3D-printed, high-performance liquid rocket engine in development for the company's Light launch vehicle.

A typical conventional-to-AM conversion might focus on a scavenge-tube component that dips into an engine sump for oil recirculation. The original is made up of eight separate parts, welded together; moving to AM consolidates those into a single component, eliminating eight potential sources of variation, and bypassing extended time spent in welding and brazing.

Another example is a microturbine for a drone. An original design for conventional manufacturing had 61 parts; the AM version consolidated them into just one. Purdue University has recently announced work on hypersonics propulsion—of understandable interest to the Department of Defense—using 3D-printed parts.

The quality of product now achievable using advanced LPBF systems, combined with the economics apparent in these examples, are making the case for AM much clearer.

Outsource to CMs First, Then Taking AM In-House

The larger names in aerospace have started to invest in AM in a big way. SpaceX has certainly taken the lead, as mentioned, and others are announcing their intentions to increase their commitment to the technology. Many begin exploring AM by outsourcing to contract manufacturers with expertise in 3D printing and finishing; later, they may purchase AM systems for direct use in their own facilities.

Now that the more advanced systems are delivering on the AM promise of geometric flexibility and precision, OEMs are seeing significant acceleration in their development programs. This summer, Pratt & Whitney, part of Raytheon Technologies, purchased a Velo3D Sapphire system (which includes print-preparation software, the printer itself, and embedded monitoring and quality control software). P&W is evaluating the technology for manufacturing production jet-engine components for their GTF™ and advanced engine programs.

P&W are experienced users of AM, much of which they'd been outsourcing to contract manufacturers for printing and finishing. While they plan to continue taking advantage of that resource, their newest system will be located in-house at the Raytheon Technologies Research Center. Raytheon is a launch participant of President Biden's AM Forward initiative.

Lockheed Martin has also recently added an advanced LPBF system to its Additive Design & Manufacturing Center, which pilots new AM technologies for production deployments in the company's Space division.

Upstarts Start Up With AM

In the innovative world of aerospace, size of company matters less than in the past when AM is part of the picture. Smaller enterprises such as Aerojet Rocketdyne, a supplier to NASA; Launcher, a satellite-launch startup; even a teenage schoolboy whose one-piece aerospike engine is soon to undergo ignition testing—all of these have achieved headlines in the past year thanks to 3D printing.

- Aerojet Rocketdyne has been providing NASA with 3D-printed end-use components for a variety of projects, among them the massive RS-25 engines that will carry the Artemis mission to the Moon (with a goal of placing the first unmanned Orion lunar module into orbit this year) and later Mars.

  NASA has half the budget than it did in the 1960s; recent progress is due, in no small part, to advances in 3D printing. According to James Horton, aerospace engineer and mission architect at Aerojet Rocketdyne, "As with any complex endeavor, the more affordable you can make it, the greater the chance that you will ensure its completion. Metal AM plays a key role in achieving these goals."

Now-20-year-old rocket designer Ewan Craig with his aerospike engine (right). Part consolidation made possible by advanced metal laser powder-bed fusion enabled the high schooler to design a multifunctional component that was 3D-printed as a single piece.

Using AM, Aerojet Rocketdyne has been able to drive down propulsion costs, speed up time-to-market, and improve the performance of its products. Most recently, the company employed advanced LPBF to overcome the limitations of an earlier injector design for the RS-25 engines that will carry the Artemis mission into space.

This time they were able to make the injector out of lighter-weight titanium instead of the original Inconel, resulting in a thruster that is 1/5 the mass, 1/2 the size, and 1/3 the cost of a conventionally manufactured version. Since the newest model contains far fewer components, it's also easier to assemble, with much less chance of failure during operation. Said Horton, "We've shown that, by leveraging additive manufacturing and advanced software technology, we're able to interject affordability, reduce lead times, and greatly improve upon system performance compared to the way we built parts in the past."

- Another young company, Launcher, intended from the get-go to take advantage of AM as it built up its low-cost, small-satellite-launch program. Earlier AM systems they were using required significant redesign work and post-processing. But the more recent purchase of one of the newest LPBF systems provided the level of technology needed to fulfill a rideshare opportunity with SpaceX.

  Launcher was able to shift priorities from developing its own rocket to completing the production of their Orbiter satellite-transfer vehicle so it could piggy-back on a SpaceX rocket. While its proprietary rocket (which will launch the Orbiter directly) continues in development, the enhanced capabilities of their new AM system "made it very easy for us to pivot in the face of shifting priorities," said Launcher's head of manufacturing, Tim Berry.

  "That's a benefit of additive technology in general, but especially when you're using a highly-capable print platform," he said. The company has now printed shrouded impellers, fuel tanks, brackets, combustion chambers, and injectors for various projects—and purchased additional AM equipment to use in-house.
- Only his dorm room served as the R&D department for Ewan Craig, a 16-year-old British schoolboy who used his time during the pandemic lockdown to investigate the long-sought-after aerospike rocket, which engineers have been pursuing since the 1950s. With support from a software provider and an AM-system maker, Craig designed and had printed his own single-piece aerospike, which is now undergoing ground and eventual flight testing at a U.S. university.

As AM technology continues to evolve, the most advanced systems are already delivering the level of quality that meets the highest standards demanded by aerospace and defense. The larger-capacity, taller 3D printers that are now being delivered will only expand the potential for innovative applications that can be explored—and delivered—by the industry's OEMs, contract manufacturers, and energetic startups alike.

This article was written by Ben Wilson, Applications Engineer, Velo3D (Campbell, CA). **For more information, go to https://velo3d.com.**

A typical GAIA modular power supply board.

Simplifying Power Design *with* Modular Architectures

The design of complex, high-power DC-to-DC converter architectures poses some challenges to engineers developing aerospace and military-grade power systems. DC-DC converters must comply with multiple standards and stringent requirements in terms of input voltage, EMI (electromagnetic interference) environmental conditions, and thermal management.

A modular approach can significantly simplify the design process, enabling engineers to design complex power conversion systems using COTS and SWaP-C optimized building blocks. Engineers can meet multiple industry standards and power requirements while optimizing their power architectures according to new industry standards such as the Sensor Open System Architecture (SOSA).

Modular Power Solutions

Whereas a centralized power solution tends to be a single unit that provides multiple outputs, a modular approach offers the same (or better) performance through a combination of modules. The structure of each modular solution will vary according to the application's needs. Typically, it will include several DC-DC converters that change a common bus voltage to meet the needs of the load(s).

Other modules may be included to provide an auxiliary voltage rail alongside EMI filters, limiters, and hold-up modules. This way, the output voltage remains present when there is a 'dip' on the input, for example, when cranking a vehicle engine. Depending on the available supply type (AC or DC voltage), there may be an AC-DC front-end power supply including power factor correction to create a voltage rail to power all the modules in the system.

The modular approach offers significant flexibility to meet non-standard requirements without involving the cost and complexity of a custom design. As it typically uses pre-qualified modules as building blocks, challenges such as EMI are already quantified, and necessary approvals are already in place.

Military/ Avionic Applications

For all power solutions in military/avionic applications, the most common power source is a pre-defined bus that will deliver either 24V DC or 28V DC. This applies to both airborne and ground-borne applications.

Various standards exist covering power systems within military/avionic applications, primarily to sustain input voltage excursions (including transients, spikes, dips due to engine cranking, or power source commutation and shut down).

While the nominal voltages available within an aircraft or vehicle are well defined, the nature of military applications means that the system design must allow for fluctuations. Wide input range DC-DC converters can cope with either a 24V DC or 28V DC input and meet the excursions in airborne applications due to abnormal or emergency operating

conditions. For vehicular ground-borne applications, the voltage deviations are most commonly due to engine starting or cranking or power source commutation. Again, using a wide input range DC-DC module will address this issue.

To meet other requirements, other types of modules can be added to the solution. For example, transients are addressed by GAIA's LGDS series voltage limiter modules, while EMI filter modules (FGDS series) offer compliance to EMI emission standards.

The system should also continue to deliver power for a brief (defined) period in the absence of any bus power. This 'hold-up' time is often addressed with a bulk capacitor connected across the bus at the input to the DC-DC converter modules. However, there are two issues with this approach. Firstly, the charged voltage of the capacitor being the nominal bus voltage, the size of capacitor will be extremely

International Standards	<---------- Steady State ---------->			<------------ Transient --------------->			<- Spike ->	GAIA Converter DC/DC and Front-end
	Normal	Abnormal	Emergency	Low Normal	High Abormal	Low Abnormal		Module Compliance
MIL-STD-704A (cat A)	25 - 28,5V	23,5 - 30V	17 - 24V	10V/50ms	80V/50ms	0V/up to 7s	+/-600V/10µs	GAIA DC/DC range : 9-36V, 16-40V or 16-80V PGDS series : 10V/15s or GAIA DC/DC range 9-36V PGDS/LGDS series HUGD series with capacitor* FGDS series
MIL-STD-704F	22 - 29V	20 - 31,5V	16 - 29V	18V/15ms	50V/50ms	0V/up to 7s	/	GAIA DC/DC range : 16-40V or 16-80V GAIA DC/DC 16-40V with 50V transient or 16-80V HUGD series with capacitor*
DO-160D (cat B) spike cat. A	22 - 30,3V	20,5 - 32,2V	18V	12V/30ms	60V/100ms	0V/up to 7s	+/-600V/10µs	GAIA DC/DC range : 9-36V, 16-40V or 16-80V PGDS series : 10V/15s or GAIA DC/DC range 9-36V PGDS/LGDS series HUGD series with capacitor* FGDS series
DO-160D (cat Z) spike cat. A	22 - 30,3V	20,5 - 32,2V	18V	12V/30ms	80V/100ms	0V/up to 7s	+/-600V/10µs	GAIA DC/DC range : 9-36V, 16-40V or 16-80V PGDS series : 10V/15s or GAIA DC/DC range 9-36V PGDS/LGDS series HUGD series with capacitor* FGDS series
DO-160E (cat Z) spike cat. A	22 - 30,3V	20,5 - 32,2V	18V	12V/30ms	80V/100ms	0V/up to 7s	+/-600V/10µs	GAIA DC/DC range : 9-36V, 16-40V or 16-80V PGDS series : 10V/15s or GAIA DC/DC range 9-36V PGDS/LGDS series s HUGD series with capacitor* FGDS series
AIR2021E	24 - 29V	20,5 - 32,2V	17V	12V/30ms	60V/50ms	0V/up to 5s	+/-600V/10µs	GAIA DC/DC range : 9-36V, 16-40V or 16-80V PGDS series : 10V/15s or GAIA DC/DC range 9-36V PGDS/LGDS series HUGD series with capacitor* FGDS series

International Standards	Steady State	Start Engine	Cranking	<------ Surge ------> Low	High	Spike	GAIA Converter DC/DC and Front-end Module Compliance
MIL-STD-1275C/D (generator + battery)	25 - 30V	6V/1s	16V/30s	20V/500m	40V/50ms	+/-40V/1ms/15mJ +/-250V/70µs/15mJ	GAIA DC/DC range : 9-45V or 9-36V with 40V/100ms PGDS series : 6V/1s FGDS series
MIL-STD-1275C/D (battery only)	20 - 27V	6V/1s	16V/30s	/	/	+/-40V/1ms/15mJ +/-250V/70µs/15mJ	GAIA DC/DC range : 9-45V or 9-36V with 40V/100ms PGDS series : 6V/1s FGDS series
MIL-STD-1275C/D (generator only)	23 - 33V	/	/	15V	100V/50ms	+/-100V/1ms/15mJ +/-250V/50µs/15mJ	GAIA DC/DC range : 9-45V or 9-36V PGDS/LGDS series FGDS series
DEF STAN 61-5 issue 5 (generator + battery)	25 - 30V	6V/1s	>15V	20V/500ms	40V/50ms	+130V/-100V/<10µs +90V/-60V/10µs +70V/-40V/5ms	GAIA DC/DC range : 9-45V or 9-36V with 40V/100ms PGDS series : 6V/1s FGDS series FGDS series PGDS/LGDS series
DEF STAN 61-5 issue 5 (battery only)	22 - 27V	1V/1s	>10V	/	/	+130V/-100V/<10µs +90V/-60V/10µs +70V/-40V/5ms	GAIA DC/DC range : 9-45V or 9-36V with 40V/100ms External capacitance FGDS series FGDS series PGDS/LGDS series
DEF STAN 61-5 issue 5 (generator only)	15 - 40V	/	/	15V/500ms	80V/80ms	+280V/-220V<10µs +130V/-70V/10µs +110V/-50V/5ms	GAIA DC/DC range : 9-45V or 9-36V PGDS/LGDS series FGDS series FGDS series PGDS/LGDS seriess

Figure 1. Various international and national standards define requirements for airborne (top) and ground-borne (bottom) military/avionic power.

Specifications	MIL-STD-461C	MIL-STD-461D/E/F	DO-160C/D/E/F/G	GAIA Converter Module Compliance
Conducted emission (CE) :				
Low frequency	CE 01	CE 101	Section 21	module compliant stand alone (see product datasheet)
High frequency	CE 03	CE 102	Section 21	module compliant with additional filter
Conducted susceptibility (CS) :				
Low frequency	CS 01	CS 101	Section 20	module compliant with additional filter
High frequency	CS 02	CS 114	Section 20	module compliant with additional filter
Radiated emission (RE) :				
Magnetic field	RE 01	RE 101	Section 21	module compliant stand alone (see product datasheet)
Electrical field	RE 02	RE 102	Section 21	module compliant stand alone (see product datasheet)
Radiated susceptibility (RS) :				
Magnetic field	RS 01	RS 101	Section 20	module compliant stand alone (see product datasheet)
Electrical field	RS 03	RS 103	Section 20	module compliant stand alone (see product datasheet)

Figure 2. MIL-STD-461 and DO-160 define the requirements for conducted and radiated electrical noise in military applications

Tests	Standards	GAIA Converter DC/DC module qualification
Life at high temperature	per MIL-STD-202G Method 108A	Operation : 1.000 hrs @ +105°C case Storage : 1.000 hrs @ +125°C ambient
Low temperature	per MIL-STD-810E/G Method 502.3/502.5	Storage : 1.000 hrs @ -55°C ambient
Temperature cycling	per MIL-STD-202A Method 102A	Number of cycles : 200 Temperature change : -40°C / +85°C Transfert time : 40 min. Steady state time : 20 min
Temperature shock	per MIL-STD-202G Method 107G	Number of shocks : 50 Temperature change : -55°C / +105°C Transfert time : < 10 sec Steady state time : 30 min
Low Pressure (Altitude)	per MIL-STD-810E/G Method 500.3/500.5	40.000ft, unit functioning 1.000ft/min to 70.000ft,unit functioning
Humidity (Cyclic)	per MIL-STD-810E/G Method 507.3/507.5	Damp heat : 60% to 88% relative humidity Cycle I : (31°C to 41°C) : 240Hrs
Humidity (Steady state)	per MIL-STD-202G Method 103B	Damp heat : 93¨% relative humidity Temperature : 40°C Duration : 56 days
Salt spray	per MIL-STD-810E/G Method 509.3/509.5	Temperature : 35°C Duration : 48 hrs
Vibration Frequency range Acceleration	per MIL-STD-810D/G Method 514.3/514.6	10 cycles in each axis frequency : 10 to 60Hz/60 to 2 KHz acceleration : 0.7mm/10g
Shock (Half sinus) Peak acceleration Duration	per MIL-STD-810D/G Method 516.3/516/6	3 shocks in each axis Peak acceleration : 100g duration : 6ms
Bumps	per MIL-STD-810D/G Method 516.3/516.6	2000 bumps in each direction duration : 6ms peak acceleration : 40g

Figure 3. Multiple harsh environmental tests are applied to ensure the power modules withstand the conditions they will be used in

large. Secondly, a capacitor that large will require external circuitry to limit inrush current.

A hold-up module (such as GAIA'sHUGD-300) can help address these challenges. This module charges the capacitor at a higher voltage (usually in the range of 31V DC to 80V DC) and manages any inrush current associated with the bulk capacitor. As the energy stored increases by the square of the voltage, this approach results in a much lower value of the bulk capacitor, which is also physically smaller and more affordable.

Electrical Noise

Due to the enhanced efficiency and smaller size, almost all DC-DC converter modules are switching devices; they switch the DC input to create an AC waveform that is then regulated to give the output DC voltage. As mentioned, this approach enhances size and efficiency. However, it also creates the potential for electrical noise, which can have a detrimental effect on other system components if not properly controlled. For this reason, standards including MIL-STD-461 and D0-160 define the maximum amount of permissible noise, both conducted and radiated.

Many converters contain some form of inbuilt noise suppression for conducted noise and a grounded metal case significantly diminishes radiated noise. For more stringent standards, external filter modules (like GAIA's

FGDS series) can be added to the input of DC-DC converters to reduce noise further.

Many of GAIA's DC converters are equipped with a synchronization pin that allows the switching frequency of the module to be 'steered' away from frequencies to which the system may be sensitive. Additionally, in multi-module systems, the switching frequencies of each module can be aligned exactly by connecting the synchronization pins. In doing this, the designer can eliminate the low frequency 'beat' noise that can be generated by small differences in the switching frequency of individual modules.

Operating Environment

Military/avionic systems may be deployed in a variety of locations and subjected to different and challenging environmental conditions, including temperature extremes, humidity, shocks, and vibrations. A range of standards defines the requirements for the operating environment, along with outlining the tests to undertake to ensure that a module is compliant.

In the case of a custom power solution from discrete components, these tests would have to be passed after the design is complete. This process would involve a significant amount of time, cost, and design risk and probably require some design changes. Also, any significant design changes or upgrades would be subject to re-test and re-certification – again with time, cost, and risk. However, the modular approach uses pre-qualified modules that have already demonstrated their ability to meet the relevant standards, eliminating much of the design risk and dramatically simplifying the approval process.

Thermal Management

Heat is always an issue for any power system, no matter how efficiently it can operate. This is especially true for any system used in a confined and/or enclosed space, as in military/avionic applications. Any thermal design must include some design margin to ensure the reliability of the modules.

GAIA converter modules are designed for a maximum case or baseplate temperature (depending upon the style) of 105°C. In almost all cases, thermal management will be required, including forced air cooling using a fan, thicker and larger metallization on the circuit board, some form of heatsinking, or a combination of these techniques. In many cases, a preferred method is a thermally conductive heatsink that is in contact with the metal case/baseplate of the power module.

Conclusion

Designing power solutions for military/avionic applications can be challenging due to the operating environment and the stringent standards. In many cases, taking a modular approach using off-the-shelf, pre-approved modules is the best approach as it reduces design time and risk.

While many of the applicable standards have been in use for some time, there are updates made to address new applications or incorporate new technology. Designers must ensure that the modules used in their designs are compliant with the latest versions of all standards to ensure design longevity. Additionally, other organizations like the Sensor Open Standards Architecture Consortium (SOSA Consortium) are actively enabling governments and industry to develop open standards and best practices that apply to the military use of sensing devices.

This article was written by Christian Jonglas, Technical Support Manager, GAIA Converter (Laval, QC, Canada). **For more information, go to https://gaia-converter.com.**

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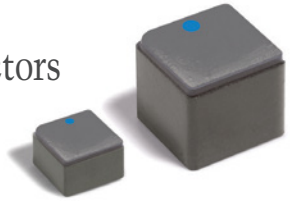

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The Role of DevSecOps *in* Modern Edge Systems

DevSecOps evolved to address the need for building in security continuously across the software development lifecycle so that teams could deliver secure applications with speed and quality. Incorporating testing, triage, and risk mitigation earlier in the continuous integration, continuous delivery (CI/CD) workflow prevents the time-intensive, and often costly, repercussions of making a fix post system deployment.

This concept is part of "shifting left," which moves security testing toward developers, enabling them to fix security issues in their code in near real time rather than "bolting on security" toward the end of the development. When development organizations code with security in mind from the outset, it's easier and less costly to catch and fix vulnerabilities before they go too far into production or after release.

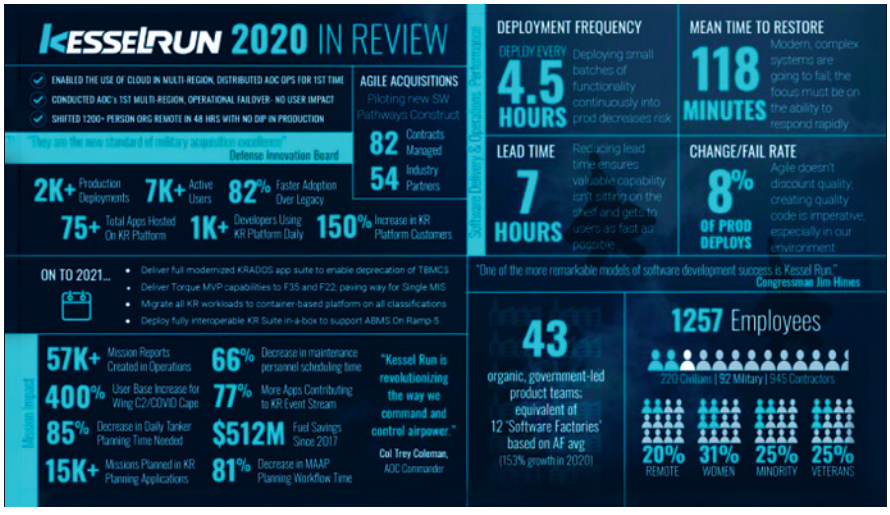
DevSecOps in the IT domain implies that any infrastructure (software and hardware) can be created with a set of scripts and all the testing and integration can be automated. A typical embedded developer is used to having the hardware (aka target board) sitting right next to a development system.

This worked fine for small software teams or if the software could be divided neatly into sub-components. However modern edge systems that combine the best of new IT development methods

with traditional embedded requirements (deterministic real-time performance, security, and reliability) are complex and require parallel development workstreams for software development and hardware design. Lynx refers to this as the Mission Critical Edge. The DevSecOps thinking of automated testing and integration can alleviate some of the issues caused by this new model.

We are clearly not alone. The Department of Defense (DoD) published its Digital Modernization Strategy in 2019, which called out DevSecOps as a foundational element of its approach to implementation. Since the "Software is Never Done" report, the DoD rapidly has made progress in the pursuit of those improvements and the strategy in the DoD Modernization guide. Even amidst the COVID-19 pandemic, significant progress was demonstrated in the transformation process, as prototype or minimal viable product (MVP) solutions have been tested on real programs (GBSD, B2 Bomber, F-22), are being required on new funded programs (Air Force's ABMS), and are soon to be mandated across many new programs.

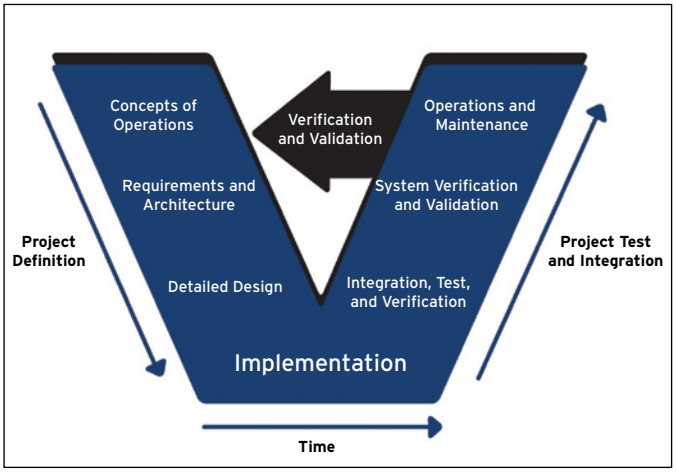
With the DoD CIO office up-leveling the work of the Air Force and pushing requirements across the Joint Force, it appears only a matter of time before



The US Air Force has implemented a number of "Software Factories" as part of their implementation plan, including one from Kessel Run.

transformation is DoD-wide. The U.S. Air Force has implemented a number of "Software Factories" as part of their implementation plan. While the exact structure of these is somewhat unclear at the time of this writing, the results of one, Kessel Run, for 2020, show that there are benefits to be had.

One of the key challenges associated with mission critical platforms (aircraft, automotive, healthcare, critical infrastructure) that needs to be considered though, is that the software technology is required to undergo safety certification before the systems can be deployed. The challenge is that any change in software, in most cases, leads to the need for re-certification. Typically, certification efforts are a significant factor in the timeline and cost of the programs. Integration issues for large programs, that have multiple software teams working on different aspects of the infrastructure and applications, cause delays in delivery timelines and cost overruns. These issues become particularly exacerbated if the system-level testing and integration is not started early in the program lifecycle.



V-Model

Many Agile methods and DevSecOps processes and techniques aren't defined in detail; engineering teams are effectively empowered to embrace the details they see relevant to themselves. This is counter to industries' safety and security standards that require a rigorous, well-defined process. This means that software teams must define and document their DevOps tools, processes and techniques. An important example of this is traceability. Proving requirements are satisfied with validation evidence is important for demonstrating system functionality and airworthiness. Therefore, any DevSecOps process must manage traceability precisely.

DevSecOps and DO-326A/DO-356

An interesting approach that has come out of the DevSecOps practice is the concept of treating security requirements in the same ways as safety and functional requirements. Guided by the outcome of detailed threat analysis and the implementation of security controls, then to validation through testing, and of course documentation. This is the key to integrate security into DevOps and a good way to build security into the development culture and have software teams communicate using a familiar language.

DO-326A defines an airworthiness security process (AWSP) which, at the thirty thousand feet level, defines certification, security risk assessment and security development activities. Security risks that are identified during the assessment require development activities to mitigate the risk to the aircraft. These activities are meant to be integrated into the safety processes required for the software. DO-356 is a companion document to DO-326A that proves compliance with airworthiness security requirements throughout the stages of development. The provisions in these documents are not yet mandatory and therefore, merely serve as guidelines. It is also noteworthy that they focus on intentional unauthorized electronic interaction including instances of malware installation and system manipulation, as opposed to offering guidance on physical attacks.

Good engineering practices dictate adoption of coding guidelines or standards such as MISRA, or SEI CERT guidelines. This approach assures newly developed code follows industry best practices. However, a coding standard by itself does not prevent all complex security vulnerabilities. Additionally, it isn't practical to implement coding standards on existing code.

In practice, many avionics systems have requirements defined up front as part of the request for proposal (RFP) process during vendor selection. It is also probable that milestones are established as part of large-scale airframe projects where deliverables are well outlined. In such cases, planning around these requirements and milestones is necessary as they feed the design and implementation phases that can still be iterative, Agile processes.

Today most system development of safety critical platforms follows a V-Model where equal weight is given to coding and testing. V shape shows the relationship between each phase of the development/design and the corresponding testing phase. Testing (right side of the V) is performed for verification and the left side is used for validation.

The software development method chosen during the design, implementation and testing of code is left up to the manufacturer as long as it meets the basic criteria of good engineering practices with traceability, safe and secure practices, and reporting and documentation evidence for results. Agile and iterative methods can work well in this phase despite the entire lifecycle not necessarily working within the Agile framework. In fact, the approach leads to better results by shifting many important parts of development earlier such as testing.

Categories of Software Tools Used During DevSecOps Development

Our experiences of engaging with customers that are implementing DevSecOps for the Mission Critical Edge indicate the use of the following application security testing (AST) tools during the CI/CD process:

- Static application security testing (SAST): These tools scan proprietary or custom code for coding errors and design flaws that could lead to exploitable weaknesses.

- Software composition analysis (SCA): These tools scan source code and binaries to identify known vulnerabilities in open source and third-party components. They also provide insight into security and license risks to accelerate prioritization and remediation efforts, as well as being used to continuously detect new open source vulnerabilities.
- Interactive application security testing (IAST): These tools work in the background during manual or automated functional tests to analyze web application runtime behavior. For example, the Seeker® IAST tool uses instrumentation to observe application request/response interactions, behavior, and dataflow. It detects runtime vulnerabilities and automatically replays and tests the findings, providing detailed insights to developers down to the line of code where they occur. This enables developers to focus their time and effort on critical vulnerabilities.
- Dynamic application security testing (DAST): This testing technology mimics how a hacker would interact with your product, testing applications over a network connection.

Software development tools require qualification to certification bodies such as the Federal Aviation Administration (FAA). As such, it's important that any tools used have an acceptable pedigree and the ability to meet tool qualification requirements. The process to qualify tools for use in software that will be certified to DO-178C is described in DO-330. The requirements for a code-coverage tool differ to those for a compiler, which differ again for a static analysis tool. At a high level, a project needs to describe how it plans to use the tool in a Tool Operational Requirements Document, and provide a Tool Qualification Plan outlining how to prove that the tool performs correctly. The latter typically requires a set of test artifacts and expected results.

Summary

DevSecOps brings a really interesting approach to treating security requirements in the same ways as safety and functional requirements, which is a perfect fit for modern edge systems with a mission critical element. It's encouraging to see this approach increasingly being built into development culture and supporting the next wave of mission critical product innovation in the industries of aviation, automotive and more.

This article was written by Ian Ferguson, VP Marketing, Lynx Software Technologies (San Jose, CA). **For more information, go to https://www.lynx.com.**

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Making Machines Curious

Remote and autonomous vehicles are now helping us make discoveries in places where humans cannot easily go. A recent mission to explore marine life at the bottom of the Clarion-Clipperton Zone between Hawaii and Mexico, over 5,000 meters below the surface at its deepest point, discovered over 30 potential new species.

These uncrewed underwater vehicles (UUVs) are running missions that allow humans to make better decisions (the Clarion-Clipperton survey was conducted to assess the impact of seabed mining). They're also mapping the unknown deep sea, following a trajectory and mission instructions designed before the dive, then "flying" just a few meters off the seafloor for hours while relaying data to a ship above them. These are just two examples; vehicles can be programmed to find old sea mines buried in the ocean floor, inspect pipelines for leaks, or search for lost shipping containers.

The problem is, right now these autonomous vehicles lack an important trait—curiosity. They execute a pattern (like a lawnmower search) or collect data and pass it to humans to decide which objects are interesting, and then get directed back to those targets.

Soon these missions will be executed with autonomous vehicles as true teammates, where a machine is given a general mission directive and a search area, then is released to explore and make decisions about what needs further inspection, instead of needing to be remote-controlled or remain in constant contact for instructions.

Curious machines can modify their mission to get more information. They don't just identify targets; they can realize they've found a new *kind* of target. They know enough to say, 'That looks like a starfish, *kind of*, but it's not what I was expecting. I need to know more.' Of course, machines don't really speak like this… yet. However, the recently established field of XAI (Explainable AI) is giving deep learning systems a voice with which they can convey the reasons

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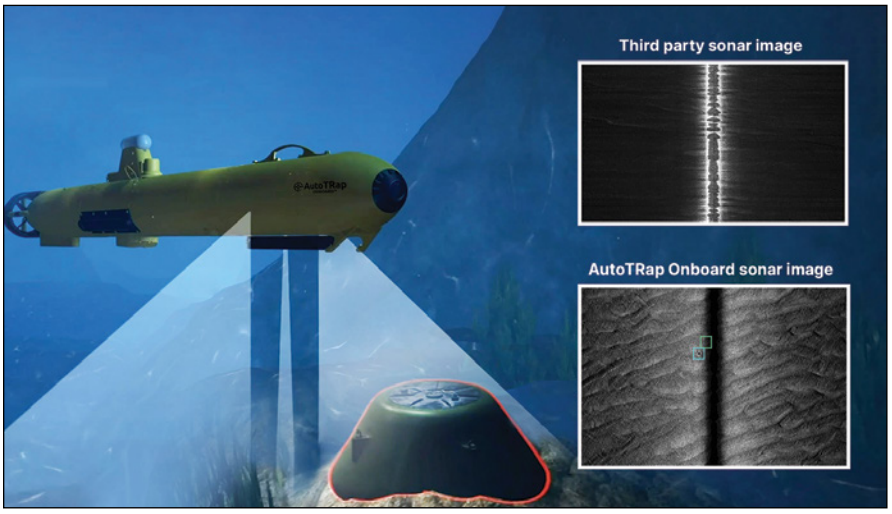
behind their decision and actions in a way that is natural and easy for humans to understand.

The future of autonomous vehicles means deployment for very long-term missions in unexplored locations and environments, from the deep sea to outer space. When they come across an anomaly, they need to know that what they're observing is new and interesting, and either make the decision to get closer or follow it to learn more.

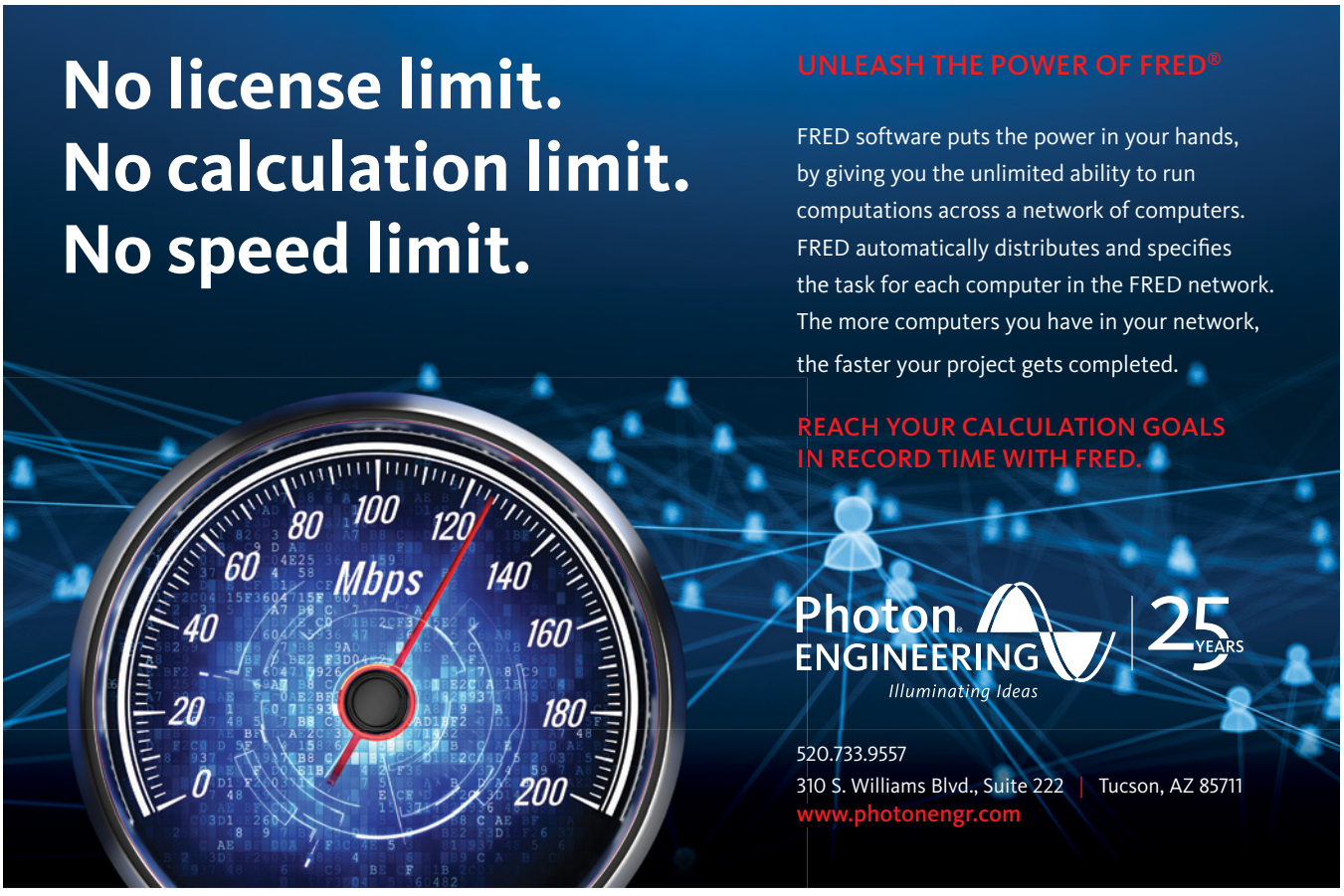
But creating a curious machine is not easy. To be curious, a machine must discern what's out of the ordinary; in other words, it must perform anomaly detection. Anomaly detection is complicated. It requires the machine to perceive something (detection) and know what it is or isn't (classification). This applies to a stationary object, like an undersea mine, or a moving one, or even groups of objects moving together, like marine life, which can require observation over days or weeks to gather enough data to determine what normal behavior is (that is, a baseline in a pattern of life analysis).

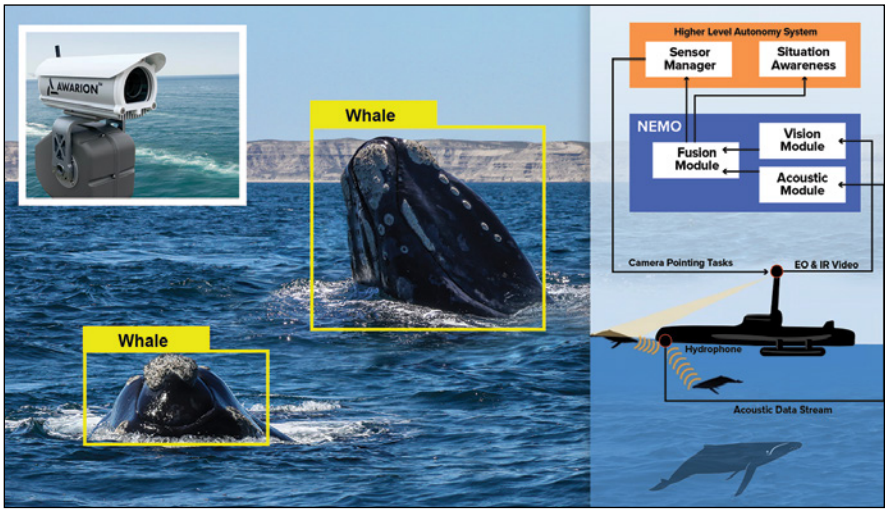
How Do We Construct Curiosity?

To be a curious member of a human-machine team, at-sea vehicles require more advanced R&D in many



AutoTRap Onboard™ automated target recognition and sonar image processing is being tested on Teledyne Gavia platforms for mine detection. (Image: Charles River Analytics)





NEMO combines information from the Awarion™ autonomous lookout system with deep-learning YOLO neural networks and probabilistic data fusion methods to accurately detect and classify marine mammals in visual and acoustic sensor feeds. (Image: Charles River Analytics)

The ALPACA machine learning agent not only learns how to navigate in outdoor environments, it also learns about its own competence at the task. (Image: Charles River Analytics)

fields: perception, AI algorithms, world modeling, navigation, anomaly detection, human-understandable communication, and more. Let's examine a few.

Perception: Signal Processing and Data Interpretation. Visual sensors (EO/IR) become less effective underwater, so their information must be fused with acoustic sensors (sonar, doppler, vibrometers). Advances in onboard image processing are needed to remove artifacts like "marine snow"—bright spots in underwater images from the reflection of particles suspended in the water—so the images are clear enough to support decision-making. All sensors must become smaller and require less energy to support longer missions to fully explore an area or track species' patterns of life.

Onboard Intelligence: Autonomy, Planning, Situational and Self-Awareness. We need a big shift in AI and machine learning to incorporate true situational awareness; that is, awareness of the surrounding external and internal environment. Artificial "intelligence" doesn't guarantee mission success—how AI performs depends on its knowledge of the environment and everything in it, including itself.

To accurately identify whether something is worth investigating in an image of the seafloor, an AI must also know the seafloor type, the state of the water column, and what is usual for that environment. It also needs to be aware of its own performance; if something is wrong with a sensor, it must discount that sensor's observations, the same way we would if we were wearing glasses with a smudge on the lens. At a higher level, it needs to know if it has enough experience in a certain environment, or if it has previously performed well or poorly in that environment.

All this information must feed into a decision-making process that supports curious behaviors. Decision-making software, that is, the combination of AI algorithms and knowledge models that can make a machine exhibit curiosity, must be able to run on small, lightweight, low-power processors onboard the vehicle.

Anomaly Detection: Target Detection, Classification, and World Modeling. Advances in target detection and classification on their own can't determine whether an object is unusual. That judgment requires a model of the environment, and an understanding of what is normal within it.

Currently, baseline parameters are mostly provided by humans, but by replacing these hardcoded rules with complex models, a machine can know, for example, how water and sediment tend to mix in a certain underwater environment, and how the information being returned by the sonar sensor should be interpreted differently as a result.

Development of a world model is in progress for the topography of the seafloor. Companies like Terradepth are using a fleet of autonomous submersibles to generate a set of detailed bathymetric maps so we can Google Earth above and below the water's surface.

Human-Machine Collaboration and Communication: Current methods of docking and transferring data

miss opportunities for discovery. By transferring (or even live-transmitting) raw data for human analysis, autonomous vehicles must wait to be redeployed or directed towards an interesting target.

Consider the alternative: a machine determines a finding is interesting enough to share, so it modifies its behavior—navigating toward the surface where it can communicate what it's found, then diving back down to find the next new thing. To make this real, humans must trust their machine teammate. To earn that trust, a machine must know when it may need human help to perform well, and it must be able to explain its decisions and actions in a language humans can understand.

Curiosity-Enabling Technologies

Scientists at Charles River Analytics are conducting leading-edge R&D in many of the areas required for humans to encode curiosity into autonomous underwater and surface vessels. AutoTRap Onboard™ is a target detection and classification system that delivers object type, confidence of detection, and position to a UUV's navigation system, letting it act on sonar data in real time. Awarion™ is an AI and computer vision system with a camera that sweeps the horizon and autonomously finds and tracks objects for follow-up observations, including whales, ships, and other objects at sea. Laser doppler vibrometry is also being explored for aerial, surface, and subsurface sensing.

In projects sponsored by NOAA and DARPA, sensors, detection, and classification software are being developed to support surveys of marine mammals. Learning agents aware of their own competence and software that can explain how an AI performs classification, such as detecting pedestrians in images, or how it makes decisions in game environments, have also been delivered.

Research on decision making under uncertainty is ongoing with the use of Figaro, a probabilistic programming language. World modeling is supported by Scruff, a newly released framework for combining different modeling paradigms in a coherent framework so they can be used for AI reasoning. In one application, these languages made it possible to convert "normal" software to adaptive software, which navigation and path-planning software onboard a UUV could use to quickly acclimate to new conditions.

For uncrewed systems to be truly autonomous and a trusted human-machine teammate, they must be curious. Curiosity is a specific form of intelligence, encoded by knowing what's normal and what's not, having the autonomy and ability to make a decision, and then executing behaviors to investigate further. To be trustworthy, machines must be aware of their own performance and communicate understandably about their decisions and actions. The pace of discovery will increase exponentially once a fleet of curious machines can be deployed in service to exploration and conservation.

This article was written by Arjuna Balasuriya, Sr. Robotics Scientist and Karen Pfautz, Principal Science Writer, Charles River Analytics (Cambridge, MA). **For more information, go to https://cra.com.**

Designing Multi-Channel Microwave Radio Systems Using Optical Interconnects

Imagine if it was possible to build multi-channel microwave radio systems leveraging optical rather than copper interconnects. Several benefits of this paradigm shift seem likely to occur including:

- Streaming sample control and configuration data, as well as reference clock and synchronization signals via fiber, simplifies radio front-end design and signal distribution whilst simultaneously reducing cable mass.
- Eliminating copper signal wiring in future radio designs offers increased architectural freedom and flexibility whilst reducing crosstalk and inter-channel interference for better performance.
- The optical concept substantiates a valuable separation of front-end analog design from back-end digital signal processing heralding the arrival of fully digital antennas with enhanced operation arising from advanced electronic beam steering.

On initial consideration, this optical transport idea may not seem especially innovative, given the profusion of optical links widely used across global data centers. There is a strong case for using fiber as highlighted in the accompanying sidebar. However, in the context of radio design, there are novel engineering challenges to be resolved.

It is important to highlight that this approach aims to transport all signaling between the analog signal environment and digital domains and thus must manage low-speed control signaling, handle reference clock distribution and, critically, ensure deterministic multi-channel synchronization. This is key since signal spatial (phase) information must be preserved if highly desirable electronic beam steering capabilities are to be facilitated.

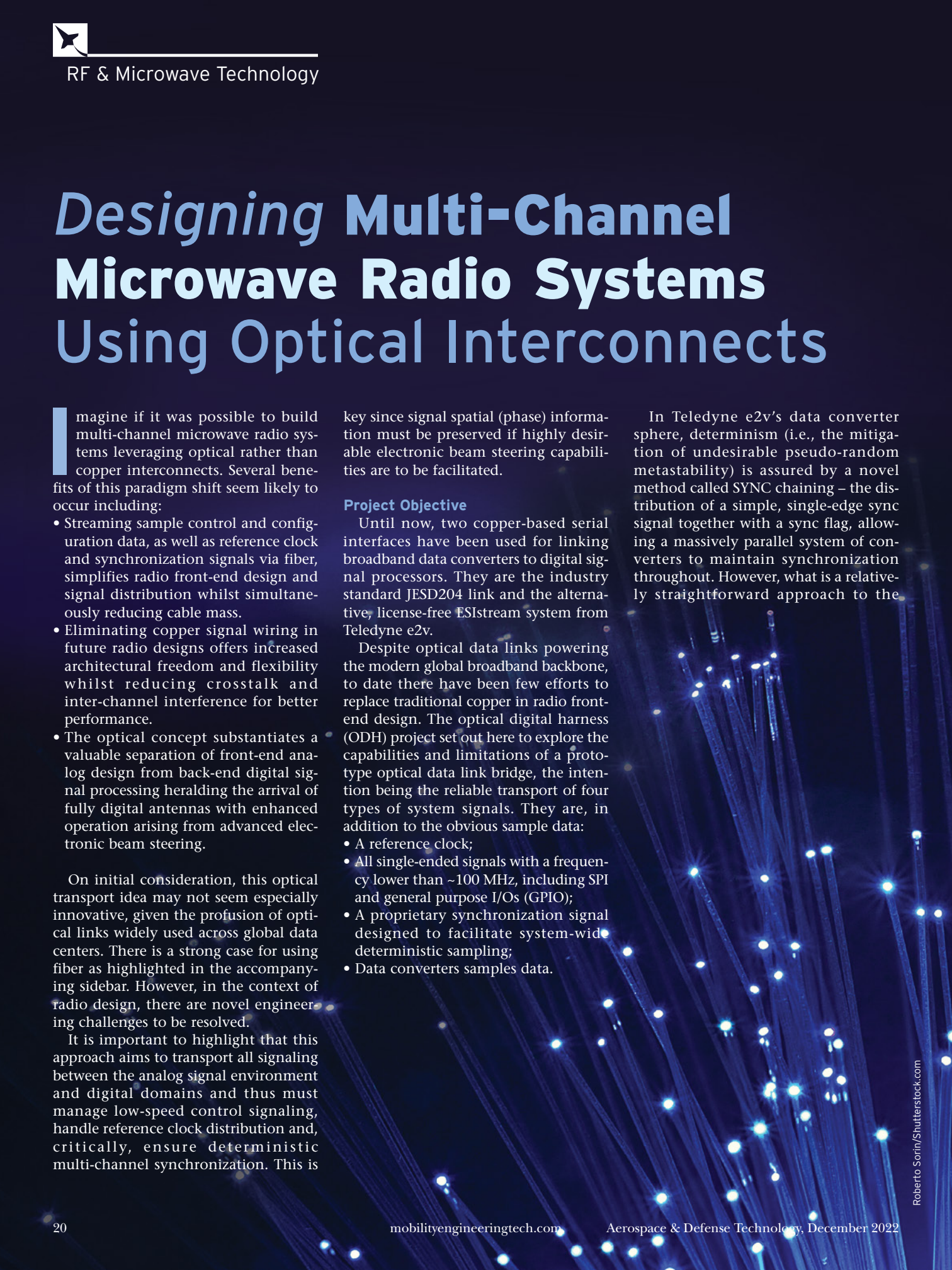
Project Objective

Until now, two copper-based serial interfaces have been used for linking broadband data converters to digital signal processors. They are the industry standard JESD204 link and the alternative, license-free ESIstream system from Teledyne e2v.

Despite optical data links powering the modern global broadband backbone, to date there have been few efforts to replace traditional copper in radio front-end design. The optical digital harness (ODH) project set out here to explore the capabilities and limitations of a prototype optical data link bridge, the intention being the reliable transport of four types of system signals. They are, in addition to the obvious sample data:

- A reference clock;
- All single-ended signals with a frequency lower than ~100 MHz, including SPI and general purpose I/Os (GPIO);
- A proprietary synchronization signal designed to facilitate system-wide deterministic sampling;
- Data converters samples data.

In Teledyne e2v's data converter sphere, determinism (i.e., the mitigation of undesirable pseudo-random metastability) is assured by a novel method called SYNC chaining – the distribution of a simple, single-edge sync signal together with a sync flag, allowing a massively parallel system of converters to maintain synchronization throughout. However, what is a relatively straightforward approach to the



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problem and easily implemented in copper, becomes more challenging in the shift to a fiber transport layer.

An experimental fiber-based prototype has been designed to evaluate its suitability as an alternative to copper as well as to identify any performance effects introduced by temperature and other environmental factors.[1] In the initial experimental phase, the physical fiber link is a modest ten meters – enabling significant separation between the microwave RF analog and data processing domains.

ODH Implementation

The main challenges defined at the start of this project were twofold:

1. Ensuring the reliable transport of relatively slow control signals of which the most important is;
2. The delivery of error-free, deterministic synchronization to multiple converters to ensure system-level determinism and thus synchronous sampling. This remains on the work in progress list at this point.

Earlier efforts working with fiber links have been described in a combined control and data context. One of note, from Lincoln University in the UK, describes an FPGA-based project[2] to aggregate SPI and GPIO data, to be sent over a single optical link. The article describes data coding approaches for extended transmission distances and illuminated the challenges arising. The earlier conclusions were:

- Care to establish reliable link synchronization, necessitating a master reference clock.
- Encoding is a key success factor. In the example described, 8b/10b coding proved orders of magnitude better than other simpler coding schemes (such as exclusive OR - XOR, or Grey codes).
- Finally, if latency is important, as it is for this experimental work, the authors detailed how re-synchronizing the link could compensate for known system latencies.

This previous work forms a basis from which to extend the current prototype work. A new solution proposed (Figure 1) takes economic, low-power programmable logic devices (here FPGAs) to be configured as simple coding engines with the objective to format, aggregate and serialize slow control vectors generated directly from system GPIO and SPI messages. Encoded message vectors are then transported across three parallel optical lanes with a reference clock and a discrete coded SYNC signal.

Experimental Implementation

The starting point for the prototype is an existing high-end IC evaluation system. A system comprising an advanced microwave front end card for the EV12AQ600 was selected. This quad channel, 12-bit 6.4 Gsps broadband RF ADC with the ability to sample up to 6.4 GHz offers a suitable FMC based target ADC for the prototype work. The EV12AQ600 has been designed to mount directly onto a powerful signal processing (DSP) card using

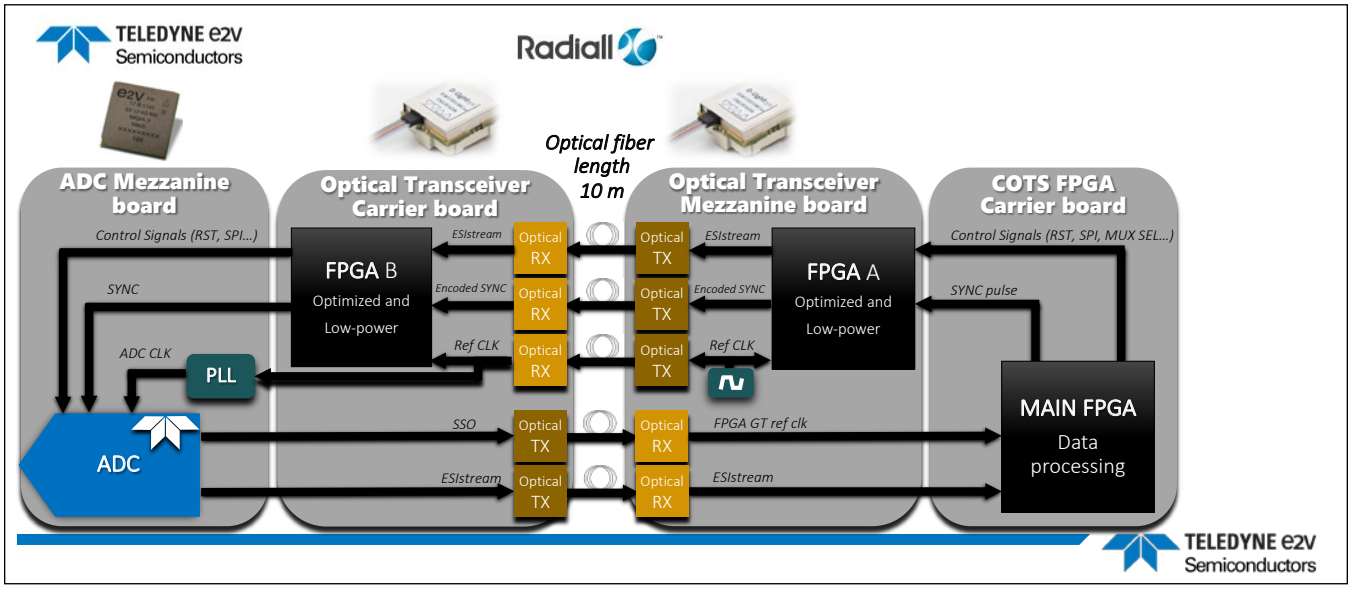

Figure 1. Optical Digital Harness Conceptual Design.

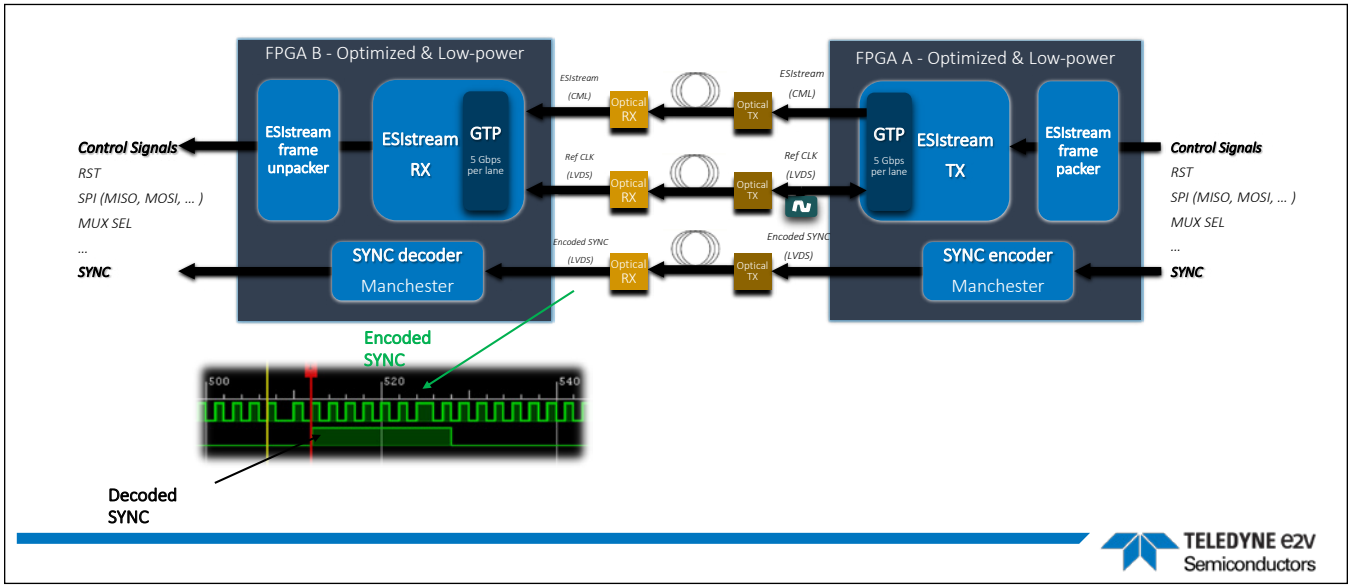

Figure 2. Manchester Encoding of the SYNC Edge.

a standard FPGA Carrier card format (FMC) connector. The FMC provides a useful physical break in the existing interconnect and, thus, an ideal insertion point for a modified fiber-based digital transport layer as shown.

Taking inventory of the various digital control and clock signals needed to bridge the FMC break point, three discrete fiber channels are required for control signaling headed to the remote receiver ADC. Moreover, two further channels handle data and SSO communication back to the DSP card.

Focusing on a practical solution, the search for cost-optimized, low-power programmable logic devices (PLD) was on. Following a market scan, Artix 7 FPGAs emerged as a suitable choice for the code engines. Referring to the system partitioning shown in Figure 2, it should be apparent that for future implementations the encode engine resources could easily be merged with the DSP FPGA for economy. Less than 5% of the Artix 7 resources are used today. Prototype expediency and programming ease meant that the coding engines would remain as discrete blocks in the early design.

Note also how the need for remote access to a reference clock forced the decode end of the prototype to require a

local clock generator. The physical layer is implemented using Radiall D-lightsys® VCSEL optical drivers. These drivers claim to support data rates from 100 MHz to 10 GHz with excellent clock jitter performance over this range. Radiall's rugged D light portfolio offers three data rate grades (10 Mbps, 5 & 12 Gbps) and multiple package options. These components are configured either as four-channel duplex transceivers or 12-channel simplex for receiver and transmitter applications. The drivers are protocol agnostic and offer both standard LVDS and CML electrical interfaces.

Two Key System Challenges

Two core issues are addressed in this prototype. They are:

1. Encoding the non-toggling SYNC signal to establish a robust optical SYNC-chain solution for system-wide application, ensuring determinism;
2. Ensuring full rate link locking.

Providing System-Wide Deterministic Synchronization

SYNC chaining has been documented in several previous articles, and as stated previously, is a critical success factor for this project if a truly useful optical alternative to copper is to emerge. The challenge in transitioning to robust SYNC distribution over fiber is that the SYNC signal is flagged by a relatively slow, 10ns logic level change. Given the 'un-clocked' nature of SYNC, how can its precise level transition be transported over fiber?

Manchester encoding is a simple phase-shift keying technique that provides a suitable option. Binary data gates the phase of a clock (Figure 2), effectively ensuring a mid-bit level transition, helpfully maintaining DC balance (in copper interfaces) and provides a regular source of data edges to ensure the optical link remains locked yet can distinguish SYNC assertion.

Manchester code is easily implemented by exclusive OR-ing (XOR) the SYNC signal with the reference clock which is already needed throughout the system. Even though a steady stream of zeros precedes SYNC assertion seen here, the receiver registers, within half a reference clock period, SYNC's low to high transition. Incidentally, latency might impact system-level synchronization and is part of the challenge to ensure determinism with copper-based links. With fiber, latency is orders of magnitude lower than copper. Accordingly, adjusting for differing SYNC travel times across multi- array systems becomes a vanishingly small problem in most practical cases giving the optical approach an edge.

Benefits of Fiber

- Enhanced performance – No crosstalk, Zero EMI
- Long distance communication >> 20 m
- Reduced weight, increased data density

Full Rate Link Locking

Success here relies on two factors. The first is inherent to the digital design of the coding engines. Moreover, the coding engine relies on the embedded PLL's ability to discriminate clock edges and synchronize to the reference clock. External to the code engine, is the optical link characteristics. Over a wide range of data rates, the performance of the link varies. For this reason, the optical transceivers provide internal current modulation control. This aspect of the prototype performance is not yet characterized and will be explored in greater detail as the project looks to performance over temperature.

Results So Far

Despite extensive digital simulation, the proof of operation is only possible once the hardware is in place and ready for power-up. Perhaps unsurprisingly, despite a rigorous round of checking, a couple of minor hardware errors slipped into the initial design which required some minor reworking.

Initial power-up also disappointed. Despite the evidence from comprehensive simulation effort, it proved challenging to track down the source of a problem preventing the receive end to lock to the reference clock. Suspicion started to form around the quality of the received serialized reference clock. This source became clear when lowering the reference clock rate from the nominal maximum 12.8 Gbps lane rate of the EV12AQ600 to a substantially reduced level at 9.0 Gbps (4.5 GHz reference clock) finally produced the sought- after link locking.

Conclusions

Despite not having attained full rate data signaling, the experimental design is proven to be robust over a ten-meter fiber although at a slower data rate than targeted. Furthermore, once link synchronization is established, the prototype runs non-stop without loss of link locking or change in bit-error rate (BER). Better still, the Radiall optical transceivers provide digital control of the optical modulation current. This permits further tweaking of optical transmission characteristics. This should ensure, that with some further optimization, that the data transmission eye can be enlarged to allow full rate transport at 12.8 Gbps soon.

Several important issues require further verification before the development team can claim success. The most important of these is to verify that rather than simply demonstrating SYNC decoding at a single receive location, that a wider system-level deterministic multi-channel operation is possible. Moreover, that determinism can be maintained over varying environmental conditions - particularly temperature and voltage shifts.

Time will tell, but progress to date is encouraging and we stand on the brink of a major paradigm shift towards advanced digital, smart microwave antenna design.

This article was written by Stéphane Breysse, Application Engineer, Teledyne e2v (Chelmsford, UK). **For more information, visit https://www.teledyne-e2v.com.**

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2. Cross-channel synchronization is further complicated by metastability – an inherent, pseudo-random behavior of digital systems. It can be mitigated through careful design.

mmWave is enabling 5G-based systems such as augmented reality displays to enhance situational awareness for soldiers on the battlefield.

Solving Military Satellite, Radar and 5G Communications Challenges with GaN-on-SiC MMIC Power Amplifiers

Developers of aerospace and defense systems need RF power amplifiers (PAs) to perform much better across both existing and emerging applications such as military 5G and satellite communication. Systems need to meet higher gain targets but not if it comes with any increases in cost and complexity, or size and weight. As systems move to higher-order modulation schemes, they also must deliver adequate linearity and efficiency in an environment that is even more susceptible to distortion than was the case with earlier schemes. Reducing board space is another critical issue that has required challenging peak-to-average power ratio (PAPR) tradeoffs

A new generation of Gallium Nitride (GaN) Monolithic Microwave Integrated Circuits (MMIC) PAs offers a solution to these challenges, which are especially difficult for bringing 5G networking to both on-battlefield and off-battlefield applications in the unused millimeter wave (mmWave) band that is not as vulnerable to high-power jamming signals.

New Applications, Tough Challenges

In the aerospace and defense sector, some of the biggest challenges and opportunities for RF PA technology are in satellite communications and radar systems, as well as emerging 5G communications solutions for both on-battlefield and off-battlefield applications.

For instance, NASA has enabled private-sector companies to launch thousands of low-Earth-orbit (LEO) satellites that are now circling the Earth and delivering broadband Internet access, navigation, maritime surveillance, remote sensing and other services. New types of radar systems are also in demand (Figure 1).

Figure 1. RF PA applications in military communications range from satellite communication and tactical platforms and terminals to acoustical and optical communication platforms, base communications infrastructure, network security and encryption systems, and interception and jamming systems.

One example of these radar systems is used to alert pilots to any hostile or foreign radar activity and whether they are being "painted" by the radar of a friend or foe. This can be accomplished with both primary and secondary radar systems. A primary radar system transmits pulsed RF power and receives backscatter data that is used for tracking, surveillance and weather. In contrast, a secondary radar system transmits RF signals at one frequency, which is received by an antenna and decoded, and then responds on a different frequency. In addition to performing friend-or-foe identification using 1030 Megahertz (MHz) and 1090 MHz frequencies, secondary radar systems can be used for distance-measuring equipment using the 960 MHz to 1090 MHz frequencies, and general communications using transponders.

RF PAs are also needed for a new generation of mmWave 5G communications solutions that, by virtue of their speed, ultra-wide bandwidth, and low latency for broadband communication, will substantially increase how much information can be shared in support of real-time decision-making and other military applications. 5G systems operating in wide bandwidths have been vulnerable to high-power jamming signals, but jammers will now have to move into the mmWave range for these close-range 5G-based systems. Examples include battlefield sensor networks for command-and-control data gathering, and augmented reality displays that enhance situational awareness for pilots and infantry soldiers (Figure 2).

5G will also enable virtual reality solutions for remote vehicle operation in air, land, and sea missions. Off the battlefield, 5G will enable a variety of smart warehouse, telemedicine, and troop transportation applications. Each of these applications requires high-performance power technology to meet the high-speed data rates required for video and broadband data. RF PA suppliers have had to balance a mixture of conflicting requirements in order to increase performance from one end of the transmission path to the other.

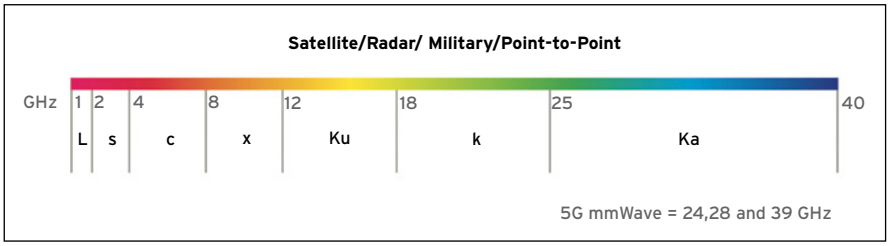


Figure 2. Frequencies for military and 5G applications.

Component	Key parameter	Key Benefit
LNA	Noises Figure (dB)	Improved Range/Signal Sensitivity
PA	OIP3 (dBm) & Pidb (dbm)	Linear/Power - Low Distortion
Prescalers	Phase Noise (dBc) @ khz offset	Low Noise Floor - More Range
Wideband Switches	Low Loss (dB) / High Isolation (db)	Low Harmonics in system

Figure 3. Key figures of merit used in military components for satellite communications, radar systems and 5G networks.

RF PA Requirements Vary by Application

Defense and aerospace applications operate in different frequency bands (Figure 2). Satellite communications for LEO and geosynchronous communication operate in the K band, which spans from 12 GHz to 40 GHz. Radar systems operate in the 1 GHz to 2 GHz L band for applications including "identify friend or foe," distance-measuring equipment, and tracking and surveillance. S band (2 GHz to 4 GHz) is used for selective response Mode S applications and for weather radar systems. X band (8 GHz to 12 GHz) is used for weather and aircraft radar, while C band (4 GHz to 8 GHz) is used for 5G and other sub-7 GHz communications applications. 5G mmWave provides the highest bandwidths and data rates of these applications, operating in the 24 GHz and higher frequency bands.

Each application also has different needs. For instance, one of the critical figures of merit for 5G applications is the PA's linear output power. Power density must be as high as possible across a broad frequency range. The table in Figure 3 shows the key points of merit used in components for today's existing and emerging aerospace and defense applications.

One of the biggest PA requirements is that it can operate in its linear region where distortion products are minimal. This increases complexity, cost, size and weight though, since more gain stages are then required to offset the reduction in RF output power that can be delivered in this region. Even then, gain distortion can come into play. Also known as AM/AM and AM/PM distortion, it describes the output phase variation against input power and is often caused by a PA's nonlinear capacitors. This occurs when the PA is operated near or even beyond its saturation point to maximize conversion efficiency and generate as much power as possible, which leads to device nonlinearities and a compression or peaking of the PA with input power. Compensation is required using techniques like digital predistortion.

Developers face another flavor of distortion with satellite communications systems that use higher-order modulation schemes. This includes 64/128/256 Quadrature Amplitude Modulation (QAM), which is extremely sensitive to non-linear behavior. Another challenge

is achieving satisfactory peak-to-average power ratio (PAPR) – that is, the ratio of the highest power the PA will produce to its average power. PAPR determines how much data can be sent, and is proportional to the average power. At the same time though, the size of the PA needed for a given format depends on the peak power.

These and other conflicting challenges can only be met with GaN MMIC PAs, especially for satellite and 5G applications.

GaN MMIC PA Benefits for Ka-Band Satcom Applications

Most of today's LEO satellites operate in the 27.5 to 31 GHz Ka-band spectrum where they are playing a major role in supporting the tsunami of traffic being generated by video and other data-intensive applications. Unlike the traveling-wave tubes (TWTs) traditionally used as power sources at these frequencies, GaN offers higher efficiency and much lower operating voltages. GaN is also ideal for satellites in geosynchronous orbit that need their inherent radiation tolerance.

GaN-based PAs are also much smaller than TWTs and better aligned with the needs of active phased array antennas. They remove any requirement for complex and burdensome power combiners. They also deliver more RF power in a smaller footprint than gallium arsenide (GaAs) options, while operating at higher voltages.

GaN MMIC PA Benefits for Military 5G Networks

The mmWave (24 GHz to 100 GHz) frequency spectrum is much less congested than lower frequency bands that are struggling to keep up with the signal traffic from TV, radio, and current 4G LTE networks operating between 800 and 3,000 MHz. The higher the frequency bands, the more data can be carried (albeit over much smaller areas). This is what the military needs in its coming generation of close-range 5G-based systems. The mmWave band can be used to increase data bandwidth over smaller, densely populated on-battlefield and off-battlefield networks.

GaN can extend 5G New Radio (NR) femto- and pico-cell base stations deployments into the mmWave band for these military applications, where they will deliver the necessary bandwidth and data rates. Laterally-Diffused Metal-Oxide Semiconductor (LDMOS) MOSFETs are insufficient at >3.5 GHz. GaAs is incapable of delivering high enough power in the mmWave band without moving to an extremely large die. GaN offers the right balance of higher frequencies and power, wide bandwidth, and the required thermal properties, gain, low latency, and high switching speeds.

To fully realize their promise though, GaN MMIC PAs also need silicon carbide (SiC) substrates that improve power density by enabling MMICs to offer better thermal conductivity than is possible with silicon-based wafers.

Effects of Adding SiC Substrate

The use of SiC-based substrates improves GaN MMIC PA power density through better thermal conductivity than is possible with silicon-based wafers. Additional benefits include higher wafer yields because of SiC's better lattice match with GaN, and a 20 percent smaller package size as compared to LDMOS technology, plus greater efficiencies. Air and space-based systems get the optimum combination of high-power density and yield in the smallest footprint, along with lower weight, the highest possible power support, superior efficiency, and support for high-voltage operation with a longevity of at least 1 million hours at a junction temperature of 255 °C.

Component suppliers are bringing GaN MMIC PAs to market across more frequency options and more choices of bare die and packaged MMIC PA products. These offerings, along with complementary discrete high electron mobility transistor (HEMT) devices and other components, will give military system developers new ways to meet the unique needs of next-generation radar systems, satellite communications solutions, and 5G mmWave networks. GaN MMIC PAs will help solve the difficult linearity and efficiency challenges of higher-order modulation schemes and enable system designers to bypass the shortcomings of GaAs, LDMOS and TWT-based PAs so they can reach the necessary gain improvements for aerospace and defense applications without compromising on cost, size, weight, complexity or PAPR requirements.

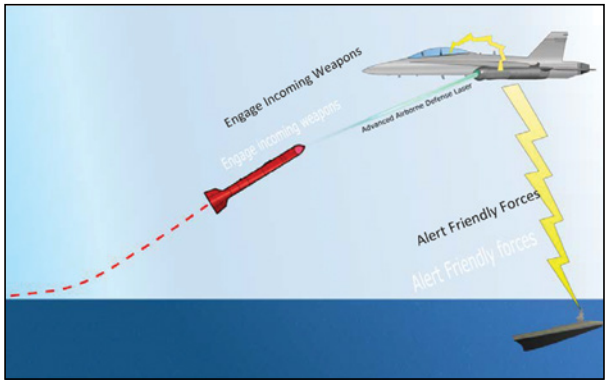
This article was written by Michael Ziehl, Senior Manager of Product Marketing; and Baljit Chandhoke, Product Manager, Microchip Technology Inc. (Chandler, AZ). **For more information, visit https://www.microchip.com.**

Advanced Airborne Defensive Laser for Incorporation on Strike Fighter Aircraft

A technical and operational analysis of an airborne "hard-kill" Ytterbium fiber laser-based anti-missile system for use on strike fighters.

Naval Postgraduate School, Monterey, California

Short-range missiles pose a significant threat to U.S. strike fighters. These missiles are usually small and highly mobile and can be carried on light vehicles and by individual people. Although these missiles do not have a long range, the unpredictability of their launch sites increases their lethality. Also contributing to their lethality are the methods of homing in on their targets. Most are passive methods, such as infrared. Unlike active radar homing, these missiles provide no warning to the aircraft that it is being tracked until the missile has been launched.



Single Missile Fired at Host Aircraft.

The varieties of homing methods for these missiles can also provide problems for aircraft countermeasure systems. Each type of homing method requires a different type of countermeasure. All current airborne countermeasure systems rely on "soft-kill" methods of protection involving confusion or distraction of the homing system. These systems work differently for different homing methods and must be constantly upgraded to protect against ever more complex targeting systems.

A "hard-kill" Advanced Airborne Defensive Laser (AADL) system could use a high-energy laser to either destroy an incoming missile or cause enough physical damage to prevent the missile from intercepting its target. The AADL will be an external pod mounted on a strike fighter and will be almost entirely autonomous. The system will detect missile launch, track targets, and eliminate them. It will use built-in systems for power generation, target tracking, and laser transmission.

The concept of operations (CONOPS) of the system begins with detecting missile launch. The system detects the missile and automatically begins tracking it and plotting a firing solution. Simultaneously, the mission computer of the AADL uses the host aircraft's communication systems to alert the pilot and friendly forces to the threat. Once a firing solution has been determined and the laser transmitter moved into position, the incoming missile is fired upon and neutralized. This action is taken without input from the pilot as any delay from human reaction time can cause disaster.

After the threat is neutralized, the pilot and friendly forces are once again notified. If there are further incoming missiles, the highest priority threat is targeted and engaged. A set of requirements describing the actions necessitated by the CONOPS in further detail was also developed. Based on these requirements, a functional architecture was created. This architecture breaks those requirements down into a hierarchy of functions and allows, in combination with the physical architecture, creation of an allocated architecture. This physical architecture is a generalized relationship of components based on research into existing systems analogous to the subsystems of the AADL. Following this, an allocated architecture was developed, showing that every function is accomplished by a component.

Research was then conducted into currently existing technology that could be used to develop design alternatives for the AADL. These alternatives consisted of technology for the power supply, laser transmission, and targeting subsystems. These specific subsystems were analyzed because these were the main subsystems whose functions could not be accomplished by technology commonly used by the U.S. military. These technologies were analyzed for cost, effect on flight performance, technology risk, and functional performance. Because of the immature nature of these technologies, the cost could not always be established. Where that information was not available, information on construction materials and methods was used to provide a comparative cost between alternatives.

Effect on flight performance was established by comparing the weights and speed limits of the alternatives. Technology risk was based on the Technology Risk Level standards established by the Department of Defense. Finally, the functional performance was assessed through the use of computer simulations. These simulations use a program named ExtendSim to model the positions and velocities of the aircraft and incoming missiles. This information was then passed to a physics-based high-energy laser modelling program called HELEEOS to determine the amount of time needed to neutralize the missile.

This work was performed by Stephen Cannon, Timothy Kaniss, Nathan Lautzenheiser, Cesar Rios, Greyson Siegel, Jeremy Smith, and Eric Wright for the Naval Postgraduate School. **For more information, download the Technical Support Package (free white paper) at mobilityengineeringtech.com/tsp under the Lasers & Photonics category. NPS-0026**

Additive Manufacturing Utilizing a Novel In-Line Mixing System for Design of Functionally Graded Ceramic Composites

Exploring the development of a direct ink writing system with multimaterial and in-line mixing capabilities for printing inks composed of high solids-loaded ceramic particulate suspensions.

Army Research Laboratory, Aberdeen Proving Ground, Maryland

The impetus for advancing brittle ceramic materials used for armor applications has been identified as both an increased mass efficiency for greater weight reduction and enhanced performance against ballistic threats through manipulating the physics of failure.

Development of functionally graded ceramic composites is a potential solution for enabling new dynamic fracture and deformation mechanisms in armor materials, surpassing that of the individual intrinsic material behaviors. However, engineering of these composite structures is currently limited due to the stochastic nature of traditional powder mixing and processing. Thus, additive manufacturing (AM) is being studied as an enabling technology for processing discrete mesostructural features, complex geometries, and compositional variation.

Various traditional ceramic forming technologies exist including pressing, extrusion, slip casting, tape casting, and injection molding. However, these traditional forming techniques often only allow 2-D design freedom, cannot create internal or multiscale features, and require complicated and expensive dies. On the other hand, AM enables the production of parts with complex, multiscale geometries including internal structures. Additionally, multi-material AM allows for the mimicking of biological composites that take advantage of hierarchical structures and compositional gradients to increase their strength and toughness.

Three main categories of AM exist: extrusion-based processes, liquid-bed processes, and powder-bed processes. Extrusion-based processes, such as fused deposition modeling (FDM) and direct ink writing (DIW), raster a print head across the print-bed layer by layer while extruding a continuous trace of material. Liquid- bed processes, such as stereolithography, use a laser or other energy source to cure resin layer-by-layer as the build plate further submerges. Powder-bed processes, such as selective laser melting/sintering, use a laser or other high-power energy source to melt/sinter powder in a layer-by-layer fashion as the print-bed moves downward and more powder is spread over the print area.

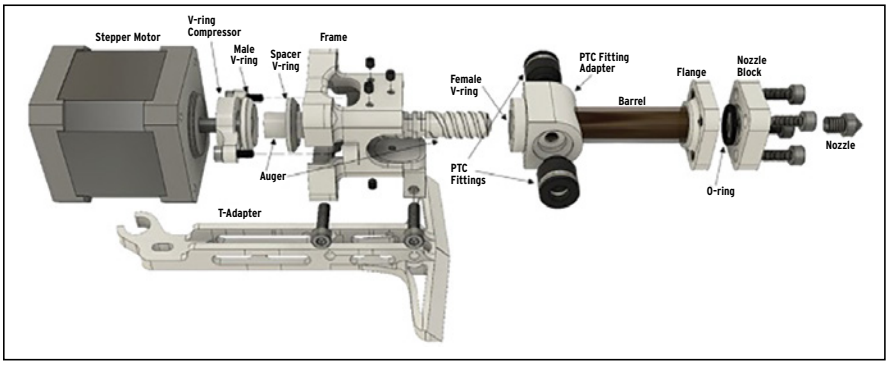
Exploration of next-generation ceramic armor composites will require high-resolution, multi-material, and mixing capabilities to print structures that have compositional gradients, internal structures, and hierarchical organization. Powder- and liquid-bed processes run into issues with multi-material applications because the powder/liquid vat must be switched for every composition variation. The extrusion-based FDM method of ceramic-filled polymer filament creates parts with low green density, leading to low percent theoretical density following sintering. Ink jetting, a popular commercial solution to ceramic AM, again produces porous parts with low density. DIW, on the other hand, shows significant promise for studying these composites because it fulfills each requirement.

The DIW technique, also known as robocasting, involves extrusion of a line of highly loaded colloidal suspension, termed "ink", through a small nozzle in a specific pattern layer by layer to produce a 3-D part. Unlike FDM, where printed material solidifies directly after extrusion, DIW relies on the yield-pseudoplastic rheological behavior of the ink for structural integrity following extrusion.

Yield-pseudoplastic rheology gives the ink structural integrity up to its yield stress, followed by shear-thinning behavior. When the ink is designed with this rheological behavior, it can easily flow through the nozzle due to the high-shear environment, but after extrusion (yield stress goes to zero) it can retain its shape due to its yield strength.

Just as important as ink printability is post-print processing performance – namely shape retention and densification characteristics. A postprocessed part must be as close to 100 percent theoretical density as possible to have acceptable ballistic performance.

A prerequisite of high sintered density is high green density, necessitating high particulate-loading and low binder/dispersant content in the ink. However, high solids-loading and low binder/dispersant content leads to dilatant behavior and poor printability. Thus, a balance must be found between printability, yield-point, and post-print processing behavior. These competing factors result in a complex ink design process, where



Exploded view of a print head to demonstrate component positioning.

constituent type, content, and interaction are of paramount importance. Although complicated, understanding of colloidal ink processing has advanced to a point where there is flexibility available in terms of binder/dispersant selection, allowing selection of a variety of material systems.

This work was performed by Joshua Pelz, Nicholas Ku, Marc Meyers, and Lionel Vargas-Gonzalez for the Army Research Laboratory. **For more information, download the Technical Support Package (free white paper) at mobilityengineeringtech.com/tsp under the Manufacturing & Materials category. ARL-0249**

Hierarchical Diamond-Based Ceramic Composites

An innovative combination of experimental synthesis and testing and multiscale simulation techniques explored the effects of hierarchical microstructure (mesoscale diamond packing and nanoscale interfaces) on the mechanical and ballistic performance of diamond–silicon carbide (SiC) composite ceramics.

Army Research Laboratory, Aberdeen Proving Ground, Maryland

This research developed and utilized advanced processing, modeling, and micromechanical tools to discover and demonstrate hierarchically structured diamond-based composites with exceptional mechanical and ballistic behavior. Understanding how nanoscale and mesoscale microstructural features in diamond–silicon carbide (SiC) composites influenced the physics of failure was critical in uncovering ways to improve performance for soldier protection and discover potential defeat mechanisms.

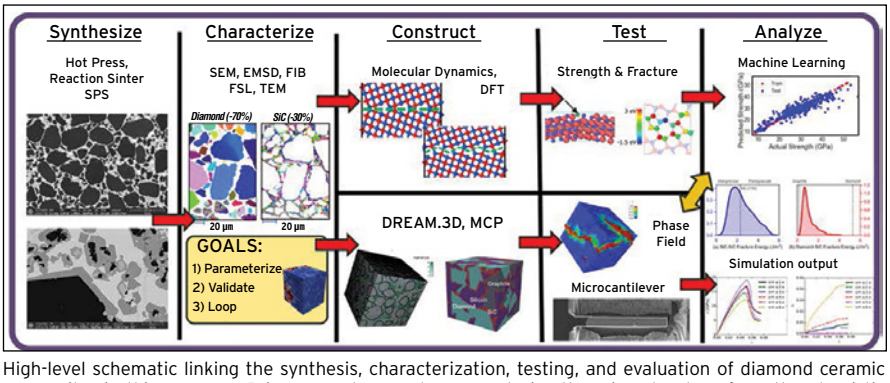
Emphasis was placed on the fundamental understanding of the deformation and failure mechanisms, which enabled the design and development of robust materials to support Army core functions. Development of new materials was the focus with specific emphasis on fundamental knowledge of microstructural grain boundaries in diamond-SiC composites. Novel processing routes to selectively tailor the nano-mesoscale microstructure in heterogeneous ceramic armors were explored via conventional hot-pressing, reactive hot-pressing, and spark plasma sintering (SPS). Correlations between the nano-mesoscale hierarchical microstructure, deformation mechanisms, and mechanical response were explored using advanced characterization methods and small-scale mechanical testing. Higher fidelity mesoscale mechanics models were sought by using experimentally obtained microstructural information coupled with atomistic models of relevant grain boundary interfaces.

SiC and boron carbide (B4C) have long been investigated as materials critical to the performance of armor ceramic and related systems. Their combination of high hardness, low density, and strength have long been identified among the key differentiating characteristics for ceramic materials. Over roughly the last two decades, diamond-SiC composites have been developed for commercial applications requiring high abrasion resistance, thermal stability, and thermal conductivity. Thus, it follows that composites made from the hardest known bulk material, diamond, could be integrated and optimized for armor ceramic systems.

While extensive work at the U.S. Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) has improved the knowledge and performance of SiC- and B4C-based armors, the inclusion of diamond has received comparatively little attention. Globally, the diamond grit industry is driving down costs such that diamond-based composite armor solutions are more tractable. These factors combined to inspire this basic research study in diamond-based ceramic composites.

The most common low-pressure processing route is a liquid silicon (Si) infiltration method where Si reacts with a carbon (C) source to form SiC under ambient or low pressure. Diamond-SiC composites made by this technique require a minimum of large open pathways between the diamond particulates for Si migration, which constrains the amount of diamond solids loading. Low C diffusivity in SiC can also limit the reaction leaving residual Si metal within the matrix if the initial distribution of carbon and infiltration pathways are not carefully optimized.

Research studies investigating diamond ceramic composites currently produced using these methods have shown that



High-level schematic linking the synthesis, characterization, testing, and evaluation of diamond ceramic composites in this program. Primary goals were to parameterize the microstructure from the atomistic through mesoscale hierarchy using an array of modeling and targeted experimental techniques that validate the outputs and allow iterative developments that improve material properties.

their performance is linked to hierarchical microstructure features. In diamond-SiC these hierarchical microstructural features can be divided between the mesoscale distribution of super hard diamond particulates and the nanoscale interfaces between the diamond-SiC and SiC grain boundaries. Prior research studies have shown there are likely correlations between these hierarchical features on the mechanical response. For example, the overall concentration of diamond particulates plays a major role in the hardness as described by composite theory.

Prior work in this area noted that the performance of diamond-SiC is also influenced strongly by the interfacial strength between diamond and SiC[12] and that decreasing the grain size of the SiC matrix can improve the fracture toughness from 8 to 12 MPa·m$^{1/2}$ (a dramatic increase over bulk diamond at 3–5 MPa·m$^{1/2}$). Because the initial intended application of these composites was never for armor, prior research on the terminal mechanics of diamond-SiC under high strain rates is extremely limited. The only known ballistic data on high-solids content diamond materials demonstrated a 45 percent improvement over B4C in the transition impact velocity against tungsten heavy alloy penetrators. Extensive studies have not examined the ballistic response of polycrystalline or single crystalline diamond due to high material costs and unavailability in sizes of interest.

This work was performed by Anthony DiGiovanni, Shawn Coleman, Matthew Guziewski, Jerry LaSalvia, Mathew Ivill, Samuel G. Hirsch, William T Shoulders, Raymond Brennan, Philip Goins, Thomas Scharf, Jonathan Ligda, Daniel Magagnosc, Brian Powers, Richard B. Leavy, John Clayton, Debjoy Mallick, Jennifer Dunn, S. Vennila Raju, Michael Kornecki, Scott Walck, and Brian Schuster for the Army Research Laboratory. **For more information, download the Technical Support Package (free white paper) at mobilityengineeringtech.com/tsp under the Manufacturing & Materials category. ARL-0251**

Biobased Carbon Fibers and Thermosetting Resins for Use in DOD Composites Applications

Using biological resources to make advanced fibers and high-performance thermosetting resins will help reduce the dependence of military composites on the volatile cost of petroleum, resulting in significant technological gains and reducing the toxicity of composite materials.

Army Research Laboratory, Aberdeen Proving Ground, Maryland

The goal of this research was to use renewable resources derived from plants and other sources to prepare high-performance carbon fiber and thermosetting matrix resins with high strength and high thermal resistance. The scientific objectives were to 1) develop methods for breaking down, modifying, and processing renewable resources to make epoxy resins, vinyl resins, and carbon fibers, and 2) determine structure-property relationships for these novel materials.

Numerous scientific and engineering advancements were developed in this project. Bacteria can successfully decompose lignin into useable structures for the formation of small filaments that might be possible to convert into carbon fibers. Approximately 300 strains of bacteria that decompose lignin were identified, and some have the potential to make lignin into fiber-forming oligomers, including newly identified species of Serratia. However, scale-up of this process proved problematic and unfeasible for completion in this project.

Lignin was chemically fractionated to alter its molecular weight distribution and its usefulness for separating chemically modified lignin. Various chemical modifications of lignin have been used successfully in carbon fiber development. These methods include acetylation and methacrylation, and separation strategies were developed to produce carbon fiber precursors. Both melt- and solution-spinnable lignin-based fibers were produced. Thermo-oxidation and UV curing were successful stabilization methods for these fibers.

Carbon fibers were produced from a few types of lignin and chemically modified lignin. The resulting mechanical properties were relatively poor, but there are obvious steps that need to be taken to improve these properties. Electrical conductivity of these fibers ranged from moderately conductive, similar to that of polyacrylonitrile (PAN)-based fibers, to highly conductive, indicating a significant graphitic content. The highest mechanical properties were achieved for lignin-based carbon fibers by stretching the fibers during processing, resulting in modulus of 35 GPa, strength of 1 GPa, and elongation to failure of 3 percent, significantly exceeding the state of the art in lignin-based fibers. However, life cycle analysis of the lignin-based carbon fibers is not favorable due to the recent reduction in cost of PAN-based carbon fibers.

Numerous biobased resins were developed, including epoxies, vinyl esters (VEs), unsaturated polyesters (UPEs), and polyurethanes, many with excellent properties that can be used in high-performance polymers, composites, and coatings applications. Lignin-based cross-linkers have been prepared that have performance similar to that of bisphenol A cross-linkers while having significantly reduced toxicity. For example, Isosorbide methacrylate was developed with the highest ever transition temperature of greater than

250 °C for a VE system. This work has also produced numerous reactive diluents and viscosity reducers for VE and UPE technology based on fatty acids, lignin, and isosorbide that will maintain or increase polymer performance while reducing hazardous emissions.

Biobased lignin-derived resins with high-bioatomic efficiency that are good for the lower end of high-performance composites and most coatings applications were identified. Furan epoxies are very promising with good thermomechanical properties and very high toughness, making them excellent candidates for composites and coatings applications. Higher-performing UPE resins using isosorbide as an additive or component were developed, but the feasibility for scale-up is low due to the long reaction times required.

Various weapons platforms that use composite materials including the Apache helicopter, the high-mobility multipurpose wheeled vehicle, Stiletto, F-22, and USS Radford.

This work was performed by John J. La Scala, Joshua Sadler, Faye R. Toulan, Anh-Phuong Lam, Christopher Annunziato, Amod Ogale, Meng Zhang, Annel Greene, Steven Chambers, Joseph Stanzione III, Kaleigh Reno, Richard Wool, Fengshuo Hu, Eric Hernandez, Donghun Koo, and Giuseppe Palmese for the Army Research Laboratory. **For more information, download the Technical Support Package (free white paper) at mobilityengineeringtech.com/tsp under the Manufacturing & Materials category. ARL-0252**

MOVPE Growth of LWIR AlInAs/GaInAs/InP Quantum Cascade Lasers: Impact of Growth and Material Quality on Laser Performance

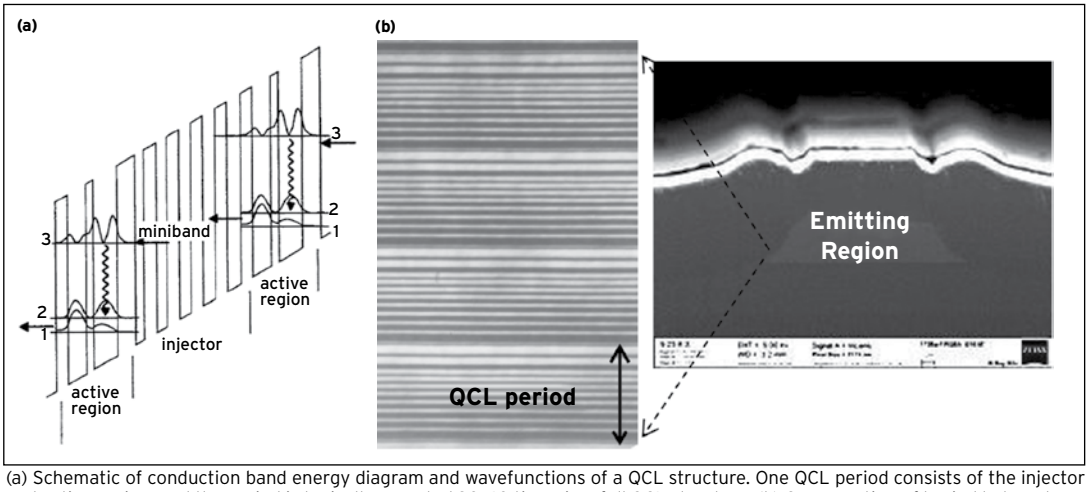
The quality of epitaxial layers in quantum cascade lasers (QCLs) has a primary impact on QCL operation, and establishing correlations between epitaxial growth and materials properties is of critical importance for continuing improvements in QCL performance.

Massachusetts Institute of Technology, Lexington, Massachusetts

Quantum cascade lasers (QCLs) are compact coherent optical sources that emit over a wide wavelength range in the mid- to long-infrared (3-25 µm) as well as into part of the terahertz spectrum. With recent developments of AlInAs/GaInAs/InP QCLs exhibiting watt-class output power levels at room temperature in the mid-wave infrared (MWIR, 3-7 µm) and long-wave infrared (LWIR, 8-12 µm) regions, QCLs have become increasingly attractive for numerous technological applications including infrared countermeasures, free-space communications, and chemical and biological sensing.

As interest in QCLs continues to grow, so does the desire to improve performance and understand factors that may ultimately limit these unique and complex devices. QCLs are unipolar devices based on tunneling and intersubband transitions between quantum-confined energy states in the conduction band of a coupled quantum-well structure. These structures are designed using band structure engineering to optimize optical transitions and electron transport for laser characteristics such as wavelength, threshold, power, efficiency, and high-temperature operation.

A typical QCL structure consists of a complex sequence of barrier and quantum well layers, totaling ~600-1000 layers, with thickness ranging between 0.6 to 6 nm. With the requirement of so many ultra-thin layers being reproducibly grown over microns of thickness, it is not surprising that while the first proposal to use intersubband transitions for radiation amplification was proposed in 1971, it was over 20 years before QCLs operating at cryogenic temperatures were first demonstrated in 1994, and another eight years for room temperature continuous-wave (cw) operation in 2002.



(a) Schematic of conduction band energy diagram and wavefunctions of a QCL structure. One QCL period consists of the injector and active region, and the period is typically repeated 30-40 times in a full QCL structure. (b) Cross-section of buried heterostructure QCL (right) and transmission electron microscopy cross-section of a portion of a QCL core.

Exacting epitaxial growth of QCL structures goes hand-in-hand with optimization of its band-structure and wavefunction modeling, advanced processing involving fabrication and epitaxial regrowth of high-aspect ratio devices, and demanding heat-sinking packaging.

Impressive progress has been made in each of these areas and QCLs with improved operating temperature, wavelength range, output power, and efficiency are routinely possible. Record performance at room temperature is 5W cw output power and 21 percent wall plug efficiency (WPE) in the MWIR and 2W cw power and 10 percent WPE in the LWIR. Those QCLs were grown by molecular beam epitaxy (MBE) or gas-source MBE, which are both high-vacuum growth processes.

Another viable growth technique for QCLs is metalorganic vapor phase epitaxy (MOVPE), which operates at or slightly below atmospheric pressure. It is the mainstream platform for more conventional p-n optoelectronic devices and was shown to be also suitable for QCL growth in the early 2000s. Comparable performance between MOVPE and MBE-grown QCLs was demonstrated in 2006, although the QCL structures were different. With these encouraging results, numerous groups have pursued MOVPE for development of QCLs, and have achieved a high level of success.

Despite these accomplishments, the epitaxial growth of QCL structures continues to be a challenge. In particular, the emission wavelength from QCLs of the same structure can not only be different when grown by MBE or MOVPE, but also different when grown by MOVPE at different organizations. For example, even though the same QCL structure was used, MBE- and MOVPE-grown QCLs emitted at different wavelengths. MBE-grown QCLs had emission at 9.3 µm, while MOVPE-grown QCLs from different organizations were reported with emission at 8.4 µm and at 9.2 µm. QCLs of that same structure grown elsewhere emitted around 10 µm. Thus, it is critical to gain additional knowledge of the relationships between epitaxial growth, their materials properties, QCL band structure modeling, and resulting QCL performance in order for MOVPE to be a more predictable growth process.

This work was performed by Christine A. Wang, Benedikt Schwarz, Dominic F. Siriani, Leo J. Missaggia, Michael. K. Connors, T. S. Mansuripur, Daniel R. Calawa, Daniel McNulty, M. Nickerson, J.P. Donnelly, and F. Capasso for the Massachusetts Institute of Technology. **For more information, download the Technical Support Package (free white paper) at mobilityengineeringtech.com/tsp under the Lasers & Photonics category. MIT-0007**

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Application Briefs

Integrated Flight Deck System

Garmin International, Inc
Olathe, KS
800-800-1020
www.garmin.com

Garmin International, Inc., a unit of Garmin Ltd., announced the selection of the Garmin G3000® integrated flight deck by Tactical Air Support, Inc. (Tactical Air) as part of a contract with the U.S. Department of Defense (DOD) F-5N+/F+ Avionics Reconfiguration and Tactical Enhancement/Modernization for Inventory Standardization (ARTEMIS) program. Tactical Air first selected the Garmin G3000 for their F-5 adversary aircraft training fleet in 2018. This recent award builds upon Tactical Air and Garmin's strategic relationship now serving the DOD fleet of F-5 adversary aircraft. Garmin's commercial-off-the-shelf (COTS) G3000 open architecture supports integration with a wide range of mission equipment including military sensors, helmet mounted displays, and advanced electrically scanned radar systems.

The F-5 is a supersonic, multi-role tactical fighter and attack aircraft that in this role will provide air-to-air combat training, close-air support training, tactical development and evaluation support. The upgraded F-5 Advanced Tiger (AT) will be used in an aggressor training role, and the G3000 will transform the cockpit with one large area display and two touchscreen controllers. These upgrades bring modern safety systems and new tactical capabilities to the older airframes while also solving parts obsolescence and reliability issues within the existing avionics system.

The G3000 boasts a large and vibrant high-resolution flight display that seamlessly interfaces to the F-5's existing mission computer, enabling advanced mapping, tactical radio capabilities, radar display and more. The non-proprietary interface, software-based Human Machine Interface (HMI), and mission integration will enable the DOD to rapidly deploy new technologies in the future, while providing access to the latest in commercial Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) capabilities. Tactical Air has integrated the L3Harris ForceX mission computer along with a wide range of military sensors, communications equipment, and weapons systems into the G3000 touchscreen HMI.

In addition to night vision goggle (NVG) compatibility, the G3000 contains modern, state-of-the-art synthetic vision technology (SVT™) that blends an "out-the-window" view of surroundings on the large area, primary flight displays, which is particularly helpful during nighttime operations and during close air support missions. Additional features within the G3000 integrated flight deck on the F-5 include Terrain Awareness and Warning System (TAWS), Traffic Collision Avoidance System (TCAS), and Automatic Dependent Surveillance-Broadcast (ADS-B IN) traffic.

For More Info Visit www.garmin.com

Real-Time Signal Analyzer

Narda-MITEQ
Hauppauge, NY
631-231-1700
https://nardamiteq.com

Jamming and spoofing, two types of intentional disruption of communications, are ever-increasing threats, and getting ever more difficult to combat. The Narda Safety Test Solutions' SignalShark real-time signal analyzer monitors, identifies and localizes jamming and spoofing in electronic warfare (EW) attacks on government and satellite communications and makes it possible to combat them. This high-performance receiver is designed for intense signal monitoring and enables localization, which means that if there is an interfering signal emission, SignalShark will find it and can localize it.

SignalShark is a low-SWaP-C optimized and interoperable, commercial off-the-shelf solution that easily adapts to particular mission-driven applications across all domains. The SignalShark sensor can interconnect to hardware that supports situational awareness, for example, and can integrate with any software, such as signal processing and battlefield management systems. SignalShark's integrated computer means that software is efficiently installed directly on the SignalShark.

Portable, light, compact, and robust, the SignalShark family offers advantages for mobile, flexible, and full coverage monitoring units. All three types – handheld, 19" rack-mounted brick, and outdoor unit – are built with the same high quality and deliver the same RF characteristics such as sensitivity, real-time bandwidth, performance, dynamic range and intelligence. SignalShark's reliable, stable results are consistent and without limitations, whether in mobile field use, in the com-

mand center, or in long-term outdoor applications under extreme environmental conditions.

Of course, localization is essential to elimination of interfering emissions. SignalShark can be paired with the Narda Automatic-Direction Finding Antenna (ADFA), the optimal addition to enable precise and reliable automatic localization of signals in a small footprint that supports stealth and concealment applications.

The SignalShark system actively compensates for the specific values stored in the receiver, antenna, and cable at the factory, and therefore requires no system calibration. Individual elements can be easily replaced, creating a very important logistical advantage.

While still on the move, the operator can overlay a heat map on a local area map on an external display, or use the SignalShark display, as well as view the found direction. SignalShark's powerful localization software automatically indicates where the signal is most likely to be located, meaning there's no need for an additional PC.

For More Info Visit https://nardamiteq.com

Digital Manufacturing Solution

CAD / CAM Services
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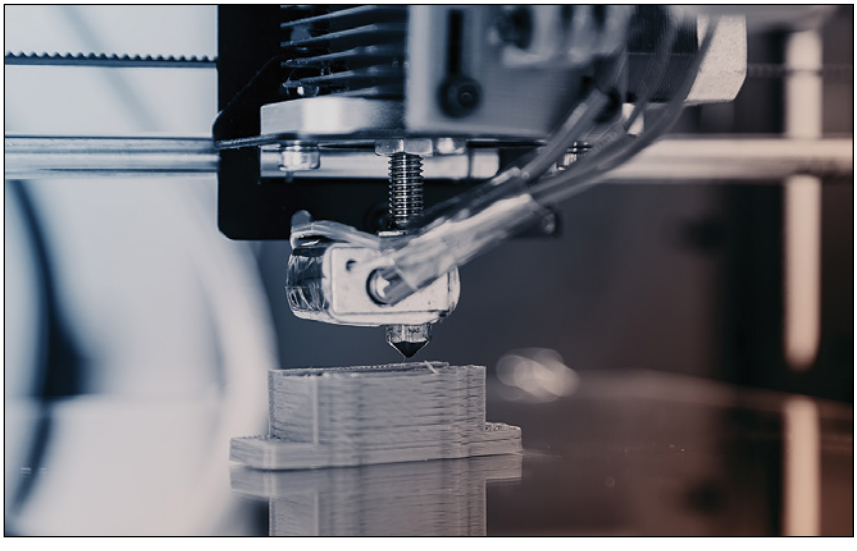
800-938-7226
www.cadcam.org



Advanced manufacturing has yet to even crack the surface of what is possible. From generative design and lightweighting to software simulation and decentralized production, the transition to digital manufacturing promises to unlock an enormous amount of potential. However, large aerospace and defense organizations are struggling to fully capitalize on these benefits due in large part to the complexities of integrating these technologies into an enterprise-wide solution.

An ideal platform would enable design cycle times to be slashed from weeks to hours, project costs would greatly decrease, while at the same time the quality of each part would be perfected. Additionally, supply chain complexities would be virtually eliminated because components could be designed in one part of the world and printed anywhere else on the planet, even in space or on Mars, with a push of a button.

The U.S. Navy is looking to tackle this problem by aligning the skill sets of a trio of outside expert organizations to develop an end-to-end additive manufacturing (AM) system that could be utilized across the entire Department of Defense (DoD).

CAD / CAM Services – a Texas-based prime contractor for the U.S. federal government – was brought in to integrate the commercial-off-the-shelf (COTS) technologies into a single interface. This would enable the DoD, as well as other large manufacturers, to manage and scale their AM processes.

"As a starting point, the Navy wanted to solve the increasingly problematic issues of supply chains and logistics. For example, an aircraft carrier in the middle of the Indian Ocean that needs a specific part immediately," explains Scott Shuppert, CEO of CAD / CAM Services. "They want to be able to just push a button and have that part start printing directly on the ship's 3D printer or the closest printer available."

To enable this to take place, Shuppert and his team had to provide a workable solution for each step along the lifespan of

a part, from development and certification to service and replacement. This required matching each solution with the best possible technology provider along the way, starting on the frontend.

"Eventually, the Navy and the DoD want to have a complete repository of every single part in its arsenal cataloged, certified, and ready to be digitally manufactured," says Shuppert.

Transitioning to this advanced manufacturing process requires that each component undertake a thorough assessment of its design. Is it best suited for additive or subtractive manufacturing? Could it be improved through generative design or material science? Does it need digital simulation and/or finite element analysis (FEA) – which can mathematically predict how a component will hold up under real-world forces like vibration, heat, fluid flow, and other physical effects?

With ParaMatters' platform the Navy can simply input the characteristics it needs for a specific component and the software will optimize it through testing, simulations, and inspection. The software selects the appropriate material, determines the best orientation for printing, where to include support structures, nests the parts on the build tray, and generates all slicing data for each component. It is also technology and material agnostic which was a critical feature for the Navy.

Through generative design, this approach will improve weight versus performance, structural integrity, and a variety of material properties. It can also reduce the number of parts required in an assembly by combining them into a single printed piece.

These elements are then incorporated into a machine learning system that utilizes artificial intelligence (AI) to ensure future design work becomes even smarter. It creates repeatability, accuracy, standards, and the ability to streamline the operation through remembered systematic processes that can be applied repeatedly allowing automation to begin taking place in developing the output.

For More Info Visit www.cadcam.org

Through-Wall Imaging System

Camero-Tech Ltd.
Kfar Netter, Israel
+972-73-7172333
https://camero-tech.com

Camero-Tech – a member of Samy Katsav Group (SK Group) that specializes in developing, producing, and marketing pulse-based UWB micro-power radar 'Through Wall Imaging' systems – has launched the Xaver™ 1000, a new generation of the Camero Xaver™ product line that offers unique operational capabilities to military forces, law enforcement agencies, intelligance units, and first responders.

The Xaver™ 1000 has an AI-based tracking algorithm of live targets and its own 3D 'Sense-Through-The-Wall' capability, enabling it to detect and 'see' people or static objects behind walls and obstacles. Live objects can be seen in high resolution down to the level of specific body parts. This includes determining whether an object is sitting, standing, or lying down, even after they have been stationary for a long period of time. The system also enables users to measure the height of objects and decide whether they are adults, children, or animals, resulting in a clear operational advantage and the ability to 'step into the known'.

Capable of being operated by a single user and ready for use with the push of a button, the Xaver™ 1000 is optimized for tactical and ISR operations, making it a useful system for military, law enforcement, search & rescue teams, and intelligence units operating in various situations, including hostile urban environments and natural disaster sites.

The Xaver™ 1000 is controlled by an embedded 10.1" touchscreen display with a simple user interface for intuitive interpretation. The display also features easy menu navigation and integrated data recording and playback for post-mission analysis, training, and debriefing. Completely radiation safe, the system meets human exposure international standards.

"The Xaver™ 1000 determines the most suitable approach to ensure successful life-saving missions in a variety of operational scenarios, such as hostage rescue situations," says Amir Beeri, CEO and founder of Camero.

Camero-Tech's other systems in the Xaver™ family – the short-range Xaver™ 100 and Xaver™ 400, and the long-range Xaver™ LR 40 and Xaver™ LR80 – have been successfully deployed by customers in military, law enforcement, intelligence, and search & rescue applications in more than 50 countries worldwide.

For More Info Visit https://camero-tech.com

Main Propulsion Electric Motor

Leonardo DRS, Inc.
Arlington, VA
703-416-8000
www.leonardodrs.com

Leonardo DRS, Inc. ("DRS") announced recently that it successfully completed factory acceptance testing and shipment of the first production unit of the main propulsion motor for the U.S. Navy's new Columbia Class submarine. The motor was recently shipped to General Dynamics Electric Boat (EB) for integration into the lead ship of the class.

DRS was chosen by EB and the U.S. Navy to design and manufacture the major Columbia Electric Drive Propulsion system components including the main propulsion electric motor. All prototype components of this system successfully completed full power endurance and other testing at the Navy's land-based test facility in 2020, where operational testing continues. In addition to the main propulsion motor, other lead ship components are being manufactured and prepared to ship to EB.

The Columbia class program goal is to design and build a class of 12 new ballistic missile submarines (SSBNs) to replace the U.S. Navy's current force of Ohio class SSBNs. The Navy has identified the Columbia class program as its top priority program. The Columbia class submarines will be larger than the current class in terms of submerged displacement and will become the largest submarine ever built by the United States.

The DRS Naval Power Systems business was awarded contracts for the electric propulsion system components which included design, test, qualification, and production of the full-scale components for both a land-based test facility and first two ships of the class. Over the past several years, the Navy has completed successful land-based tests of DRS' electric propulsion components. With significant testing completed, the program is transitioning to production with DRS presently manufacturing the components for the first two ships of the Columbia class.

For More Info Visit www.leonardodrs.com

B-2 Spirit Modernization

Northrop Grumman
Falls Church, VA
703-280-2900
www.northropgrumman.com

Northrop Grumman and the U.S. Air Force are continuing enhancements to the B-2 Spirit Stealth bomber fleet providing new capability, including its first long-range stealth missile.

The B-2 successfully released a Joint Air-to-Surface Standoff Missile – Extended Range (JASSM-ER) during a flight test late last year. The JASSM-ER further enhances the B-2's ability to hit any target, anywhere. The integration of JASSM-ER enables the delivery of a low observable asset capable of traveling greater distances than its predecessor.

JASSM-ER is one of three new advanced capabilities being introduced to the B-2 to further modernize the platform. The B-2 fleet, capable of delivering both conventional and nuclear ordnance, is also integrating crypto modernization and a Radar Aided Targeting System (RATS). The latest system advancements are part of integrated functional capability (IFC) P6.4, which was certified last year by the Air Force. RATS will complete the latest phase of nuclear modernization of the B-2 Spirit.

The integration of RATS allows the B-2 to fully employ the B-61 mod 12 nuclear bomb. RATS is the key element of the nuclear modernization, as GPS may not be available during a bomber task force mission.

Crypto modernization further improves the communications security of various high frequency transmissions. The B-2 may now securely utilize advanced communication devices in the future threat environment. Earlier this year, Northrop Grumman conducted a successful communications flight test with modern cryptology at its Oklahoma City Weapons System Support Center site.

The capabilities of this IFC continue to position the B-2 fleet as a key component of the Department of Defense's nuclear triad. It is also part of Northrop Grumman's ongoing modernization efforts leveraging 21st century technology incorporating digital engineering.

For More Info Visit www.northropgrumman.com

New Products

Self-Encrypting Drives

DIGISTOR® (Vancouver, WA), a CRU Data Security Group (CDSG) brand, has added to its line of secure DIGISTOR Citadel™ self-encrypting drives with pre-boot authentication by introducing PBA to its Citadel C Series lineup. The new drives, powered by Cigent®, add the critical PBA function to their existing DIGISTOR C Series of self-encrypting drives. In addition, DIGISTOR is announcing that the Citadel C Series Advanced version has been listed by NIST as a FIPS 140-2 L2 certified storage device with NIST certificate #4294. Citadel C Series drives offer additional cybersecurity functions such as multi-factor authentication (MFA), zero-trust file access, unreadable storage partitions protected by non-recoverable keys, automated threat response that renders data invisible if Cigent Data Defense is disabled, and secure access logs that capture all insider threat activity. Citadel C Series SSDs are built on DIGISTOR TCG Opal or FIPS 140-2 L2/Common Criteria self-encrypting drives.

For Free Info Visit http://info.hotims.com/82328-471

Ruggedized Computing Modules

General Micro Systems (GMS) (Rancho Cucamonga, CA) announced its X9 Spider family of distributed, ruggedized computing modules offering interlocking mechanical design, MOSA Thunderbolt™ interfaces, OpenVPX cross-platform compatibility, and patented LightBolt™ connectors. Features of the X9 Spider family include: Two "Host" modules powered either by Intel's® latest 11th-generation Xeon W (Tiger Lake-H) 8-core CPU, or by NVIDIA's® Jetson AGX Orin GPGPU with ARMcore engine, plus GPGPU CUDA and Tensor cores; interconnectivity via the COTS open standard Thunderbolt™ 4 technology, developed by Intel® and Apple® and 100Gb Ethernet over fiber; and six (6) companion X9 modules that include a "workstation" with removable storage and up to 14 sites for add-in I/O like MIL-STD-1553, a network "switch" with four 100Gb and eight 10Gb Ethernet ports, and a removable canister with up to eight high-density M.2 or U.2 SSD storage devices.

For Free Info Visit http://info.hotims.com/82328-470

2 Slot Rapid Rugged VPX Test System

LCR Embedded Systems (Norristown, PA) has released a dual slot rugged test system for VPX/SOSA aligned payloads that is part of its emerging RTS line. Designed for in-vehicle use, the RTS-210 allows functional testing at, or near, application-level environments. A front expansion module provides access to the development backplane and discrete I/O panel connectors, allowing for signal connectivity and backplane profile layout using Meritec cabling. The chassis offers backplane versions supporting the latest module profiles for four different VPX/SOSA aligned payload modules in up to three, 2-slot combinations (plus VITA 62 PSU slot). Slot options include VITA 67 full and half width apertures. The VITA 48.2 conduction cooled base chassis design, along with the final custom I/O panel, meets MIL STD shock, vibration, thermal and ingress requirements.

For Free Info Visit http://info.hotims.com/82328-473

Company

Anritsu Company (Allen, TX) announced that its Signal Quality Analyzer-R MP1900A now supports the PCI Express® 6.0 (PCIe® 6.0) Base Specification Receiver Test (Rx Test) and has been further enhanced with an SKP function to filter SKP packets to support separate clock architecture (SRNS). As a result, one MP1900A supports PCIe 3.0 to PCIe 6.0 and can calibrate stressed test signals and measure jitter tolerance using a real-time oscilloscope. Link Training Status State Machine (LTSSM) functions are supported by PAM4/NRZ PPG for high-quality waveforms, high-sensitivity input ED, high-accuracy jitter generation source (SJ, RJ, SSC, BUJ), and vertical noise generation source (CM-I/DM-I and white noise).

For Free Info Visit http://info.hotims.com/82328-474

Flight Data and Cockpit Voice Recorders

Curtiss-Wright's Defense Solutions division (Ashburn, VA) introduced a 25-hour flight data recorder (FDR) and cockpit voice recorder (CVR) designed for use on military fixed-wing and rotor aircrafts. The latest additions to Curtiss-Wright's Fortress® product family, the Fortress FDR-25 and Fortress CVR-25, are designed in accordance with RTCA/DO-178C and RTCA/DO-254 (DAL D) standards and meet or exceed all current FAA and EUROCAE ED-112A standard requirements. Fortress CVR-25 provides 4 channels of cockpit voice recording and 1 channel of CPDLC datalink recording, each for 25 hours minimum capacity supporting EUROCAE class 6 CVR requirements. Fortress FDR-25 supports parametric flight data recording for 25 hours minimum with data recording capacity up to 3,500 hours of data before the oldest data is overwritten, with a maximum data rate of 4,096 words per second.

For Free Info Visit http://info.hotims.com/82328-475

COM Express Compact Type 6 Evaluation Board

Sealevel Systems (Liberty, SC) has released the 12009 COM Express Compact Type 6 Evaluation Board. At 95 millimeters square, the 12009 is identical in size to a Compact Type 6 COM Express module. The 12009 evaluation board supplies a diverse I/O mix and robust processing support. Standard I/O includes Gigabit Ethernet, USB 3.0, USB 2.0, GPIO, RS-232, and Mini DisplayPort. The complete evaluation kit (Part #12009-001-KT) includes a Type 6 module with Intel Core i3-8145UE CPU and 8 GB DDR4 RAM. Additionally, to improve the development process, the kit includes a 128GB M.2 SATA SSD module (supports Windows® and Linux® operating systems), desktop power supply, and a wide variety of cables to facilitate connections to serial and Ethernet ports and optional fans. A power button and power-indicating LED are also included.

For Free Info Visit http://info.hotims.com/82328-472

Radiation Tolerant Space Processor

Teledyne e2v (Grenoble, France) announced delivery of qualified flight models (FMs) of its advanced, space qualified, quad core Cortex-A72 edge processing platform - the LS1046-space. Clocked at up to 1.8 GHz, Teledyne e2v's 64-bit LS1046-Space processor delivers 30k DMIPs. Moreover, a fast, 2.1 GT/s, 64-bit DDR4 SDRAM memory controller with embedded 8-bit error corrected code (ECC) is provided, plus a 2 MB L2 cache shared across the four ARM cores. L1 and L2 caches also benefit from ECC-protection, providing a high degree of in-flight immunity to data corruption. This high-reliability processor is further enhanced with a wide range of embedded interfaces - including 10 Gbit Ethernet, three PCI-Express (PCIe) v.3.0 lanes, SPI, I2C, and multiple UARTs. The device is supplied in a compact 23 × 23 mm, 780-ball BGA package.

For Free Info Visit http://info.hotims.com/82328-478

Rugged Vision Computer

Concurrent Technologies (Colchester, UK) has launched an ITAR-free, commercial off the shelf (COTS) vision computer system. The new Helios vision computer system is based on a high-performance Intel® Core™ i7 processor mated with an Nvidia® graphics module with sufficient I/O and storage flexibility to meet a range of customer applications including command and control display, degraded vision enhancement and 360° vehicle navigation. The system is designed in alignment with the SOSA™ specification which will enable Concurrent Technologies to launch future rugged storage, sensing, and control systems by using a different mix of Plug In Cards (PICs).

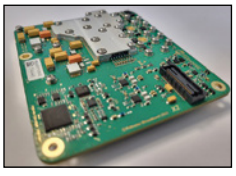
For Free Info Visit http://info.hotims.com/82328-482

Linear DC Power Supply

RIGOL Technologies (Portland, OR) announced their next generation of Programmable Linear DC Power Supplies, the DP2000. This completely new benchtop power supply features 3 fully isolated channels with automatic internal series and parallel connections and an intuitive 4.3" touch screen. The DP2000 delivers high resolution for measuring low-range currents down to 1 µA, a high-speed sampling mode, an arbitrary output mode with a 1 ms dwell time, and low output noise and ripple < 350 µVrms. The DP2000 will auto range between an amps range with 1 mA resolution and the new 10 mA range with resolution down to 1 µA. RIGOL's new DP2000 Power Supply complements these measurement capabilities with a high-speed arbitrary output mode made of up to 512 arbitrary points with dwell time down to 1 millisecond and the ability to edit waveforms including sine waves, square waves, ramps, pulses, or stair step functions.

For Free Info Visit http://info.hotims.com/82328-479

E-Band Transceiver



Filtronic plc (Sedgefield, UK)) a designer and manufacturer of RF-to-mmWave components, announced the launch of Morpheus X2, the latest generation of its E-band transceiver for carrier-grade applications in 5G backhaul, midhaul and fronthaul – collectively known as XHaul. Morpheus X2 is the latest design based on Filtronic's E-band (71–76 GHz and 81–86 GHz) transceiver platform. Integrating all the RF transmit and receive functions required for an E-band radio link, the transceiver module offers a linear transmit power output of +23dBm – 3dB higher than the standard Morpheus II product – while occupying the same compact footprint of 90 × 80 mm. Receiver noise figure is typically 7 – 8 dB, and an enhanced option with 4.5 – 5.5 dB noise figure is also available for specialized applications.

For Free Info Visit http://info.hotims.com/82328-480

FPGA Co-Processing Board

Mercury Systems, Inc. (Andover, MA) introduced the Model 5560, its next-generation 3U OpenVPX™ SOSA™ aligned co-processing board that is the first to be powered by the AMD Xilinx Versal® HBM series with integrated high-bandwidth memory. Mercury's Model 5560 is directly integrated with the on-chip HBM via the Versal Programmable Network-On-Chip, resulting in up to an 8x increase in bandwidth and 63% lower power compared to a system using external memory. With gigabytes of HBM directly accessible by the Versal HBM adaptable engines, the overall amount of data that can be pushed through the system can be significantly increased. Model 5560 is the new flagship in Mercury's portfolio of co-processors that use HBM technology, joining the Model 5585 and 5586 modules.

For Free Info Visit http://info.hotims.com/82328-481

Micro-ATX Motherboards

Review Display Systems (RDS) (Milwaukee, WI) has introduced a new family of industrial motherboards from leading embedded computing technology supplier, Kontron. New to market, the Kontron K384x series Micro-ATX motherboards all feature Intel's latest high-performance 12th Generation Alder Lake chipset technology. The Micro-ATX K3481-Q, K3482-Q and K3843-B offer support for Intel processors including the Core i9, i7, i5, i3, and Pentium and Celeron processors. Features across all three motherboards include four memory sockets supporting up to 128 GBytes of the latest DDR5-4800 DIMM, four DisplayPorts enable support for four independent external displays, multiple M.2 solid-state drive (SSD) expansion capability, four PCI Express (Gen5) sockets, four USB 3.2 (Gen1/Gen2), RS232 serial comms and one 8-bit GPIO.

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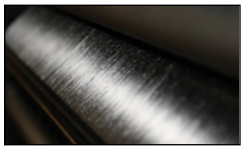
Low-Temperature Prepreg



Solvay (Heanor, UK) has introduced LTM® 350, a next-generation carbon fiber epoxy prepreg tooling material designed to deliver significant time and cost savings for the industrial, aerospace, automotive and race car markets. The carbon fiber epoxy tooling material offers a fast, low-temperature cure cycle (3 hrs at 60°C) and can also be cured at temperatures as low as 45°C with an extended post-cure. Tools built from LTM® 350 can be continuously cycled at temperatures up to 150°C delivering highly accurate composite parts. Available in optimized formats for both surface and bulk plies, LTM® 350 takes advantage of a 1-5-1 lay-up (surface to bulk plies ratio) saving time and costs versus a more traditional 1-8-1 format. LTM® 350 is manufactured in the United Kingdom, ensuring reliable security of supply across Europe and beyond.

For Free Info Visit http://info.hotims.com/82328-484

PCIe 5.0/CXL FPGA Accelerators

BittWare (Concord, NH), a Molex company, has introduced new card and server-level solutions featuring Intel® Agilex™ FPGAs. The new BittWare IA-860m helps customers alleviate memory-bound application workloads by leveraging up to 32 GB of HBM2e in-package memory and 16-lanes of PCIe 5.0 (with CXL upgrade option). BittWare also added new Intel Agilex I-Series FPGA-based products with the introduction of the IA-440i and IA-640i accelerators, which support high-performance interfaces, including 400G Ethernet and PCIe 5.0 (CXL option). Early access units of the BittWare IA-440i and IA-640i accelerators are slated for availability in Q4 2022 with production units targeted for delivery in Q1 2023. Early access units of the IA-860m accelerators are scheduled for Q2 2023 with production units expected by Q2 2024.

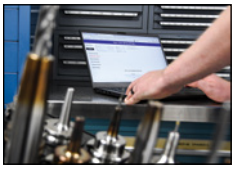
For Free Info Visit http://info.hotims.com/82328-485

Multi-Port Connectors

Carlisle Interconnect Technologies (CarlisleIT) (St. Augustine, FL) launched the newest in its signature line of Octax® high-speed data connectors: the Octax® Hybrid. Designed for use in the defense, commercial aviation, and industrial markets, this new series of high-performance, multi-port connectors combines 10 Gb data with additional discretes in a single 38999 shell. It is available in six standard key configurations to prevent mis-mating with adjacent connectors and multiple finishes. Features include density of up to 8 Octax® in a size 25 shell; six key configurations in 11, 15, and 25 shell sizes; standard M39029 crimp contacts, enabling re-termination and field repair without the expense of single-use connector solutions; and compatibility with CarlisleIT 26 & 24 AWG Gigabit Series Ethernet cables.

For Free Info Visit http://info.hotims.com/82328-486

Digital Ecosystem



ProShop ERP (Vancouver, BC) offers the ProShop ERP digital ecosystem, a combination ERP/MES/QMS solution developed to address the needs of job shops. This paperless digital operating platform (DOP) links every job shop department from those estimating projects to shipping. Customized ERP modules help get jobs off to a cohesive start. The integrated MES system picks things up by tracking time, tooling, fixtures, work cells, personnel, part programming information and more in real-time. The QMS function features numerous modules that grab data from the ERP/MES systems and create reports reflecting preventative and corrective actions, generate audits, capturing every aspect of the manufacturing process for complete quality reporting. ProShop's 25+ dashboards provide shops with a big picture view of the entire operation, identifying waste and ineffective procedures in one smart digital ecosystem.

For Free Info Visit http://info.hotims.com/82328-497

Test System Software

Rohde & Schwarz (Munich, Germany) is implementing a full range of 5G NR Release 17 features in its signal generation and analysis test solutions. Software options for the R&S SMW200A vector signal generator and R&S FSW signal analyzers have been upgraded to fulfil the latest 5G specification. The R&S FSVA3000 signal and spectrum analyzer and R&S SMM100A vector signal generator also handle 5G NR Release 17. Some key features for Release 17 include ultra-reliable low latency communications (URLLC) for industrial IoT, integrated access and backhaul (IAB), and radio access network slicing for NR. In addition, 3GPP extends the frequency support to 71 GHz. This extension requires an adaptation of the physical layer, notably the addition of two new subcarrier spacings (480 kHz and 960 kHz), and the support of wider signal bandwidths of up to 2 GHz. Moreover, a new 67 GHz frequency option for the R&S SMW200A vector signal generator allows up to 72 GHz in overrange mode.

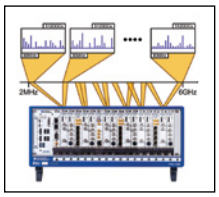
For Free Info Visit http://info.hotims.com/82328-477

Arbitrary Waveform Generator

Keysight Technologies, Inc. (Santa Rosa, CA) announced the new M8199B arbitrary waveform generator (AWG), which gives R&D engineers a high-performance signal source for arbitrary signals that enables development of designs employing multi-level modulation formats (e.g. 64QAM) at well beyond 160 GBaud. Applications beyond 128 GBaud demand a new class of generators that provide high speed, precision and flexibility at the same time. The new M8199B AWG offers a signal source for arbitrary signals with sampling rate up to 256 GSa/s and analog bandwidth exceeding 80 GHz, including up to eight synchronized channels operating simultaneously. The system also enables data transmission greater than 400 Gb/s per lane in intensity-modulation/direct-detect (IM/DD) and greater than 1.6 Tb/s per carrier in coherent optical communications.

For Free Info Visit http://info.hotims.com/82328-476

Multi-Purpose COMINT Receivers



Novator Solutions (Sollentuna, Sweden) announced the upcoming release of its HUGIN 4000 family of receivers optimized for strategic COMINT applications. HUGIN 4000 is based on the latest software defined radio technology and build on a modular hardware and software architecture. The HUGIN 4000 features 12 individual RF inputs, 960 MHz aggregated bandwidth, and 6144 narrowband DDCs. The new platform provides superior sensitivity of -163 dBm/Hz and high dynamic range of 112 dB enabling interception of both very weak and strong signals side by side. The 12 receiver inputs with 80 MHz bandwidth each can be individually tuned from 2 MHz to 6 GHz. With 6144 narrowband DDCs and 960MHz aggregated bandwidth operators can intercept any emitter without compromise and decide later which interceptions to process and analyze. HUGIN 4000 has 6 times more receiver inputs, 3 times more DDCs, 2 ½ times more real-time bandwidth and overall improved performance compared to its predecessor HUGIN 2000.

For Free Info Visit http://info.hotims.com/82328-488

Fanless 300W Power Supply

The Vox Power (Dublin, Ireland) VCCS300 power supply series delivers a silent 300 Watts of continuous output power in a rugged and miniature 4" x 2" x 1.61" package that can be cooled using conduction, convection or forced air cooling techniques. Now available with standard output voltages of 12, 15, 24, 28, 36, 48 and 56 VDC the VCCS300 platform can also be tailored to suit any other customer specific output voltage ranging between 12 – 58 VDC. The VCCS300 offers power densities exceeding 23 W/in^3 with efficiencies up to 95% in a scalable power architecture. Power solutions of 300W, 600W, 900W, and beyond can be achieved by using the onboard droop current share function, which allows end users to scale up or down depending on their power requirements.

For Free Info Visit http://info.hotims.com/82328-489

Flight Data Recorder

CAS DataLoggers (Chesterfield, OH) introduced the latest model in the Influx ReXgen family. The ReXgen Air is a vehicle and flight data recorder targeted at applications that require capturing CAN 2.0, CAN-FD, and LIN messages. The ReXgen Air is capable of recording data to onboard memory and then automatically uploading it via a built-in LTE CAT1 cellular modem to a local server on the cloud. The ReXgen Air is designed to be fitted on your product during development or as part of a fleet during production, continuously capturing data and events. Features include: up to 4 CAN/CAN FD buses + 1 LIN bus; Integrated 18 Hz GNSS; integrated 6 axis IMU; 2 analog and 2 digital Inputs; and up to 64 GB of eMMC on-board memory.

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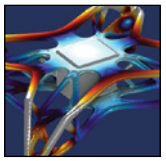
Product Spotlight



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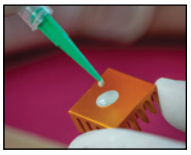

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Upcoming...
Webinars

How to Perform Accurate Spacecraft Thermal Analysis With Multiphysics Modeling

Wednesday, December 14, 2022 at 2:00 pm U.S. EST

The ability to predict and optimize designs and process for spacecraft and satellite are key to successful missions. New advances in simulation that provide fully coupled multiphysics and single-physics modeling capabilities are revolutionizing the modeling workflow and simulation process, providing a deeper understanding of designs and processes and making the entire experience more efficient. This 60-minute Webinar will explore a new user interface for satellite and spacecraft thermal modeling that uses multiphysics modeling to compute infrared radiative loads and temperature fields over time.

Please visit www.techbriefs.com/webinar348

Webinars on Demand!

Advances in Unmanned Aircraft: AI and Autonomy – Threats, Countermeasures, and Opportunities

Adoption of unmanned aircraft technology continues across military and civilian applications. As these vehicles become increasingly autonomous, questions arise about potential security threats, managing communication, and system reliability.

This 60-minute Webinar from the editors of *Aerospace & Defense Technology* discusses the challenges posed by growing autonomy, new solutions for safe drone operation, and how implementing artificial intelligence (AI) can lead to major advances in unmanned aircraft.

Speakers:

Jason Hardy-Smith
Vice President of Product,
Iris Automation

Jeffrey Starr
Chief Marketing Officer,
D-Fend Solutions

Rich Wronski
Vice President, Sensing, Perception, and Applied Robotics Division, Charles River Analytics

Please visit www.techbriefs.com/webinar321

Transforming the Future of Aviation by Utilizing Modeling, Simulation, and Training

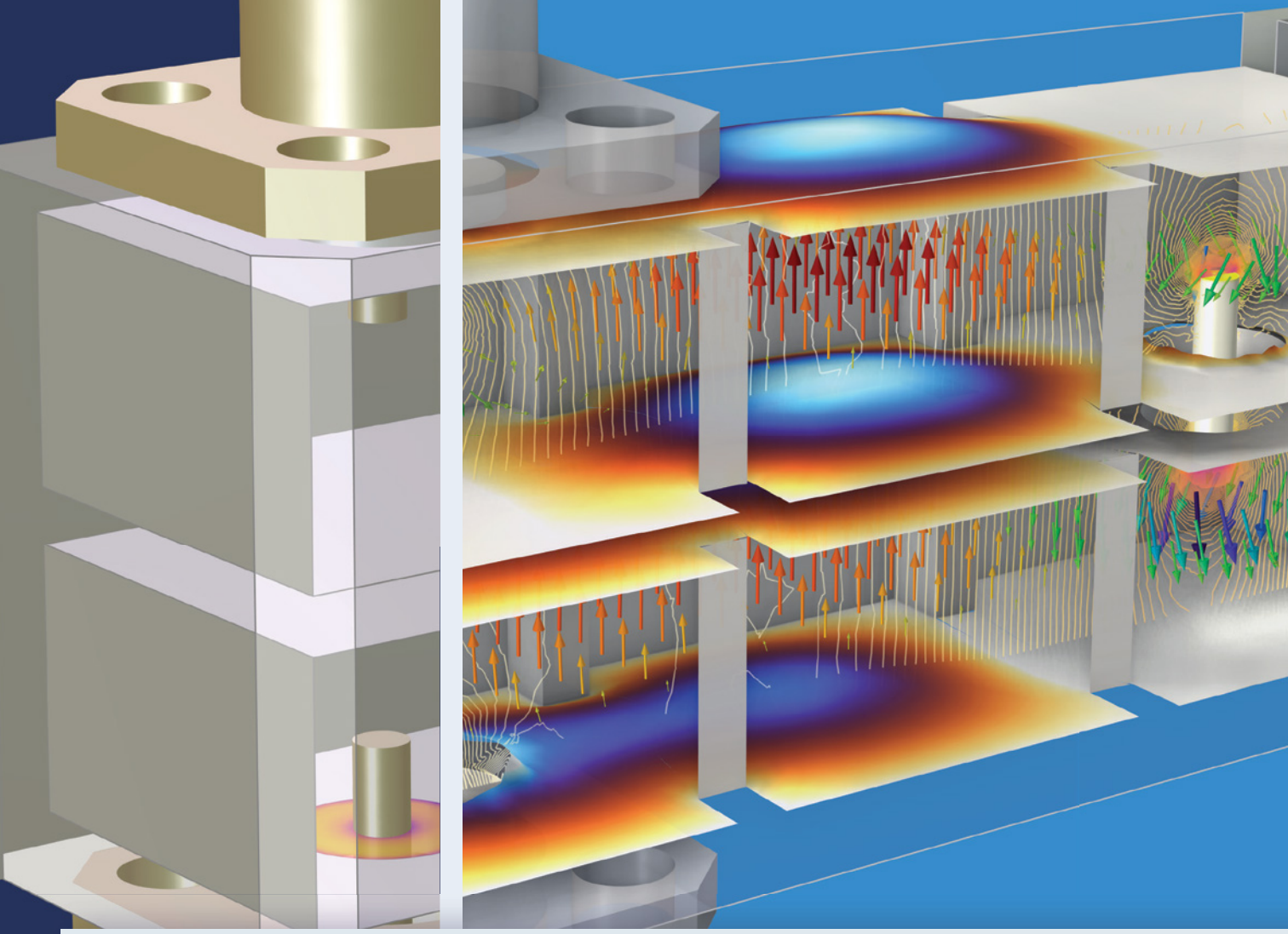
The SAE International G-35 committee on "Modeling, Simulation, and Training for Emerging Aviation Technologies and Concepts" addresses the complete certification process from aircraft to training device to pilot on-board and remotely operated vehicle certification. This Webinar will introduce the committee and discuss how G-35 is enabling digital transformation by integrating modeling, simulation, digital twin and AI into end-to-end standards that can be adopted by CAAs to support a totally new transport modality.

Speakers:

Marilyn Pearson
Global Regulatory Affairs Specialist,
Advanced Air Mobility/eVTOL/UAS, CAE and Co-Chair,
SAE G-35 Committee

Dr. Andreas Schweiger
System Architect,
Airbus Defence and Space and Co-Chair,
SAE G-35 Committee

Please visit www.techbriefs.com/webinar343



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