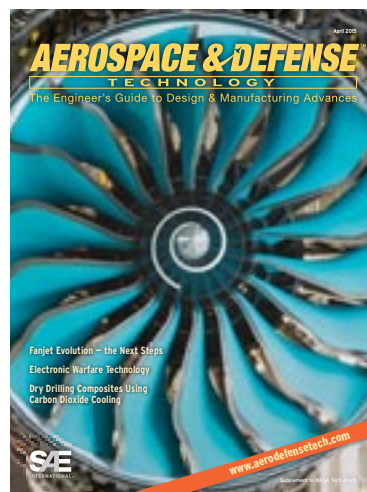


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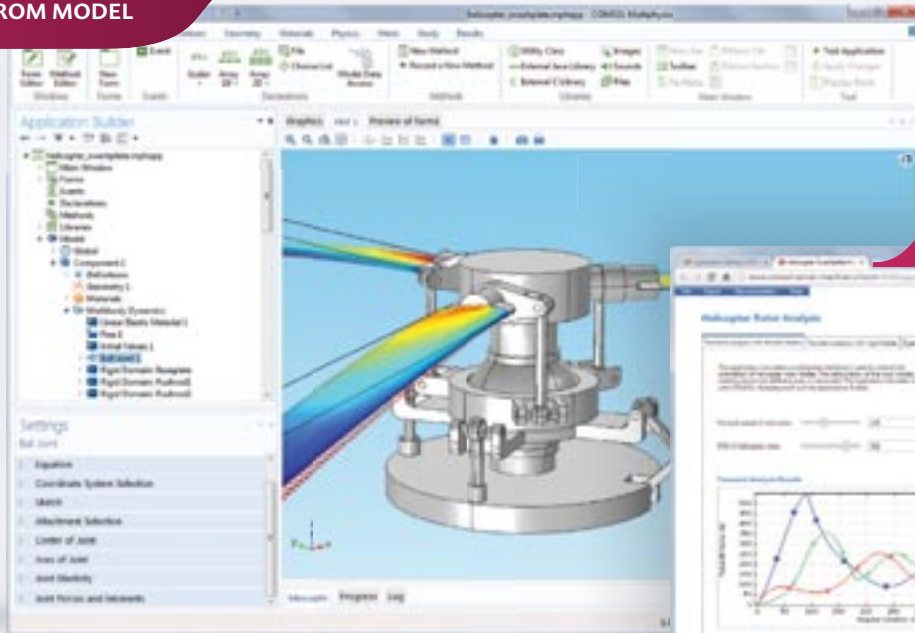


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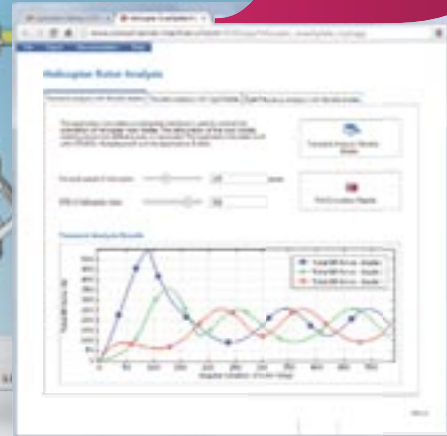


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ON THE COVER

End-on view of the Rolls-Royce demonstrator Trent 100 engine with new carbon-titanium (CTi) fan blades. The new, lighter fan blades, combined with a composite engine casing, could reduce weight by up to 1500 lb. per aircraft. That's the equivalent of carrying eight more passengers at no additional cost. To learn more about Rolls-Royce's new engine technology, read the feature article on page 21.

(Photo courtesy of Rolls-Royce)





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Electronic Warfare Technology

Overcoming TWT Limitations with GaN Solid State Power Amplifiers

Military electronic warfare (EW) systems including navigation, radar guidance, terrain mapping and others, require lightweight compact components, with radio frequency (RF) output power levels to several kilowatts typically needed to meet system requirements. As GaN transistor technology advances in frequency and power output, solid state power amplifiers (SSPAs) have begun replacing traveling wave tubes (TWTs) at frequencies up to 6 GHz. The utilization

of this technology results in a lower cost and greater efficiency over the life of a product.

Available TWT Technology

TWTs are available in two basic configurations: the cavity and the helix. Cavity TWTs are capable of very high powers—into the megawatt region—and are physically larger than helix TWTs. With their smaller size, helix TWTs lend themselves to a miniature traveling wave tube (MTWT) configuration to provide a com-

compact, lightweight solution for UAV and other EW applications where size and weight are major issues. Yet, helix TWTs have output powers limited to approximately 2.5 kW, which is much lower than the required output for many high power applications.

While the helix TWT is operating, the heated cathode is the source for the electron beam. Electrons are accelerated toward the collector by the anode and channeled into a narrow beam by the focus electrode. An RF input signal is then applied to the helix by an input RF coupler. As the RF signal travels down the helix wire, it absorbs energy from the electron beam providing gain and increased power as the RF moves along the helix wire. The RF output is coupled off of the helix coil by the output coupler.

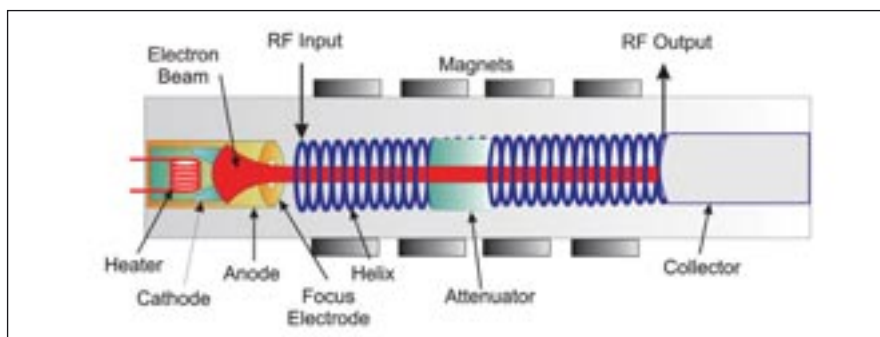


Figure 1. Conceptual drawing of TWT. Major components of a helix TWT include the heater, cathode, anode, focus electrode, attenuator, helix wire, collector and RF input and output couplers.

Decreasing Risk through SSPAs

Reliability and life of a TWT fall into three major categories:

- Infant Mortality
- Cathode Exhaustion
- Mean Time Between Failures (MTBF)



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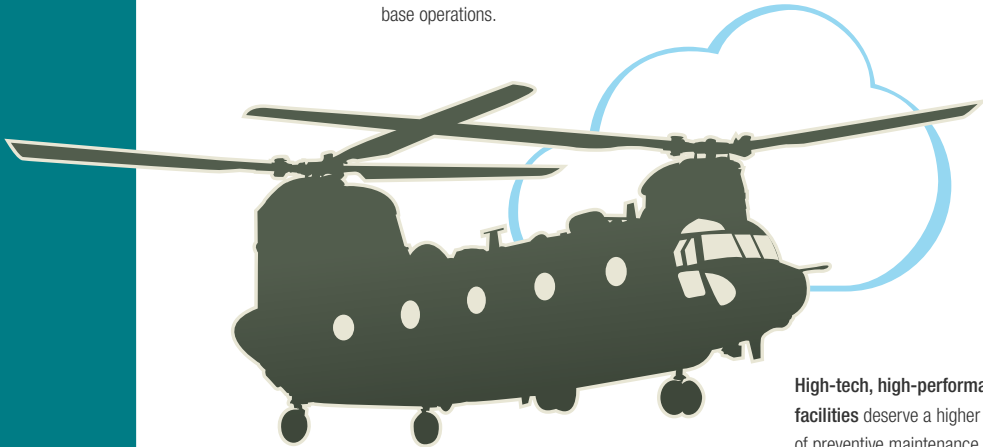
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Infant Mortality

Generally an issue with all electronic hardware including solid state power amplifiers, infant mortality is controlled by amplifier burn-in at the manufacturing facility. TWTs also have an additional concern if they are stored for a long period of time. Specifically, there is the potential for damage when first turned on after an extended storage period. To minimize damage risk, an 8 to 24 hour heater burn-in is recommended before cathode voltage is applied. SSPAs eliminate the risk associated with immediate turn-on after extended storage periods.

Cathode Exhaustion

A second reliability advantage of replacing a TWT with an SSPA is eliminating cathode exhaustion. Although there are steps that can be taken to extend cathode life in a TWT, it cannot be eliminated, resulting in the system having a finite operating lifetime. However, an SSPA eliminates the cathode exhaustion issue altogether, significantly extending the system's operating life.

MTBF

An SSPA also enhances system integrity by eliminating single point failure sources associated with older TWT technology. Since the TWT relies on energy transfer from the electron beam into the RF signal traveling along a helix wire, all components in the tube are potential single point hard failure sources.

In contrast, the replacement SSPA uses parallel combined transistors that provide a soft fail configuration. Parallel power sources in the SSPA provide the opportunity to monitor amplifier health at multiple power stages.

Increasing Performance

TWT amplifiers meet the output power and size requirements for compact airborne systems; however, using a TWT has some disadvantages including a finite lifetime, single point failure sources, and low reliability in harsh environments.

Recent advances in GaN transistor technology have made solid state power transistors through Ku-band frequencies available. A 100 W CW GaN device at X-band is the building block for the 1 kW MTWT replacement, and the SSPA re-

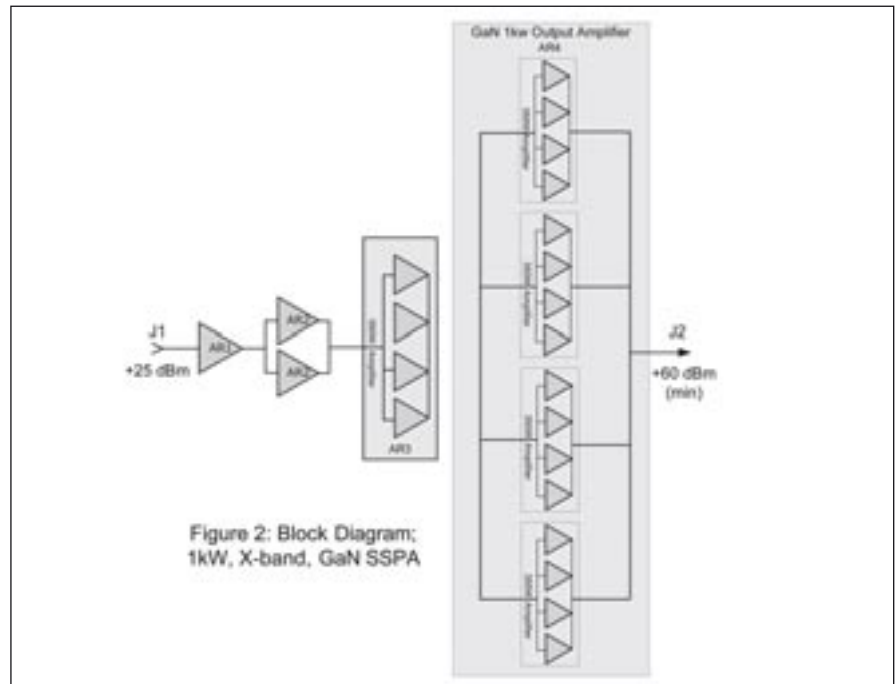


Figure 2. Block diagram of a 1kW, X-band, GaN SSPA. The GaN RF section of this SSPA incorporates a four-stage design.

placement has a major impact on microwave power module (MPM) reliability.

Comparative Analysis

The comparison below shows how an SSPA can operate over the 9.2 to 9.75 GHz frequency band with 1 kW peak output power at pulse widths up to 100 μ sec and 10% duty cycle with an efficiency of 20%.

The X-band MPM has 60 dB of gain and operates from a 28 VDC MIL-STD-704 airborne power bus efficiency in an 11" L X 6" W X 2" D package. Components in the MPM include a MTWT, SSPA driver, power supply and control functions.

A general comparison of TWT vs. SSPA MTBF can be completed using MIL-HDBK 217. Table 1 provides the equations for calculating MTBF for a TWT based on operating environment, operating fre-

quency and output power. The table further illustrates the MTBF results for operation at 9.5 GHz, 1 kW output power in ground benign, ground mobile and aircraft uninhibited cargo environments.

$$MTBF = \frac{10^6}{(11 \times (1.00001)^P \times (1.1)^F \times \pi_E)}$$

P = peak power in watts (1000);
F = Frequency in GHz (9.5)

The GaN RF section of the SSPA shown in Figure 2 is a four stage design. Stages AR4 and AR5 use 0.25 μ m GaN transistor technology. The design uses discrete die in multi-chip modules (MCM) for driver stage AR3 and final output stage AR4. AR4 MCMs are combined using a low loss 4-way splitter and combiner.

For comparison purposes, Table 2 depicts the MTBF for a 1 kW SSPA calculated using the MIL-HDBK-217 parts

Environment	π_E	TWT MTBF (hrs)
Ground Benign	0.5	72,000
Ground Mobile	7.0	5,199
Aircraft Uninhibited Cargo	6.0	6,066

Table 1. 1000 W, 9-10 GHz, TWT MTBF calculation using method of MIL-HDBK-217 notice 2.



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Environment	π_E	TWT MTBF (hrs)	SSPA MTBF (hrs)
Ground Benign	0.5	72,000	111,800
Ground Mobil	7.0	5,199	44,043
Aircraft Uninhibited Cargo	6.0	6,066	37,258

Table 2. 1000 W, 9-10 GHz, comparison between TWT and SSPA MTBF.

count method, as well as the TWT. The calculation is done at 85°C case temperature and 9.5 GHz with 10% duty cycle. The MTBF of the GaN amplifier was completed based on using ground benign, ground mobile and airborne uninhibited environments. Capacitor and resistor stresses were calculated with the SSPA case temperature at +85°C and 50% electrical stress per design guidelines and GaN transistor reliability was based on 175°C junction temperature (10% duty cycle and 85°C case temperature).

As shown in Table 2, in a passive environment like ground benign, the SSPA MTBF is about 55% greater than the TWT. However, in more challenging environments, there is a seven-fold improvement in MTBF of an SSPA compared to the TWT.

Modern Advancements

GaN technology advances including higher power density and 0.25 μm gate lengths allow GaN transistors to effectively replace TWTs at X-band.

The advantages of using a GaN SSPA to replace a TWT include:

1. Eliminating a system's finite life due to cathode exhaustion in the TWT.
2. Removing concern about TWT damage at turn-on after extended storage periods.
3. Eliminating multiple single point failure sources in the TWT.
4. Providing distributed final stage health monitoring and early failure warning while maintaining system operational integrity.
5. Offering improved reliability to meet modern EW system requirements.

As EW systems are upgraded, GaN will undoubtedly continue to advance and compete for more market share with TWT applications due to affordability and longer system life requirements in the defense community.

This article was written by Frank Decker, Design Engineer, API Technologies (Orlando, FL). For more information, visit <http://info.hotims.com/55588-500>.

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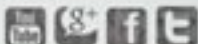
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Cloud Security & Compliance

What Every Defense Organization Needs to Know



Not too many years ago, network security was a relatively low level priority in most organizations. That has changed today due to such high level failures as the recent breaches at Sony and Target. Closer to home, the University of Maryland is now incurring large expenses for all students due to the recent leak of personally identifiable student information.

There is a lot of discussion around fewer federal dollars being available for Defense IT spending. Actually, the more finite pool of funding is causing government leaders to pause and think strategically about how they are spending their security dollars. It is really making them consider the best possible ways to secure their data centers, while also being cost-effective in their approaches.

What's becoming increasingly clear is that the technology isn't the core issue — it's the architectural approach to cybersecurity that's the issue. It's time for organizations to improve their security postures by thinking of security differently.

This may be the most critical time in IT in the past 30 years. The datacenter must operate more efficiently, in a more automated fashion, and in a more secure manner. As hardwired devices get reconfigured as virtualized resources, there's an opportunity to supply "a new security enforcement layer." Thanks to network virtualization, defense agencies are seeing true benefits by having access to new information and isolating the

actual network when they experience an incident — all while saving money.

Virtualization and the broader infrastructure of the software-defined data center provide a unique opportunity to get it all — isolation, context, and a horizontal layer that provides near-ubiquitous coverage. Through virtualization, organizations can insert security in a location that provides end-to-end coverage, isolation, and the full context of application, user, and data. In a physical environment, it is much more difficult to actually isolate and remove the problem. Moreover, this also prevents intruders from communicating between infected virtual machines if they do break into the network.

In a recent Center for Digital Government (CDG) survey of state and local government IT leaders, 45 percent of

respondents said network security is the most important IT issue to their organization. So security is clearly top of mind at agencies around the nation. Even so, respondents did not express great confidence in their organizations' current defense systems to protect against threats. While 38 percent said cybersecurity ranked "very high" among their organization's other top technology priorities, a quarter said they were either very unprepared or didn't know if they were prepared to shield themselves from zero-day targeted attacks, advanced persistent threats, and unknown threats.

New solutions are allowing government customers to better isolate and manage security breaches and incidences. But as mentioned above, better technology alone is far from the com-

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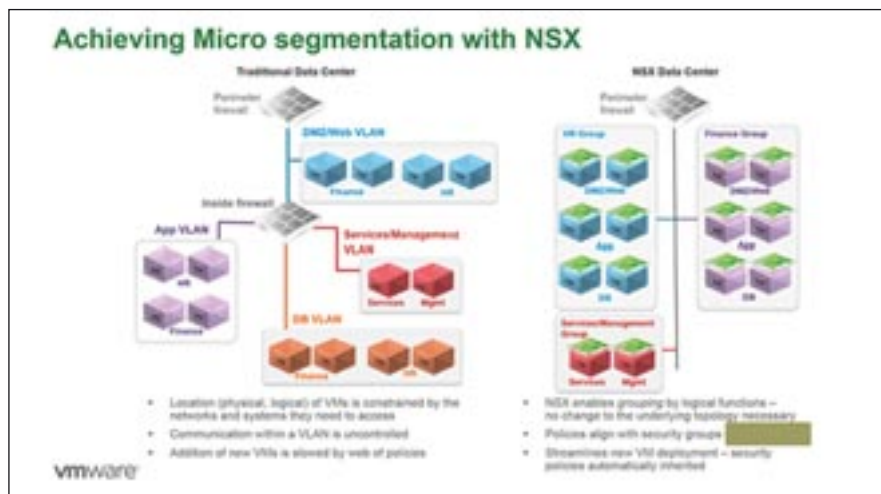
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Data Security



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The traditional data center security architecture is overly perimeter-centric, with the majority of data center security investment spent on the north-south boundary. Why? Because putting security inside the data center turns out to be extremely difficult. On the perimeter you have a few egress points. Inside the data-center, you have a complex web of data paths. The more controls you use, the more complex a distributed policy problem you have. The fewer controls you use, the more choke points you create.

The “Goldilocks Zone” is a term that is often used to describe a new approach that addresses these challenges. The term was originally coined to describe a planetary location that exhibits characteristics that must be simultaneously present for a planet to support life – not too hot, not too cold, etc. Security professionals borrowed it to describe the location for security controls that simultaneously provides context and isolation—key characteristics required to create a secure information infrastructure.

When it comes to instrumenting IT infrastructure with security controls, defense IT historically had two choices: the network or the host. With those two choices, IT was forced to make a trade-off between context (visibility into the application layer) and isolation (protection of the control itself).

If IT places controls in the network, there is isolation, but we lack context.

Visibility is limited to telemetry such as ports and protocols. These were never good proxies for applications, but in modern IT architectures such as the cloud, where workloads are mobile, these physical identifiers become even worse. Next-generation firewalls emerged precisely because of this issue.

If IT places controls on the host, we get context about the application, processes, files, and users — but lack meaningful isolation. If the endpoint is compromised, so will be the control. In both cases we lack ubiquity, a horizontal enforcement layer that places control everywhere.

The next logical step for defense agencies is more virtualization of the network itself. We're seeing more and more adoption of this in the enterprise space right now, because of enhanced security capabilities and the ability via software to build cloud functionality on top of existing infrastructure. Companies are tired of the constraints inherent in a siloed approach to compute-network-storage, and can't afford those types of vulnerabilities in this new age.

Government IT leaders simply are no longer satisfied with the status quo, nor can they afford to be. Despite the increased risk profile today, it's a thrilling time to be involved in cybersecurity.

This article was written by Steven Coles, Vice President of Networking and Security for U.S. Public Sector, VMware (Palo Alto, CA). For more information, visit <http://info.hotims.com/55588-501>.

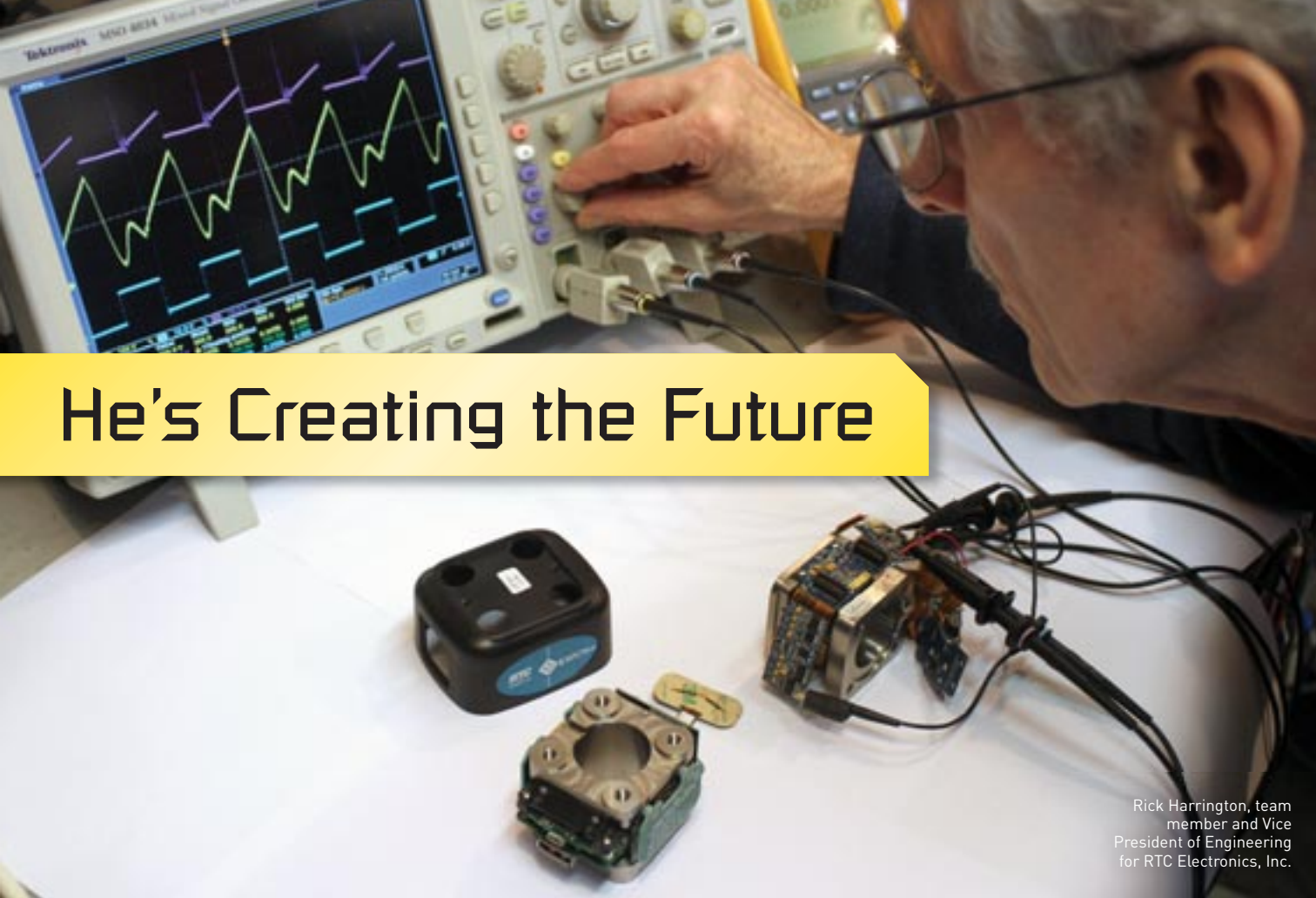


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He's Creating the Future

Rick Harrington, team member and Vice President of Engineering for RTC Electronics, Inc.

Rick Harrington, team member and Vice President of Engineering for RTC Electronics, Inc. (formerly College Park Industries), was the Electronics Category Winner in the 2011 and the 2013 Create the Future Design Contest.

The iPECS (Intelligent Prosthetic Endo-Skeletal Component System) provides researchers with a tool to accurately measure human locomotion or gait parameters on users of lower limb prostheses. IPECS measures 3-axis forces and moments in a lower limb prosthetic user.



"Exposure from being a category winner legitimized iPECS as a viable and valuable measurement tool for prosthetic research. The 2011 win gave an immediate boost to engineering and management," says Tom Grey, president of RTC Electronics. "Winning in 2013 has opened our marketing and sales options, and we are expecting a record year of sales. No longer can potential customers say 'I never heard of iPECS.'"

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MicroTCA Computing for Mil/Aero Applications

Small Form Factor (SFF) embedded systems have been gaining popularity due to their small size, weight, and power (SWaP) advantages. The SFF architectures are typically purpose-built, providing just a few specific functions. But, the performance level is often limited and the versatility and re-usability across multiple applications is typically very low. Is a balance available where there is high performance and versatility in an open standard architecture, but a compact size that is optimized for SWaP-C (C stands for cost)?

Open Standards

There are many SFF solutions in the market, but many are not based on an open standard. Why is this significant?

The critical importance of open standards is often overlooked, but there are many benefits to a Modular Open Standard Architecture (MOSA) design. One of the key reasons is to reduce the risks posed by a single source technology and obsolescence. With several vendors in the industry supporting an open standard, the de-

sign engineer is not putting all of their eggs in one basket. The Mil/Aero community has learned the lessons of choosing a server blade approach from a Fortune 100 corporation and getting locked into a single vendor solution. It backfired when that corporation sold their business unit to the Chinese. Had the program gone to a MOSA solution, even if their prime supplier sold the business, they would still have had many other vendors to choose from and an open specification available. Additionally, with competition between the various MOSA hardware vendors, the constant drive to innovate, upgrade/improve, and reduce costs is prevalent.

Finally, the scalability of open standards is a key element. There is tremendous cost and time savings in upgrading on a scalable architecture versus a stand-alone, purpose built approach, which may not leverage much in forward compatibility.

What is SFF?

What size do we consider SFF? Comparing it to the traditional VME and CompactPCI form factors of Eurocard

(3U and 6U) may be the best start. Those are the most common sizes for legacy open-standard architecture equipment in the embedded market. A 3U Eurocard board is 100 mm high (133.5 mm including subrack) by 160 mm deep, and a 6U is 233.4 mm (266.70 mm with subrack) × 160 mm. Nearly half that size is MicroTCA, a high-performance embedded architecture that offers significantly more performance than most SFF systems. MicroTCA is 75 mm by 180 mm in the single module size and 150 mm × 180 mm in the double module size. See Figure 1 for size comparison of MicroTCA to Eurocard.

Comparing Open Standard Architectures

AdvancedTCA is often used for Telco applications where massive throughput is required and size, power, and cooling limits are much more flexible. The modules are a large 8U (355.6 mm x 280 mm) size with a 30.48 mm backplane pitch. They typically have dual socket high-end processors that require more board space and cooling. The other area for AdvancedTCA is Mil/Aero where the processing power outweighs the architecture's SWaP limitations.

MicroTCA is an excellent fit for a wide range of applications because of its high performance-to-size ratio and versatility. The COTS (Commercial Off The Shelf) architecture has benefits over other form factors due to its robust system management, e-keying, and high-reliability features. In addition, the open-standard COTS architecture is typically more interoperable and lower cost than competing standards.

VPX is mostly a MOTS (Military Off The Shelf) architecture, serving one market. The architecture was billed as the "next VME", although ironically it is not standardly backwards-compatible. It does, however, share the Eurocard

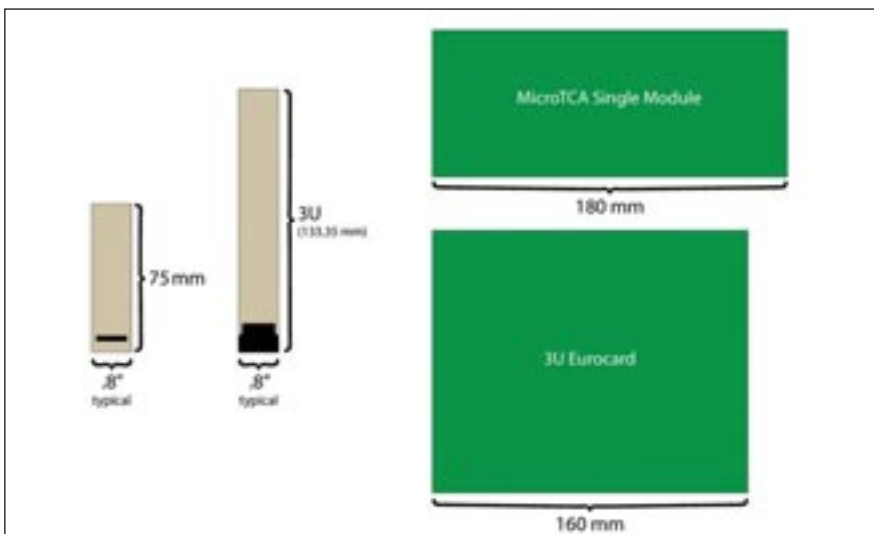


Figure 1. MicroTCA is more compact than the Eurocard form factor and offers significantly better performance than legacy 3U and 6U bus-based systems.



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	VPX	MTCA	VITA 74 SFF
Board Height	133.5mm (3U) or 266.7mm (6U)	75mm or 150mm	75mm
Board Depth	160mm	180mm	89mm
Pitch	1.0", .85", or .8"	.8" (most common) & .6" and 1.2"	.49" or .75"
Bus/Fabric	Serial fabric - PCIe Gen 3, 10/40 GbE, SRIO Gen 2	Serial fabric - PCIe Gen 3, 10/40 GbE, SRIO Gen 2	Serial fabric - PCIe Gen 3, 10/40 GbE, SRIO Gen 3
Routing	Serial Fabric, Redundancy	Serial Fabric, Redundancy	Serial Fabric, Redundancy
Rugged	Yes	MTCA.2, MTCA.3 specifications	Yes
Rear I/O	Yes	MTCA.4 specification	No
System/Health Management & Failover	VITA 46.11 draft for trial use	Yes	No
Keying	Mechanical	Electronic	Mechanical
JTAG Integrated	No	Yes	No
Geographical Addressing	Yes	Yes	Yes
Advanced Clocking with Redundancy	No	Yes	No
High Availability (99.99999% uptime)	No	Yes	No
High Interoperability	No	Yes	No
Power Limit	276W/slot (3U/12V), 768W/slot (6U/48V)	84W/slot or 120W/slot with tongue 2	10W/slot or 20W/slot
Vast Ecosystem	Yes	Yes	No

Figure 2: Performance and feature comparison of OpenVPX, VITA 74 SFF, and MicroTCA.

form factor. Like MicroTCA, it can easily be ruggedized for hardened applications. Figure 2 takes a closer look at MicroTCA, VPX, and one of the open standard SFF form factors.

As shown in Figure 2, MicroTCA modules are close to half the size, weight, and cost of VPX. For the power, it obviously depends on the application. But, MicroTCA systems often have lower power consumption as well.

The SFF specification shown in the chart is roughly the same board height as MicroTCA, but about half the depth and a thinner pitch. But, there is a big tradeoff for the small size and architecture – lower computing performance. With a 20W limit for even the larger SFF conduction-cooled modules, that limits the processor selection to mostly single core, lower-performing Atom™ and G-Series™ types of chipsets. For graphics modules, many of the upper-end chipsets will exceed 30W. Most higher-

performance FPGAs such as Stratix-IV, Stratix-V, Virtex-6, Virtex-7 and digital converters are also above the threshold for the open standard SFF.

Now, purpose-built SFF systems are available that can use some 3rd Generation Core i7 processors, but you are losing the many advantages of an open standard architecture and its vast ecosystem.

Pico Chassis Versions of MicroTCA

Although MicroTCA is typically 19" rackmount, there are Pico style and other shorter width enclosures. Pico shelves are a standard option in the core MicroTCA.0 specification. Fig 3a shows an example of a 2-slot Pico chassis with two AMCs (chassis courtesy of partner for this product, Schroff). This chassis is approximately 10" wide for dimensions of 44.5 mm high × 250 mm × 320 mm deep. Often, a MicroTCA Carrier Hub (MCH) is not required in Pico units. The chassis

utilizes an active backplane with fan speed control circuitry that is triggered by temperature sensors in the chassis. The IPMI connections are routed to both AMC slots.

Many of the SFF applications require a conduction cooled enclosure. Similar to the previous enclosure, the conduction-cooled version in Fig 3b also can hold 2 slots.

One of the advantages of utilizing a smaller MicroTCA system is the ability to leverage hundreds of standard AdvancedMCs (AMCs) that are readily available in the marketplace. This includes dozens of options of modules that are geared for:

- Processing, FPGAs
- A/D & D/A Conversion, Transceivers
- Storage
- Graphics
- I/O, Network Interface
- Switching
- Carriers (FMC, XMC, PMC, etc)





High Performance

MIL/Aero applications can be a driver for leading-edge performance, but often the long design cycles and conservative approach can slow down the innovation. An advantage of a truly COTS architecture serving multiple markets is that the advances contrived from other markets such as communications and High Energy Particle Physics can be leveraged. For example, the physics community requires very high performance digitizers, with more channel options, and various RF boards for LLRF, beam position monitoring, etc. The technology can be leveraged to high-end radar and radar jamming applications drive powerful DAQ, A/D and D/A converters. Today, there are AMCs (and FMCs) that offer a DAC 14-bit @ 5.7 GSPS and ADC 14-bit @ 4.0 GSPS. In communications applications, the push for faster networking has driven 100G processors and FPGAs.

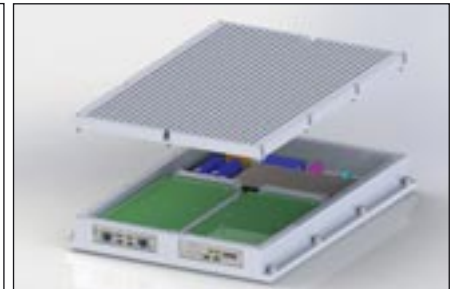


Figure 3a/b. SFF or MicroTCA? With a compact size, small enclosures are available for AMC modules that compare with SFF systems.



Figure 4. Ranging from 1/3 to 1/5 the size of competing MOSA rugged chassis, this 1U unit offers 6 AMCs, system management, precision clocking & time stamping for many RADAR processing and storage applications.

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An example of a high-performance density system is a 1U rugged chassis that holds 6 AMCs. Figure 4 shows the chassis layout with an integrated MCH that provides GPS receiver/IEEE 1588/SyncE capabilities. The precision timing and time stamping features pro-

vide deadly accuracy for target acquisition. Ten years ago, a weapon system would have the RADAR as part of the system or a short distance away. In today's network-centric warfare, the RADAR and weapon system can be many miles away. In sending and receiving data, by the

time the system receives the input and is ready to analyze the data, the target is in a different location. With SyncE and IEEE 1588, the packet is time-stamped to the exact Grand Master Clock (GMC) time when it is sent. When the packet is received, the system can adjust the time differential and allow the algorithms to predict the location of the target. Therefore, the precision-timing of the system can help make targeting more accurate.

In just a 1U height one can have a powerful core i7 quad-core processor, four Virtex-7 FPGAs with removable 5.7 GSPS DACs and 4.0 GSPS ADCs, and a 12 Gbps SAS 800GB storage module with Advanced RAID and external expansion. Or, for more storage, a JBOD module can hold up to 8 mSATA chips at up to 1 TB each (for a total of 8 TB in one bay). The chassis is designed to meet MIL-STD-810F for shock and vibration, and MIL-STD-461E for EMI.

MicroTCA also offers a wealth of high-end storage, graphics, I/O, FPGA and other boards which make the ecosystem rich and diverse. Other specialty products in the MicroTCA form factor include a 72-core Tiler Processor, 40GbE chassis platforms, a PCIe Gen3 carrier with the ability to use the highest performance commercial NVIDIA or other graphics cards. MicroTCA also provides multiple ruggedization levels including MTCA.0 (Core specification), MTCA.1 (Rugged Air Cooled), MTCA.2 (Hardened Air/Conduction Cooled Hybrid), MTCA.3 (Hardened Conduction Cooled) and MTCA.4 (with RTMs for Physics, other applications).

Conclusion

SFF systems can be a great fit for applications requiring some specific functionality in a small space. But small doesn't have to mean low performance or limited features/capabilities. As an "SFF-like" architecture, MicroTCA can provide massive performance in small spaces. There are a wealth of configurations and options to allow for SWaP performance across a wide spectrum of application requirements.

This article was written by Luis Teruel, Hardware Engineering Manager, VadaTech (Henderson, NV). For more information, visit <http://info.hotims.com/55588-502>.

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Fanjet Evolution – the Next Steps

Rolls-Royce is on a determined path to equip commercial airplanes over the coming decades with new engines that take advantage of engineering breakthroughs in materials and core architectures.

by Richard Gardner

The global aerospace sector has always represented the cutting edge of practical technology advancement. When the first military jet engines emerged in the post-war 1940s it was clear that commercial applications would soon follow. The leap in performance, payload capability, maintainability, and speed compared to the best that turbo-supercharged piston-engines could offer was truly revolutionary.

Subsequent decades saw jet air travel becoming the normal, preferred way to travel, and when the first big-fan-powered wide-body Boeing 747 entered service the way was open for the world to become an interconnected network of safe, reliable air routes.

Thanks to the birth of mass air transport and subsequently a relentless growth in market demand, the technology needed to deliver the means to satisfy that demand has proceeded in steady increments. New families of wide-body transport airplanes were developed, and these regularly incorporated technological advances in aerodynamics, materials, and propulsion until today when it might be thought that evolutionary development had almost reached the end of the trail, with such impressive products as the Airbus A380 and A350, and the Boeing 777-X and 787.



End-on view of the Rolls-Royce demonstrator Trent 100 engine with new carbon-titanium (CTi) fan blades.

The more futuristic proposals for airplanes powered by prop-fans, or open rotors, are continuing as active research and development programs on both sides of the Atlantic, but customer-power is still the dominant factor in launching new en-

gines, and what airline chiefs are now demanding is evolutionary engines that will be a more risk-free stepping stone toward even more efficient products that can be in service a lot sooner than the super-advanced designs.



Close up of a Rolls-Royce CTi fan blade, consisting of technology that delivers lighter fan blades while retaining aerodynamic performance. Combined with a composite engine casing, it forms a system that reduces weight by up to 1500 lb per aircraft, the equivalent of carrying eight more passengers at no additional cost.



The CTi fan blade for the Advance and UltraFan next-gen engine completed testing in September 2014 at Rolls-Royce's Outdoor Jet Engine Test Facility at the Stennis Space Center.



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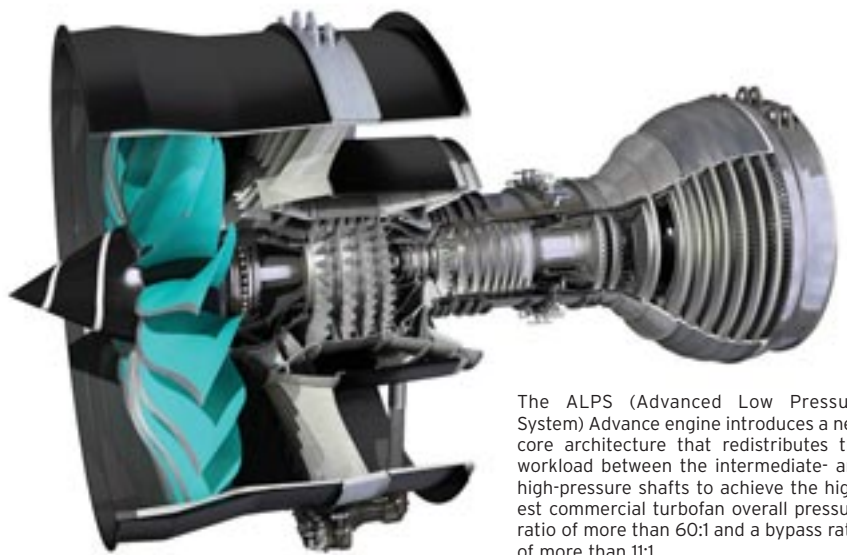
Open rotors still have a long way to go before such important factors as noise, airframe integration, and maintenance accessibility—and blade-off safety issues—are fully de-risked. So although the potential +25% reduction in fuel consumption and overall operating efficiency might be a very attractive incentive, what airlines really want is a new generation of big fan engines suitable for powering later developments of today's generation of airplanes, including the A380 and 787, and also possibly any replacement 250-seat design that Boeing might introduce to replace its successful but out-of-production 757. The sales success of both the new Boeing 737 Max and Airbus A320neo, with orders for an incredible 6280-plus aircraft yet to be delivered, demonstrates the willingness of airlines to adopt new engine options where the extra efficiencies can save them significant sums of money.

New Engine Options

Despite a recent dramatic drop in world oil prices, the familiar efficiency-driven demand for new engines is still building up in the market for application on existing wide-body airplanes. High oil prices were seen as a prime motivator for the switch to newer, more efficient engines, but the overall benefits, including lower emissions and noise as well as better fuel economy, have kept up the sales momentum.

Last year Airbus made the decision, under pressure from some key customers, to launch the A330-800 and -900neo (new engine option) models featuring the latest Rolls-Royce Trent 7000 engines, even though the company was simultaneously introducing a similar size all-new wide-body, the A350, which everyone assumed would replace the A330 in production. Airbus claims the neo versions of the A330 will save 14% fuel consumption per seat compared to the existing -200 and -300 aircraft.

While R-R has been frozen out of the new 777-X program as a result of an exclusive supplier arrangement between Boeing and General Electric, it has taken some of the best design aspects of its previously proposed RB3025 engine to incorporate these with other new technology design features to create a two-stage product



The ALPS (Advanced Low Pressure System) Advance engine introduces a new core architecture that redistributes the workload between the intermediate- and high-pressure shafts to achieve the highest commercial turbofan overall pressure ratio of more than 60:1 and a bypass ratio of more than 11:1.



Shown is the UltraFan's first flight test aboard Rolls-Royce's 747 flying test bed. UltraFan is a geared design with a variable pitch fan system, based on technology that could be ready for service from 2025

route-map toward the next generation of large-fan production engines.

The first new engine, named "Advance" is aimed at a 2020 timeframe, offering a 20% fuel-burn reduction over the earliest Trent, with the second, named "UltraFan," delivering a 25% reduction, to become available around 2025.

To arrive in the highly competitive marketplace within these timescales, the new engines draw on experience gained from its latest two products, the Trent 1000 powering the 787 Dreamliner, and the Trent XWB powering the A350. Innova-

tion has been at the heart of all Trent engines to date, with the three-shaft architecture a common feature.

Advance Advances

Advance introduces a new core architecture. This redistributes the workload between the intermediate- and high-pressure shafts to achieve the highest commercial turbofan overall pressure ratio of more than 60:1 and a bypass ratio of more than 11:1. As well as reducing the parts count and weight, Advance will incorporate a lean-burn low-NOx combustor and ad-



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vanced heat-tolerant materials, which will further improve thermal efficiency and improve component life.

The most noticeable feature of the new engine will be the use of the new R-R carbon-titanium (CTi) fan blades (replacing hollow titanium blades) and the associated integrated composite engine casings, which have built in electrical harnesses and pipework.

Amongst the other performance gains these features provide a major weight saving of some 1500 lb on a twin-engine aircraft, equivalent to carrying another eight passengers. These new features are the result of extensive design work over recent years and much R&D testing and evaluation, which is now continuing at an increasing pace.

The company's hollow titanium fans have established a reputation for per-



The latest member of the R-R Trent family, the 7000, for the new A330neo

formance and reliability, but a series of successful technology demonstrator programs has pointed toward composite materials as the next step, incorporating specific technology innovations. Many years of looking at how advances could be gained from the weaving of the material used led to the adoption of a CTi design that delivered a lighter,

thinner fan blade that was very robust and offered high performance.

In September 2014, R-R completed ground testing of the CTi fan system at the Stennis Space Center in Mississippi. This involved crosswind testing on a Trent 1000 ALPS (Advanced Low Pressure System) technology demonstrator to verify the new fan design performance in advance of flight tests taking place.

The R-R Outdoor Jet Engine Test Facility at Stennis was expanded in 2013 to add a second test stand and it can now carry out specialist development engine testing including noise, crosswind, thrust reverse, cyclic, and endurance testing on all large R-R engine types.

Last October the new fan blades took to the air for the first time in Tucson aboard a company-owned Boeing 747

Coherent beam propagation

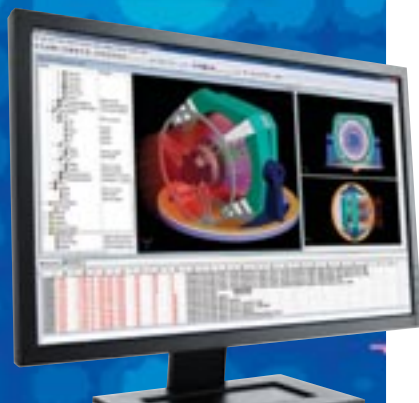
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The Airbus ACJ350-900 will be the corporate jet version of the A350.

flying test bed. This aircraft had the ALPS demonstrator engine fitted in place of one of the regular RB211 engines. The demonstrator engine was from a donor

Trent 1000, as fitted to the Boeing 787, but had been modified with the use of CTi fan blades. Six flights took place over 11 days.

"We look forward to testing the system even more rigorously in the next phase," said Mark Pacey, the Rolls-Royce ALPS Chief Project Engineer. "We had two main aims in testing—proving flight dynamics and the performance of the fan. This involved approaching the limits of the aircraft's operating envelope, recording data at altitudes up to 40,000 ft and speeds from Mach 0.25 to 0.35."

He pointed out that the European Commission Clean Sky initiative has supported the ALPS program from the beginning and this has helped to progress the new technology.

In November noise testing of a second ALPS composite fan engine continued at Stennis. The work on the integrated composite engine case is also making progress, with manufacture of a complete unit underway and the coming together of new fans and a new casing is planned for mid 2015, which will allow ground testing to take place.

The Advance engine is likely to become the basis for a new-generation of Trent-derived big fan engines, though it will represent a significant technological advance, as the name suggests. Apart from the new CTi fans and integrated composite casing, it will have a new lean-burn combustion system and use ceramic matrix composite material. Ground testing in the U.K. and Germany has validated emissions predictions and later this year flight test will begin and continue into 2016.

The key to the Advance design is the redistribution of workload between the intermediate- and high-pressure shafts. This core architecture, the conceptual design of which is completed, is scheduled to be incorporated into a demonstrator to run in 2016. Long-lead time components are in manufacture and this demonstrator will be based on a donor Trent XWB, as fitted to the Airbus A350, but minus its high- and intermediate-pressure spools. The investment in this rolling development, test, and evaluation program is up and running to ensure that all the advanced technology elements are in place and proven to meet the company's own 2020 timescale. It will then be very well placed to respond rapidly to the expected demand for a new-generation big fan engine from the airframe companies.

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The UltraFan

The second new engine, the UltraFan, is also the subject of much investment in even more advanced techniques as the design is refined, components developed, and it is prepared for testing. This program may seem far from the target timescale, a decade into the future, but the company is determined, once again, to de-risk and prove the new technologies well ahead of the market demand to retain a competitive edge and to ensure a potential world-beating product is ready at the right time.

The UltraFan will incorporate all the new technologies used in the Advance engine, but will address new challenges involving larger fans and smaller cores to achieve even greater engine pressure ratios. When the bypass ratio increases to around 15:1 the low-pressure turbine system driving the fan gets disproportionately large and heavy and managing temperatures, pressures, and aerodynamics between the fan and smaller core becomes more of an issue, according to Alan Newby, R-R Chief Engineer, Future Programs and Technology, Civil Large Engines.

"Our solution with UltraFan is to eliminate the LP turbine in its current form and drive the larger fan through an enhanced intermediate-pressure turbine," he said.

A power gearbox between the fan and IP compressor is a key element in this design as it enables the IP turbine to do that without running too fast for the low-speed fan.

"By doing this, we can continue to be confident our three-shaft architecture ensures our compressors and turbines run at optimum speed and deliver optimum performance, and also enables us to remove the need for a thrust reverser and we can introduce an integrated, slim-line nacelle," said Newby.

Very large fan engines need greater integration with the nacelle and airframe, as weight, drag, and ground clearance can all be issues. For the UltraFan, R-R is developing a new power gearbox to deliver the 15:1 bypass ratio. Testing will begin at the end of this year at a new purpose-built R-R facility at Dahlewitz in Germany.

Gear units and oil systems will be tested at a variety of angles and this work is supported by the European Clean Sky 2 and German national LUFO programs. Continued work on geared designs will build on much company heritage experience from turboshaft and turboprop engines in

the civil market and also the R-R LiftFan system that is an essential propulsion feature delivering VSTOL capability aboard the F-35B combat aircraft.

"One element of the Advance and UltraFan program that was critical to its success was informing the industry well in ad-

vance," said Simon Carlisle, Executive Vice President, Strategy and Future Program-Civil Large Engines, R-R.

These are early days still, but it certainly looks like this important new engine design initiative is being built on a solid foundation.



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Dry Drilling Composites Using Carbon Dioxide Cooling

The use of composite materials and composite stackups continues to grow at high rates due to the high strength and low weight of the materials. However, efficiently drilling holes through the layers to install fasteners and other components has traditionally offered numerous problems.

The ground vehicle and aerospace industries use carbon-fiber-reinforced plastic (CFRP) because it is more durable and lighter than other materials. CFRP is used in components such as aircraft fuselages, wing skins, door panels, automotive body panels, and many other areas that are trickling down to mainstream production vehicles from racing applications. Multiple layers of CFRP and another material, such as titanium (Ti), are called a stackup.

The use of composite materials for applications demanding strength, flexibility, and elimination of corrosion is well

documented. Using composites rather than aluminum in aircraft structures saves weight on the order of 20%. This weight reduction is combined with the ability to achieve aerodynamically more advantageous shapes through precision molding, resulting in better payload fractions and reduced fuel requirements.

For the Boeing aircraft line, the 777 consists of 11% composite by weight, while the 787 Dreamliner contains more than 50% composite by weight and about 80% by volume. The Bell/Boeing V-22 Osprey uses composites for the

rotor blades, the rotor hubs, the wings, the interconnect drive shafting, the nacelle structure, the fuselage, and empennage, except for the fuselage frames. Carbon fiber manufacturing is also used in Formula 1 racers, high-end bicycles, and the Bugatti Veyron sports car.

All of these factors combined explain the ever-increasing popularity of composite materials in many high-performance applications. This is in spite of their significantly higher raw material costs and relatively involved processing—frequently requiring expensive autoclaves or other pressure- and heat-producing devices to compact and cure the materials.

A key machining/drilling challenge for CFRP applications is that traditional liquid coolants, particularly petroleum-based coolants, should not be used for cooling during machining operations. For this reason, nearly all composite manufacturing operations are performed completely dry. Since CO₂ cooling is a dry process, it is a particularly suitable solution for heat buildup in this difficult, expensive, and time-consuming operation of composite stackup machining.

Drilling and Milling

One of the major challenges of using CFRP or CFRP layered with titanium



The CO₂-based EFCS (environmentally friendly coolant system) used for a series of tests by Cool Clean Technologies delivers a cooling fluid consisting of CO₂ ice crystals, CO₂ gas, and in some cases air, directly to the cut zone where cooling is required.



The EFCS equipment designed and manufactured by CCT.



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The EFCS system is capable of delivering CO₂ coolant to the tool-work piece interface in two methods. The first method, shown here, is used for drilling and delivers CO₂ coolant through coolant ports in the tool.

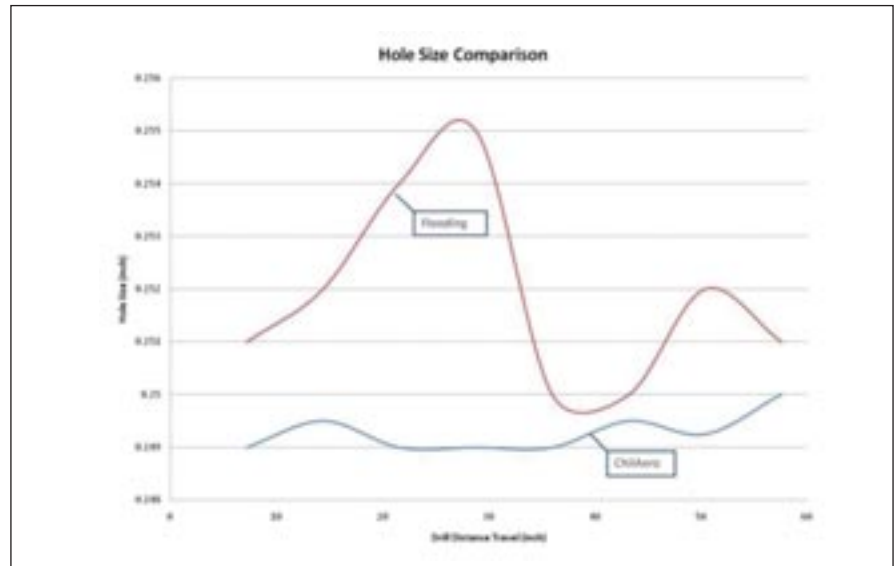
(CFRP-Ti) is drilling holes in this stackup material for bolts or rivets to secure the CFRP-Ti panels in place. The carbon fibers in the CFRP-Ti are very abrasive to drill, plus significant heat is created in the drilling process, which damages the resin binders of the composite material.

The addition of a Ti layer introduces an even more damaging chip that can erode the corners and inner diameter of the drilled hole and, therefore, create a sloppy fit between the panel and fastener.

CFRP-Ti stackups, where a layer of CFRP is either glued or fastened to a Ti panel, are most commonly used for the fuselage of an aircraft. Thousands of holes that are typically 0.64 cm diameter need to be drilled through the stackup to fasten the panels to the frame of the aircraft.

The manufacturing process of an aircraft wing involves starting with oversized sheets of CFRP that have been formed into the approximate size and shape required. An overhead gantry mounted CNC milling spindle is then often used to trim the sheet to the finished dimensions.

Dust-like chips created in this machining operation are very abrasive and



Depiction of the difference in the hole sizes between the EFCS and the conventional flood coolants. The composite hole diameter drilled with the flood coolant was significantly larger than the titanium hole, thus causing the composite hole size to increase above the 6.35 mm +0.0762 mm customer specification.

there is a large amount of heat generated. The heat generated in the milling process, just like in drilling, can soften the binders in the resin that holds the layers of carbon-fiber fabric together. This softening can lead to the layers delaminating and eventually failing. This downside can be eliminated by using CO₂ through-tool cooling, which significantly reduced the heat in the cut zone, while maintaining a dry machining environment.

Composite Stackup Drilling Issues

Focusing on the drilling of CFRPs, it is necessary to contend with three primary issues.

First, CFRPs have very low heat conductive and storage properties. This issue forces relatively slow cutting speeds to maintain an acceptable equilibrium between heat generation and heat disposal.

Second, CFRPs are very abrasive. This issue makes diamond-reinforced tools desirable, but they are heat sensitive by themselves.

And lastly, CFRP layups can easily delaminate on the exit side of a drilled hole. This issue must be handled in part by maintaining low matrix material temperatures. Other additional measures can include

sacrificial backing material, the addition of an outer scrim cloth layer, and controlling drill exit forces.

When drilling a CFRP-Ti stackup, a frequent challenge for airframe manufacturers is to hold a consistent hole size in the softer composite. Usually the composite is the top layer and is drilled first, then the titanium is drilled with the titanium chips passing through the composite. Coolants such as water and oil, or misting of oil, are often used with stackup structures.

Economic Analysis	Dry	CO ₂	Savings
Increased Productivity			
Minutes per Part	3.0	1.3	1.7
% Time Reduction			57%
Hours Per Month	336	146	190
Monthly Labor Costs @ \$100/hr	\$ 33,600	\$ 14,600	\$ 19,000
Tool Life Savings			
Parts per Tool	30	36	6
Tools per Month	224	187	37
Saved Tools / Month			17%
Monthly Tool Costs @ \$90/tool	\$ 20,160	\$ 16,830	\$ 3,330
Coolant Consumption			
Monthly Coolant Cost	\$ -	\$ 2,628	\$ (2,628)
Total Monthly Costs & Savings	\$ 53,760	\$ 33,430	\$ 20,330

Details of the cost savings achieved by incorporating an EFCS CO₂ coolant system for an aerospace application. This relatively small increase in tool life turns into a significant savings when taking into account that the PCD drills typically used to drill CFRP cost around \$750 each. Based on the data presented, the projected savings from the use of CO₂-based cooling for this drilling application was nearly \$20,000 per month.



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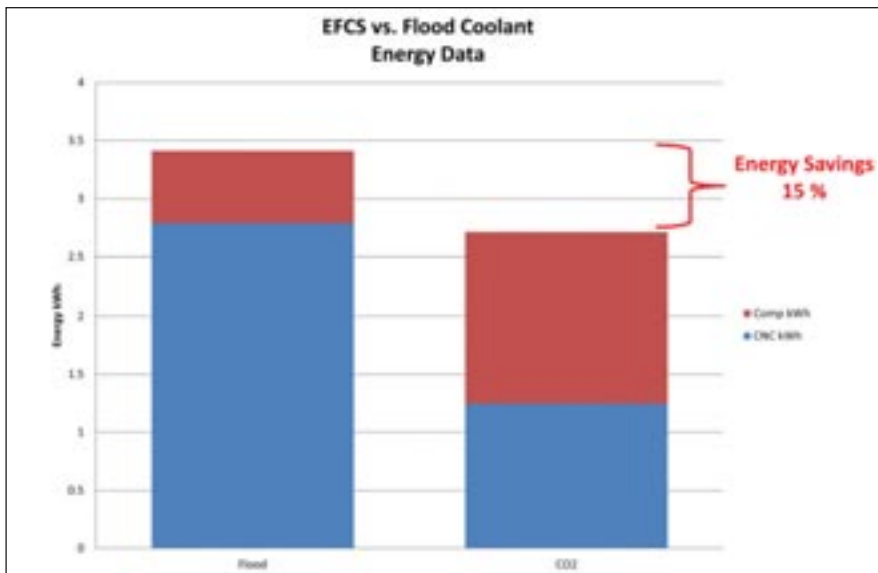




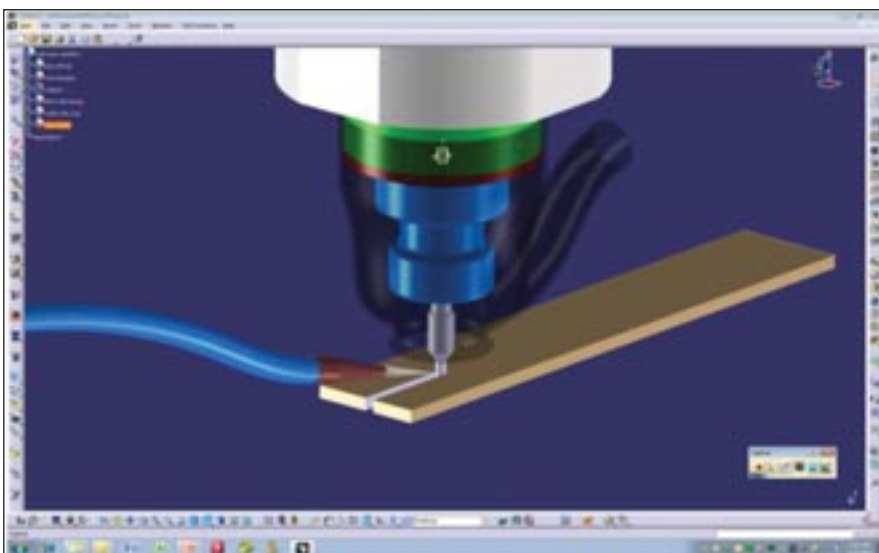
These conventional coolant approaches do not provide optimal cooling for machining of these stackup materials, which often results in poor hole surface quality or holes out of dimensional tolerance.

Composite-titanium (CO-Ti) stackups are utilized in the fuselage of most new aircraft. In part due to the size of aircraft frame assemblies, it is not feasible to clean liquid coolants or oils from them

during manufacturing. Therefore, the drilling operations performed to secure fuselage panels to the frame are typically done dry. Drilling through Ti without any coolant is a difficult process that is very time consuming. The feed rate of the drill bit through the Ti layer must be kept very slow to keep the created chips light, fluffy, and relatively cool, so they do not damage the CO layer.



Energy data was collected from drilling samples during the machining using a Fluke power data collector. The data showed a significant energy savings in the range of 10-15% for the overall system.



For the composite filling test setup, a FLIR thermal imaging camera and a Fluke IR thermometer were used to measure and verify temperatures. A custom vacuum boot was made to accurately simulate the current production process. This image shows the setup with the vacuum boot, tooling, and CO₂ spray applicator.

CO₂ Cooling Testing

Through work supported by the National Science Foundation and Department of Energy, researchers from Cool Clean Technologies have shown that CO₂ through-tool cooling can significantly increase productivity while maintaining required hole tolerances in both the composite and Ti layers.

A series of tests were conducted to compare the effectiveness of CO₂-based cooling sprays over traditional machining, both dry and flooded, of CFRP and CFRP stackups. The key metrics to be evaluated were drilling temperature, tool life, hole quality, productivity, and energy savings.

The experimentation and testing performed utilized an EFCS (environmentally friendly coolant system) to provide the CO₂ coolant. The EFCS, designed and manufactured by Cool Clean Technologies, is capable of delivering CO₂ coolant to the tool-work piece interface in two methods. The first method is used for drilling and delivers CO₂ coolant through coolant ports in the tool. The second method, which delivers CO₂ through an external nozzle, is used for milling.

The tooling used was carbide drills 6.337 mm diameter with a WD1 coating. The carbide drill went through a stackup of composite and titanium, with the composite component being 10.16 mm thick on the top and the 12.7-mm thick titanium component being on the bottom. Two panels with 32 holes each were drilled, equaling a total of 1463 mm of drill travel.

Work was performed on a vertical CNC mill that ran one panel of 32 holes over the course of about 8.5 minutes, with each hole taking about 16 seconds. The drill and stackup conditions were inspected at the end of each panel.

During the drilling process the temperatures of the drill, the composite, and the titanium were recorded. Temperature data was measured with a laser IR gun as the drill broke through the bottom of the part. This temperature measurement process was not ideal as it likely overestimated the temperature and thus underestimated the cooling benefit. Nevertheless, the data did show the general trend of lower temperatures, rang-



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ing from 20°C for the titanium layer measurements to 27°C for the drill and composite temperatures.

The EFCS process produced composite hole diameters in close tolerance with the hole size in the titanium. The composite hole diameter drilled with the flood coolant was significantly larger than the titanium hole, thus causing the composite hole size to increase above the 6.35 mm +0.0762 mm customer specification.

The EFCS system provided a significantly better hole size tolerance within specification, as compared to the holes drilled with conventional coolant. The flood coolant produced a significantly larger hole in the composite during the first half of its tool life. Improvement occurred as the drill cutting edge was dulled resulting in smaller chips causing less damage to the composite hole size. The EFCS system produced a hole with 0.0254 mm variability vs. 0.1524 mm

for conventional coolants, or 6x less variability.

Productivity and Tool Life

The researchers verified that the CO₂ coolant is able to provide productivity increases of 30% or more when compared to conventional coolants in drilling CFRP-Ti stackups and composite milling. This processing time reduction combined with an increased tool life of 10% or higher, an improved surface finish by up to 2x, and a dry work environment to contribute to energy savings on the order of 17%, reduce carbon emissions by 100% and improve the bottom line of the users by 22.5%.

Based solely on the productivity and tool life cost savings achievable with the CO₂ over flood coolants, not even taking into account the dollars related to energy and flood coolant maintenance and cleanup, the typical payback on a CO₂ coolant system is less than one year.

CO₂ coolant provides a significant reduction in tool and work piece temperature when compared to a dry process. The ability to put your hand on the tooling immediately after milling is proof that the work piece and cutter are kept at a temperature below 43°C. This is impossible to do when using traditional liquid coolant.

By keeping the temperature of both the composite work piece and tooling down near ambient conditions, no degradation to the resin binders occurs. This significant temperature reduction also leads to an increase in feed rate and therefore productivity. Finish cuts with CO₂ are smoother than when run dry, almost polished looking. Under a microscope, no inclusions or gouging caused by the milling process are evident.

This article is based on SAE International technical paper 2014-01-2234 by Nelson W. Sorbo and Jason J. Dionne, Cool Clean Technologies.

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Calibrating the sights on a radar system in Iraq to constantly monitor the skies in search of indirect fire attacks. (Pfc. J. Princeville Lawrence)

Next-Generation Phased Radar Systems Lead to Hardware Improvements

More compact, lightweight, and efficient power dividers increase resolution and range for the next wave of fixed phased array systems.

Meeting the performance needs of the next generation of radar systems that will be deployed by the military is spurring the development of more efficient and sensitive hardware components to go along with the rapid advances in signal processing techniques and bandwidth.

The military uses radar for many purposes, including guiding missiles to targets, directing the firing of weapon systems, and providing long-distance surveillance and navigation information. However, for the next generation of systems currently in development, the most

critical requirement is the ability to successfully counter saturation attacks. Such attacks may include numerous aircraft and missiles converging from multiple directions at the same time.

To meet this challenge, very high data rates are required to track a large number of simultaneous targets. Unfortunately, the level of data quality required is not achievable with the traditional rotating or fixed radar systems in use today.

Mechanical Rotation

Radar systems are often identified by type of scanning. The most common,

mechanical scanning, involves the rotation of a parabolic dish or antenna through a 360-degree sweep of the horizon. As it rotates, pulses of radio waves or microwaves are transmitted and bounce off any object in its path. The object returns a tiny part of the wave's energy.

These systems are not without limitations. Such systems provided limited tracking capabilities. Upon detecting a potential target, the radar typically waits a second or two for an additional sweep return so that it can correlate the two echoes, extract course and speed information, and start a new tracking



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process. Depending on the sweep rate, this wastes valuable time against an incoming enemy aircraft or weapon.

Mechanical-scan radars are also susceptible to damage. If the servomotors that cause the antenna to rotate or stabilize it fail, or the antenna is damaged, the radar is rendered inoperable. As a result, later generations of radar moved away from mechanical scanning toward fixed, phased array radar systems in which all movement is eliminated.

Fixed Phased Arrays

Phased arrays are composed of evenly spaced antenna elements, each of which emits a signal that incorporates a phase shift to produce a phase gradient across the array. The amplitudes of the signals radiated by the individual antennas, and the constructive and destructive interference caused by objects, determine the effective radiation pattern of the array.

By digitally varying the signal phases and amplitude of the elements in an array – a process known as digital beamforming – the main beam can be “steered” to determine the direction of the signal source, even though the antenna does not physically move.

Because of the rapidity at which the beam can be steered, phased array radars can perform search, track, and missile guidance functions simultaneously with a capability of over a hundred targets.

Phased array systems vary in size and complexity. For several decades, massive planar arrays have been used aboard Navy warships and are at the heart of the shipborne Aegis combat system and the Patriot Missile Systems. Smaller phased array antenna



By improving the performance of the receiver, next-generation products expect to improve the radar results in more complex, real-world scenarios such as tracking a suspicious vehicle moving through a densely populated area.

can be built to conform to specific shapes, like missiles, infantry support vehicles, ships, and aircraft.

Although there are several ways to accomplish electronic beam steering, one such technique involves varying the

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phasing between elements in a fixed, multi-element array. This is typically accomplished with power dividers that emit signals of varying phase and amplitude to the antennae.

As an example of the hardware improvements required in next-generation systems, power dividers serve as a prime example.

Hardware Improvements - Power Dividers

Power dividers are passive components that divide an input signal into two or more identical output signals. For phased array systems that require a range of signal amplitudes, the input signal is often altered using attenuators to vary the signals prior to output to deliver the desired signal level.

The traditional way of accomplishing this is to utilize a standard, multi-channel power divider with attenuators at each of the output ports. Attenuators,

however, increase the overall size and weight of the unit while drawing additional precious watts of power. The size and weight of the power divider with attenuators made it difficult to deploy on jet planes that could benefit from more sophisticated radar.

There are power dividers that split power from 6.7 to 18.4 dB across the output ports and do not require attenuators. Operating between 1100 and 1500 MHz, the 8-way divider is optimized for space-constrained applications. The divider can handle 350W peak and 35 W CW.

The output signal is staggered in fixed amplitudes that begin at 18.4 dB at ports 1 and 8, 12.4 dB at 2 and 7, 8.6 dB at 3 and 6, and 6.7 dB at ports 4 and 5. The 8-output ports are each connected to a fixed antenna. The power divider extends the coverage from one mile to several miles.

The next generation of phased array systems, along with advanced signal process-

ing techniques, could have significant benefits for many branches of the military. For example, higher-resolution radar could be used to initiate a computer takeover in the event of a missile attack on a jet plane. Using sophisticated evaluation of the missile's speed and trajectory, millisecond-to-millisecond, computer-controlled micro-adjustments could be used to evade the threat.

In an intense battlefield application with numerous vehicles and personnel, advanced radar could be used to not just track high-speed targets, but also slow-moving targets like ground troops. Armed with this information, the command center could have complete, real-time visibility of all moving components of a battlefield.

This article was written by Anuj Srivastava, President and CEO of Renaissance Electronics & Communications, Harvard, MA. For more information, visit <http://info.hotims.com/55588-541>.

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Electronic Warfare Development Targets Fully Adaptive Threat Response Technology

When U.S. pilots encounter enemy air defenses, onboard electronic warfare (EW) systems protect them by interfering with incoming radar signals — a technique known as electronic attack (EA) or jamming. Conversely, electronic protection (EP) technology prevents hostile forces from using EA methods to disable U.S. radar equipment assets.

Defeating hostile radar helps shield aircraft from ground-to-air missiles and other threats, so it's a military priority to ensure that EW systems can defeat any opposing radar technology.

At the Georgia Tech Research Institute (GTRI), which has supported U.S. electronic warfare capabilities for decades, a research team is developing a new generation of advanced radio frequency (RF) jammer technology. The project, known as Angry Kitten, is utilizing commercial electronics, custom hardware development, novel machine-learning software, and a unique test bed to evaluate unprecedented levels of adaptability in EW technology. Angry Kitten has been internally funded by GTRI to investigate advanced methods that can counter increasingly sophisticated EW threats.

"We're developing fully adaptive and autonomous capabilities that aren't currently available in jammers," said research engineer Stan Sutphin. "We believe a cognitive electronic warfare approach, based on machine-learning algorithms and sophisticated hardware, will result in threat-re-

sponse systems that offer significantly higher levels of electronic attack and electronic protection capabilities, and will provide enhanced security for U.S. combat aircraft."

When an EW encounter begins, the Angry Kitten system chooses an optimal jamming technique from among many available options, explained Sutphin, who leads a GTRI development team that includes senior research engineer Roger Dickerson and senior research scientist Aram Partizian.

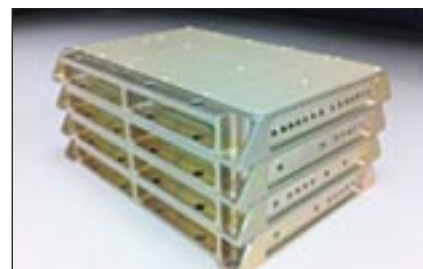
As the engagement progresses, the next-generation system is designed to adapt. It will assess how effective its jamming is against the threat and quickly modify its approach if necessary.

Angry Kitten research also includes investigation of cognitive learning algorithms that allow the jammer to independently assess and respond to novel opposing technology. The team is developing techniques to enable an EW system to respond effectively should it encounter unfamiliar hostile radar techniques.

Moreover, the flexibility of the Angry Kitten system allows it to represent a range of threat EA systems. That will help to support the development of new and improved EP measures.

Adaptive Digital Technology

Traditionally, Sutphin explained, radar jamming has consisted of two basic approaches. One employs mechanical techniques that reflect radar beams back at the sender using chaff material spread through the air behind the carrying platform. The other uses electronic techniques to emit powerful electromagnetic signals that interfere with incoming hostile radar beams. But these techniques are relatively basic, and they involve overt



This image shows stackable RF system enclosures used for the Phase-I GTRI next-generation EW prototype. (Stan Sutphin)

suppression strategies that are often obvious to the other side.

Today's top EW systems are more subtle, thanks to digital techniques. The most advanced technology today – digital radio frequency memory (DRFM) – can deceive an enemy by recording his received radar signals, manipulating them, and sending back false information that seems to be real.

"A DRFM jammer is a very effective way of adding clutter to the scene without just using unsophisticated noise-jamming techniques," Sutphin said. "You can create false targets, or hide real targets, using the enemy's own waveforms against him."

The GTRI team believes that countering such techniques will lead to the development of increasingly more precise digital techniques for radar EP. That could spark an equivalent race for more advanced jammer techniques.

"We need an approach to more quickly evaluate advances in digital RF signal generation, and to rapidly field countermeasures without expensive hardware upgrades," said Tom McDermott, GTRI's director of research.

In the first phase of developing a next-generation system, the GTRI team completed an advanced jamming system prototype. This custom hardware utilizes a wideband tunable transceiver system, and is built using open architecture/open source approaches that are low-cost and enable operators to quickly modify the system in response to changing conditions.

The team is currently developing machine-learning algorithms that will allow the Angry Kitten system to continually assess its environment and switch among



GTRI's next-generation EW equipment – carried in a bright blue pod at the bottom of the photo – being flight-tested aboard an L-39 Albatros jet trainer aircraft. (Stan Sutphin)



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GTRI research engineer Stan Sutphin in an L-39 Albatros jet trainer aircraft used for EW flight testing. (Stan Sutphin)

the best methods for jamming incoming threats. The ultimate goal is a robust platform that will characterize any threat emitter and respond in real time in the most effective way.

A Unique Test Bed

Today, DRFM jammers employ a computer-based "library" of known threats that are used to identify and neutralize incoming signals, Sutphin explained. DRFM equipment may also include an electronic-intelligence (ELINT) capability, which monitors and collects information on enemy signals and jammers. The ELINT data gathered may eventually be used – possibly weeks, months, or years later – to improve U.S. threat-response techniques.

"What we want is to perform those same ELINT analysis and adaptive-response tasks in seconds – while the jamming is occurring – not months later," Sutphin said. "And obviously, our system must work autonomously, because there's no time for human input."

To support the current effort, the researchers are utilizing a GTRI-designed tool called the enhanced radar test bed. Devised by a team led by Partizian, the test bed simulates opposing radar signals and enables convenient, low-cost, and highly realistic testing of jammers.

The test bed is an important asset in the development of the Angry Kitten system, Sutphin said. It offers the ability to collect realistic, representative jammer data on advanced waveforms. It can be used to represent virtually any known threat – and even hypothetical radar systems that don't currently exist.



The test bed allows the team to rapidly prototype a software approach, test it out against simulated enemy hardware, and come up with high-fidelity data. The researchers can perform this work without having to build or acquire actual hardware radar systems or jammers, or engage in expensive flight tests.

"And we can do it all in a lab, behind closed doors," Sutphin said. "This is a good approach for us, because it's not only effective and low-cost, it's quite secure."

This article was written by Rick Robinson for Georgia Tech Research Institute (GTRI). For more information, visit www.gtri.gatech.edu.

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Damping Measurement for Wafer-Level Packaged MEMS Acceleration Sensors

Two methods were developed for mechanical analysis of MEMS sensors.

Army Research Laboratory, Adelphi, Maryland

Microelectromechanical system (MEMS) three-axis acceleration threshold sensors have been developed to measure acceleration threshold levels using voltage switching when the threshold is reached. Determining damping coefficients is important for categorizing how each threshold sensor or switch operates. Switches with different damping coefficients result in different mechanical impedances and response times. Analytical and numerical methods to model damping coefficient values based on empirical data are needed to characterize three-axis acceleration sensors; traditional methods use the displacement of an underdamped system to calculate the damping ratio.

Mechanical switches are single output devices that distinguish whether closure occurs or not, and lack a transduction mechanism to turn acceleration into a readable displacement signal.

Two damping measurement techniques were developed that are unique in their application, and cover all

damping ratio values: underdamped and overdamped systems.

The first method, the acceleration table damping predictor, computed the damping coefficient at the time of specified voltage changes. MEMS acceleration switches developed for 60G fusing impact environments were used to evaluate this non-destructive method for damping measurement. The MEMS impact sensors are omnidirectional, consisting of two out-plane contacts (top and bottom) and one in-plane contact for lateral or side acceleration events.

In the second method, the harmonic excitation model damping predictor (HEMDP) method, underdamped 50-2000G MEMS impact acceleration sensors were tested. The sensors were omnidirectional; therefore, switch closure is dependent upon switch orientation during vibration.

The goal of the experimental approach was to empirically characterize MEMS acceleration switches on a linear impact table and an inductive shaker,

and use these results to determine damping values. During an impact event, typically all modes are excited, resulting in a superposition of modal displacements. During harmonic excitation, a particular mechanical mode can be excited, generating a very simple motion. Damping values determined from harmonic excitation will be very specific to the mode, whereas damping values obtained from impact tests will be generalized.

A linear shock table was used to test the sensors, allowing the data acquisition device to plot acceleration and voltage change over time (Figure 1). An open switch indicated little or no voltage drop, but at switch closure, the short circuit caused a change in voltage. The system setup was arranged to analyze one sensor at a time. Four channels connected to the data acquisition device were used to collect data. Channel 1 was used for measuring acceleration of the table at impact and Channels 2, 3, and 4 measured the voltage changes for each contact (top, in-plane, bottom).

Six sensors were attached to a voltage divider circuit that was connected to the data acquisition device (Figure 2). The sensors were attached to a mounting plate in different orientations using screws and washers. Different pads were used to absorb the shock from the impact. Softer cushions were made of rubber, and the harder cushions were made of a harder plastic.

The linear impact table method used acceleration shock profile to induce MEMS acceleration switch closure. This method differs from the harmonic excitation method because when the MEMS switch is put into a transient shock environment, multiple modes are excited. The harmonic excitation method uses an inductive shaker to excite single modes of interest. The harmonic excitation method only works for an underdamped system, which is a limiting factor for this testing method. Both testing methods re-

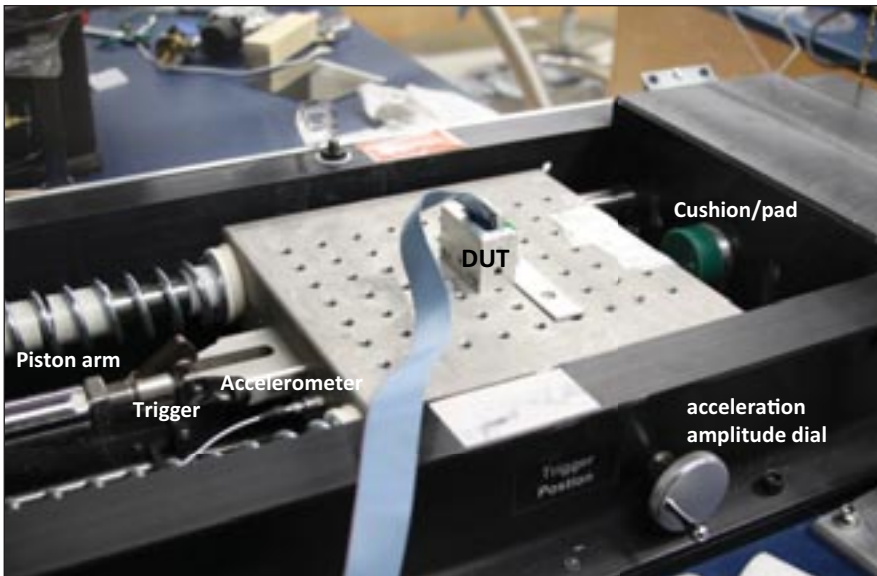


Figure 1. The LSM-100 linear shock machine used pressurized air and a piston arm to pull back the plate, which compressed the spring coils. The piston arm would hit the trigger and release the plate, forcing the plate into a damping pad at high speeds. The trigger could be moved at different, measurable distances to vary the acceleration amplitude.

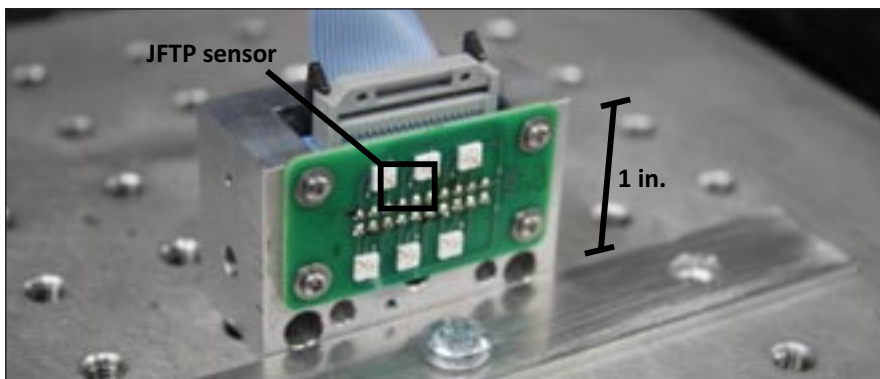


Figure 2. Six 60G MEMS sensors were attached to a voltage divider circuit that was connected to the data acquisition device. The sensors were attached to a mounting plate in different orientations using screws and washers.

vealed nonlinearity to damping as a function of input amplitude.

Determining the damping values of an impact acceleration switch helps categorize how the switch functions. The novel method developed to measure damping by measuring closure time helps model designs to further improve design to more accurately close at the expected acceleration.

This work was done by Ryan Knight and Evan Cheng of the Army Research Laboratory. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Sensors category. ARL-0175

Sensing Suspicious Powders Using Noncontact Optical Methods

This handheld sensing instrument enables identification of suspicious powders in near-real time at the site of an incident.

Army RDECOM, Durham, North Carolina

Suspicious powder incidents continue to be a disruptive and costly problem. In-situ assessment of suspicious powders within inorganic matrices, particularly with powders of biological origin, is currently limited to detection by biochemical methodologies that react with monomers such as amino acids, nucleic

acids, lipids, or macromolecule compounds comprised of these basic sub-units. Current optical methods such as Raman spectroscopy using excitation in the near infrared at 785 nm or visible at 532 nm, have not been able to detect or distinguish biological materials from background or other materials.

A handheld technology was developed that employs a fusion of deep UV excited Raman and fluorescence spectroscopic methods. The proposed Biological Reconnaissance & Analysis using Non-Contact Emission-spectroscopy (BRANE) sensor enables detection and classification of a broad

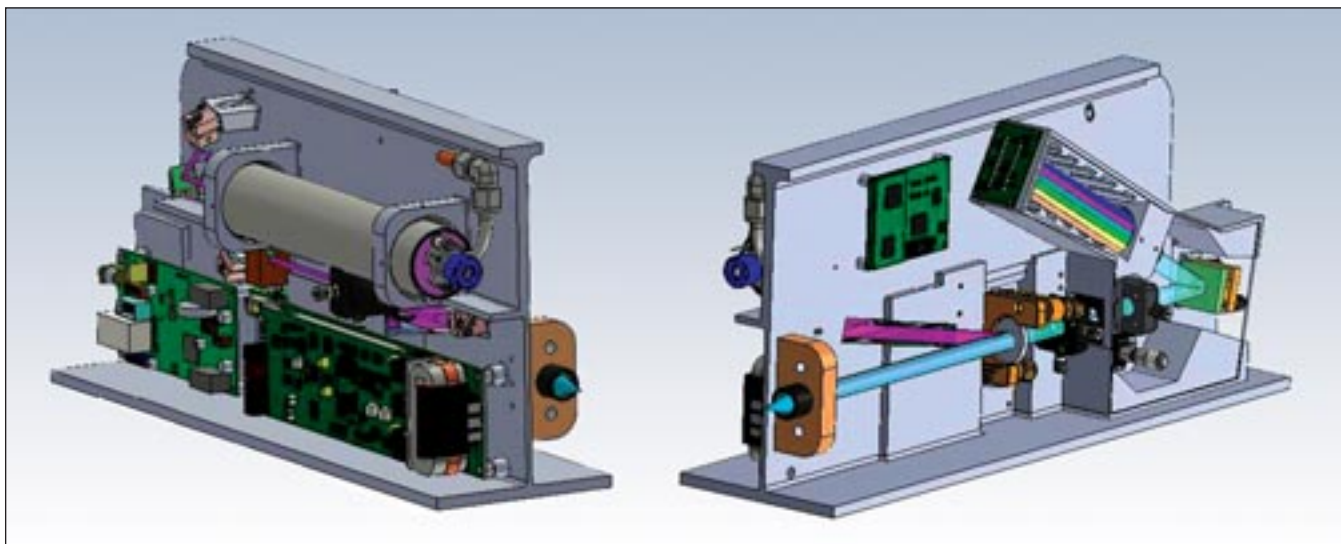


Figure 1. The laser/computer side (left) and spectrometer/detector side (right) of the BRANE sensor instrument.





Figure 2. Photos of the BRANE sensor left and right sides, with most key elements physically in place.

range of suspicious powders in real time at the site of a contamination incident without the need for reagents, labels, or other consumables. It also avoids contact with or disturbing the suspicious powder and the subsequent need for decontamination of the sensor, or spreading, growing, or dispersing biological threats in suspicious powders. It provides rapid analysis; for each 60- μ s laser pulse, a full spectrum analysis is possible.

The BRANE sensor has the noncontact, no-sample-handling advantages of Raman-based sensors, with the advantages of deep UV excitation of samples at wavelengths that enable simultaneous detection of both Raman emissions without obscuration by fluorescence, and fluorescence emissions without alteration by Raman emissions. This can only be conducted in the deep UV below 250 nm. The BRANE sensor is capable of making millions of tests with no consumables cost in an instrument with indefinite field life-time. It is also capable of detection and classification of a much broader range of contaminants beyond biological that includes chemical and explosive hazards. All this is done in a single sensor without the need for modification for different applications.

The BRANE sensor optically analyzes the nucleic, protein, and lipid components of biological threats to assess their presence and identity. This is enabled by three new technology elements: 1) a miniature deep UV laser with narrow linewidth that enables simultaneous Raman and fluorescence detection; 2) a high-speed linear CCD array detector that enables handheld miniaturization; and 3) chemometric algorithms that enable classification of biological material using a fusion of deep UV Raman and fluorescence spectroscopy. The BRANE instrument weighs about 7 pounds, including batteries, and measures about 4" wide by 9" high by 16" deep.

Operating at excitation wavelengths below 250 nm, both Raman and fluorescence emissions can be collected simultaneously on a single array detector, with Raman emissions providing information about molecular bonds with the unknown sample, and fluorescence emissions providing information about overall electronic structure of the sample.

Figure 1 illustrates the BRANE sensor's laser/computer and spectrometer/detector sides. The right side of the instrument houses the laser, laser drive, and control electronics; input/output control board with onboard battery charging electronics and embedded Microprocessor; memory for

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storing all suspicious powder library data and processing all spectroscopic data to compare with library data to determine identity of a suspicious powder; and optical element for processing the laser output. The I/O board will also include an onboard GPS to enable logging of position along with date and time for each data set collected. The left side has the objective lens, contextual imaging camera (not yet shown), laser injection optics, and spectrometer input optics and entrance slit with recollimation optics,

grating, spectrometer imaging lens, linear CCD array detector, and detector control and processing electronics.

Controls include a simple mechanical on/off button or switch to power up the basic system, energize the display, and prepare the sensor for data acquisition. Under this standby condition, BRANE will draw battery power of about 5W. A trigger in the handle activates the laser and detection electronics, and the system begins taking data on suspicious powders at a rate of about 40 combined Raman and fluo-

rescence spectra per second, proving real-time display of the results. For some weak materials, it may be necessary to dwell on a sample for up to about 10 seconds, although most data can be achieved in less than 1 second.

This work was done by William F. Hug, Ray D. Reid, and Rohit Bhartia of Photon Systems for the Army RDECOM. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Instrumentation category. ARL-0174

Isotope Beta-Battery Approaches for Long-Lived Sensors

The energy density of isotopes enables long-life electronics in sensor network applications.

Army Research Laboratory, Adelphi, Maryland

The energy density of isotopes exceeds that of chemical energy storage by six orders of magnitude. Isotopes are used in many commercial applications, and are produced and available at modest prices. The power requirements of many sensors and communications equipment can greatly reduce the power requirements of many devices such as sensors, light sources, and transmitters. Chemical batteries are the mainstay of power for these devices. However, chemical batteries have limited lifetimes. This makes remote use and replacement difficult for applications extending the lifetime use.

The most compelling reason to use isotope power sources for remotely located unattended sensors and communications nodes is the long lifetime power source capability. Isotope batteries provide a continuous flow of energy from decaying isotopes. When isotopes decay, they emit alpha, beta, or gamma particles. The particles' emitted energy can be converted to electrical energy without intermediate thermalization. Isotopes decay in five possible modes: alpha decay, beta decay, positron emission, electron capture, and isomeric transitions. Combinations of particles are commonly emitted during a given type of decay.

The characteristics desired for unattended sensor are long-life operations and safety. There are several beta emitters that exhibit long life. Long life, in this case, means the lifetime of Infrastructure; ~150 years. Keeping safety first means limiting gamma emission and keeping the amount of radioactive material as low as is reasonably possible, while still providing 100 μ W trickle charge output.

Technology issues associated with developing isotope batteries include choices of isotope material, approach to converting energy stored in nucleus to electrical power, and power management. The impact of long-lived power

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sources can begin to have impact on sensors and network arrays now. The most compelling interest in a radioisotope (RI) power source is the unique niche of long-lived power unmatched in chemical power sources. The potential for nano-sized power sources exists because of the isotope energy density; however, energy conversion in the balance of the system presently accounts for a much larger volume in this type of device.

There are several long-lived isotope candidates; these are low gamma emitters, in addition to having long half-lives. They are not commonly produced for industry, making the cost higher. The cost can be lowered if the commercial use increases; as more material is required, the process can be made efficient.

Sealed radiation sources are one of the important tools available in affecting safety and handling. Sealed Source is a term used to describe radioactive sources that have been designed to prevent spread of radioactive material under normal working conditions.

The most straightforward approach to getting a power source out in the field for trials utilizes components that are commercially available. This completely commercial-off-the-shelf approach represents an inexpensive route to producing and licensing a long-lived power source quickly. The device is not the most efficient, most energy dense, or novel in design. It is simple and straightforward, with the goal of getting this extended lifetime power source into the hands of users. Because of the extended lifetime capability, these types of power sources can have great impact towards persistent sensing, communications signal relay, and unattended remote sensing.

This work was done by Marc Litz of the Army Research Laboratory. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Sensors category. ARL-0173

Selective, Sensitive, and Robust Electrochemical Detection of Anthrax

The basic approach should be applicable toward developing biodetection assays against other important targets.

Army Research Laboratory, Adelphi, Maryland

There exists an unmet need for rapid, sensitive, and field-stable assays for pathogen detection. *Bacillus anthracis* is the causative agent of anthrax poisoning. This Gram-positive bacterium secretes a tripartite toxin including a cell-binding protective antigen (PA), and the delivered toxins edema factor (EF) and lethal factor (LF). Anthrax poisoning has high mortality and, when delivered in the form of *B. anthracis* spores, has a very high environmental stability.

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These attributes make the detection of anthrax a priority with regards to issues ranging from food safety to bioterrorism. PA is an important target for detection, so it is not surprising that various biosensor platforms for the detection of PA have been reported, with peptide binders coupled to graphene-, carbon nanotube-, and ZnO-based electrodes or surface-enhanced Raman spectrometer (SERS) substrates achieving limits of detection under 20 pg/mL. These systems are, by and large, not appropriate for field use due to their experimental complexity and/or unproven capacity to detect PA out of complex media such as blood serum.

Of the five fatalities in the 2001 bioterrorism attacks against the United States involving anthrax, the causative agent was only identified in one individual before death. This points to the need for high-performance assays for the analysis of complex samples under such demanding physical conditions.

This work focuses on the development of a stable, synthetic peptide-based capture agent against PA that, when coupled with a specially designed electrochemical assay, permits the detection of PA with a limit of detection (LoD) of 170 pg/mL (2.1 pM), with little sensitivity loss in diluted human serum. The powdered capture agent may be safely stored in a sealed environment at up to 65 °C for several days.

The gold standard reagents for protein detection are monoclonal antibodies (mAbs). Although they can exhibit impressive affinity and specificity, as biological reagents, they can also be plagued by high cost, batch-to-batch variability and poor stability. Alternative capture agent technologies address some of these problems, although achieving high target selectivity is often challenging.

The technique of iterative in-situ click chemistry was developed for the production of protein catalyzed capture agents (PCC Agents). The technique uses the pro-

tein target itself as a highly selective catalytic scaffold for promoting the reaction between two substrates (one presents an azide, the other an acetylene group) to form a covalent triazole linkage. It uses, as one of the substrates, a peptide that was identified via bacterial display screening techniques. That peptide was chemically altered to present an acetylene group, plus a biotin handle linked through a polyethylene glycol oligomer.

A gold-black nanostructured substrate was used as the working electrode to significantly increase the available electrode surface area, and thus amplify the electrochemical signal used for PA detection. A drawback of electrochemical ELISAs is that the layers of immobilization and recognition species that cover the electrode surface can inhibit diffusion-limited electron transfer from the redox-active substrate to the electrode.

A DNA-encoded antibody library technique was used to prepare a dense DNA scaffold for a high-density display of the PCC Agent. An advantage of this scaffold is that electron transfer to the redox-active reporter substrate is facilitated by the DNA duplex monolayer. The detection limit of the electrochemical assay was sharply decreased relative to an otherwise equivalent optical ELISA assay. Electrochemistry also provided a straightforward approach toward detecting PA in optically dense or turbid samples, such as 5% human serum, and exhibited excellent physical stability.

This work was done by Blake Farrow, Sung A Hong, Errika Romero, Bert Lai, Matthew B. Coppock, Kaycie M. Deyle, Ame-thist S. Finch, Dimitra N. Stratis-Cullum, Heather Agnew, Sung Yang, and James R. Heath of the Army Research Laboratory. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Sensors category. ARL-0172

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Technology Update

F-35 Gets Cold Treatment in Step Toward IOC Remedy

Since it first became an active cold-weather testing facility in 1947, the 96th Test Wing's McKinley Climatic Laboratory at Eglin Air Force Base, FL, there have been a wide variety of aircraft to undergo testing at the facility, ranging from the B-29 Superfortress and P-51 Mustang through to the Lockheed F-117, Boeing 787, and Airbus A350 XWB.

Most recently, one of Lockheed Martin's F-35Bs from the F-35 Patuxent River Integrated Test Force in Maryland underwent rigorous climatic testing at the laboratory to verify its all-weather capabilities on its way toward Initial Operating Capability (IOC). The F-35B arrived at McKinley in September 2014, to begin a six-month assessment of the aircraft's performance in wind, solar radiation, fog, humidity, rain intrusion/ingestion, freezing rain, icing cloud, icing build-up, vortex icing, and snow.

With 13 countries currently involved with the program, the F-35 must be tested in all the meteorological conditions representative of those locations from which it will operate, ranging from the heat of northern Australia to the bitter cold of the Arctic Circle above Canada and Norway.

Testing for the F-35 can be done from -40° to +120°F "and every possible weather condition in between," said Billie Flynn, an F-35 test pilot who performed extreme cold testing on the aircraft. "It has flown in more than 100°F heat while also flying in bitter subzero temperatures.



An F-35 shown enduring freezing temperatures in the 96th Test Wing's McKinley Climatic Laboratory. The aircraft is undergoing climate testing in the lab to certify the fleet's ability to deploy to anywhere in the world.



An F-35 is shown sitting under a giant solar lamp setup for extreme testing in the McKinley lab.

In its final days of testing, it will fly through ice and other conditions such as driving rain with hurricane force winds. We are learning more and more about the aircraft every day."

The chamber allows for the simulation of "virtually any weather condition—all while flying the jet at full power in either conventional or vertical takeoff mode," said Dwayne Bell, the McKinley Climatic Laboratory technical chief.

As the F-35 approaches its IOC debut for the U.S. Marine Corps this year, testing for the STOVL (short takeoff/vertical landing) variant required a few more adaptations to procedures than aircraft before it. Eglin AFB reports that the lift-fan system of the F-35B required the design of a 12-ft high "restraint and support" structure interwoven with a system of ventilation ducts. This apparatus secures the aircraft and allows it to operate at high power in both conventional and STOVL mode while inside the building.

To ventilate the exhaust and thus maintain

a stable temperature inside the chamber, conditioned air is constantly pumped in to ensure the pressure in the building is always higher than the pressure inside the ducts surrounding the engine and other openings on the aircraft. This difference in pressure is a safeguard that maintains the jet exhaust is flowing out of the chamber through the ducts, allowing the facility to sustain a constant temperature.

Over days of high-temperature climatic testing, the temperatures of the engine runs were steadily and incrementally increased until it reached the test maximum of 120°F. While the chamber itself was set to a pre-determined temperature, additional solar lamps above the aircraft recreated the intense heat of the sun on the surface of the jet. This is done for the obvious reason that air temperature does not remain constant throughout the day—it increases each hour the sun is up, reaching its apex in the late afternoon. In the chamber, engineers recreated the temperature fluctuation of a 24-h day.

In a matter of days, the chamber transitioned from a seemingly Arizona sauna to the Arctic Circle. Outside air was super-cooled using McKinley Lab's refrigeration system and pushed into the chamber. In increments, the chamber temperature fell



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to -40°F while the jet completed test runs along the way. At such frigid temperatures, aircraft fluids start to thicken and mechanisms operate slower—all points test engineers monitor closely.

The F-35 then faced a harsh barrage of snow and ice. When an aircraft flies through clouds at high speeds in freezing climates, large pieces of ice can form quickly on the exterior. Heavy chunks of ice could potentially break off and damage the aircraft, errantly fly into the engine or create a foreign-object-damage

concern. For this reason, icing is one of the most dangerous elements in climatic testing.

A large apparatus composed of three massive cylinders stacked in a pyramid, parallel to the ground, was placed in front of the F-35 test aircraft. Inside the cylinders were nine ducted fans that blew a large amount of air through a single funnel in the front. Attached to the front of this funnel was a spray bar capable of producing “clouds” of various water droplet sizes.

Those droplets were blown toward the plane and froze upon contact. While the lab cannot generate the precise wind speeds experienced by airborne aircraft, the unique setup inside the chamber is capable of producing sustained wind speeds up to 120 mph—all while subjecting the F-35 to precipitation.

Snow and ice testing gauges the effectiveness of the aircraft’s Ice Protection System and the ability of the jet to perform in winter weather.

Jean L. Broge

EOS and MTU Advance Quality Measures for Metal-Based Additive Manufacturing

EOS and MTU Aero Engines have partnered to develop quality-assurance measures for metal engine components using additive manufacturing (AM), signing a framework agreement for the joint strategic development of their technologies.

The first result of the collaboration is the optical tomography (OT) developed by MTU, which complements the modular EOS monitoring portfolio. In addition to several sensors that monitor the general system status, the camera-based OT technology controls the exposure process and melting characteristics of the material at all times, to ensure optimum coating and exposure quality.

“MTU and EOS have been working intensively for several years, and this collaboration is now about to develop into an even closer, partner-based technological cooperation, centered on their quality-assurance tool,” Dr. Adrian Keppler, Head of Sales and Marketing (CMO) at EOS, explained in a statement. “The OT solution enables us to perform an even more holistic quality control of the metal additive manufacturing process—layer by layer and part by part. A very large proportion of the quality control process that previously took place downstream can now be performed during the manufacturing process, with a considerable saving in quality-assurance costs. This also allows us to satisfy a central customer requirement in the area of serial production.”

Thomas Dautl, Head of Production Technologies at MTU in Munich added,



MTU has deployed its camera-based optical tomography on EOS systems for years now to gain experience and advance the technology for additive manufacturing (AM).

“By employing the quality-assurance system developed by us for use in serial production, EOS is backing an industrially proven solution for its direct metal laser-sintering [DMLS] process. It has proven itself in practical testing and we now intend to make it available to other customers too.”

MTU has deployed the tool on EOS systems for years now, gaining experience and knowledge. Dautl says that this solution ensures comprehensive transparency and also provides a quality-analysis method for the entire manufacturing process and supports its full documentation.

“In this way, EOS and MTU are jointly furthering the qualified use of

additive manufacturing in aerospace engineering while also reducing costs,” said Dautl. “The monitoring solution represents a value enhancement not only for the EOS technology but for each and every customer as well.”

Quality assurance is especially important in serial production, the companies note, because it ensures repeatable high component quality and continually reduces the quality-control costs of components made

using the technology. This ultimately helps to reduce unit costs.

The system settings and process parameters are constantly monitored in the ongoing manufacturing process on EOS systems, to ensure that system and manufacturing process conditions are ideal for maximum component quality.

Because the quality-assurance product is in early development, EOS declined to provide more details on its application, development timeline, and how it will help expand the use of AM in aerospace and other industries. The company plans to release additional information at the end of the year.

Ryan Gehm



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Application Briefs

Multi-Spectral Targeting System

L-3 WESCAM

Burlington, Ontario, Canada

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The MX™-15D designating turret from L-3 WESCAM was successfully used during a weapons demonstration on the Bell Boeing V-22 Osprey tiltrotor aircraft. The demonstration effort was part of the Advanced Technology Tiltrotor (ATTR) program. Through a cooperative agreement between Bell Helicopter and L-3 WESCAM, the designating trials were conducted over a 14-day period in November of 2014 at the U.S. Army's Yuma Proving Ground in Arizona.



During the trials, the V-22 Osprey successfully launched conventional 70mm (2.75") rockets, BAE Systems' Advanced Precision Kill Weapon System (APKWS™), and Raytheon's Griffin® B light-weight precision-guided missiles.

L-3's MX 15D is a multi sensor, multi spectral targeting system



used in military operations, including medium-altitude covert intelligence, surveillance, and reconnaissance; armed reconnaissance; CSAR; and target-designation missions. The stabilized turret enables customers to incorporate up to five separate digital imaging and four discrete laser capabilities into their configurations.

Another successful trial of L-3 WESCAM's MX-15D was conducted in March 2013 when the system obtained Bell Helicopter's qualification as an optional advanced targeting system for the company's 407GT tactical helicopter.

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Radar-Based Threat Detection

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Rapiscan Systems recently announced the addition of CounterBomber, a radar-based threat-detection technology, to its portfolio of security products. The CounterBomber system can identify concealed person-borne threats, such as suicide vests and weapons, at stand-off distances. Using an optional remote networking capability, CounterBomber's video-steered radar technology detects threats, even when the system operator is hundreds of meters away.

CounterBomber has been extensively tested by the U.S. Government, and successfully deployed by the U.S. Armed Forces in all recent major conflicts and other volatile areas around the globe, since 2008. While originally designed to identify suicide vests, the CounterBomber technology also detects other concealed person-borne threats, including handguns, machine pistols, pipe bombs, and grenades, all while maintaining a low false-alarm rate.



CounterBomber® deployed in SW Asia.

Once in operation, the CounterBomber system automatically assesses approaching personnel for hidden threats — without the need for operator interpretation. In addition, CounterBomber's plug-and-play functionality enables quick and secure integration into the command and control (C2) network of a customer's overall security architecture.

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A Floating Armor Torso System (FATS), designed for marine-based forces, inflates when coming into contact with water. If the wearer were to be shot or injured in the line of duty and fall into a river, lake or the sea, the BCB technology would automatically inflate within seconds. The armor increases to the capacity of the size of the inflatable.

FATS has 275 Newtons of buoyancy within the armor, enough to counter the weight of a soldier, the system's insertable ballistic plates, and the soldier's equipment. When the casualty or conscious soldier falls into the water, the 4-kilogram FATS device self-rights, keeping the wearer's airways clear of water.

Ballistic inserts — protected with welded, lightweight waterproof covers — are made of low density and buoyant ultra-high molecular weight polyethylene. The front and back hard-armor plate pockets measure 25 x 30 cm (10" x 12"). An interface on the front and the back provides modularity, with



pouches in any configuration. The rear of the suit has a grab handle, for scenarios where a casualty must be extracted. The FATS technology is adjustable on each side so that the armor fits a variety of human sizes.

The system features a lightweight PU-coated nylon 500 denier outer fabric and easy access to the bladder for rearming, servicing and cleaning. The bladder itself is completely removable so the body armor can be used alone.

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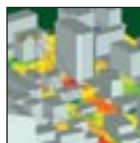
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New Products

Silicon Carbide Foam

Silicon carbide (SiC) foam from Goodfellow (Coraopolis, PA) provides the exceptional hardness, high-temperature durability and performance of solid silicon carbide, but in a lightweight foam structure. The matrix of cells and ligaments of silicon carbide foam is completely repeatable, regular and uniform throughout the material, yielding a rigid, highly porous and permeable structure with a controlled density of metal per unit volume. Characteristics of SiC foam include: exceptional hardness (Mohs 9) and resistance to wear and corrosion; can withstand temperatures up to 2200°C; high thermal and electrical conductivity; and low thermal expansion.

Silicon carbide foam is available from stock in a standard pore size of 24 pores per centimeter (60 ppi), with a bulk density of 0.29 g.cm⁻³, a porosity of 91% and a thickness of 10mm.

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Dual-Node, Short-Depth 4U Chassis



Advantech (Irvine, CA) has launched the 4U, dual-node, short-depth (350mm), industrial chassis ACP-4D00 designed for machine automation applications that require two computers in one piece

of equipment. The dual node architecture allows the user to install two half-size slot SBCs in two sub-systems and integrate them in a compact 4U cage. Each ACP-4D00 node supports a PICMG 1.3 or PCI half-size CPU card with computing power up to desktop Core™ i7, 6-slot backplane with maximum 3 PCIe or PCI expansion slots (3 slots are occupied by CPU card) and 250W or 350W high-efficiency 80 Plus power supply.

Currently Advantech offers two PICMG 1.3 CPU cards—PCE-3028 (Intel® Q87), PCE-4128 (Intel® C226), and three PICMG 1.3 backplanes—PCE-3B03-00A1E, PCE-3B06-00A1E, and PCE-3B06-03A1E, for use with ACP-4D00. The system configurations support the latest Intel® 4th generation Core™ i processors, advanced PCIe Gen 3, or legacy PCI expansions.

For Free Info Visit <http://info.hotims.com/55588-511>

Custom 19" Fan Tray

Verotec (Derry, NH) recently custom designed intelligent fan trays for a major defence project. The 19-inch rack-mounted 1U trays have six fans, strategically located within the tray to maximise the cooling of critical elements of the electronic system located above the fan tray. Key issues for the fan tray design were noise levels, current consumption and reliability. A custom control board sequentially powers up each of the fans in order of importance to minimise initial in-



rush current. An embedded microprocessor controls fan speed using PWM technology.

Reliability is critical, so three separate events will trigger a warning signal: if power is lost to the fan tray, if the controller board itself develops a fault or if the speed of any fan falls below 20% of maximum. The fan cooling the main processor board is deemed to be a critical component, so if its speed falls below 20% the relay latches into the alarm position. If triggered by any of the other five fans, the alarm relay will re-energise when the speed increases above the 20% threshold.

For Free Info Visit <http://info.hotims.com/55588-512>

Signal Conditioning Modules

Precision Filters Inc. (Ithaca, NY) has introduced a new family of signal conditioning modules for measurement systems built on National Instruments™ rugged, compact, low power cRIO™ platform. The four analog input/output modules condition charge, bridge, dynamic strain, IEPE or voltage-based sensors. With the supplied LabView™ driver VI, you can integrate PFI™ signal conditioning module technology with proven NI™ voltage input A/D modules to build a complete high performance sensor measurement system for charge, voltage, bridge and dynamic strain.

For applications where a rugged, low-power, compact standalone signal conditioning system is required as a front-end for a data acquisition system, the new signal conditioning modules can be housed in low-cost 4-slot or 8-slot chassis and controlled by PFI's Graphical User Interface software with no code development needed. All modules feature fully programmable gain and excitation and are equipped with Precision Filters' Test Input for inserting calibration signals at the module input allowing full end-to-end verification.

For Free Info Visit <http://info.hotims.com/55588-513>



Flange Couplings



RINGFEDER POWER TRANSMISSION (Westwood, NJ) has announced the launch of its new RfN 5571 series flange coupling for heavy industry. RINGFEDER® flange couplings provide a superior solution to standard press fits. Equipped with the Ringfeder Shrink Disc this new series eliminates the needs for additional components such as keyways or shims. Eliminating the need for heating and cooling of the part reduces installation complexity. RINGFEDER® flange couplings are slip fit with frictional engagement achieved by torquing the shrink disc screws. Available with hexagon head screws or hexagon socket head cap screws. Some of the advantages provided by this system are: a stronger connection than keyway systems, no wear parts, higher torque carrying capacity, backlash-free shaft hub connection, and a high level of true running accuracy.

For Free Info Visit <http://info.hotims.com/55588-514>



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Digital Meter



The New Technology Meter (NTM) from OTEK (Tucson, AZ) has everything you need to measure and control your process while operating with less than 50mW of power. OTEK's NTM boasts a full tricolor bargraph with 2% resolution and four alarm set points. The NTM includes isolated Serial I/O, isolated O.C.T. or SPDT relays and isolated analog output with P or PID algorithm. OTEK has included signal failure (open or short) detection with date and time transmission. The meter is available in over 30 different input signals. It is also available in loop or signal powered versions, but feature restrictions apply.

The NTM-9 replaces fit, form and function any 6" x 1.74" panel cut-out and has up to two channels. The meter is available in an industrial plastic or a metal housing and can meet nuclear or military grades.

For Free Info Visit <http://info.hotims.com/55588-515>

Virtual Environment Tool Chain

The DiSTI Corporation (Orlando, FL) has commercialized their scalable tool chain and process for producing 3-D virtual maintenance training environments. Previously only available in conjunction with DiSTI's professional services, the Virtual Environment Software Development Kit is now productized as VE Studio and allows users to engineer their own virtual environments for maintenance training.



The foundation of VE Studio is the Fidelity Matrix, a relational database that correlates requirements, 3D objects, 2D support equipment, environment properties, and constraints that feed the automated build and testing tools. The tools that populate and reference the Fidelity Matrix include: Requirements Analyzer, an optional tool to analyze job procedures that in turn auto-populate the Fidelity Matrix with the objects and actions needed to complete the tasks; a graphical user interface for creating and modifying Fidelity Matrix content (FM Editor), a 3ds Max plug-in to associate 3-D model geometry with objects in the Fidelity Matrix (MaxLink), VE Builder, and VE Tester.

For Free Info Visit <http://info.hotims.com/55588-516>

Rugged 1U MicroTCA Chassis Platform



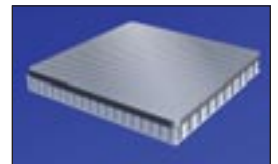
VadaTech (Henderson, NV) now offers a rugged 6-slot MicroTCA chassis in a 1U height designed to meet MIL-STD-901D and 810G for shock and vibration and MIL-STD-461F for EMI. The VT950 holds up to 6 Advanced Mezzanine Cards (AMCs) and has an integrated MCH with IEEE1588/SyncE/GPS capabilities. This includes clock disciplining with arbitrary clock frequency output and holdover (Stratum-3 option) including 1 pulse per second (PPS) regeneration and holdover. The MCH can use various fabrics such as 40GbE/10GbE, PCIe Gen 3, or Serial RapidIO.

The rugged 1U chassis offers front-to-rear cooling with a 500W universal AC or 400W DC power supply. Another feature of the VT950 is an optional JTAG Switch Module, including a Virtual JTAG probe. MicroTCA.1 modules with front panel retention screws can be plugged into the chassis. VadaTech offers special retention clips so that standard MicroTCA.0 AMCs can be securely held into the chassis during shock and vibration.

For Free Info Visit <http://info.hotims.com/55588-517>

Titanium/Composites Brazing

Morgan Advanced Materials (Windsor, UK) announced that it now has the capability to braze carbon fiber, ceramics, composites, or other engineered materials directly to a titanium honeycomb.



Carbon fiber and other similar non-metallic engineered materials have exceptional thermal conductivity capabilities, and are able to remain strong at temperatures exceeding 2000°F, far higher than those at which any metals retain their strength. Titanium honeycomb adds greater strength to the carbon fiber and eliminates fracturing issues by transferring forces from impact better than the carbon fiber alone. Both materials are exceedingly lightweight.

In addition, the strength of the braze bond is exceptional, equaling or exceeding the strength of each component material, unlike the reduced strength of adhesive, riveted, or other bonds. The addition of the titanium honeycomb to the carbon fiber allows easy joining of the titanium to other structures through traditional joining techniques.

For Free Info Visit <http://info.hotims.com/55588-518>

8-Channel Portable Serial Recorder



Pentek, Inc. (Upper Saddle River, NJ) has announced a new recorder for the popular family of Talon® recording systems: the Model RTR 2736A multi-channel Serial FPDP (sFPDP) rugged portable recorder, suitable for military and aerospace, radar, and communications applications. The RTR 2736A is capable of capturing up to 8 Serial FPDP data streams in real time to solid state drives (SSD). It fully complies with the VITA 17.1 specification and additionally supports sFPDP baud rates up to 4.25 Gbaud.

The RTR 2736A includes a high-performance PCIe Gen. 3 SATA III RAID controller capable of streaming contiguous data to disk in real time at aggregate rates up to 3.2 GB/sec. The hot-swappable SSD array is available in 1.9 TB to 15.3 TB configurations and supports RAID levels 0, 1, 5, or 6. The new Talon portable chassis for the RTR 2736A boasts a smaller footprint that is lighter in weight, and provides double the storage capacity, number of channels and the recording rates of previous generation of Talon portable recorders. It also supports AC and DC power options.

For Free Info Visit <http://info.hotims.com/55588-520>



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Most-Viewed Articles

The following are the top 4 most-viewed aerospace-related articles of the month as of mid-February. Additional articles across all transportation sectors can be read at <http://articles.sae.org/>.

1 High-Performance PEKK-Based 3-D Printing a First

<http://articles.sae.org/13830/>



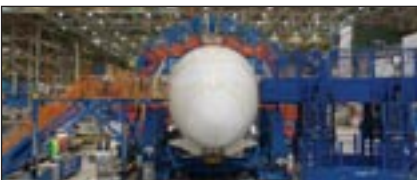
2 NASA Testing Under Way of Shape-Changing Aircraft Flap

<http://articles.sae.org/13803/>



3 Study Weighs in on Emissions From Composite Aircraft

<http://articles.sae.org/13802/>



4 AFRL, ThermAvant Collaborate on Technologies to Help Electronics Stay Cool

<http://articles.sae.org/13819/>



The Ever-Changing Mobility Landscape

"In reality, all technology trends inter-relate; they're all intertwined," Jim Keller, Senior Manager/Chief Engineer for Automobile Technology Research at Honda R&D Americas, Inc., said during an exclusive interview in advance of the SAE 2015 World Congress that his company is hosting.

When drivers started using their cell phones inside vehicles, the unwanted side-effect was distracted driving.

"Distraction changes the way people drive, and that changes what people expect from a vehicle," Keller said. "Honda as well as everyone else in the industry is looking at technical solutions that will allow a variable amount of information flow. It's all about striking a balance. So if a turn signal is on, or a change in yaw rate is sensed, or the brake pedal is depressed, that's not a good time to get a call."

In this SAE World Congress preview article, Keller discusses connected-vehicle technology, augmented reality, and a new Tech Hub venue where these topics and more will be further explored at the upcoming engineering event.

Read more at <http://articles.sae.org/13884/>. Go to <http://www.sae.org/congress/> for more on the April 21-23 event.



"The intent of using augmented reality is to let the driver see the navigation route, including all of the necessary turns, on the roadway as projected through the vehicle's head-up display," said Honda R&D America's Jim Keller. "This advanced vision technology is really cool, and it is something that customers are going to want."

Products

Rugged COTS enclosure

The air-cooled 3U nine-slot D2D chassis from Curtiss-Wright comes in a 3/4 ATR tall long format. The Hybricon D2D-34TLA enclosure enables a system integrator to use the same COTS enclosure throughout the complete program lifecycle, from development to demonstration to deployment. The OpenVPX enclosure eliminates the need to design a custom backplane, speeding the commencement of system design. More detail at <http://articles.sae.org/13857/>.



Walk-In Oven

The No. 1031 is a 650°F electrically heated walk-in oven from Grieve, currently used at a customer location for curing composite components. Workspace dimensions of the oven are 96-in width x 96-in depth x 84-in height. The oven chamber is heated via 140 kW installed in Incoloy-sheathed tubular elements, while a 10,000 ft³/min, 7-1/2 hp recirculating blower provides a combination airflow to the workload. More detail at <http://articles.sae.org/13859/>.

Multi-Display Controller Board

The CC10S multi-display controller board from MEN Micro is based on a Freescale ARM i.MX 6 Series processor. The board provides full HD resolution to LCD TFT panel PCs from 7 to 15 in. The CC10S module is widely scalable from low-end to high-end graphics requirements, depending on an application's needs. More detail at <http://articles.sae.org/13860/>



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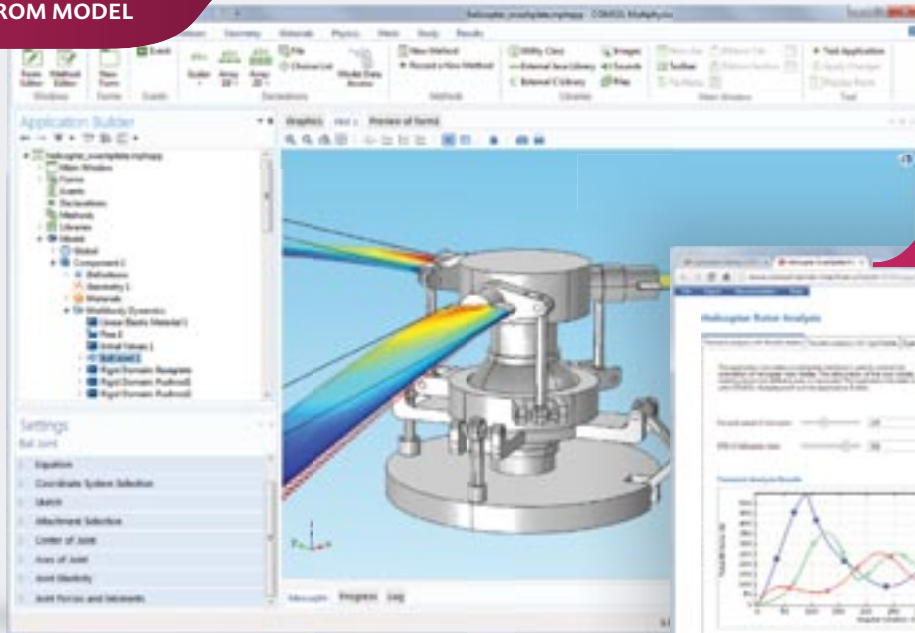
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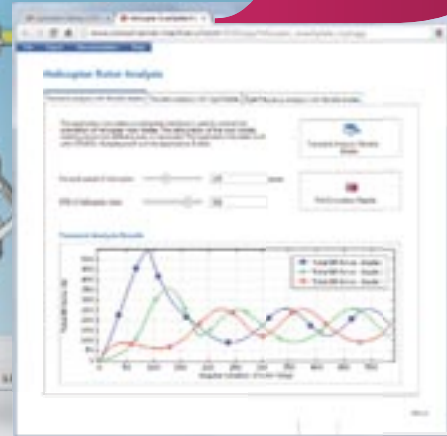


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