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The Engineer's Guide to Design & Manufacturing Advances

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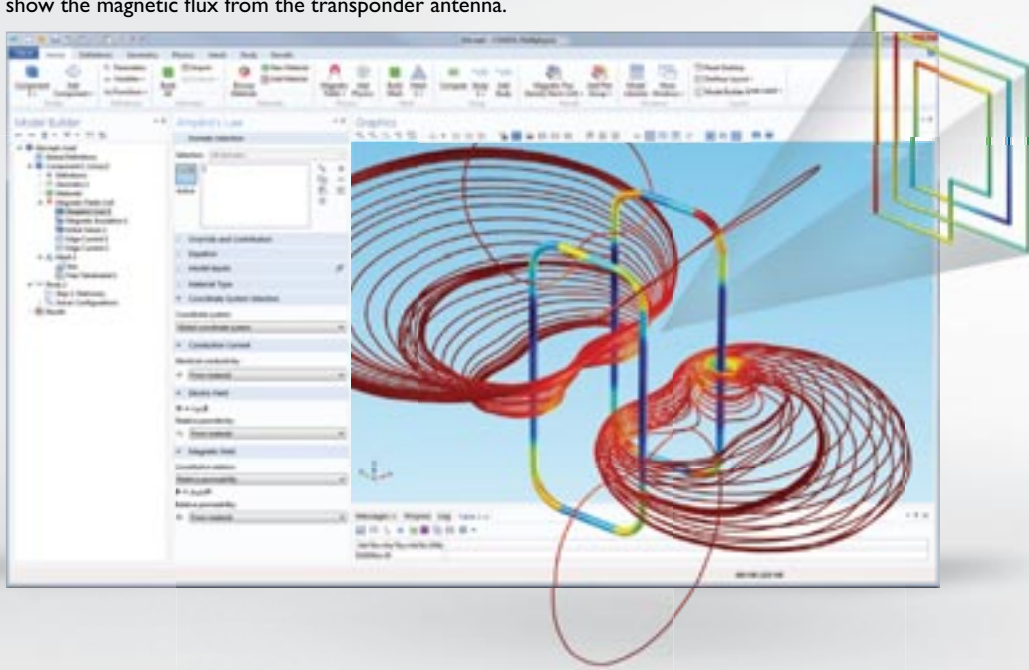


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RFID: Simulation of a reader-transponder pair for radio-frequency identification applications. Results give the mutual inductance and show the magnetic flux from the transponder antenna.



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Covert Infrared Battlefield Combat Taggants

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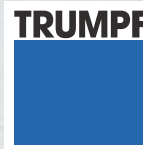


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ON THE COVER

Signals intelligence, radar and communications are just some of the military applications being supported with small form factor computers and software radio boards these days. To learn more, read the feature article on page 16.

Illustration courtesy of Pentek



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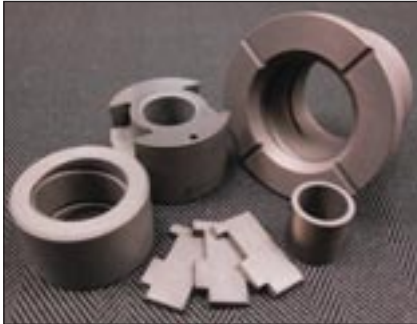




Top products

Engine fuel pump bushings

Metallized Carbon Corp.'s Metcar carbon-graphite bushings offer advantages over traditional metals for use in gear pumps that pump aviation fuel for aircraft engines. The carbon-graphite bushings are used to support both the drive gear shaft and the idler gear shaft. The bushings are preferred for this application because they can use aviation fuel as the bushing lubricant. The bushings are self-lubricating—they can run dry for short periods of time without catastrophic pump failure or significant wear. In addition, they are dimensionally stable, which permits close bushing-to-shaft running clearances. More detail at <http://articles.sae.org/12700>.



Lightweight compression latch

The E3 Vise Action Compression Latch from Southco Inc., delivers robust, vibration-resistant fastening. The latch is suitable for use in a variety of transportation applications and across numerous other industries. It features lightweight, aluminum construction and provides higher strength and superior cycle life for heavy-duty installations. Commonality with existing products allows for simplified installation. More detail at <http://articles.sae.org/12701>.

Microwave analog signal generators

Agilent Technologies Inc.'s N5183B MXG and N5173B EXG microwave analog signal generators provide the signal purity, output power, and modulation developers need for advanced radar, electronic-warfare, and satellite-communications applications. The N5183B MXG analog offers accuracy and efficiency in two rack units. Its best-in-class phase noise of less than -124 dBc/Hz (at 10 GHz, 10 kHz off-set) and -75 dBc spurious enables module- and system-level testing up to 40 GHz. It also accelerates the calibration of complex systems with best-in-class switching speed of less than 600 μ s. More detail at <http://articles.sae.org/12702>.

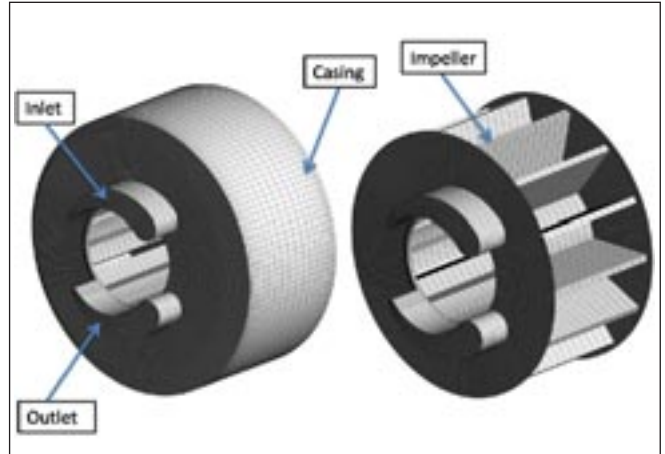
High-power TIG welders

The Dynasty 280 and Maxstar 280 TIG welders from Miller Electric Mfg. Co. deliver more power and can weld metal up to 3/8 in thick, yet are significantly lighter, more portable, and use less energy than machines of similar output capabilities. Weighing 52 lb and 47 lb, respectively, the Dynasty 280 and Maxstar 280 deliver up to 280 A of output power along with a smooth, stable arc to handle any job from small to large. More detail at <http://articles.sae.org/12698>.

Top articles

Predicting cavitation in fuel pumps

Liquid ring pumps are used in aircraft fuel systems in conjunction with main impeller pumps and serve the function of removing fuel vapor and air from the fuel. Thus, their reliable functioning plays a critical role in the safe operation of aircraft during flight. Read more at <http://articles.sae.org/12709>.



The same mesh was used for both the multiple reference frame and the sliding mesh calculations to achieve mesh consistency between the two models for relative comparison and assessment.

Boeing examines expanded metal foils for lightning protection of composite structures

A widely used material for lightning strike protection of CFRP structures within the aerospace industry is expanded metal foil (EMF). An issue with EMF is micro cracking of the paint, which can result in corrosion of the metal foil and subsequent loss of conductivity. Read more at <http://articles.sae.org/12712>.

Falcon 5X gets advanced avionics

Dassault Aviation has built into its upcoming Falcon 5X flight controls and displays experience not only from the Falcon family of business jets but also from the Rafale multi-role combat fighter. Read more at <http://articles.sae.org/12728>.

SR-72 flies into 21st century at Mach 6

Lockheed Martin recently confirmed that its Skunk Works engineers are developing a hypersonic aircraft that will go twice the speed of the SR-71 Blackbird, called the SR-72. Read more at <http://articles.sae.org/12619>.

Thermal management for fuel-cell systems studied

A cooling architecture should be designed in a way that cooling loops and heat sinks are used by different heat sources, researchers at the Hamburg University of Technology say. Read more at <http://articles.sae.org/12737>.



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The Attack-Counterattack Game

Leveraging Digital RF Memory Electronic Jammers for Modern Deceptive Electronic Attack Systems



Modern aircraft feature a variety of electronic counter measures for protection.

In the world of electronic counter measures (ECM), there is a constant battle of one-upmanship, where each side is continually innovating to stay ahead of the other. ECM are typically developed and implemented to thwart an adversary's specific radar technology. To be effective, Electronic Attack* (EA) systems must be able to identify emitters in the environment and then selectively attack with specific techniques. They must also possess the ability to attack multiple emitters simultaneously with a combination of non-coherent and coherent jamming techniques.

As an example, assume a missile system is targeting an enemy aircraft. To confuse the oncoming missile, the enemy aircraft triggers an ECM. The goal of the ECM is to deny or deceive the incoming missile's targeting system so it will miss the aircraft. In order for the missile to succeed against various ECM techniques, the missile's targeting system must be "taught" to counter the countermeasure.

This attack-counterattack game has given rise to the need to develop electronic attack (EA) systems that mirror enemy techniques in order to test U.S. and allied systems performance. These

systems enable the testing and verification of weapon and defense systems against an enemy's ECM techniques. Armed with this knowledge, you can develop capabilities to counter any electronic countermeasures they employ.

Denial Jamming

One EA technique is denial jamming. Put simply, if an enemy system emits one frequency with a particular pulse-width and pulse interval, your system detects and identifies that signal. It then blasts a massive amount of noise at that frequency, jamming the enemy and preventing that frequency from being used. The next move belongs to the enemy radar, which might simply jump to another frequency. Think of it as a countermeasure followed by a counter-countermeasure. Then the detection game starts again.

Deceptive Jamming

A step above denial jamming is deceptive jamming. Deceptive jamming requires a higher level of sophistication and this is where Digital RF Memory (DRFM)-based jammers come into play. A DRFM-based jammer receives and records the frequency, pulse-width and pulse interval of an enemy system and

produces a false return signal by playing back the recorded signal. This false signal deceives the enemy system so that it sees the false return as a real target. The enemy then tracks the false target instead of the real one.

As an example, assume enemy radar has detected a fighter jet and starts tracking it. If the fighter has an EA system on-board using a DRFM-based jammer, this system can detect the enemy radar, ingest the signal and create a false return to the enemy radar. This false return can take several variations including "ghosting" so that the enemy radar thinks that the target plane is in a different location. DRFM-based systems are highly effective at accomplishing this based on their extremely low latency and ability to faithfully reproduce returns with all the signal characteristics of the radar source. The goal is to make the enemy radar think that the return signal is from the target rather than generated by a jammer.

In order to do this effectively, the DRFM must faithfully reproduce the characteristics of modern radar systems including frequency and phase modulations on signal pulses. An advanced DRFM-based EA system also adds the necessary modulations to the return sig-

* Electronic attack (EA) or electronic countermeasures (ECM) involves the use of electromagnetic energy, or counter-electromagnetic radiation weapons to attack personnel, facilities, or equipment with the intention of directly affecting, degrading, neutralizing, or destroying an enemy's combat capability.



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nal, such as Doppler frequency modulation to match the range rate of the false target. Lastly, an EA system using a DRFM follows any changes in signal characteristic produced by the enemy system in order to deceive the enemy system into “believing” that the false target being generated is real. This takes the focus away from the actual target and protects it.

Threat Analysis

Anticipating the capabilities of an adversary’s ECM system is a key component to reducing the vulnerability of friendly radar systems to new techniques. Meanwhile, adversaries are constantly attempting to develop radar systems less susceptible to being jammed. This ongoing cat-and-mouse game is what pushes industry innovation forward.

The best way to ensure that an adversary cannot counter friendly radar and weapons systems is to test against actual enemy jammers. In the U.S., that is where the test and evaluation (TE) community comes into play. The TE community is composed of various agencies within the Navy, Air Force and other governmental agencies. They assess and analyze any existing or future ECM weapon systems that present a threat to U.S. or allied systems and warfighters. It is the goal of the TE community to ensure that electronic systems are not vulnerable to jamming techniques.

The TE community collects signals intelligence data or predicts signal trends in order to identify the capabilities of enemy EA systems. Using this information, ECM techniques can be generated which mirror the behavior of enemy systems. The TE community then tests these techniques against U.S. and allied radars and weapons systems to determine their level of jamming success.

Various Testing Scenarios

Simulated RF Environments: There are multiple ways to test the effectiveness of electronic systems. In one testing scenario, an EA technique can be positioned against a radar system in a laboratory or anechoic chamber. By running the EA system in this type of setting, it is possible to safely and cost-effectively determine if a jamming technique is able to



Various methods, such as anechoic chambers, are used to test the effectiveness of ECMs.



High performance EA systems are critical for producing DRFM deceptive jamming.

interrupt a radar system’s ability to acquire and track a target.

Some systems for test laboratories and anechoic chambers feature radar environment simulators (RES). State-of-the-art RES systems generate targets, weather, and other obstacles that a radar would normally encounter. Electronic

countermeasures can be generated to further simulate the RF environment.

Depending on the application, an actual plane or missile seeker can be brought into a test chamber. Their radars are tested to determine if they can still track simulated targets amidst standard ECM techniques.





Flight Systems: A second testing method calls for the mounting of an EA system on an aircraft. An adversary ECM system, or an ECM system which simulates the adversary system, can be placed in a pod that is mounted on another plane's wing. The two planes are then flown against each other in an exercise which allows military analysts and/or pilots to see exactly what the aircraft's radar displays in a real combat situation.

ECM systems can also be placed in unmanned drones, which are then targeted by actual missiles. In this case, if the missiles never reach the drone, it would verify the effectiveness of the ECM system. This level of real-life testing eliminates any suppositions or estimations by engineers.

Jammer Simulation: Jammer simulation is the third EA testing method. When armed with the knowledge of specific jammer methods and tech-

niques, a jammer simulator can be programmed to mimic the capabilities of an EA system. The fidelity of the simulation can be evaluated for analysts to generate a validation report to be used by the TE community for test planning. Validated simulators can be used against radar to verify the radar's ability to operate in the presence of a particular EA system and to minimize the system's vulnerability to jamming.

Roles and Responsibilities

It is important to note that the TE community is set up to coordinate the vulnerability testing for electronic systems and then make determinations based on its findings. It is their job to identify which systems work against which techniques, and to what degree. Additionally, the TE community — not the supplier of the EA test asset — is responsible for programming the EA system to make specific signal measure-

ments and to generate particular jamming techniques.

Conclusion

DRFMs play a critical role in ECM and hence, in EA developments. By leveraging information captured from present and future enemy systems, DRFM-based test systems can be employed to test new EA systems and verify whether or not these systems will succeed. With the growing reliance on electronic attack systems to protect warfighters and equipment, continuous testing and updating is required. And leveraging DRFM-based test systems fills this need in a modular, programmable, and cost-effective manner.

This article was written by Tony Girard, Director of Engineering, Mercury Defense Systems (Cypress, CA) — a subsidiary of Mercury Systems, Inc. For more information, visit <http://info.hotims.com/49744-500>

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Covert Infrared Battlefield Combat Taggants

Modern warfare often involves poorly defined battle lines accompanied by multi-level fire support systems that can deliver firepower with high precision and devastating lethality from a long distance. The ability to immediately and accurately discriminate through sight between friend and foe is of great importance to military operations for effectively destroying hostile forces while preventing fratricide. This ability is even more crucial for irregular and unconventional warfare such as anti-terrorism operations where US forces often engage enemy combatants well entrenched in urban settings or rugged terrains at night. In such battlefield conditions, using conventional daylight and thermal imagery often exceeds the ability to accurately identify targets as friend or foe, and more reliable battlefield identification methods are needed.

Tagging, Tracking and Locating

Tagging, tracking and locating represent a valuable technology for both commercial and military applications. For military operations, the tagging systems (taggants and detectors) must satisfy three basic requirements: covertness, (i.e., signals cannot be easily detected by common techniques), quick and accurate identification from a long distance (up to a mile or farther), and both lightweight and ruggedness suitable for field applications. Other important criteria may include two-way communication, the ability to track and identify a large number of subjects and objects, and specific capabilities tailored for unique battlefield conditions.

Materials and devices emitting in the infrared region represent an important class of covert optical taggants. Infrared (IR) light (from 0.75 μm to 1000 μm) is electromagnetic radiation with wavelengths longer than those operating in the visible region. For military applications, the IR wavelength is usually limited to 15 μm . An integrated infrared

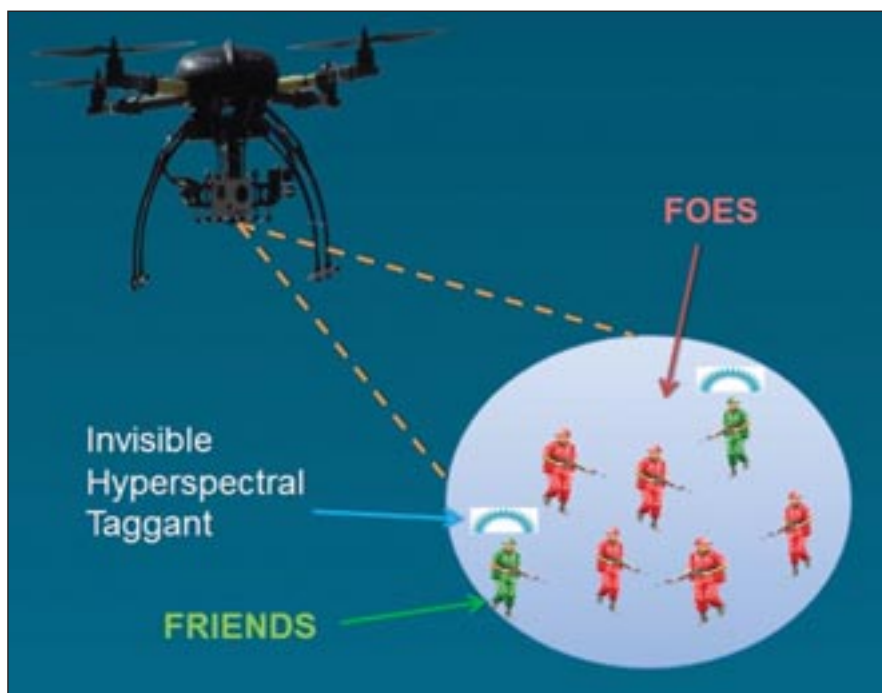


Figure 1. Optical taggants can be used effectively in battlefield situations known as "identification friend or foe (IFF)". Here a hyperspectral imager from the air identifies friendly soldiers in the general area where both sides are present. (Diagram courtesy Brimrose Corporation)

tagging system consists of three essential parts: infrared emitting (or absorbing) taggants, photodetectors, and an intelligence interface. Certain materials can emit infrared light through chemiluminescence, photoluminescence or electroluminescence.

There are three general groups of infrared emitting materials: organic IR emitting dyes, lanthanide IR emitters, and semiconductor IR emitters. Many pure organic dyes have been developed especially for NIR bimolecular imaging. The use of NIR fluorophores will eliminate background noise caused by the autofluorescence of biosubstrates. Common organic NIR fluorophores include cyanine, oxazine and rhodamine dyes. The fluorescence maxima of these dyes are between 700-850 nm. Organic near IR dyes can be used to make glowstick-type IR light sources through chemiluminescence.

Organic dyes with fluorescence maxima extending to far near IR and into short wave IR (SWIR) can be achieved by the formation of metal ion complexes. The most notable group of metals whose ions are capable of narrow band infrared emission is the lanthanide series with atomic numbers 57 to 71 (lanthanum to lutetium). Lanthanide infrared phosphors can also be hosted in inorganic matrices. These inorganic host materials include fluoride and oxyfluoride optical glasses, such as NaYF_6 , $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-NaF-YF}_3$, and oxide glass/ceramics including SiO_2 , ZrO_2 , Y_2O_3 , and $\text{Y}_3\text{Al}_5\text{O}_{12}$ (yttrium aluminum garnet; YAG). These inorganic host materials are generally optically transparent, especially in the IR spectral region.

Infrared emissions of lanthanide are often achieved through photoluminescence. Photoluminescence of lanthanide cations are due to their abundance of 4f-



He Created the Future.

Mark Wagner, President
of Sensorcon, Inc.
Grand Prize Winner of the
2012 Create the Future
Design Contest.



Smartphones are getting smarter thanks to Sensordrone, a keyfob-sized device that dramatically extends the sensing capability of phones and tablets for applications ranging from medical to environmental monitoring. For the inventors at Sensorcon, Inc., entering the Create the Future Contest was another smart idea.

"Winning the Grand Prize in the 2012 Create the Future Design Contest validated the Sensordrone as a truly unique new product and helped bring additional positive attention to it, enabling a successful production launch in 2013," says Mark Wagner, President of Sensorcon.

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Figure 2. A soldier wearing an optical taggant on his right sleeve. In the left photo, the taggant has not been activated. At the right photo, the optical taggant has been activated. The activated taggant is not available in the visual spectrum, but only when using the hyperspectral imager, scanning at the predetermined wavelength. (Photos courtesy Brimrose Technology Corp.)

4f and 4f-5d transitions. Well known IR emission wavelengths from lanthanide ions are generally in the 1-3 μm regions, and this has led lanthanide ions to become active centers in laser gain medium materials. It is also known that several trivalent lanthanide ions possess possible emission transitions in the MWIR spectral region (3-5 μm).

Semiconductor Materials

Semiconductors are important optical materials. Unlike organic fluorophores or lanthanide ions whose optical properties are mainly determined by molecular or atomic structures and are usually un-tunable, optical emission and absorption of semiconductors are due to their unique band gap, which often falls into the infrared energy region. Their wavelengths can be further adjusted, either by forming compound semiconductors or reducing the size to cover a broad wavelength range. Semiconductors are the foundation materials for modern infrared detectors as well as infrared light emitting diodes (LEDs) and laser diodes. LEDs and laser diodes are commercially available for infrared light emission at wavelengths from near IR to mid IR (1-5 μm).

LEDs and laser diodes both have their advantages and disadvantages. Compared to LEDs, laser diodes produce much narrower band emissions, but they may require cooling features such as heat sinks, especially when operating at high-energy densities, while for LEDs no cooling is needed. Light emissions from LEDs and especially laser diodes are highly directional. This not only raises concerns about eye safety, but also limits wide-angle visibility. There-



Figure 3. A Brimrose hyperspectral imager used for identifying optical taggants at unconventional wavelengths.

fore, light scattering/diffusing media are often integrated with LEDs and laser diodes. Examples of these optical media include side-emitting fibers/strips and light scattering lenses/coatings.

A new class of semiconductor-based infrared absorbers and emitters are semiconductor quantum dots. Quantum dots (QDs) are tiny semiconductor particles usually below 20 nm in diameter. Quantum confinement occurs when the size of a semiconductor crystallite is reduced below its exciton bohr radius. These small semiconductor crystallites, commonly referred to as quantum dots, have properties between those of bulk materials and of molecules.

For smaller quantum dots (usually below 10nm), quantum confinement dominates the electronic properties leading to highly discreet energy levels. In this region, the band gap and splitting of energy levels are highly dependent on the size and shape of the quantum dot, and in general the band gap is inversely related to size. Therefore, the electronic and optical properties of quantum dots can be easily tuned by

varying the size during synthesis.

The high versatility of quantum dots for wide spectrum infrared absorption and emission is also due to the availability of many types of narrow bandgap semiconductors. Compared with quantum well structures grown with either molecular beam epitaxy or chemical vapor deposition, colloidal synthesized semiconductor quantum dots are much cheaper to make. With this low-cost factor, combined with the capability of highly efficient narrow wavelength photon absorption and emission spanning a broad spectrum, quantum dots show promise for revolutionizing infrared detection and emission applications including low-cost infrared detectors and infrared emitting devices such as LEDs, laser diodes, and electroluminescent displays (ELDs).

The encoding of optical signals generated by taggant materials is a crucial step for achieving a rich collection of distinct markers/signals. Basic encoding techniques can rely on the manipulation of the population makeup of emitter mixtures; the emitter/host material relation/interaction; the taggant excita-



They Created the Future.



The team at SunFriend Corporation (l-r) Leonard Egan, Siddharth Potbhare, Karin Edgett, and Shahid Aslam (not pictured — Tariq Aslam). Winners of the 2011 Consumer Product Category.



The UVA+B SunFriend will be available for purchase in April 2014.

SunFriend Corporation developed a wristband that uses NASA inspired sensor technology to tell you when you've had enough sun exposure. The designers were exposed to a world of opportunity when they entered their product idea in the Create the Future Contest.

"Winning the Consumer Product Category in the Create the Future Design Contest gave us the confidence and momentum to bring the UVA+B SunFriend activity monitor all the way to market," says Karin Edgett, CEO of SunFriend. "We were able to leverage the value of the award to help at every phase, from funding to attracting valuable team members."

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tion algorithm; the choice of detectors and detection techniques; and the use of logical analytical tools such as computers. For instance, through taggant markup manipulation, materials with

different emissions and excitation wavelengths can be blended into multi-wavelength compound-emitters or strategically distributed into patterns/layers to produce sophisticated signals and codes

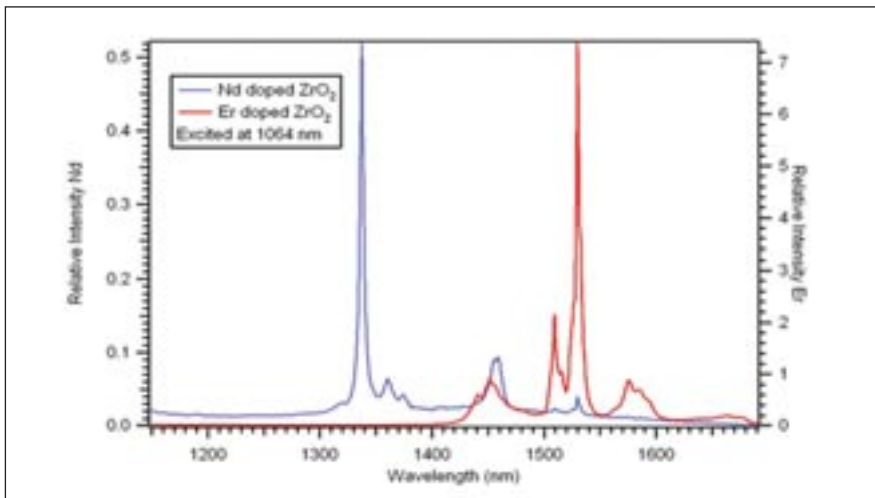


Figure 4. Photon emissions of a mixture of Nd-doped ZrO₂ and Er-doped ZrO₂ excited at 1064nm.

that can only be fully identifiable to taggant designers/manufacturers. A simplified example of the compound taggant system can be illustrated by the excitation/emission behaviors of a two-component taggant mixture, Nd-doped ZrO₂ and Er-doped ZrO₂, as shown in Figure 4.

Taggants based on electrically powered emitters such as LEDs and laser diodes can be encoded with sequenced flashing algorithms to achieve a stroboscopic effect. The design of taggant emission spectra can also be tailored for specific detector/imager systems. Most infrared detectors/imagers are only effective with certain wavelength ranges. Therefore, taggant systems emitting signals that cannot be fully detected with a single type of detector are more covert.

Multispectral and hyperspectral tunable optical filters, such as MEMS optical modulators and Acousto-Optic Tunable Filters (AOTFs), can greatly enhance an infrared detector's capability for detecting

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and de-convoluting complex optical signals such as clustered emission peaks. Unlike other optical filter systems, AOTFs do not suffer from the mechanical constraints, speed limitations, image shift, and vibration associated with rotating filter wheels, and can easily accommodate multiple wavelengths. They are mechanically robust and lightweight, and are ideal for field and handheld applications.

Acousto-optic technology can expand the capability of common infrared detectors in many aspects. When an AOTF is integrated with an IR camera, they together become a hyperspectral imager. With an AOTF-based hyperspectral imager, multiple LEDs with different wavelengths can be used in the taggant. This allows the taggant to emit messages coded with algorithms such as wavelength hopping and scrambling, enabling covert optical communication. Such signals can only be correctly recognized by the hyperspectral imager, while a broadband infrared imager cannot receive the valid message. Full-duplex communications between the taggant and AOTF imager can be achieved when a simple photodetector is added to the taggant, and an AO deflector (AOD) is added to the AOTF imager. The AOD can direct an eye-safe laser beam to the taggant's photodetector and send a message by modulating the laser. This modulation function is an intrinsic feature of AOD. The AOD can also point a narrow laser beam on to an individual taggant to deliver a coded message.

Optical taggants emitting in the near infrared range have been deployed for battlefield operations. These include infrared light sticks and the LED-based Tron system. However, with the global availability of 3G IR goggles capable of seeing up to 1 μm , they lose their covertness. Future taggants should operate in an IR wavelength that cannot be detected with common night vision scopes or human body thermal imaging devices such as FLIR. Currently shortwave IR (SWIR) between 1-3 μm is a very attractive range for several reasons. First, it cannot be detected by either near IR wavelength night vision scopes or long wavelength IR FLIR systems. Secondly, IR cameras in this range are lightweight, compact, and operate at room temperature, not requiring

cryogenic cooling. Finally, IR emitters (such as LEDs and laser diodes) with various SWIR wavelengths are available at relatively low cost. Although taggants in the mid-infrared region (3-8 μm) are also highly desirable, their development has been hindered by the lack of low-cost de-

tectors and scarcity of available emitters in this range.

This article was written by Dajie Zhang, PhD, Senior Scientist, Brimrose Corporation (Sparks Glencoe, MD). For more information, visit <http://info.hotims.com/49744-501>.

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Small Form Factor Strategies for Military Embedded Systems

The proliferation of unmanned military vehicles tasked with critical communications and radar requirements drives the need for powerful data acquisition and signal processing products that must fit into increasingly tighter spaces. New industry standards meeting these needs offer smaller circuit boards and enclosures, optical gigabit serial links, and advanced thermal management strategies. With new resources found in the latest processors and FPGAs, system designers can now create powerful, compact systems surpassing performance levels achievable only a few years ago.

Emerging Small Form Factor Industry Standards

The VITA and PICMG organizations actively promote and maintain standards for embedded systems suitable for commercial and military applications. Consisting of interested members from industry, academic and government organizations, each working group contributes towards the development of a new standard.

Once adopted and put into practice, refinements, and extensions to these standards ensure the long life cycle support required for most government programs. Customer acceptance of a new standard fosters an open community of vendors offering compatible products compliant with the standards. Competitive market forces help keep costs down, encouraging customers to request new systems based on successful standards.

Five new small form factor standards for embedded system modules and backplanes are currently in draft or trial use status awaiting final adoption. While each of these standards offers unique mechanical features, all of them are derivatives of existing embedded system standards. They all combine the most appropriate aspects of proven designs and leverage new technology to help reduce size, weight, power and cost (SWaP-C).

VITA 59 – Rugged COM Express

The PICMG COM Express standard defines a series of modules (cards) and backplanes supporting processors, memory, networks, and specialized I/O. VITA 59 extends COM Express for use in harsh environments of extended temperature, shock and vibration. As shown in Figure 1, this is accomplished through relatively simple mechanical modifications to the printed circuit board of the module, leaving the central PCB design largely intact.

This strategy allows developers to create two similar versions of each module, one for commercial, and one for rugged applications. Software and firmware can be developed on the commercial platform and then later deployed without changes in a fully ruggedized system.

VITA 73 – Rugged Small Form Factor

Based on the electrical specifications of VPX (VITA 46 and 48), VITA 73 aims to shrink the modules and chassis as much as possible, while maintaining full system-level performance in rugged environments. Definitions for single- and double-wide modules, both 101.5 mm deep and 71 mm across, include a variety of backplane pin configurations supporting various module functions. These include power supplies, CPUs, 2.5 inch disk drives, and payload functions such as digital and analog I/O. The backplane uses different types of pin/socket connectors for power, SATA, analog I/O, and data. Gigabit serial data pins are rated to 10 Gb/sec to handle the latest versions of popular serial standards.

VITA 74 – System Small Form Factor Module

Like the VITA 73 specification, VITA 74 embraces all of the VITA 46 VPX electrical signal definitions for two sizes of small form-factor modules. Both are 89 mm deep and 75 mm across, with a width of either 12.68 or 19 mm. The



Figure 1.
VITA 59 Rugged COM Express module adds thermal tabs to the sides of COM Express boards to pull heat out to a rugged aluminum frame. (Image courtesy MEN Micro)

modules connect to the backplane using the same connectors defined in VITA 57 for FMC modules and carriers, with 200 or 400 contacts, depending on the module width. Unlike VITA 73, these same connectors handle all power and signal connections to the modules.

The gigabit serial pins support rates up to at least 8 Gb/sec to support PCIe Gen 3 interfaces commonly found in embedded platforms. VITA 74 defines a comprehensive IPMI (intelligent platform management interface) using the I²C management bus that maintains and monitors system components and the identities of FRUs (field replaceable units).

VITA 75 – Rugged Small Form Factor

Unlike the other standards, VITA 75 addresses SWaP-C challenges by defining characteristics for the system chassis, saving the details of module size and internal connectors for later extensions. VITA 75 stresses the importance of thermal management packaging techniques to place hot components as close as possible to the cold plate or chassis walls. VITA 75 proposes two types of modules: stacked and bladed. Stacked modules use a male connector on one side of the PCB and a female on the opposite side, so that adjacent modules can be joined by pressing them together. Bladed modules are joined by a backplane with connectors similar to those on VITA 46.



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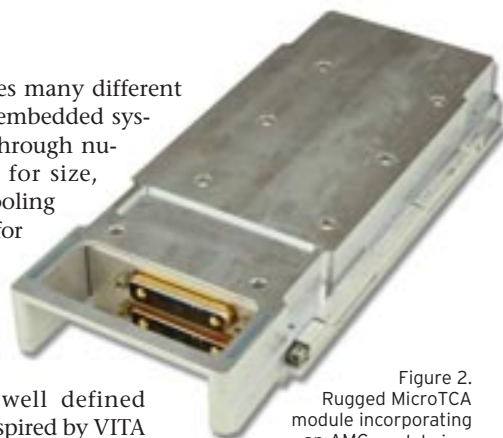


Figure 2.
Rugged MicroTCA module incorporating an AMC module in a conduction-cooled enclosure suitable for harsh environments. (Image courtesy VadaTech)

VITA 75 defines many different types of rugged embedded system enclosures through numerous profiles for size, mounting and cooling options. Profiles for circular military connectors to handle power, signals, networks, and other interfaces follow a well defined nomenclature inspired by VITA 65. Likewise, numerous front panel profiles define various combinations of connectors to meet requirements for a wide range of chassis sizes and system I/O requirements.

PICMG Rugged MicroTCA

PICMG Specification 3.x defined ATCA (Advanced Telecommunication Computing Architecture) boards, backplanes and chassis for the latest generation of commercial communications equipment. AMCs (Advanced Mezzanine Cards) are daughter-cards that attach to the main ATCA carrier boards. Widespread adoption of ATCA for high-volume commercial markets helps to keep product prices lower than equivalent functions from traditional COTS vendors.

The MicroTCA specification converts AMCs to modules that can be plugged into a small form factor chassis with a backplane. Its well-defined backplane topology using gigabit serial interconnections and platform management strategies, presents a very capable architecture for high-performance embedded systems for government and military applications in benign environments.

Rugged MicroTCA extends these systems for deployment in harsh environments of temperature, shock, vibration, humidity, etc. Specified limits proven in qualification tests of the latest versions of Rugged MicroTCA meet or exceed those of VPX. As a result, vendors of Rugged MicroTCA are now securing design wins for ruggedized military system programs.

Small Form Factor Enabling Technologies

Gigabit Serial Interfaces

A common theme pervades all five of these new standards: the use of gigabit serial interconnects to eliminate the parallel bus backplanes of previous generation systems like VMEbus and CompactPCI. Virtually all consumer, commercial, industrial, and military applications have enjoyed widespread adoption of these gigabit serial standards including Gigabit Ethernet (GbE), PCI Express (PCIe), SATA, Serial RapidIO (SRIO), and others.

A single gigabit serial link can deliver high speed data over a single differential pair at rates to 10 GB/sec, or more. This reduces the circuit board area and the number of connector pins required to sustain a given data transfer rate.



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FPGAs

FPGAs offer designers more ways to achieve smaller form factors than virtually any other device. Built-in gigabit serial interfaces and standard protocol engines for PCIe and GbE eliminate the need for additional interface chips. Custom protocol requirements, like SerialFPDP, can be configured using internal FPGA resources. This technique extends easily to simpler tasks such as custom data formatting, buffering and packetizing.

Configurable I/O ports on FPGAs handle direct connections to specialized peripheral interfaces for exotic sensors and transducers, like a 48-bit interface to a 3.6 GHz 12-bit A/D, for example. Timing, gating, triggering, and synchronization structures for critical applications like phased array radars take advantage of configurable logic, state machines, and counters, all inside the FPGA.

FPGAs also feature built-in advanced SDRAM controllers for direct connec-

tion to external DDR3 memory chips, essential for transient capture of radar pulses, digital delay lines and signal processing workspace. Sophisticated circuitry automatically trains the memory timing signals for optimum performance at power up.

Front end digital signal processing requirements, like digital down converters for software radios, are perfect candidates for the many DSP engines found on most FPGAs. The largest Virtex-7 device now contains 3600 DSP48E engines, vastly outstripping the raw processing power of DSPs and GPPs. This type of pre-processing can deliver two-fold savings: lower output data rates and simpler downstream processing engines.

These many benefits result in smaller circuit boards, fewer components, and simpler connections. At the same time, power dissipation for a given function within a Virtex-7 FPGA has dropped by

half compared to the previous generation Virtex-6. This eases thermal management and extends missions for battery operated or power sensitive applications.

Backplane Optical Interfaces

Initiatives by standards organizations for optical interconnections are now yielding product offerings. Approved standards from the VITA 66 Fiber Optic Interconnect group define three backplane optical interfaces for 3U and 6U VPX that are variants based on MT, ARINC 801 Termini, and Mini-Expanded Beam optical technology, respectively.

All of them support single- or multi-mode fiber interfaces by replacing one or more of the standard VPX bladed connectors. Blind-mate connectors between the VPX module and the backplane feature spring-loaded inserts containing optical cable assemblies

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Figure 3. Pentek Model 5973 3U VPX Virtex-7 FMC carrier uses Samtec FireFly™ Micro Flyover delivering 12 optical fiber pairs to the proposed VITA 66.4 backplane I/O. (Image courtesy Pentek)

that float within metal housings. Alignment pins and holes in each half of the mating assemblies ensure exact alignment of the polished ends of each optical path. The MT variant in VITA 66.1 provides the highest density with up to 24 pairs of optical fibers, while VITA 66.2 and 66.3 both provide 2 pairs.

from major vendors, including TE Connectivity and Molex.

To ease implementation of the optical interface, Samtec is now sampling its FireFly™ Micro Fly-Over system. This small module interfaces 12 lanes of gigabit serial electrical signals to laser transmitters and receivers connected through 12-lane optical flat rib-

The unreleased VITA 66.4 standard based on the high-density MT ferrule uses a half-size metal housing for a smaller module and backplane footprint. It supports either 12 or 24 pairs of optical cable. First versions of the connectors are already available

bon cables and terminated in an MT ferrule.

Figure 3 shows a 3U VPX carrier for FMC illustrating these small form factor enabling technologies including PCIe Gen 3 system interface, the Virtex-7 FPGA, and the first implementation of the proposed VITA 66.4.

Optical interfaces benefit small form factor systems in many different ways. Optical cables are lightweight, smaller diameter alternatives to copper cables, especially important in unmanned vehicles sensitive to weight and packed tightly with electronic payloads. They are completely immune to electromagnetic susceptibility or emissions for added reliability in electrically noisy environments such as antenna masts and engine rooms, and for added security against eavesdropping.

Optical cables can transport existing gigabit serial traffic at rates beyond 10 Gb/sec, extending these interfaces between modules, chassis and racks. Depending on the optical fiber mode, these links can extend from 100 meters to several kilometers, easily covering the length of the largest aircraft and surface vessels. Remote sensors and data acquisition pods in small enclosures can be mounted close to antennas, sending digitized signals back to a central processing center across optical links.

Choosing the Best Small Form Factor Solution

With so many proposed approaches to small form factor embedded systems, customers need to determine which technical aspects of each approach are most important for a particular application and carefully consider the companies backing each standard. It is highly likely that no single standard will emerge as the winner.

However, system designers waiting for a final outcome will miss out on the significant, tangible benefits available today. New extensions to these standards will be inspired by customer-driven opportunities, helping steer the technology with real-world requirements.

This article was written by Rodger Hosking, Vice President, Pentek, Inc. (Upper Saddle River, NJ). For more information, visit <http://info.hotims.com/49744-502>.

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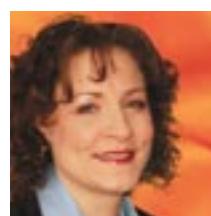
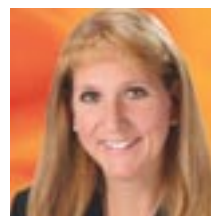
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Toward Smarter Manufacturing and Materials

At the U.K.'s new Advanced Manufacturing Research Center, engineers and innovators have at their disposal some of the world's most advanced design and manufacturing assets for precision engineering.

by Richard Gardner

For well over a century the word "Sheffield" has been synonymous with high-quality steel products, ranging from cutlery to heavy engineering products for bridges, railways, and aircraft. Following many years of industrial decline as much traditional large-scale manufacturing departed in the direction of low-wage Asian economies, the region suffered accordingly.

However, high-quality specialist engineering and manufacturing continued to remain competitive, especially for very demanding sectors such as aerospace and energy generation. This has led to the creation of R&D facilities alongside Sheffield University, within a fast expanding hi-tech business park dedicated to innovation in manufacturing processes, including composites, metallics, and hybrid components. This has just been boosted with the announcement of a new \$60 million project to build an advanced "showcase" factory, Factory 2050.

Factory of the Future Here Now

Professor Keith Ridgway, Executive Dean at Sheffield University's Advanced Manufacturing Research Center (AMRC), told Aerospace & Defense Technology, "Our ambition is for Factory 2050 to be the most advanced factory in the world. It is part of our long-term development in high value manufacturing in which we have an international lead."

The factory project will offer the latest technologies in the field of advanced robotics, flexible automation, an unmanned workspace, and off-line programming in virtual environments. Initially around 50 researchers and engineers will work in the new 14,400



Laying down composite sheets in a clean area at the Advanced Manufacturing Research Center.

ft² facility, which will incorporate "the highest environmental standards."

Sam Turner, Head of the AMRC Process Technology Group, told Aerospace & Defense Technology that in the past a lack of investment had resulted in a gap in the manufacturing food chain between those with special skills carrying out the R&D and those engaged in manufacturing activity. Fundamental research leads to core technology advantages that can deliver new business. The technology should not be a barrier to manufacturing but a key to unlocking more efficient output.

According to Turner, there is a need for a healthy interaction between academia and industry. The manufacturing industry should re-invent itself so that



Just part of the extensive machining hall facilities.

it is managing a system rather than just making parts. Design should be seen as a means of manufacturing, and greater quality is needed right through the supply chain. Closer integration at all levels is vital, he added. Best practice is essential, of course, but industry must be agile so that it can modify its products



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and this means it must have “more headroom” in how it uses technology in manufacturing.

“We are attracting new talent into engineering,” said Ridgway. He explained that setting up the AMRC was regarded as key to establishing a hi-tech engineering R&D cluster that would encourage the repatriation of more high value manufacturing back to the U.K., where there is no shortage of young people looking for a more promising future.

Technology Benefits

The AMRC is a true partnership and funding comes from the university, the U.K. government, the E.U., and 77 participating companies. From the outset Boeing has been a leading partner and other aerospace companies include Airbus, BAE Systems, Rolls-Royce, Safran, Spirit, and Goodrich.

Participating company partners, most of which are global in operation, all have a share in the technology benefits for they are involved in the overall goal of improving new means, methodologies, tools, and techniques that will advance materials and manufacturing technology within their own organizations.

As an indication of the scale of savings that can be made possible by such innovation, Ridgway said that in some cases manufacturing costs had been cut by a factor of five.

Both Boeing and Rolls-Royce have invested heavily in the AMRC site and its spreading campus. A huge futuristic Rolls-Royce single-crystal fan blade manufacturing plant is already on site and in production and is claimed to be the most efficient aerospace engine component manufacturing plant anywhere, with very advanced processes that are kept well away from the eyes of casual visitors.

A big attraction of being in partnership at the AMRC is the “win-win” situation for everyone. For the facility managers, partner companies supply free of charge their latest equipment and systems for use in the various specialized work areas. These represent the very latest examples of hi-tech machines and specialist equipment, so they are suitable for evaluating and

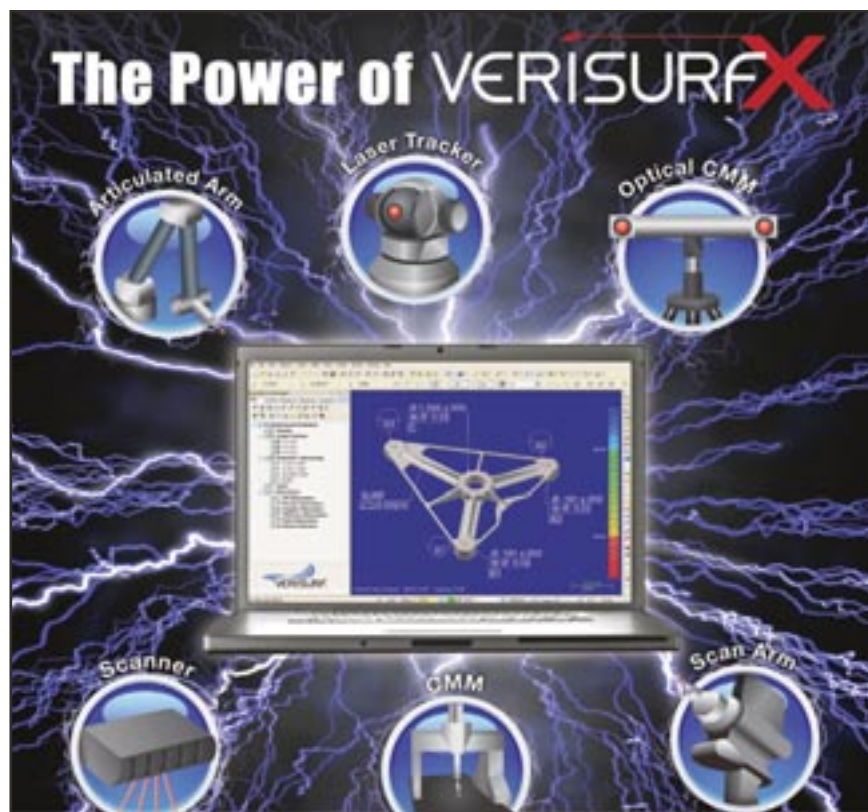
testing new innovative processes and methodologies.

In turn, this provides the suppliers with invaluable high-quality feedback that helps them improve the product to make it even more flexible and efficient and also serves as a highly visible

demonstration asset to attract new customers and sales.

Material Advances

The AMRC was originally envisaged as an R&D center-of-excellence for hi-tech machining technology, but with the in-



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creasing use of composite materials, hybrid metallic/composites, and now, 3-D printed components, as well as advanced metallics, the scope has been widened to cover all high-end manufacturing materials and processes. Examples include casting and machining titanium and aluminum and all methods of fabricating composite structures and components. Sources claim this to be at least six years ahead of any other similar facility. Europe's largest electron beam welding facilities are also included on site.

The Composites Center in the AMRC has facilities for autoclave and out-of-autoclave composites manufacture. Computer controlled automatic fiber placement of layered materials represents the latest technology, but Sheffield has a 200-year old local legacy of weaving skills and this has been exploited to incorporate traditional interwoven material patterns and techniques that can be tailored very precisely using 3-D weaving machines for today's hi-tech requirements, especially in the aerospace sector.

Using different woven patterns in the material and different thicknesses can give added rigidity or flexibility and added density for strength where it is needed, and this includes using mixed materials combining metallics with the carbon fiber. An aluminum matrix composite material has been developed and tested for automotive applications. There is almost no limit to the permutations possible in preparing and making hybrid or all-composite structures and components and the research, testing, and evaluating at AMRC extends into next generation wing spar developments and highly complex molding techniques.

Other research activities include filament winding for composite tubes and microwave curing processes. An associated aspect of all R&D work involves factoring in the need to reduce energy consumption at all stages in the manufacturing process. In some cases a re-design of processes and methods has



The new apprentice school teaches young students basic workshop skills leading to more advanced specialisation and academic qualifications.

shown a reduction of up to 80% is possible.

In the AMRC Assembly Center the latest laser scanners and robotic systems are capable of working to tolerances of 15 micron, with huge reductions in operational timescales. One program successfully reduced a procedure that previously took one and a half days to just six minutes.

Creating a safe as well as hi-tech manufacturing and assembly environment is a key feature where operating boundaries are being pushed further out all the time. The use of advanced virtual reality and simulation tools are used for training as well as in other stages in the design, evaluation, and manufacturing stages of a project.

As a part of a feasibility study with a partner, a kinematic simulation of a proposed machine for 787 manifold assembly was completed to allow the center to validate the proposed design and easily communicate the scope of the innovation to the customer. During the visit to the AMRC, this reporter was able to experience the latest 3-D virtual reality capabilities, using a visor and hand controller to allow virtual components to be removed and relocated from a large aerospace engine that was complete in every detail. It was possible to accurately manipulate the virtual hand movements quite naturally after a few minutes and to become completely immersed in the task. In reality the engine existed only in a virtual environment within an empty white-walled chamber.

Castings Technology International is wholly owned by AMRC and is a comprehensive casting research facility, with a titanium casting capability as large as any in the world. Some 75 partners are involved and the facilities on site include casting design, patternmaking, cure making, molding, preheating and assembly, melting and pouring, inspection, machining, and finishing. There is a 1000-kg titanium melting capability and high strength steel castings can be manufactured in volume.

All aspects of inspection and validation are covered and the production technologies are very wide ranging, from titanium casting to additive layered pattern manufacturing, with bespoke patterns grown from a laser using light-sensitive resins. There is a unique capability in-house at CTI for making land-based turbines and this could be expanded into aerospace structural manufacturing.

In the Design and Prototyping Center new designs for manufacturing are studied in close cooperation with many SMEs who are currently involved in some 120 active projects. The center is seen as a highly effective facility to educate personnel from smaller engineering companies who would not be able to invest in such advanced design and test tools and systems on their own.

In the Structural Test Center there are the very latest facilities for component testing and validation including 8-axis loading system tools. There is also a microscopy laboratory for micro structural evaluation where material changes require very precise and accurate measurements with screening to determine the chemical composition within the material. In another clean-room area within the AMRC, extremely accurate measuring is undertaken with the aid of 3-axis touch-sensitive probes that record surface touch points and can be used to construct planes, surfaces or complex curves that are accurate to 5 micron.

An indication of the strategic vision at the AMRC is the establishment of a





new Training Center where this past February 250 young apprentices were admitted to join others already learning basic engineering workshop skills, leading through a phased curriculum to more advanced training using the most modern CAD/CAM digital design and manufacturing tools and equipment, and classroom training aids, including virtual reality welding stations.

From these educational building blocks the apprentice students can progress on to more specialist skills and academic qualifications, while having access to advanced equipment and systems that will equip them for a forward-

thinking future career in engineering. These apprentices are sponsored by companies that will directly benefit from the high quality and motivation of these young people.

The start they are being given at the AMRC campus will ensure that they

build their personal skills and shared work experience on the basis of a sound "future-proofed" framework appropriate for the needs of the 21st Century, and not restricted by legacy practices and methods.

Speeding up the Process

GKN Aerospace is leading a project under the Structures Technology Maturity (STeM) program that aims to automate the assembly of aircraft structures with the goal of creating consistently high-quality wing structures 30% faster than is possible today. This STeM program is based around an advanced winglet as the demonstrator component, using this to progress a range of innovative assembly technologies. The complete assembly tooling and robotic strategy for the winglet has been developed by GKN Aerospace in collaboration with the AMRC and NIKON Metrology. Designed to be generic and therefore equally applicable to many future aircraft wing and fuselage structures, the process uses many emerging automated and robotic techniques that, as well as speeding assembly, will provide a consistent end product.




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More Electric, Integrated Fuel Systems

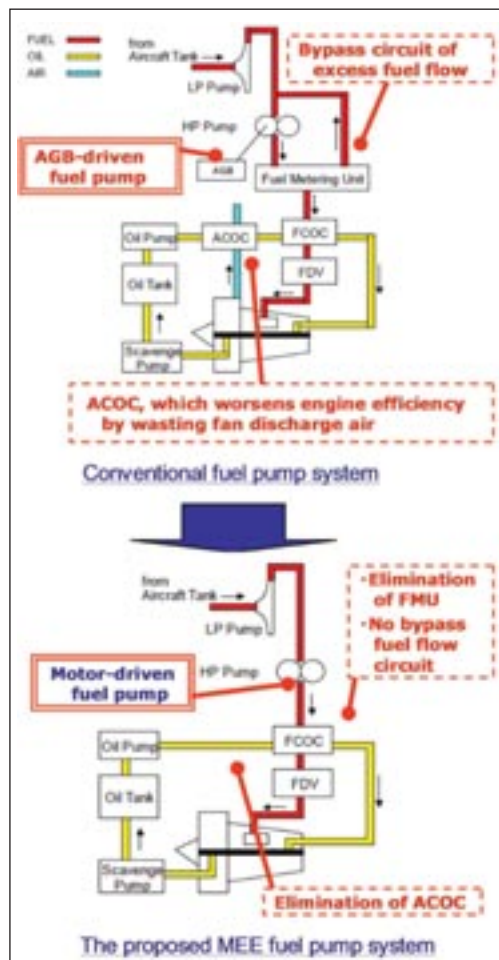
Engine system reliability can be improved by advanced electric architectures, while the reduction of hydraulic components, fuel tubes, and fittings can enhance the maintainability of the engine and minimize pilot workload.

Global warming and environmental friendliness considerations have recently been key for multiple global industries. In the commercial aviation industry, reduction of aircraft emissions, including CO₂ and noise, is an urgent priority. Both aircraft and aircraft engine manufacturers are striving to improve design to accommodate the needs of commercial airlines. Engine manufacturers in particular have worked long and hard to improve each engine component, e.g., compressors, turbines, combustors, etc.

However, the need for another approach to further improve engine efficiency motivated researchers from IHI Aerospace to focus on the system approach, including the control system, fuel system, or other engine systems, ultimately resulting in an MEE (more electric engine).

The MEE is a new engine system concept that seeks engine efficiency improvements, which results in a reduction of engine fuel burn and CO₂ emissions. The key concept of the MEE system involves the architecture for the electrical power generation by the engine and changing the power source for accessories from mechanical/hydraulic to an electric motor.

IHI focused on the electrification of the engine fuel pump system because of its contribution to fuel burn reduction. The researchers conducted a feasibility study of the MEE fuel system for an assumed small-size turbofan engine, and the result indicated an improvement in specific fuel consumption (SFC) by about 1% during cruising. The SFC improvement would be accomplished by removing the fuel bypass circuit and eliminating the ACOC (air-



Schematic of an MEE (more electric engine) electric fuel pump system vs. a conventional fuel pump system.

cooled oil cooler), which worsens engine efficiency.

There are several technical challenges for the practical design of the MEE motor-driven fuel pump system. Failure of the engine fuel pump may induce IFSD (in flight shut down) of the engine and result in catastrophic failure of the aircraft. To avoid such critical situations and ensure better reliability than that of

the conventional system, a fault-tolerant design of the electric drive is mandatory.

For the MEE fuel pump system currently being developed, IHI has proposed the use of a permanent magnet brushless ac servo motor. In the servo motor control system, the electrical current is adequately controlled corresponding to the required torque from the fuel pump. The control system contains a limiter function to avoid overload of the motor, and a motor power-off function for emergency shutoff of the fuel supply.

In addition, IHI proposed the introduction of advanced fault-tolerant technologies such as a unique active-active redundant motor control system to the MEE. The active-active control enables the supply of the same amount of fuel to the engine combustor in case a single open failure occurs in one of the redundant motor systems.

Conventional vs. MEE Fuel Systems

In current commercial aircraft, the aircraft system consists of various subsystems, and each subsystem is independently designed to accommodate the specific requirements or operational conditions designated for each subsystem. The independency sometimes causes duplicated functions and complicated system design.

One typical example of a segregated system is the engine fuel system. It is independent from the aircraft fuel system and both systems are designed to accommodate various conditions, which are designated at the interface point between aircraft system and engine inlet. Integrating the aircraft and engine fuel system would be helpful to construct a more efficient and simplified system,



but it seems not to be practical in the conventional aircraft system.

The aircraft system contains electric motor-driven fuel boost pumps, shutoff valves, and cross feed valves as a minimum. There may be fuel transfer pumps, such as electric motor-driven pumps or ejector pumps, for transferring fuel between the tanks. In the case of a twin engine aircraft, the left- and right-hand engines are supplied with fuel from the left and right wing tank, respectively, during normal operation. If IFSD occurs in one of the engines, the cross feed valves would be activated to supply fuel from the opposite side tank to avoid an imbalance of fuel mass.

The engine fuel system consists of an AGB (accessory gear box)-driven fuel pump, FMU (fuel metering unit), and FPV (fuel pressurizing valve) at a minimum. Performance characteristics of the fuel pump are determined so that the pump supplies sufficient fuel flow with the obtained fuel inlet condition and engine operating condition.

Typically, the fuel pump consists of an LP (low pressure) impeller pump and HP (high pressure) gear pump. The LP pump increases fuel pressure at the HP pump inlet for the proper suction of fuel.

A more electric architecture supports the integration, simplification, and reconstruction of the aircraft and engine fuel system because of increased controllability, a modular design, and flexibility of component installation.

The MEE electric fuel system simplifies the engine fuel system by eliminating the fuel bypass circuit and complicated FMU. In addition, the MEE fuel system increases the flexibility of the engine fuel pump installation, because

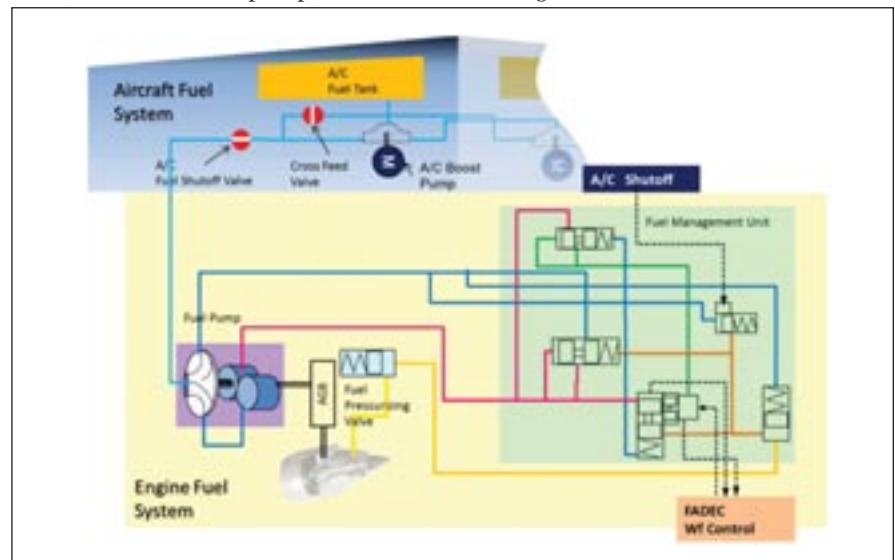
it is not necessary any more to attach the motor-driven fuel pump to the engine AGB. The location of the pump may be moved to an area other than the external surface of the engine. It means that the engine fuel pump is possibly considered as one of the components within the aircraft fuel system, and a possible location would be in the nacelle, fuselage, or wing.

Current aircraft fuel systems and engine fuel systems have duplicated functions, such as a boost pump, which en-

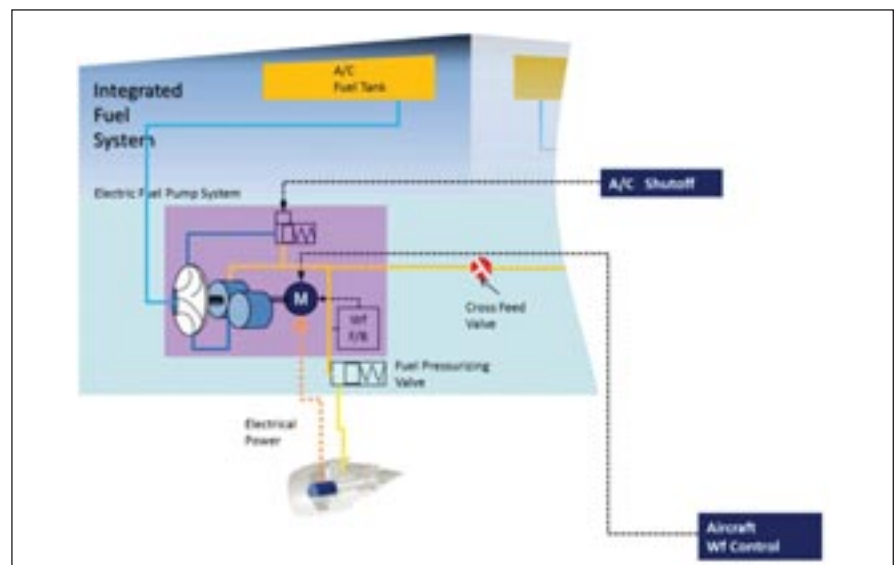
ables the provision of proper suction of fuel from the tank, and a shutoff valve that shuts off fuel to the engine combustor. An integrated fuel system would remove the burden of the aircraft and engine interface condition, removing the duplicated function as much as possible and simplifying the system construction.

Integrated Fuel System Benefits

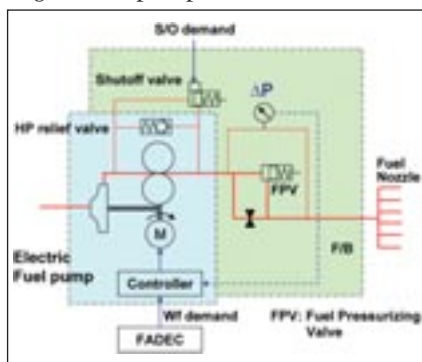
A reduction in fuel burn is expected through the introduction of the MEE



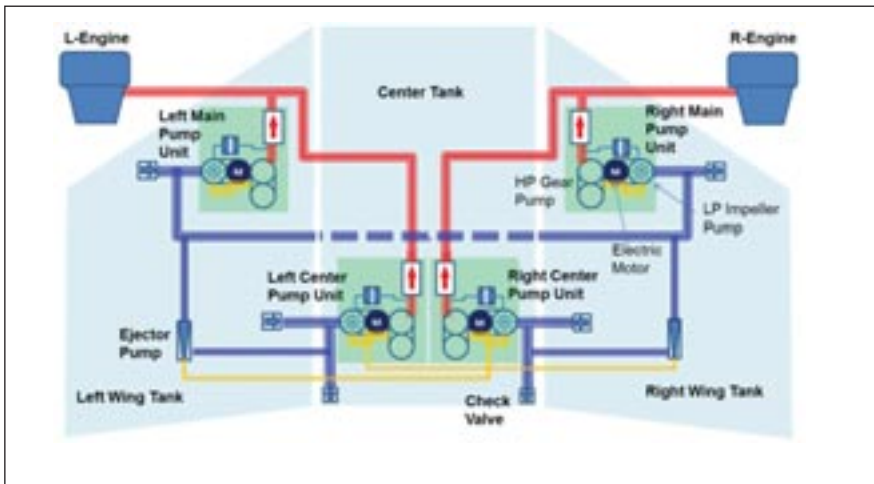
An example of a conventional aircraft and engine fuel feed system.



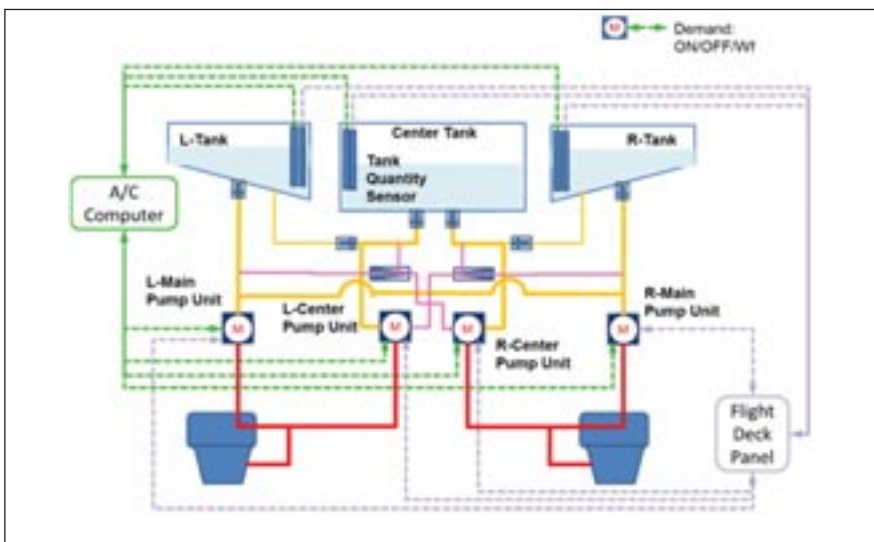
IHI researchers propose integrating the fuel feed system between the aircraft and engine, as shown in this concept.



Schematic depicting the MEE fuel pump system.



This proposed schematic of the integrated fuel feed system concept is for an assumed 150-200-seat single-aisle aircraft with twin engines, such as a Boeing 737 or Airbus A320.



Fuel connecting chart of the proposed system shows the fuel line among the tanks, electric pump units, and engines. Redundant electric fuel pump units are connected to each engine.

electric fuel system, which eliminates the loss in fuel system efficiency caused by the AGB-driven pump system.

Also, the number of components in the fuel system would be minimized. In the conventional aircraft fuel system and engine fuel system, which are separated from each other, there is a duplicated function between the aircraft components and the engine components. One of the typical examples is the pressure boosting function to ensure that the engine fuel pump properly suctions fuel from the aircraft fuel tank.

In the conventional system, electric motor-driven fuel boost pumps, which are usually submerged in the fuel tank, pressurize fuel to provide the minimum pressure required by the engine fuel system. Typically, the aircraft boost pump is the impeller type and adds about 50 psi to the tank pressure. However, the engine fuel pump also has a LP impeller pump to boost fuel pressure at the engine inlet because the engine fuel pump is required to supply fuel even though the aircraft boost pump is in operational condition.

In the proposed integrated system, the boosting function is accomplished

by the LP impeller pump in the electric fuel pump unit. The feasibility study of the small-size turbofan MEE fuel pump shows that the single shaft electric pump, which drives both the LP impeller pump and HP gear pump by the same shaft, can suction fuel during an aircraft boost pump failure. The submerged aircraft fuel boost pumps can be removed, which will not only contribute to a reduced number of components, but also remove the submerged components in the fuel tank.

Another possible approach to reduce the number of components is to remove the cross feed valves and electric transfer pumps. In a conventional fuel system, the cross feed valve is necessary to have fuel mass balance between the left and right wing tanks in case one of the engines is shut down. In the proposed integrated fuel system, the left main pump unit has fuel inlets connecting to both left and right wing tanks. It is the same for the right main pump unit. The left and right main pump units always suction fuel from both the left and right wing tanks, so the fuel mass balance between the tanks will be maintained automatically, allowing the cross feed valve to be removed.

In the integrated fuel system study for an assumed single-aisle aircraft, it was estimated that the aircraft boost pumps, engine FMUs, and MFPs (main fuel pumps) in the conventional system would be replaced by four sets of electric fuel pump units. In addition, with the cross feed valves and aircraft shutoff valves removed, the total number of LRUs (line replacement units) in the integrated aircraft system is expected to be reduced to about half of the conventional system.

The proposed integrated system eliminates electric valves such as the cross feed and shutoff valves as much as possible. However, in considering emergency situations—for example, severe fuel leakage from anywhere in the system—isolation of the fuel system may be required to avoid loss of the aircraft fuel. For that purpose, the addition of monitoring devices such as fuel pressure sensors, leak detectors, and electric shutoff valves may be considered. Also, if the aircraft system wants to control the fuel amount in the left





and right tanks independently, that would be accomplished by the addition of the electric shutoff valves in the system. Thus, the proposed integrated electric fuel system has the flexibility to incorporate additional electric devices and will support aircraft system requirements.

As mentioned above, the reduction in the number of LRUs will be achieved by introduction of the integrated fuel system. In addition, components that are submerged in the aircraft fuel tanks, such as the aircraft boost pumps, will be removed. One possible location for the electric fuel pump units is the fuselage, inside of the access door.

Currently, LRUs are installed into distributed locations among the aircraft wing, aircraft tank, and the engine. In the integrated system, the LRUs may be installed in one place in the aircraft fuselage, so that replacement of the pump unit will be much easier than the current aircraft/engine fuel system components. Reduction in the number of LRUs, accessibility, and replaceability of the electric pump unit will improve the maintainability of the aircraft/engine fuel system.

Because the integrated system allows for the removal of the cross feed valves, adjustment of the tank balance by pilots would not be necessary anymore. On/off of the current submerged aircraft boost pumps is usually conducted by pilots to maintain a minimum amount of

fuel in the tank, which is previously determined to avoid heating of the pump.

In the proposed integrated fuel system, the electric fuel pump units would be installed outside of the fuel tank, instead of the submerged boost pumps. Pilot operation for the cross feed valves

or boost pumps would not be necessary; thus, reduction of pilot workload would be expected.

This article is based on SAE International technical paper 2013-01-2080 by Noriko Morioka IHI Corp. and Hitoshi Oyori, IHI Aerospace Co.

| Conventional System | | Proposed Integrated System | |
|---------------------|--------------|----------------------------|--------------|
| | Each per A/C | | Each per A/C |
| Elec.Boost Pump | 6 | Elec.Fuel Pump unit | 4 |
| ENG FMU | 2 | Check Valve | 6 |
| ENG Main Pump | 2 | Ejector Pump | 2 |
| A/C Shutoff Valve | 2 | | 12 |
| Cross feed valve | 1 | | |
| Ejector Pump | 1 | | |
| Check Valve | 9 | | |
| | 23 | | |

Table. LRU Comparison



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RF FPGAs for Multi-Function Systems

A dynamically reconfigurable, wideband programmable RF FPGA transceiver will provide reduced lifecycle cost, reduced redesign cost, and service for multiple DoD platforms, while maintaining near-optimal performance for each application.

State-of-the-art RF integrated circuits (ICs) achieve high performance via custom circuit elements with dedicated signal paths for application-specific functions, but long design lead times and non-recurring fabrication costs increase time-to-market for new applications and limit reuse. The key to developing an RF FPGA (radio frequency field-programmable gate array) is to provide RF switching components with very low insertion loss and high isolation that can be integrated with high-performance RF circuits in silicon germanium (SiGe) and gallium nitride (GaN) technologies, and integrating these circuits in a reconfigurable topology to allow an

RF FPGA to perform a wide variety of functions.

Key elements of the RF FPGA approach are:

- Extremely low-loss, high-isolation RF switches using phase change materials (PCM). Multiport RF switch designs (Figure 1) optimize thermal design to improve PCM performance, and integrate arrays of these switches on thermally and electrically optimized substrates.
- Multiport switch designs with low simulated RF losses of 0.1 - 0.2 dB up to 20 GHz, and 35dB - 60dB isolation between ports, based on measured and extrapolated PCM data. They consume no prime power except for 100-nsec heater pulses during reconfiguration.

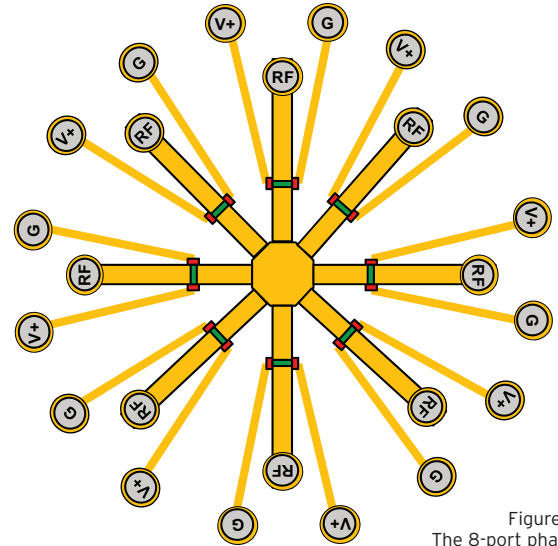


Figure 1:
The 8-port phase
change RF switch design.

- An architecture that connects these switches in a fully interconnected matrix to allow total flexibility in interconnecting and switching between RF elements and to inputs/outputs.
- Dynamically RF tuned banks of wideband, high-performance LNAs (low noise amplifiers), mixers, vector modulators, driver amplifiers, and power amplifiers using programmable circuit bias and circuit mission reconfiguration techniques.
- Development of a family of RF FPGAs that can be configured in a variety of ways: as a standalone RF transceiver, as T/R (transmit receive) elements in an AESA (active electronic scanned array), or as an IF (intermediate frequency) or baseband receiver. Packaging in 12 x 12-mm QFNs (quad-flat no-leads) packages with matched RF I/O for low package insertion loss is used to allow multiple RF FPGAs to be integrated in flexible configurations.
- Demonstration of the RF FPGA technology against multiple DoD system applications with transition potential to a wide range of DoD systems.

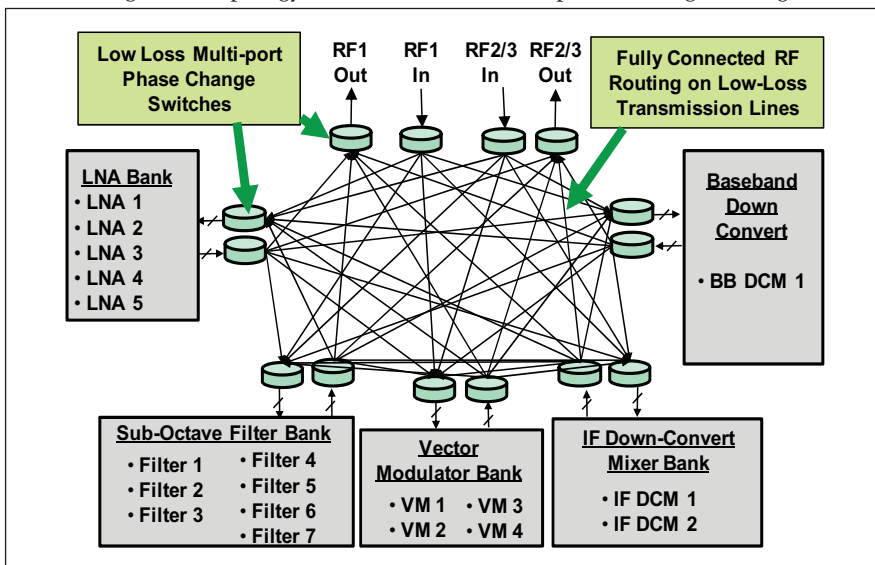


Figure 2: The flexible switch matrix connects RF circuit banks with each other and I/O for a high level of reconfigurability.

Robust, Low-Loss Switch Technologies

To produce an efficient RF FPGA, a compact, low-loss RF switch is the essential technology needed. The phase change RF switches will be used to create a fully interconnected switch matrix (Figure 2). These switches will connect banks of RF components (e.g., LNAs, mixers, filters, vector modulators) on the RF ICs to each other, also allowing routing from any of



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these circuits to the RF FPGA I/O. The RF switches are fabricated on separate silicon (SiC) wafers, optimized for RF and thermal phase change performance, and then flip-chip-bonded to the RF component IC.

To further minimize RF losses due to the switch matrix, the routing lines between switches are fabricated using high-conductivity metal (such as copper), 50-Ohm transmission lines on low loss dielectric, such as BCB. The transmission lines will be configured as microstrip, with lines over and under the ground plane to provide the isolated RF signal crossover capability required by the fully interconnected matrix. The stackup showing the integration of the RF IC, interconnect matrix, and switches in a QFN package is shown in Figure 3.

High-Performance RF Architecture

The RF FPGA uses a coarse-grained architecture consisting of major functional blocks with reconfigurability both within

the blocks and between the blocks. This approach provides higher RF performance than a fine-grained architecture, and has the degree of flexibility needed for a wide range of applications due to the fully connected RF switch matrix.

The receiver FPGA contains banks of LNAs, sub-octave filters for RF filtering, vector modulators for beam steering, down conversion mixers, and digital control. Jazz SiGe is used as the integration platform because the RF performance is very good, digital control and power supply circuits for the phase change heaters can be easily integrated into the same IC, and device fabrication is relatively inexpensive. The number of RF elements and their bandwidths in each bank have been selected to provide the 0.4 to 18 GHz range, based on previous SiGe designs.

Filter FPGAs contain receiver filtering required for application-specific needs. The transmitter FPGA contains banks of up-converters, vector modulators for beam

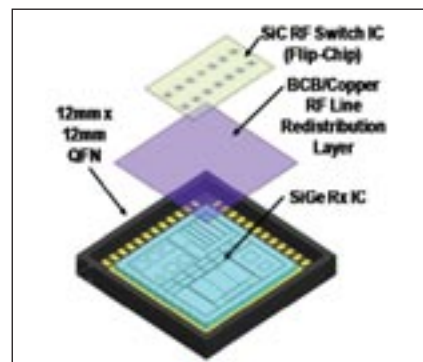


Figure 3: The RF FPGA integrates the RF IC, interconnect matrix, and switches in a QFN package.

steering, filters, output amplifiers, and digital control, and is baselined as a SiGe IC.

The power amplifier FPGA contains a bank of GaN power amplifiers with up to 8W output power, with controllable bias and switchable gain stages to service a wide range of frequency, power output, and class of operation.

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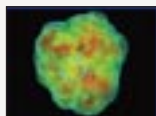
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Robonaut Gets Legs

NASA engineers are developing and testing climbing legs for the International Space Station's robotic crew member Robonaut 2 (R2). These new legs will provide R2 the mobility it needs to help with regular and repetitive tasks both inside and outside the space station.

www.techbriefs.com/tv/robonaut-legs



NASA Telescope Reveals How Stars Explode

One of the largest mysteries in astronomy — how stars blow up in supernova explosions and seed the universe with elements like gold and iron — is being resolved with the help of NASA's Nuclear Spectroscopic Telescope Array (NuSTAR). Watch this simulation showing how shock waves likely rip apart massive dying stars.

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Autonomous Landing Software Tested on Xombie Rocket

Jet Propulsion Laboratory has successfully tested new software called G-FOLD that enables a rocket to select an alternate landing site, autonomously. The test was performed with Masten Space Systems' XA-0.1B Xombie rocket. You're on-board for the flight in this video.

www.techbriefs.com/tv/G-FOLD-software



Opportunity Celebrates Ten Years of Exploration

A decade after it landed on Mars, the Opportunity Rover continues to explore. The rover's science team explains how Opportunity traversed Mars, examined the diverse environment, and sent back data that transformed our understanding of the Red Planet.

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Wideband RF Building Blocks

Relatively wideband RF components are used, and performance configurability is incorporated within these components. This gives high performance with wide frequency application range. For example, very nearly equivalent performance can be achieved in 3:1 bandwidth SiGe LNAs, as that achieved in narrow-band LNAs. The mixers and vector modulators can function over even wider bandwidths with very good performance.

A small bank of LNAs, mixers, and vector modulators can perform over 0.4 to 18 GHz. Tuning is also incorporated within these components; for example, the LNAs have adjustable bias and switchable gain stages to optimize gain, noise figure, and TOI versus power dissipation as required by the application.

Wide-Frequency, Scalable Transmit Power

The power amplifier RF FPGA contains a bank of GaN reconfigurable power amplifiers with >3:1 bandwidth capability covering 0.4 to 18 GHz frequency. Using switched-in amplifier stages, it provides up to 8W CW RF output. High efficiency of a class AB PA can be maintained as the input drive is reduced by varying the drain and gate bias with the drive signal. Greater than 40% efficiency over a 10:1 range of power levels was demonstrated. For an 8W RF output, thermal analysis shows an acceptable <100 °C temperature rise in the final output RF switch due to self-heating. Lower power-level applications (up to 100 mW) can be met with drive amplifiers in the transmit FPGA.

Digital Configuration and Control

The RF FPGAs are completely reconfigurable in the field via control with digital control words coming into the SiGe RF ICs, based on the RS-232 standard. To control performance within a circuit block (e.g., LNA or mixer), there are embedded DACs and control registers to control bias and other settings. The SiGe ICs also provide the controlled voltage pulses needed for phase change switches. The power control circuitry for each switch is located on the SiGe IC under the switch location to minimize parasitics and provide 20 nsec power turn-on and 20 nsec power turn-off, which provides for high-performance phase change switch operation and <1 microsecond reconfiguration times.

Conclusion

The RF FPGA approach uses arrays of these high-performance RF IC circuit elements, and achieves flexibility by reconfiguring the signal path between desired elements with minimal degradation, due to use of low-loss phase change switching technology. This enables multiple applications of the same RF FPGA components with near-custom performance. This shortens procurement cycles, improves affordability, and provides mid-mission reconfigurability.

This article was written by Mike Lee, Mike Lucas, Robert Young, Robert Howell, Pavel Borodulin, and Nabil El-Hinnawy of Northrop Grumman Electronic Systems. For more information, visit <http://info.hotims.com/49744-541>.



Intro

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3D Software Helps Development of Vehicle-Mounted Defense Systems

L-3 Communications Linkabit (Melbourne, FL) develops defense communications and electronic warfare systems to protect soldiers and save lives on the battlefield. A division of L-3 Communications, the sixth-largest defense company in the United States, Linkabit focuses on developing systems that safeguard troops in the field by obscuring visibility, jamming radar signals, intercepting communications, and disrupting infrared transmissions.

While Linkabit has always concentrated on the design of defense communications systems, the sophistication involved in innovating, creating, and manufacturing electronic devices has changed greatly, ushering in a new set of design and production challenges, according to Thomas A. Romanisko, mechanical engineering manager at Linkabit. "The complexity of the 3D shapes we are involved with today is simply beyond the capabilities of the 2D design tools the company once used," Romanisko pointed out.

Linkabit selected the SolidWorks 3D design platform from Dassault Systemes SolidWorks Corp. (Waltham, MA) because it is easy to use, is compatible with all major file formats, offers robust sheet-metal capabilities, and provides seamless integration with productivity-enhancing simulation and product data management (PDM) applications. The company

implemented a mix of SolidWorks Professional, SolidWorks Premium, and SolidWorks Flow Simulation software, as well as the SolidWorks Enterprise PDM system.

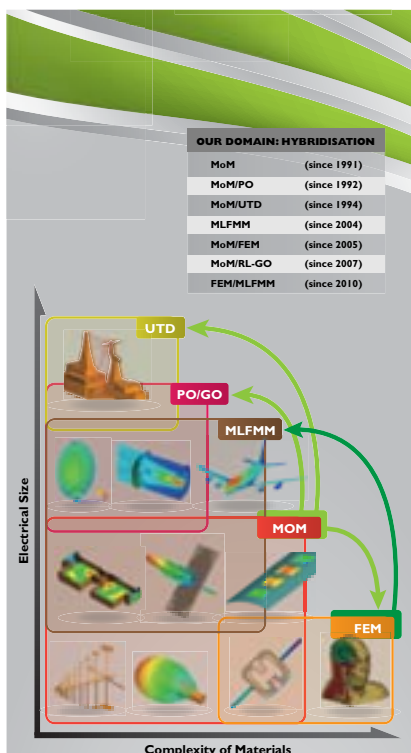
"The seamlessness and range of tools in the SolidWorks design environment make it the most capable development platform at its price point," Romanisko said. "SolidWorks software has helped us to respond to our engineering challenges quickly, innovatively, and cost-effectively."

The M56E1 Motorized Smoke Obscurant System is representative of the products Linkabit develops with SolidWorks software. Mounted on a Humvee, the M56E1 includes three types of obscurant systems: 90 minutes of smoke to obscure visual pinpointing, 30 minutes of graphite powder to obscure infrared sighting, and 30 minutes of carbon fibers to obscure millimeter-wave location. The system is designed to protect passengers from visual and electronic weapons sighting.

"We used design configurations and sheet-metal capabilities extensively on the M56E1 system," Romanisko said. "Configurations capabilities and the tolerance analysis functionality really help us design assemblies efficiently. In particular, configurations allow us to create exploded views as well as show different modes of operation, which saves a lot of time."



The SolidWorks 3D development platform helps L-3 Communications Linkabit develop sophisticated defense systems, such as the M56E1 Motorized Smoke Obscurant System shown here.



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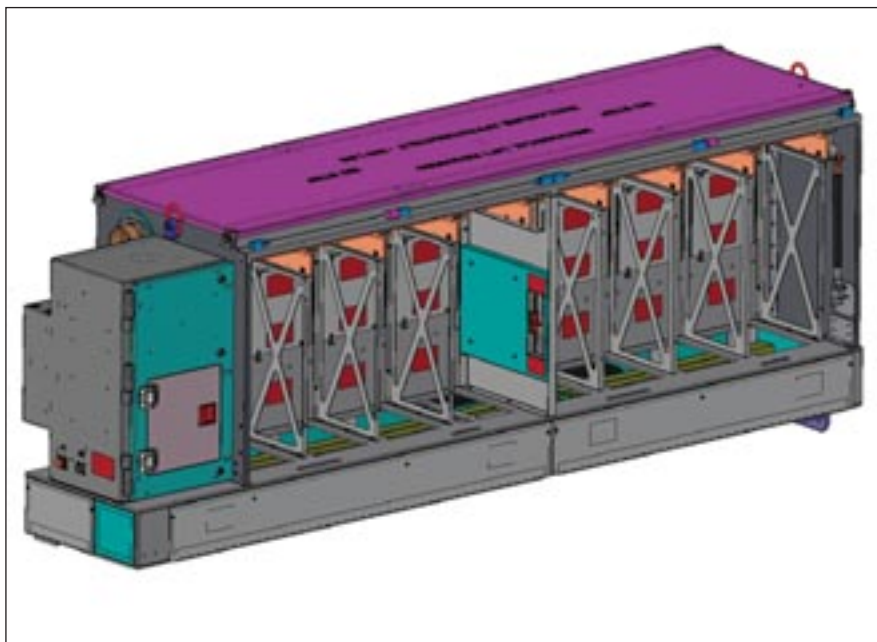
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Having the ability to simulate designs in software allows Linkabit to eliminate costly prototype iterations.

Simulation Minimizes Physical Testing

Linkabit saves additional time and reduces its prototyping costs dramatically with integrated SolidWorks Simulation tools. "Studying the effects of stress, vibration, and temperature is extremely important when developing electronics packages for equipment used in combat," Romanisko noted. "We also use SolidWorks Flow Simulation to study the impact of air-flow on temperature to design cooling systems for electronics."

Having the ability to simulate designs in software allows Linkabit to eliminate costly prototype iterations. The company also utilizes rapid prototyping to produce SolidWorks component models on a 3D printer. "Instead of creating 10 prototypes, we use simulation to complete 10 design iterations," Romanisko said. "This approach has reduced our prototype development time by 75 percent."

Worldwide Collaboration

With offices in Florida, California, and New York, Linkabit uses SolidWorks Enterprise PDM software to manage design revisions, secure access to sensitive design data, and support

collaboration across the organization. The system replicates vaults at all three locations, and enables the company to automate its already well-regimented workflows using automatic email notification. In addition, Linkabit used its PDM system to standardize its parts libraries for commonly used components such as connectors and fasteners, which eliminates unnecessary duplication of effort.

"Linkabit is a zero-geography organization, which means we could have individual engineers in California, New York, and Florida who are all collaborating on the same project," Romanisko explained. "With SolidWorks Enterprise PDM managing revisions, access, and user rights, working with someone across the country is like working with someone next door."

Using SolidWorks eDrawings® files, Linkabit has also improved communications with customers. "It's great to be able to share a 3D design with a customer," Romanisko said. "The ability to make cross-cuts, use transparency, and spin the model makes eDrawings files a much better format than using PDFs."

This article was contributed by SolidWorks Corp. For more information, visit <http://info.hotims.com/49744-542>.



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Technology Update

ETS researchers develop new methodology for wind tunnel calibration

In recent years, the École de Technologie Supérieure (ETS) Research Laboratory in Active Controls, Avionics, and Aerose-voelasticity (LARCASE) has acquired several research apparatus—a research flight simulator Cessna Citation X, an open return subsonic wind tunnel, and a flight autonomous system (UAV)—making it one of the few multidisciplinary research laboratories in Canada with a wide range of equipment with the capabilities of simulating aircraft models, especially air-foils, and validating the models with exper-imental data collected on the ground (wind tunnel) and in-flight (UAV).

LARCASE researchers have developed a new approach for wind tunnel calibra-tions using a limited number of dyn-amic pressure measurements and a predictive technique based on Artificial Neural Network (ANN). Complement-ing the development of an ANN model, a further objective of the research was to investigate an optimal method for determining local flow characteristics by means of X, Y, and Z coordinates. Using a minimum of data collected from the wind tunnel calibration for training, the ANN model would gener-ate the proper pressure for any given 3-

D coordinate inside the test section.

The 12-m open-return subsonic wind tunnel is a research apparatus used to test airfoils and validate CFD models. The wind tunnel allows for a safe control of the flow conditions and makes measurements of pressure distribution on a wing shape possible. At the begin-ning, the air pressure rises through the centrifugal fan creating lateral mixing of fluid layers, then the turbulent parti-cles are straightened by the filters pro-ducing a laminar flow. The wind tunnel consists of a centrifugal fan, a diffusing section, a settling chamber, a contrac-tion section, and a working section.

The flow develops a 0.18 Mach maxi-mum speed due to the engine and the double impeller centrifugal fan. The two inlets at the opposite side of the rotor allow the air supply to increase the pressure flow, and the use of the 24 small propellers by impeller allows the fan to turn at a much higher speed than normal fans with large blades. The en-gine and the centrifugal fan are located inside the soundproof mechanical room protected from debris and dust.

The diffusing section consists of a wide-angle diffuser, a large settling chamber, a

contraction section, and a test section. From the static pressure buildup the flow is projected to an oval-shaped circular pat-tern flow straightener. Then the flow goes through a series of five filters: the first is a honeycomb-shaped filter, and the other four are nylon squared-shape filters posi-tioned 0.5 m from each other.

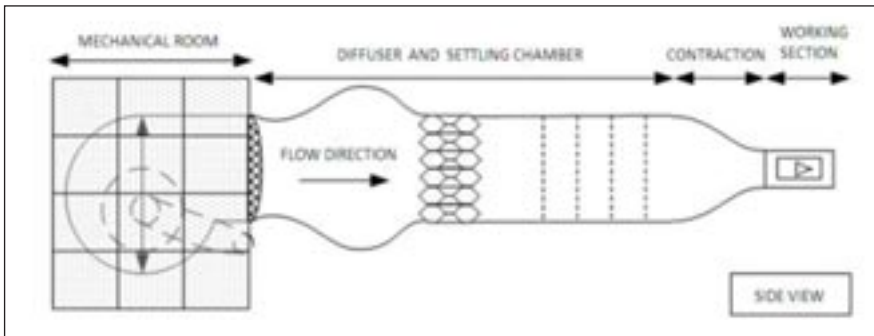
The settling section allows the flow to go from a turbulent state to a laminar flow.

LARCASE's wind tunnel has two test sections. The main one is 0.6 x 0.9 m made in wood with Plexiglass remov-able doors able to reach 0.12 Mach. The second test section, half the volume of the first one, is able to reach 0.18 Mach.

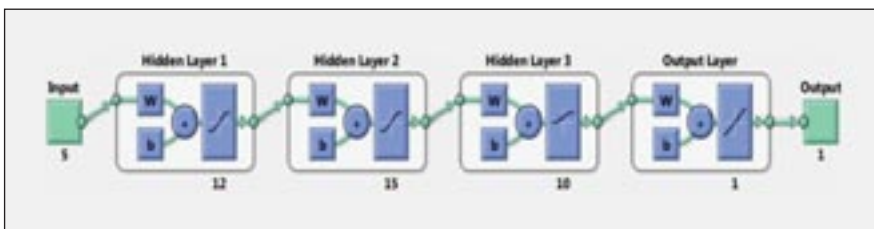
LARCASE researchers used the Ex-tended Great Deluge (EGD) algorithm in hybridization with the neural net-works to find the predicted pressure in-side of the test chamber of the open re-turn subsonic wind tunnel.

The hybrid NN-EGD method is pro-posed to control the pressure distribu-tion, by varying the coordinates of the point inside the test chamber, wing speed, and temperature. The EGD algo-rithm is used to obtain the optimal net-work configuration such that the error is as small as possible. Qualitative per-formance measures are used that de-scribe the learning abilities of a given trained neural network.

To train and test the NN, ANSYS Flu-ent software is used to determine the pressure values inside the test chamber. The coordinate (X, Y, Z), the wind veloc-ity (V), and the temperature (T) of the test chamber represent the inputs of the model, the output is the pressure. A total of 81628 points are used to train, vali-date, and test NN-EGD. The validation data represent 15 % of the data set, 15% of the data set to test the approach, and the rest to train NN. These points are se-lected randomly. Using the EGD algo-rithm, many architectures are tested. The objective was to obtain the simplest con-figuration to give the best results in a short time of compilation. After ran-domly trying different combinations of numbers of neurons and layers, the best results are obtained using a NN architec-ture composed of four layers feed-for-



The 12-m open-return subsonic wind tunnel consists of a centrifugal fan, a diffusing section, a settling chamber, a contraction section, and a working section.



Configuration of used Neural Network (NN) taken from Matlab is shown. The number of neurons in each layer is 12, 15, 10, and 1, respectively.



ward network. The number of neurons in each layer is 12, 15, 10, and 1, respectively. The NN inputs are X, Y, Z, V, and T. The output is the pressure.

The optimal architecture obtained using the EGD algorithm and obtaining the best results is composed of four layers feed-forward network. The NN-EGD are implemented in Matlab.

To test the approach, researchers used 14440 points. The average error of the obtained results in plane 1 is equal to 7.22%. In the plane 2, the error is 4.42%, and the error in the plane 10 is equal to 3.16% of the theoretic pressure.

By using this approach, the researchers successfully obtained the value of the pressure in each point of

the dataset according to the coordinates of each point, the wind speed, and temperature of the test chamber.

This article is based on SAE International technical paper 2013-01-2285 by Abdallah Ben Mosbah, Manuel Flores Salinas, Ruxandra Botez, and Thien-my Dao of École de Technologie Supérieure,

Boeing advances automation with smart and portable orbital drilling tools for 787

Since robotic work cells have proven to be highly effective in certain applications, and the technology is always improving, some might dream of a day when aircraft can be made like cars on heavily automated assembly lines with all the associated benefits. Boeing has made an advance in that direction.

Robotic workcells are only able to achieve consistent quality because everything in them is highly controlled; every aspect of the operation is carefully planned and tested and every workplace must conform to a strict set of tolerances to ensure quality. Luckily, there is an alternative: the fully autonomous robotic system.

In the fully autonomous robotic system, the robot is freed from the cell and equipped with a vast array of sensors. It can move about a large structure, identify reference points, and perform operations on an un-fixtured workpiece. The only problem with this scenario is the astronomically high cost of developing such a system—including a highly technical workforce required to maintain it.

According to researchers at Boeing and Novator AB, the smart portable tool is, at its core, indistinguishable from a fully autonomous robotic system in that a complex end effector is used to perform operation with high consistency while it is being positioned by a hyper-capable entity; the only difference with a smart portable tool is that the entity is a human, not a super-expensive imaginary robot.

The benefits of robotic systems are clear, but as with any complex system there is always the risk of protracted

breakdowns due to a complex problem. Since robotic systems are usually implemented at critical manufacturing flow points, a breakdown can cause a stop in production. The effect of a machine breakdown must be considered when designing a process. The best insurance is redundancy, but it might be difficult to justify buying a spare robot. In the case of a smart portable tool such as a portable orbital drill motor, the cost of a spare is not prohibitive and any unit can perform the task of any other like unit—meaning that so long as one motor is functioning the job gets done.

Another limiting factor to the robotic workcell, or even a fully autonomous robotic system, is the lack of versatility. The main challenge of a robotic application is creating a robust process. In general this involves developing a highly specialized process capable of performing one job very well. In aircraft final assembly, the variety of jobs is great and necessitates the development of many unique solutions. Robotic systems designed for one task might be useless on the next task and would undoubtedly need to be replaced or upgraded every time a design change is implemented on the structure. The world's scrap yards are filled with yesterday's specialized tools, but every factory is equipped with general tools that have remained unchanged for decades. Tool obsolescence is the enemy of agile assembly; tooling up for a new design should be a matter of adaptation, not invention.

The practical solution to increase the efficiency in final assembly is evolving via the development of smart portable

tools. Workers are at their most efficient when all information is available, no decisions are required, and the risk of making mistakes is reduced. With today's information technologies integrated into the portable tools, all of these issues can be addressed.

This capability to have the process knowledge built into the portable tool allows the positioning system (the human) to perform multiple activities within the work area of the final assembly. It also stabilizes the assembly process by enabling the skilled mechanics to cover for team members who may have an unplanned absence or might just be stepping out for a minute.

Boeing has traveled far down this path by introducing smart portable tool



Front spar drilling on the Boeing 787 using the automated orbital drilling technology. Here, two units are shown in operation.



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technologies for orbital drilling in the wing-to-body join of its 787 Dreamliner.

Tapping into the depth of resources across the corporation, the company found a technology from Sweden (Novator AB) being developed in California that could supply a solution for their assembly lines in Washington state. With the "One Boeing" philosophy, they were able to create a team that worked together to address all concerns of hole quality, manufacturing costs, equipment reliability, production support, and logistics.

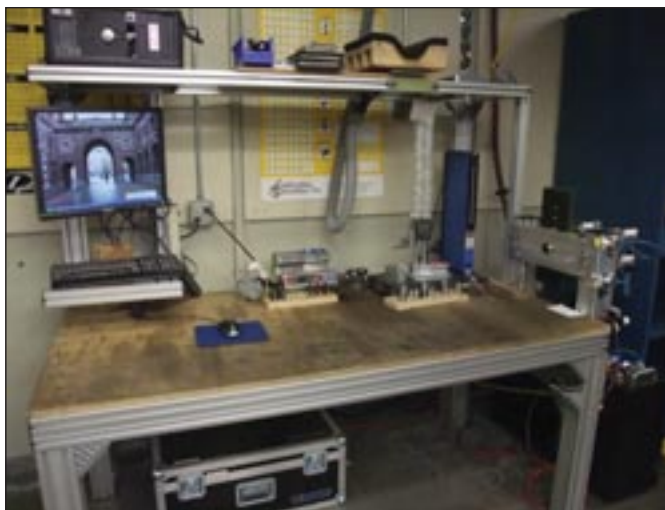
Production mechanics and motor setup technicians were brought in at an early stage to help design the layout of the workcell. All input was used to develop the most efficient sequencing of

the work to maximize productivity. With the use of simulation software and workcell mockups, the mechanics were completely familiar with the equipment

and the new work sequencing before the first airplane was drilled.

The efficiency of the process is built into the smart motor's programs, thus scaling up production rates by bringing in new mechanics for a second assembly line proved to be painless. The speed at which a technology can be expanded with the resulting increase in productivity proves the smart portable tool philosophy to be the right approach to take for today's aircraft and all final assembly lines going forward.

The article is based on SAE International technical paper 2013-01-2295 by Wesley Holleman and Eric Whinnem of Boeing Research & Technology; and Madeleine Wrede of Novator AB.



An orbital drilling motor setup bench was established prior to launch of the new automated drilling system.

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Software for Material/Structural Characterization Across Length Scales

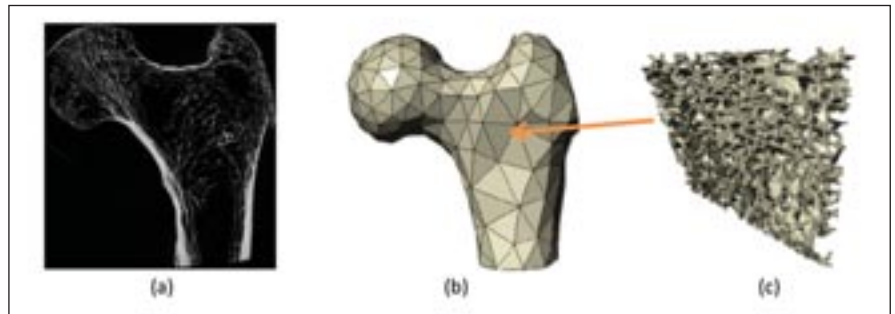
A two-stage approach is used for element-by-element analysis of a micro-structure.

Simpleware Ltd., Exeter, United Kingdom

Synthetic and natural micro-architectures occur frequently, and multi-phase functionally graded composites are becoming increasingly popular for applications requiring optimized/tailored material properties. When dealing with such materials computationally, one issue that immediately arises is the analysis of the mechanical properties of macroscopically inhomogeneous multi-scale structures. The bulk response of these structures can be determined by performing full finite element analysis (FEA); that is, with the entire geometry discretized at a resolution high enough to accurately model the smallest length scale of interest. However, these full models may easily exceed hundreds of millions, or potentially billions, of degrees of freedom, and solving problems of this magnitude may only be possible with the use of supercomputing facilities.

Additionally, in an iterative optimization process where the performance of the structure may be evaluated thousands of times, the use of full FEA simulations becomes highly impractical. When the performance of a structure is evaluated in an optimization process, typically only some aspect of the bulk response, such as deflection, is considered. For such properties, the use of full FEA simulations to model the problem may be excessive. In the present project, a novel, two-stage approach to solving such a large problem by performing element-by-element homogenization of the micro-structure, followed by solving the global problem with a coarser mesh, was explored.

The approach taken is based on creating a coarse tetrahedral/hexahedral discretization of the domain using traditional volume meshing techniques, and assigning appropriate material properties based on a finite element homogenization based on high-resolution mesh at the microstructural level of the macro tetrahedra or hexahedra. In effect, two length scales are decoupled by computing effective properties using the finite



The process of **Generating the Macro Mesh**: Femoral head modeling (a) input dataset, (b) coarse tetrahedralization, and (c) micro-element.

element approach for each macro-element. The novelty here lies in effectively discretizing the full 3D mesh into larger tetrahedra and hexahedra, and computing homogenized properties for each macro-element based on exact meshed domains representing the full microstructural complexity within the macro-elements.

For the more general case, this work exploited the use of robust, all-tetrahedral volume meshing as a method for dividing an irregular domain into smaller sub-volumes for homogenization. As each sub-volume conformed to its parent macro-element, a method for calculating their effective properties was developed.

At the highest level, the developed homogenization process involves treating the sub-volume as if it were the actual macro-element. Appropriate boundary conditions are applied based on the shape functions of the macro-element such that the sub-volume is constrained to the same modes of deformation. A series of finite element simulations is then performed in order to determine the sub-volume's effective properties.

As part of the validation of the developed homogenization technique for tetrahedral sub-volumes, a homogeneous sub-volume with fully anisotropic material properties was used as a "sanity test." The input material properties were accurately recovered. More interestingly, the technique was also used to recover the

effective properties of a real-world structure and compared to the results obtained using classical methods. The Schoen Gyroid was chosen for this purpose as its periodic geometry allows periodic boundary conditions to be used. These boundary conditions are often considered to be the exact solution.

Following the development of a technique to determine an effective constitutive matrix for an arbitrary tetrahedral sub-volume, the issue of multi-scale problems was addressed. Of particular interest is the set of problems having an irregular (i.e. non-cuboidal) domain. While problems of a more regular nature may be addressed with more conventional methods of determining effective constitutive matrices, they are nevertheless addressable using the methods developed in this work.

For many problems, it is highly impractical to attempt to include all length scales in a finite element model; consequently, it is often desirable to only capture the coarser details. Rather than excluding the smaller length scales, a coarse mesh with appropriate homogeneous material properties was produced. The process of generating the macro mesh is outlined in the figure. The homogeneous domain should conform to the bounds of the original domain as closely as possible, representing the result of a "shrink-wrap" operation.

Each of the macro-elements in the generated mesh is subsequently homog-



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enized using the developed technique. As each macro-element is considered as an independent sub-volume, the processing may occur in either series or in parallel, depending on the available computational resources. The final result is a macroscopic homogenous model with varying material properties that can be exported to a traditional finite element package.

This work was done by Philippe G. Young of the University of Exeter; and David Raymont, Joonshik Kim, and Viet Bui Xuan of Simpleware Ltd. for the Air Force European Office of Aerospace Research & Development (EOARD). For more information, download the Technical Support Package (free white paper) at www.aerodensestech.com/tsp under the Information Technology category. AFRL-0225

Model Development Using Accelerated Simulations of Hypersonic Flow Features

This code enables more accurate models for computational fluid dynamics applications.

Air Force Office of Scientific Research, Arlington, Virginia

Currently, the two main computational tools used by the aerothermodynamics community to model hypersonic flows are Computational Fluid Dynamics (CFD), and the direct simulation Monte Carlo (DSMC) particle method. Both use essentially the same physical models for rotational-vibrational excitation and dissociation phenomenon, which are based on a limited number of near-equilibrium experiments performed at low temperatures.

The purpose of this work was to develop a new modeling capability, based on computational chemistry, to provide a more fundamental understanding and develop more accurate thermochemical models for CFD and DSMC. A parallel DSMC code called the Molecular Gas Dynamic Simulator (MGDS) code, was developed that uses an embedded three-level Cartesian flow grid with automated adaptive mesh refinement (AMR). The refinement is arbitrary (non-binary) and enables accurate and efficient simulations with little user input. In addition, MGDS contains a robust "cut-cell" subroutine that cuts complex 3D geometry from the background Cartesian grid and exactly computes the volumes of all cut cells. Combined within a DSMC solver, these two features enable molecular-level physics to be applied to real engineering problems.

In addition to the practicality for complex 3D flows, the DSMC code acts as a bridge between computational chemistry modeling and continuum fluid mechanics. With existing parallel computer clusters, DSMC is able to perform near-continuum simulations using only molecular physics



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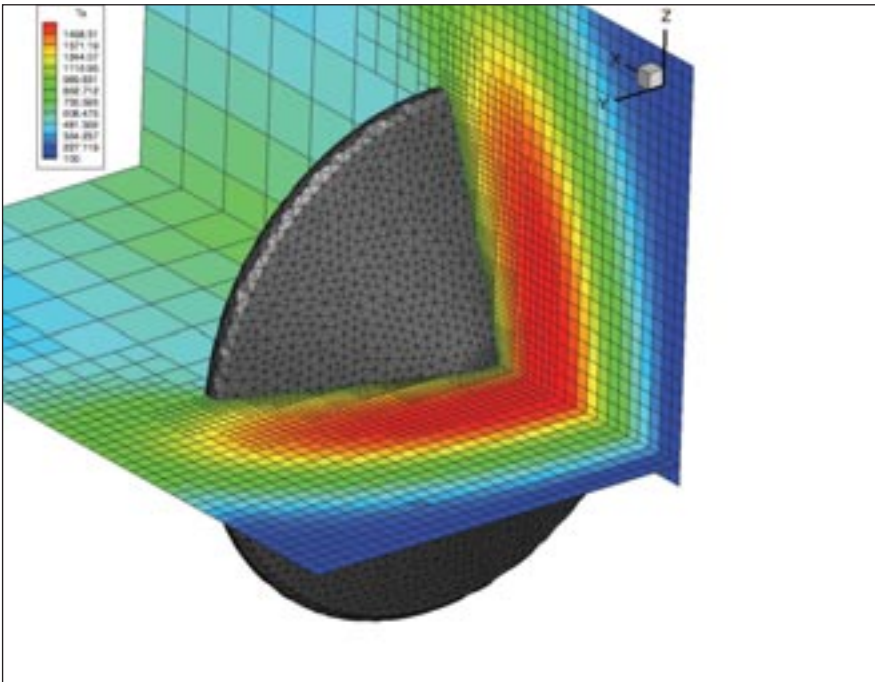
models. Pure computational chemistry of simulation of shock waves and shock layers is computationally feasible with modest parallel computing resources (100 core processors for a few days). Such simulations, which are referred to as “all-atom molecular dynamics” (MD) simulations, require only a potential energy surface (PES)

that dictates the interaction forces between individual atoms as the model input. Thus, unlike DSMC or CFD, no models for viscosity, diffusion, thermal conductivity, internal energy relaxation, chemical reactions, cross-sections, or state-resolved probabilities/rates are required. Rather, every real atom in the system is simulated.

The methodology was validated with experimental data for shock structure in mixtures of noble gases and diatomic nitrogen. All-atom MD simulations of nitrogen discovered clear “direction-dependence” of translational-rotational energy transfer that is not captured by existing models. Compressing flows involve fast rotational excitation, whereas expanding flows involve slower relaxation for the same equilibrium temperature. A new model for both DSMC and CFD reproduces experimental data and is consistent among MD, DSMC, and CFD.

A combined MD-DSMC technique replaces the collision model in DSMC with MD trajectories. The method reproduces exactly pure MD results. This is a significant advancement that enables simulation of axisymmetric and 3D flows where a potential energy surface is the only model input. Thus, the accuracy of pure MD is maintained for full flow fields, directly linking computational chemistry with aerothermodynamics.

This work was done by Thomas E. Schwartzentruber of the University of Minnesota for the Air Force Office of Scientific Research. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Information Technology category. AFRL-0226



A three-dimensional solution for **Hypersonic Flow** of argon over a capsule geometry. This simulation required only 128 cores for 12 hours using the MGDS code.

Chrono: A Parallel Physics Library for Rigid-Body, Flexible-Body, and Fluid Dynamics

This software enables 3D simulation of multi-body problems such as modeling granular terrain.

US Army TARDEC, Warren, Michigan; University of Wisconsin, Madison; and University of Parma, Parma, Italy

The Chrono::Engine software is a general-purpose simulator for three-dimensional multi-body problems. Specifically, the code is designed to support the simulation of very large systems such as those encountered in granular dynamics, where the number of interacting elements can be in the millions. Target applications include tracked vehicles operating on granular terrain, or the Mars rover operating on discrete granular soil.

In these applications, it is desirable to model the granular terrain as a collection of many thousands or millions of discrete bodies interacting through contact, impact, and friction. Such systems also include mechanisms composed of rigid bodies and mechanical joints. These challenges require an efficient and robust simulation tool, which has been developed in the Chronosimulation package.

Chrono::Engine was initially developed leveraging the Differential Varia-

tional Inequality (DVI) formulation as an efficient method to deal with problems that encompass many frictional contacts. This approach enforces non-penetration between rigid bodies through constraints, leading to a cone-constrained quadratic optimization problem that must be solved at each time step. Chrono::Engine has since been extended to support the Discrete Element Method (DEM) formulation for handling the frictional contacts



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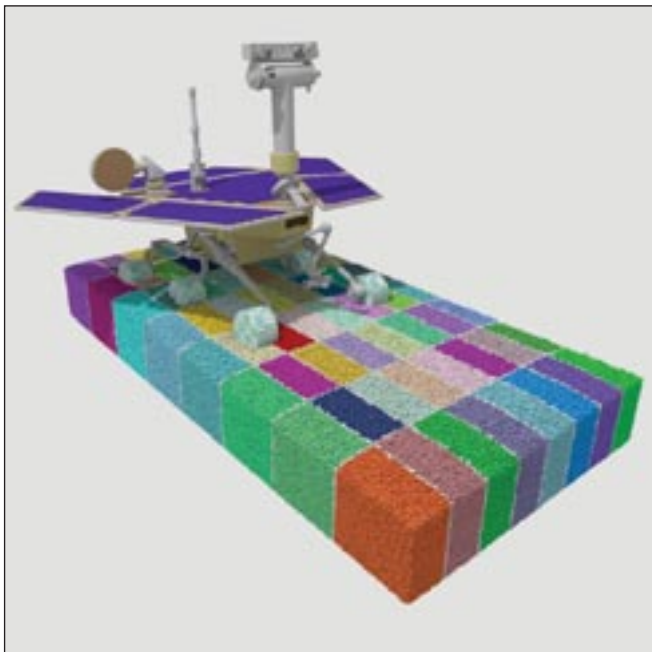


present in granular dynamics problems. This formulation computes contact forces by penalizing small interpenetrations of colliding rigid bodies. Various contact force models can be used, depending on the application.

The core of Chrono::Engine is built around the concept of middleware; namely, a layer of classes and functions that can be used by third-party developers to create complex mechanical simulation software with little effort. Given the complexity of the project, approaching half a million lines of code, the software is organized in classes and namespaces as recommended by the Object Oriented Programming paradigm, targeting modularity, encapsulation, reusability, and polymorphism. The libraries of Chrono::Engine are thread-safe, fully re-entrant, and include more than 600 C++ classes. Objects from these classes can be instantiated and used to define models and simulations that run in third-party software, including vehicle simulators, CAD tools, virtual reality applications, or robot simulators.

Chrono::Engine is platform-independent, so libraries are available for Windows, Linux, and Mac OSx, for both 32- and 64-bit versions. A modular approach splits the libraries in modules that can be dynamically loaded only if necessary, thus minimizing issues of dependency from other libraries and reducing memory footprint. For instance, libraries were developed for MATLAB interoperability, for real-time visualization through OpenGL, and for interfacing with post-processing tools.

Most C++ objects that define parts of the multi-body model are inherited from a base class called ChPhysicsItem, which defines the essential interfaces for all items that have some degrees



A simulation in **Chrono::Engine Software** of a Mars rover-type wheeled vehicle operating on granular terrain. The vehicle is composed of a chassis and six wheels connected via revolute joints. The wheels of the rover are checkered blue and white to signify that the master copy of the rover assembly is in the blue sub-domain and the rover spans into adjacent sub-domains. Shared bodies (those that span sub-domain boundaries) are white.



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of freedom. A set of more than 30 mechanical constraints is part of this class hierarchy. Furthermore, the architecture is open to further definition of new specialized classes for user-customized parts and joints. The software architecture has been designed to accommodate an expandable system for handling assets (meshes, textures, CAD models), with multiple paths from pre-processing to post-processing.

Chrono has been further extended to allow the use of CPU parallelism for certain problems. To efficiently simulate large systems, a domain decomposition approach has been developed to allow the use of many-core compute clusters. In this approach, the simulation domain was divided into a number of sub-domains in a lattice structure.

Each sub-domain manages the simulation of all bodies contained therein. Bodies may span the boundary between adjacent sub-domains. In this case, the body is considered shared, and its dynamics may be influenced by the participating sub-domains. The implementation leverages the MPI standard to implement the necessary communication and synchronization between sub-domains.

This approach enables the simulation of large systems in two ways. First, it relies on the power of parallel computing since one compute core can be assigned to each MPI process (and therefore to each sub-domain). These processes can execute in parallel, constrained only by the required communication and synchronization. Second, it allows access

to the larger memory pool available on distributed memory architectures. Whereas a single node or GPU card may have about 6 GB of memory, a distributed memory cluster may have on the order of 1TB of memory, enabling the simulation of vastly larger problems.

This work was done by David Lamb of US Army TARDEC; Toby Heyn, Hammad Mazhar, Arman Pazouki, Daniel Melanz, Andrew Seidl, Justin Madsen, Andrew Bartholomew, and Dan Negrut of the University of Wisconsin; and Alessandro Tasora of the University of Parma. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Software category. ARL-0158

Terrain Model as an Interface for Real-Time Vehicle Dynamics Simulations

The vehicle terrain model interfaces with existing vehicle and tire dynamics models.

US Army TARDEC, Warren, Michigan

In order to enable off-road vehicle dynamics analysis simulations when traveling on soft soil, a deformable Vehicle Terrain Interface (VTI) model that interfaces with existing vehicle and tire dynamics models was developed. It is modularized to be interfaced to a multi-body dynamics vehicle that supports the Standard Tire Interface (STI). Any tire model can be used that supports the STI as well; currently, both rigid and flexible tire models are supported.

Geometry associated with the terrain profile is a combination of low-fidelity terrain height measurements, with superimposed NURBS for high-frequency content. The terrain model can efficiently query the current height by locally defining the surface as an equidistantly spaced x-y grid, and using bi-linear interpolation of the nearest four points. Points on the surface also contain information on the state of deformation of the soil, notably the undisturbed terrain height, the type of terrain, and the energy and power in-

volved in the soil deformation. The terrain takes a set of tire-terrain interface forces from the tire model, applies it to the surface of the terrain, evaluates the terramechanics problem, and updates the soil states and deformed surface profile for the subsequent time step.

In the context of off-road vehicle simulations, terrain models fall into three categories of increasing complexity: rigid terrain where the main focus is an accurate surface profile, use of empirical relationships to find pressure and sinkage directly under the tire, or finite/discrete element approaches. Any off-road vehicle dynamics simulation where the soil deforms considerably requires a terrain model that accurately reflects the deformation and response of the soil to all possible inputs of the tire in order to correctly simulate the response of the vehicle.

In this approach, fast simulations are possible due to the inherent parallel nature of the subsoil stress calculations, which are the major computational bot-

tlenecks. Parallel CPU and GPU hardware is utilized to accelerate these computations. The model will be exercised using a rigid tire with and without lugs to demonstrate the ability to handle complicated tire geometry.

The Vehicle-Terrain Interaction model involves three main components: (1) a surface loading mechanism due to 3D tire geometry contact with the terrain, (2) stress propagation of the load through the subsoil, and (3) rigorous vertical soil stress/strain relationship.

At the beginning of a time step, the vehicle passes the tire wheel spindle state data, which includes the position and velocity of the Center of Mass (CM) in the reference frame indicated by the Standard Tire Interface. The tire passes an updated geometry profile to the terrain in the form of a height map query, and the terrain database returns the collision information. Forces at the tire/terrain interface are found at each time step by using a combination of

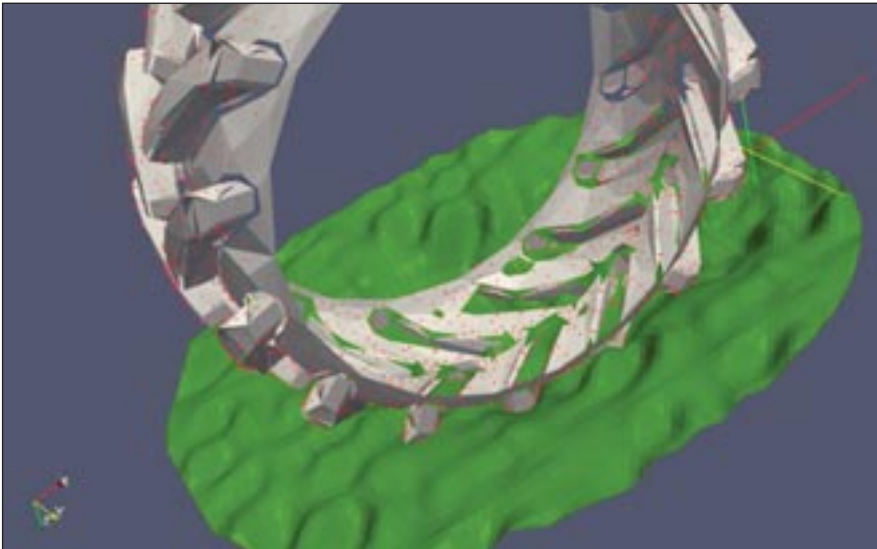


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The **3D Tire Geometry** used to determine collision points with the terrain.

normal and slip forces, in conjunction with soft-soil tire boundary forces. These forces are passed from the tire to the terrain model, where the terrain model applies Boussinesq and Cerruti soil mechanics equations to determine the pressure distribution in the volume of affected material. The model treats a column of soil as a system of discretized soil volumes, and each volume element is modeled using viscoelastoplastic compressibility relationships that relate subsoil pressures to a change in bulk density of the soil, which in turn produces soil displacements and changes to other soil state variables. The outputs of the terrain model include tire-terrain pressure distribution, terrain surface deformation, updated soil states, and power/energy required to deform the soil.

In order to determine the effect the subsoil stress equations have when they are applied to the discretized soil volume, a simplified tire that is assumed to be rigid applies a normal force on the surface of the terrain according to the tire-terrain interaction model. A compression/rebound soil response is caused by an applied vertical displacement of 7" to the tire over 1 second, followed by a horizontal wheel displacement at a constant velocity to demonstrate the rigid wheel's effects on the terrain while traveling at a steady

state velocity of 1.5 MPH. A rotational displacement is applied to result in a minimal value of slip.

The second simulation example is run, which is similar to the first, except that the rotational displacement is applied to give the tire a slip rate of approximately 15%. The total displacement of the soil in the vertical direction at the end of the simulation is concentrated about the loading area, and is strongly influenced by the choice of Frolich parameter value. There are slightly larger force vectors when compared to the low-slip simulation (mainly elongated in the direction of travel), indicating that the shear displacement-shear stress relations properly account for the tractive forces induced by wheel slip.

Example numerical results verify that the terrain database can handle tire geometry that is complex and non-uniform. The terrain model leverages parallel computing using both CPUs and GPUs and is shown to scale well, which will enable real-time deformable terrain to be simulated.

This work was done by Alexander Reid of US Army TARDEC. For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Information Technology category. ARL-0159.

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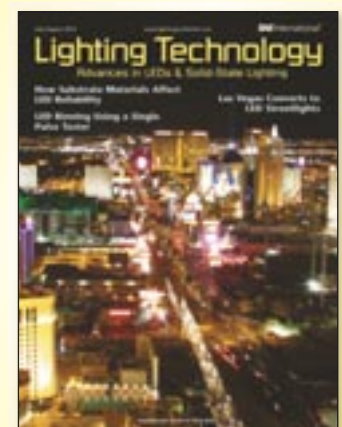


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Vacuum Regulators to Simulate Altitudes

Equilibar
Fletcher, NC
828-650-6590
www.equilibar.com

To support air assets, the US Navy's Altitude Laboratory in Maryland is tasked with testing On-Board Oxygen Generating Systems (OBOGS). The lab has three hypobaric chambers to assess mechanical breathing simulators at altitudes up to 60,000 feet. The altitude in the chambers is simulated by precisely regulating the vacuum pressure.

Testing oxygen generating systems presents unique challenges due to the high flow rates created by aircraft systems, the complexity of sinusoidal breathing, and the life-and-death importance of a reliable system. Previously, the lab used traditional vacuum control valves to throttle flow between hypobaric chambers and vacuum pumps. While common throughout industry, such systems are not capable of responding quickly enough to oxygen systems' frequent perturbations in pressure/flow balance. Barometric swings of 2000 to 4000 feet were observed in some chambers.

In 2011, the Navy contracted with Research, Engineering and Development, Inc., and Spectrum Sciences, Inc., to im-



prove the accuracy of the simulated altitude. Working with Spectrum Sciences aerospace engineer Curtis Stansfield and the Navy's Dennis Gordge, Equilibar designed three high-flow vacuum regulators. The design used high-resolution Proportion-Air electro-pneumatic regulators to pilot-operate the three vacuum regulators. The lightweight, supple diaphragm moves only a few millimeters to modulate the vacuum regulator from fully closed to fully open. The thin Viton diaphragm is sensitive to changes in pressure as small as 0.001 psi. Equilibar regulators provide stable pressure across flow rate changes of up to 1000:1 and adjust to changes in flow rate in less than 10 milliseconds.

The new system provides a significant reduction in altitude pressure variation.

Even with non-steady air crew exhalation flows, the chamber altitude is maintained within +/- 50 ft, an 85% reduction in variability. The system uses one bleed orifice and two separate solenoid valves for three different modes. A very small orifice allows a low constant bleed rate for minor adjustments. A .25" sized orifice is used for controlled descent, and a .5" orifice allows for rapid ingress of air in a simulated emergency descent. The actual rate of descent in all cases is set by providing a matching ramping electronic command signal to the electronic pilot regulator.

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Electronic Attack Capability on Unmanned Aircraft

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

Northrop Grumman Corporation has integrated and employed an internal miniature electronic attack payload on the Bat unmanned aircraft, marking the first time that such a system was used in operation on a Group III (small, tactical) system.

The Pandora electronic attack capacity, integrated in less than two months, is a low-cost derivative of Northrop Grumman's upgraded digital APR-39 systems. The lightweight, multifunction payload provides electronic attack, support, and protection. Northrop Grumman showcased the system's capabilities late last year in a demonstration that involved the jamming of radars during the Marine Aviation Weapons and Tactics Squadron One (MAWTS-1) Weapons and Tactics Instructor (WTI) event at Naval Air Weapons Station China Lake, CA.



Bat is a tactical, runway-independent, unmanned aircraft that can be launched from land or sea. Its flexible design allows for quick installation of a variety of payloads and enables rapid, expeditionary deployment. During a 2013 Weapons and Tactics Instructor (WTI) event, the Bat completed multiple flights in collaboration with fixed wing and other unmanned platforms.

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Armored Response Vehicle for Bomb Disposal Teams

Lenco Industries
Pittsfield, MA
413-443-7359
www.LencoArmor.com

Lenco Industries has introduced the BearCat® EOD “BombCat” armored response vehicle for bomb disposal teams and EOD and IEDD first responders. Designed with input from veteran explosive ordinance disposal experts, the BombCat accommodates a large tactical robot like the Andros F6A, which can be readily accessed using a fold-down ramp at the curb side door or deployed from a hydraulically controlled platform located at the front of the vehicle.

The BombCat’s spool storage reel manages the robot’s fiber-optic cable, while technicians monitor progress via computer monitors from the safety of the vehicle’s interior. Secure radio signals also transmit robot audio and video feeds.

The BombCat includes an optional, roof-mounted 24X zoom camera with high-intensity scene lighting that can be raised up to 10 feet for enhanced visibility. A thermal

image camera, CBRNE equipment, and advanced communications sensors are also available to meet operator needs.

All Lenco-armored trucks are built with Mil-Spec steel armor, plate-certified to defeat multi-hit attacks from 7.62 AP / .50 Cal BMG, while ceilings and floors provide enhanced blast and fragmentation protection. Ballistic glass windows also offer multi-hit defeat. Additionally, BombCat models are built on heavy-duty commercial truck platforms, which allow upkeep and repairs to be performed at OEM dealers and truck centers.

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The Crossroads of Manufacturing

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Signal Acquisition Module

ADLINK Technology (San Jose, CA) has released its PXI Express dynamic signal acquisition module, the PXIe-9529, featuring up to eight 24-bit analog input channels simultaneously sampling at 192 kS/s and a 108 dB dynamic range. The PXIe-9529 features a vibration-optimized lower AC cutoff frequency of 0.3 Hz, and all input channels incorporate 4 mA bias current.

The PXIe-9529's built-in phase-locked loop (PLL) allows multiple modules to lock to an external reference-timing signal; each module can perform measurements simultaneously. In addition, the PXI star trigger ensures synchronization between modules with less than 1 ns of skew.

The PXIe-9529 provides flexible input ranges up to $\pm 10V$ or $\pm 1V$, software-selectable AC or DC coupling, and both differential and pseudo-differential input configuration, with up to $\pm 42.4V$ over-voltage protection for positive and negative inputs in both configurations. The module supports Windows 8, Windows 7, Windows XP operating systems, and is fully compatible with third-party software such as LabVIEW™, MATLAB®, and Visual Studio.NET®.

For Free Info Visit <http://info.hotims.com/49744-510>



Single-Slot VPX Board

Elma Electronic (Fremont, CA) offers a dual-drive VPX storage module that provides more than 2 terabytes (TB) of storage, but requires only one system slot. The 533x family comes with either solid state SLC, MLC, or 2.5" rotating drives.

The 5330/1 boards feature a 4-port PCIe to SATA II 3 Gb/s controller, supporting two onboard and two external SATA 3G drives or four external drives. The convection-cooled versions operate from $-40^{\circ}C$ to $+85^{\circ}C$, and the conduction-cooled versions operate from $-40^{\circ}C$ to $+75^{\circ}C$. Operating shock of all boards is 40 Gs at 11 ms, half-sine wave; vibration is 2 Gs from 15 Hz to 2,000 Hz.

For Free Info Visit <http://info.hotims.com/49744-511>



Thermal Analysis Tool

A Thermal Analysis tool from Custom MMIC (Westford, MA) estimates the rise in temperature between the ambient surrounding and the bottom of a packaged MMIC when attached to a printed circuit board (PCB). The online calculator does not require a full 3D thermal simulation environment. Users select the package type, the power dissipation inside the package, the PCB board material, the via construction, and the base plate temperature (typically $85^{\circ}C$). The calculator then determines the

temperature rise through the PCB to the bottom of the package, under the following assumptions: the PCB is plated with 1 oz. copper (1.4 mils thick), the package is attached to the PCB with solder (2 mils thick), and the base plate is an ideal heat sink.



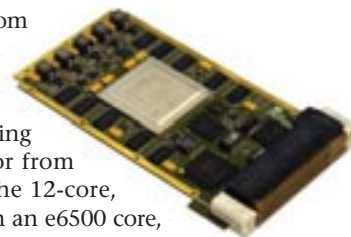
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Single Board Computer

The "Medusa" VPX3424 from AcQ Inducom (Oss, The Netherlands) is a 3U OpenVPX™ (VITA 65) single board computer (SBC) featuring the T4240 QorIQ® processor from Freescale Semiconductor. The 12-core, 24-thread processor, based on an e6500 core, runs at up to 1.8GHz and 216 GFlops. The SBC includes as much as 12GB DDR3 RAM.

To add support for application-specific interfaces, the Medusa has a Xilinx Kintex-7, user-programmable FPGA and dozens of customizable OpenVPX™ user I/O pins. A PCIe 4x communication interface enables pre-processing and video/image processing. Other features include built-in AltiVec® technology accelerators; 2Mbit of FRAM; 256MB Flash for programs; and multicore-debugging over AURORA and JTAG.

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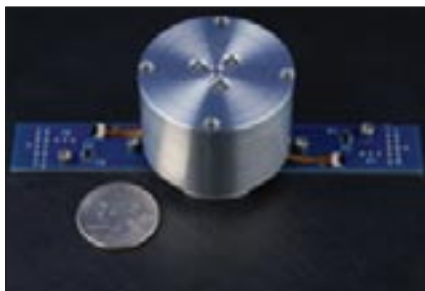




New Products

Rotary Micro Drive

New Scale Technologies (Victor, NY) has announced a prototype rotary piezoelectric micro drive system. Unlike servo drives, the new rotary drive has no measurable jitter, holds position without power, and generates no magnetic fields. The $44 \times 44 \times 36$ mm prototype operates at 350 degrees/second and has an acceleration of 3000 degrees/second²



A tiny rotating stage integrates a high-torque, direct-drive piezoelectric motor, precision ball bearings with low run out and wobble, optical encoder with zero reference mark, and New Scale drive electronics and closed-loop control system. The device is PC-controlled using New Scale Pathway™ software.

For Free Info Visit

<http://info.hotims.com/49744-512>

Microwave Analog Signal Generators

Agilent Technologies (Santa Clara, CA) has introduced two microwave analog signal generators: the N5183B MXG and N5173B EXG. The MXG has phase noise of less than -124 dBc/Hz (at 10 GHz, 10 kHz offset). The EXG offers +20 dBm at 20 GHz and low harmonics of <-55 dBc to characterize broadband microwave components, such as filters



and amplifiers. The generator also supports continuous-wave (CW) blocking for receiver testing or basic local-oscillator upconversion for point-to-point microwave backhaul links.

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Product Spotlight



ACCUFIZ 6MP HIGH RESOLUTION LASER INTERFEROMETER

The AccuFiz 6MP provides the highest available resolution for measuring steep slopes and small diameter optics. Its 2400 x 2400 pixel sensor lets you measure surface shape earlier in the manufacturing process, to capture polishing marks despite high fringe counts and to measure spherical/aspherical optics and molds with unprecedented accuracy. See us at Defense, Security and Sensing, Booth 300. <http://4dtechnology.com/products/accufiz6MP.php>

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RUGGED FIREWALL/ ROUTER/ SWITCH/VPN GATEWAY

The newly developed Firewall/Router/Switch Solution is designed for an environment of -40°C to 85°C, and is produced 100% by MPL AG in Switzerland. The product comes with the embedded Linux based OpenWRT OS and provides full functionality. It includes a wide input power range and can be customized according customer needs.

MPL AG Switzerland

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- <http://www.sitech-bitdriver.com/>

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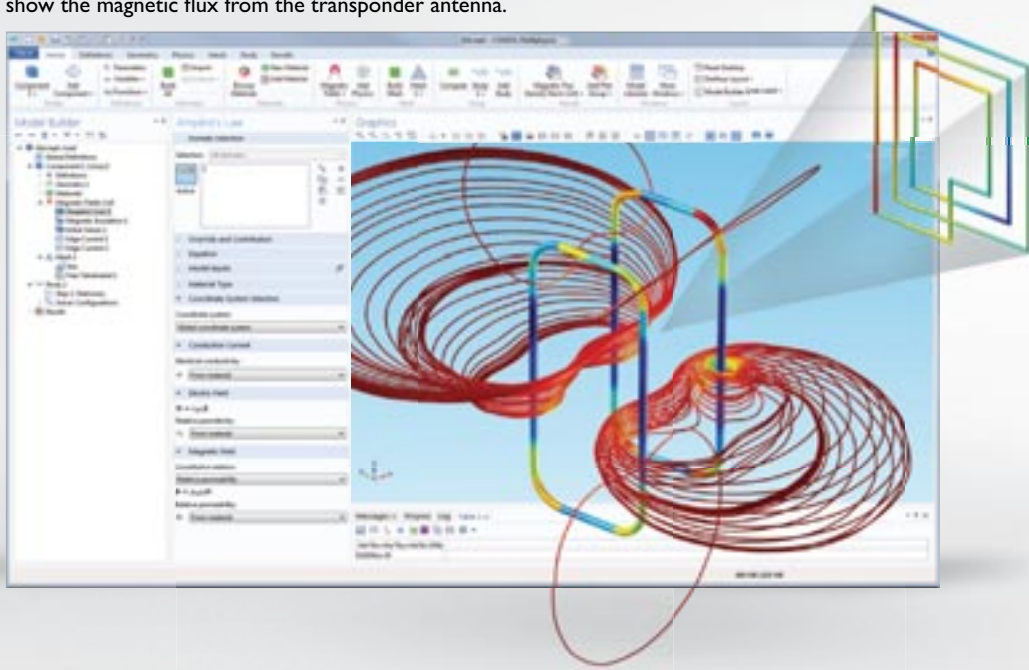
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RFID: Simulation of a reader-transponder pair for radio-frequency identification applications. Results give the mutual inductance and show the magnetic flux from the transponder antenna.



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