AEROSPACE & DEFENSE TECHNOLOGY™

The Engineer's Guide to Design & Manufacturing Advances

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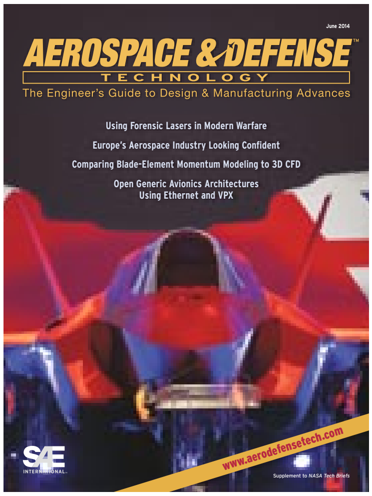

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June 2014

AEROSPACE & DEFENSE TECHNOLOGY™

The Engineer's Guide to Design & Manufacturing Advances

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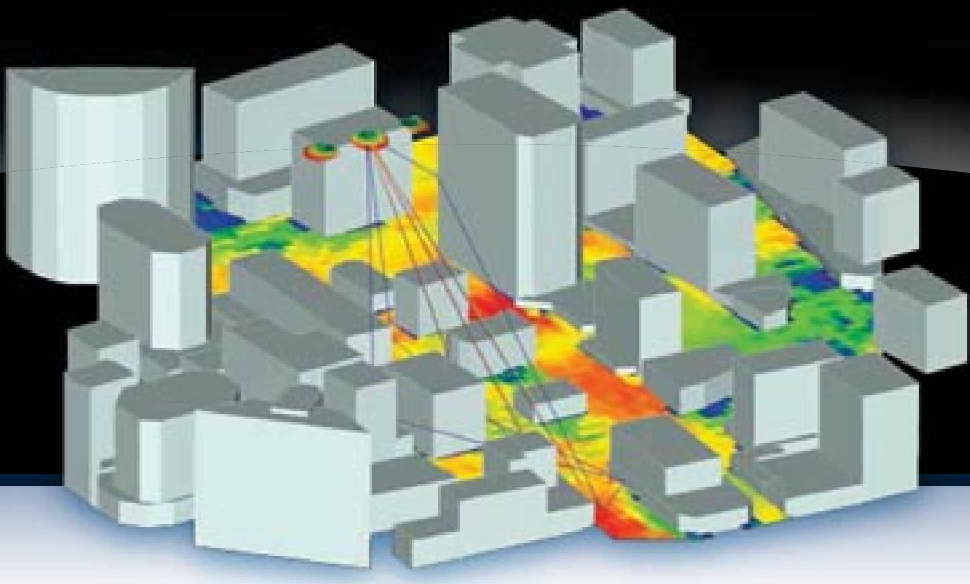

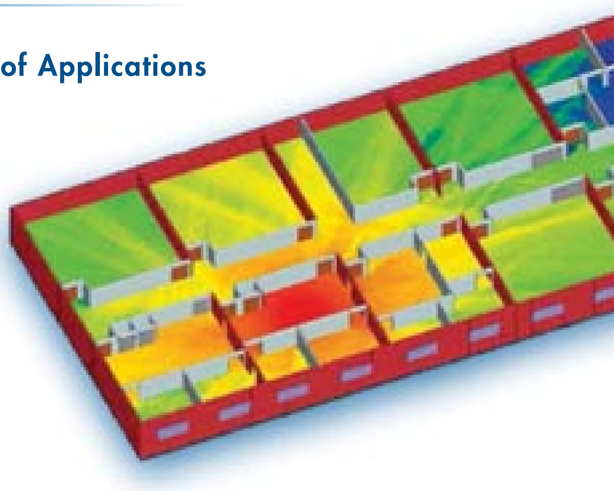

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ON THE COVER

The U.K. aerospace industry has a major share in the production of the F-35B (shown), including its rear fuselage, fin assemblies, and ejector seats. To learn more about Europe's growth in the development of defense and commercial aircraft, read the feature article on page 24.

(Image Credit: Crown copyright, Ministry of Defence)

Top Products

Integrated Servo Motor

Designed for battery-powered and low-voltage applications, the MAC402 from JVL is the VDC version of the MAC400 400-W integrated servo motor. The supply range for the MAC402 is 12 to 48 VDC, and full power of 400W (RMS) up to 1200W (peak) can be reached with 24 to 48 VDC. This powerful, compact motor measures 191 × 60 × 114 mm. Applications include, but are not limited to, remotely operated robots, robotic vehicles, portable equipment, tracking devices, antenna mounts, and positioning devices. More detail at ***http://articles.sae.org/12836***.

Nano Circular Connector

TE Connectivity's CeeLok FAS-T nano circular connector is a nano-miniature, rugged I/O connector capable of meeting 10 gigabit Ethernet performance. The proven, noise-canceling contact configuration minimizes crosstalk, making it suitable for a variety of markets and applications, including missiles, UAVs, soldier systems, and C4ISR. The connector provides a high-speed/bandwidth I/O connector in a form factor that occupies less than 3/8 in of panel space. More detail at ***http://articles.sae.org/12837***.

PEEK Wear Compounds

The LUVOCOM 8000 series of PEEK wear compounds from Lehvoss North America incorporates proprietary additives that further elevate the wear resistance of PEEK compounds. Through research and testing, Lehvoss designed the LUVOCOM 8000 product line to have a tribological profile significantly surpassing previously known materials while also preserving mechanical performance. More detail at ***http://articles.sae.org/12835***.

Wire Grid Polarizers

High-contrast IR wire grid polarizers from Edmund Optics are suited for broadband IR applications that require high transmission and contrast, including spectroscopy and thermal imaging. The polarizers are made by applying a thin layer of aluminum microwires to a glass window. They are designed using a lightweight, thin silicon substrate, making them well suited for weight-sensitive systems such as unmanned aerial vehicles. More detail at ***http://articles.sae.org/12793***.

Voltage Controlled Oscillator

Crystek's CVCO25CL-0902-0928 VCO operates from 902 to 928 MHz, with a control voltage range of 0.5 to ~3.5V. It features a typical phase noise of -108 dBc/Hz @ 10 kHz offset and has excellent linearity. Output power is typically +3 dBm. The model is packaged in the industry-standard 0.5- × 0.5-in SMD. Input voltage is 3V, with a max. current consumption of 15 mA. Pulling and pushing are minimized to 0.5 MHz and 0.5 MHz/V, respectively. More detail at ***http://articles.sae.org/12795***.

Top Articles

Dassault Magnifies Focus on Its 5X

In the latest iteration of the EASy flight deck on Dassault Aviation's new 5X business jet, the immediate priorities are separated out from follow-up actions required later during the flight when presenting data for managing safe flight. Read more at ***http://articles.sae.org/12872.***

The Falcon 5X underwent its first simulated flight, completing an important milestone in the development program, in November 2013.

Boeing Advances Automation with Smart and Portable Orbital Drilling Tools for 787

Boeing makes a leap forward in manufacturing automation with a portable orbital drilling tool that is, at its core, indistinguishable from a fully autonomous robotic system. Read more at ***http://articles.sae.org/12811***.

Government-Sanctioned Test Site Opens Up Airspace for MIT Researchers

MIT classes and researchers developing unmanned aerial vehicles and their associated systems will be able to take advantage of a new FAA-designated facility located at Joint Base Cape Cod. Read more at ***http://articles.sae.org/12993.***

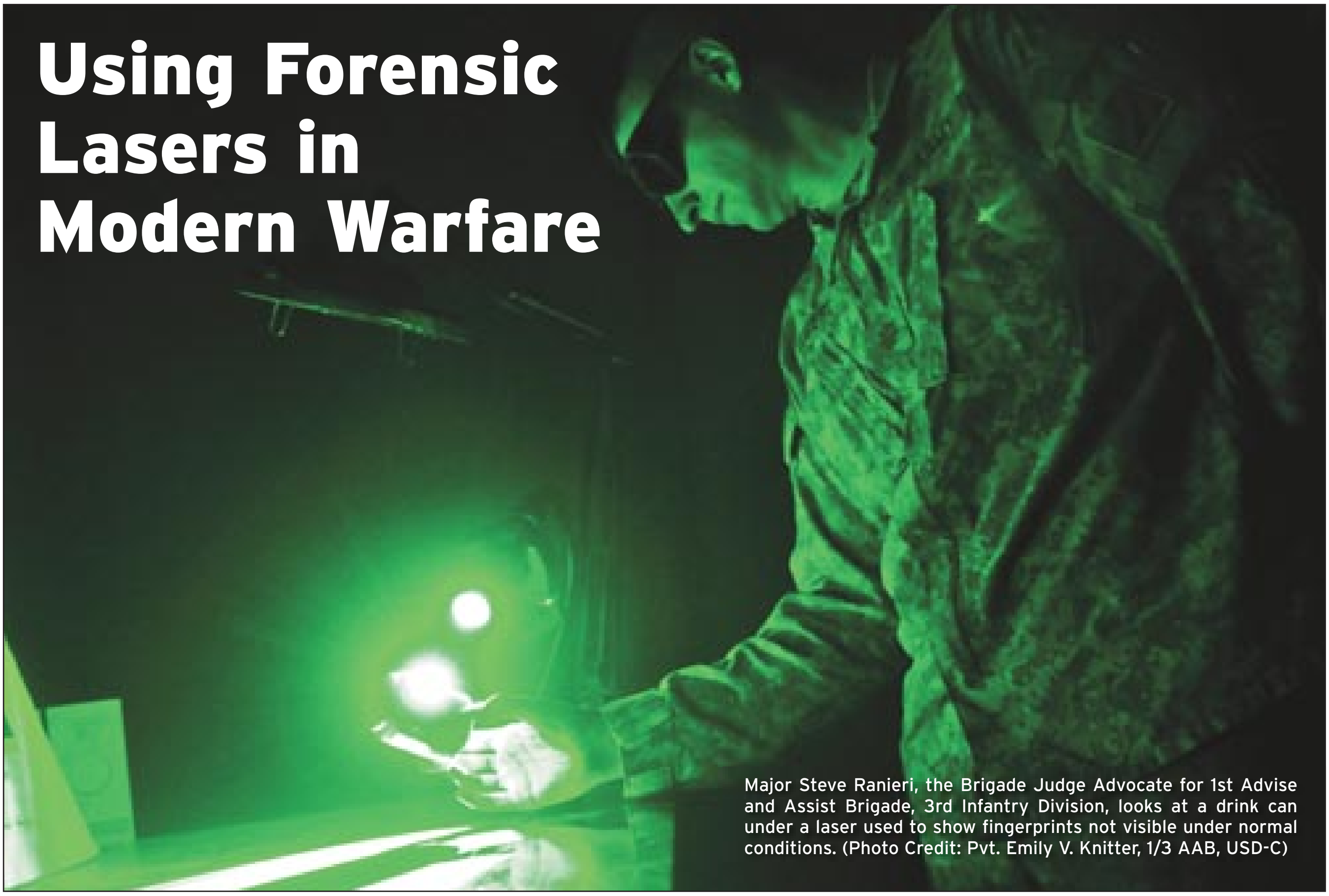
Architecture Developed for Monitoring and Anomaly Detection of Space Systems

Researchers at the University of Central Florida have found that by incorporating analysis and monitoring algorithms, such as Inductive Monitoring System, neural networks, and recent advances in deep learning within the architecture's signal processing system, engineers have a flexible and powerful end-to-end data analysis and monitoring system for instrumented remote aerospace hardware. Read more at ***http://articles.sae.org/12861***.

Maintenance Tools for Improved Engine Bearing

A number of advanced bearing maintenance products, such as customized induction heaters and sophisticated thermal cameras, can help aircraft engine OEMs and maintenance providers meet such exacting standards. Read more at ***http://articles.sae.org/12864***.

Using Forensic Lasers in Modern Warfare



Major Steve Ranieri, the Brigade Judge Advocate for 1st Advise and Assist Brigade, 3rd Infantry Division, looks at a drink can under a laser used to show fingerprints not visible under normal conditions. (Photo Credit: Pvt. Emily V. Knitter, 1/3 AAB, USD-C)

In the conflicts in Iraq and Afghanistan, the enemy's guerilla tactics have muddled the distinction between terrorism and warfare. To deal with the challenges of this new type of combat, the military has quietly built up impressive forensic capabilities, with technology more usually found in domestic crime labs than on the battlefield. Just as they have in numerous areas of weapons technology, lasers play a cutting-edge role in this work, which is performed on location, within mobile labs in Afghanistan, as well as in the US.

The main military use of forensic lasers is to find latent fingerprints on a variety of different substrates. This effort is targeted at tasks, such as identifying those who have handled an IED (improvised explosive device), and determining those responsible for its creation. This can be accomplished by examining the components of these devices either before or after explosion. Another reason for lifting prints is to establish the identity of individuals who may have handled a weapon in the commission of a crime, or to track the provenance of counterfeit documents.

Laser-Excited Fluorescence

Proven in non-military forensics, green lasers (532 nm wavelength) are workhorse tools, used primarily for locating and imaging latent fingerprints via laser-excited fluorescence. This can be accomplished on both porous and non-porous surfaces. Fluorescence occurs when a bright light, such as a laser, illuminates certain materials (such as sweat and finger oil), and some of the light is re-emitted at a longer wavelength. Because the laser illumination and fluorescence are different colors, optical filters can be used to separate them. Specifically, a filter which blocks the laser light but transmits the fluorescence significantly enhances the contrast of the print, allowing it to be viewed and photographed (Figure 1).

Sometimes a print can be imaged in this way with no chemical pre-treating. That is because many organic materials, including lipids and proteins, exhibit weak natural fluorescence, called inherent fluorescence. But, while high ambient temperatures in Afghanistan cause increased likelihood of sweating, thus yielding prints containing more bodily fluids, in most cases the substrates have to be treated with a fluorescent dye according to standard protocols used by forensic/CSI labs and domestic law enforcement groups.

In this protocol, the substrate is first exposed to superglue fumes, which preferentially bind to the lipids and other trace organics and inorganics in a print. The surface is then exposed to the highly fluorescent Rhodamine 6G dye, which clings persistently to the ethyl or methyl cyanoacrylate (superglue). As a result, when viewed through the wavelength selective glass filter, the print can be literally thousands of times brighter (Figure 2) than any scattered laser illumination light.

The Evolution of Forensic Lasers

Crime labs originally developed this application using blue (488 nm) and/or blue-green (514 nm) output from argon ion lasers. But these large, delicate, and power-hungry lasers required a 220-volt power supply and water cooling, making them impractical for field use. Because of these limitations, crime scenes were instead "swept" with an alternative light source (ALS) in order to excite fluorescence, even though the ALS usually delivered inferior results to a laser. In spite of its cryptic acronym, an ALS is actually no more than just a bright lamp whose output is passed through an optical filter, sometimes with fiber coupling to a handpiece.

The advent of compact visible lasers, based on diode-pumped, solid-state (DPSS) technology with green (532 nm) output, enabled the first portable laser applications. But these crystal-based lasers were often too expensive, and still not rugged enough for crime scene work, let alone field use by the military. The situation completely changed with the development of optically pumped semiconductor laser (OPSL) technology. This enabled the construction of highly compact green (and other wavelength) lasers, with power consumption low enough to even enable battery operation. And because OPSL technology can be readily made immune to shock and vibration, forensic lasers based on this technology provide the 24/7 rugged reliability needed for demanding field use, tough handling, and high-throughput screening.

A View from the Field

Chere S. Reynolds is a former civilian military contract employee who recently completed a third deployment to Afghanistan (two at Kandahar and one at Bagram) as a Latent Print Processing Technician. Reynolds explains the need for high throughput at these sites, "Most IEDs incorporate a lot of adhesive tape. For some cases, our lab often would have to process over 1000 pieces of tape, looking for latent prints on both the adhesive and non-adhesive side. Yet, sometimes we'd be allocated as little as 48 hours per case. We'd first perform an inherent exam of the tape or other evidence, that is, without using any chemical treatment to develop and reveal latent prints. We'd then most commonly do a standard dye and laser exam. During my first deployment in 2011, we switched from illuminating the dye using an ALS to using a green Optically Pumped Semiconductor Laser (OPSL). The number and quality of prints we obtained shot up dramatically with laser excitation."

The reasons for this difference are well documented. First, the laser has much higher monochromaticity (wavelength

(Continued on page 10)

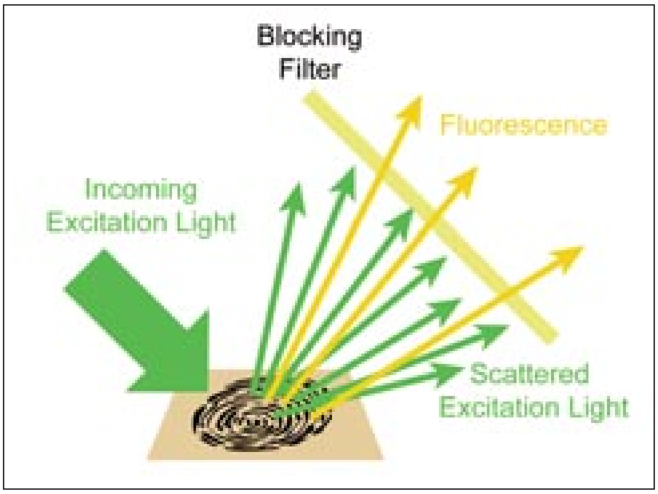


Figure 1. A filter which blocks the laser light but transmits the fluorescence significantly enhances the contrast of the print, allowing it to be viewed and photographed.

Intro Cov ToC

A&D firms achieve program excellence with Siemens integrated verification management.

Integrating virtual and physical testing enables delivery of products on schedule and on budget.

Benefits

- Reduces program risks to schedule, budget, and deliverables
- Improves program performance with a single verification management system
- Increases traceability of requirements from program through design, analysis, and test
- Reduces verification costs with improved planning and execution
- Enables proactive management of requirement compliance with real-time reporting
- Accelerates program audits with accurate, up-to-date, documented deliverables and activities

The complexity of aerospace and defense (A&D) products and the number of requirements that they must meet to gain customer or regulatory acceptance continues to grow. As a “system of systems” comprised of software, hardware and electronics, A&D products involve lengthy, multidisciplinary development programs and interrelated verification activities to gain customer or regulatory agency approval. Whether it’s a commercial airliner, weapons platform or a spacecraft, failure is not an option.

A&D companies compete in a global market place and execute programs with multiple global partners and suppliers. To be successful in this environment, A&D companies must demonstrate their ability to consistently execute programs across the extended organization, delivering products that meet requirements on-schedule and on-budget.

The Siemens PLM Software Verification Management solution enables companies to achieve this goal by connecting requirements to all tasks, analyses, tests and data involved in the requirement verification process, providing complete visibility and traceability across planning, design, analysis, test, and final compliance reporting.

Providing full lifecycle traceability

Programs must meet requirements that are set by their customers, contained in their contracts, and meet company product standards for design and safety, as well as industry requirements from regulatory authorities such as the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA). Teamcenter® software from Siemens PLM Software enables all program activities to be driven by these requirements, from initial program goals to the individual components that will make up the final product. With Teamcenter, full product lifecycle traceability makes it possible to ensure that all requirements have an approved verification method, that the method is executed, and that appropriate results are recorded to support achievement of the requirements.

Synchronizing analysis from design through test

Teamcenter is a full product lifecycle solution that can communicate requirements to all disciplines in the product development process as well as changes to those requirements. This single collaborative source permits design, analysis, and test organizations to work in unison to ensure that analysis and simulation models are synchronized with design models for both production and test articles, and that physical test articles conform to requirements across disciplines. By synchronizing these models, simulations representing the production design - as well as all the modifications made to the test article - remain valid for proving requirements are met. Teamcenter also provides integration of analysis-to-analysis (an often-overlooked failure point) by managing the process to take the outputs from one analysis and them as inputs to the next analysis, as well as all the other artifacts required to conduct the next analysis; other boundary conditions or inputs, models,etc. Only in this way are design analyses and tests truly integrated and connected.

Tracing the test to the physical test article

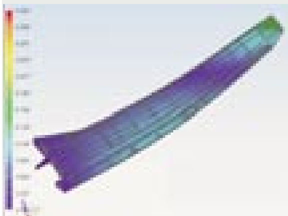
Physical tests are a necessity for aerospace and defense products, and it's imperative that tests prove that requirements are met. Proving a test valid requires that a sequence be followed from requirements to be verified to test plans that define the verification approach and that test articles and equipment are configured properly. Teamcenter establishes the path from requirements to test plans to test article to confirm that a test is required, properly planned, and accurately executed. If changes in requirements or the product design occur, Teamcenter can be used to immediately provide full visibility of their impact on plans, test articles, and tests - including those already run that need to be re-executed.

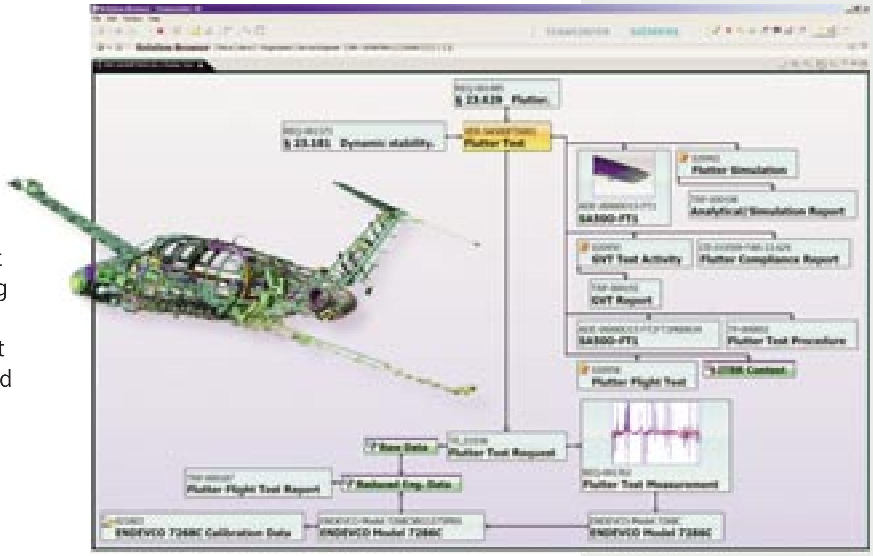
Teamcenter also maintains the complete history of all test articles and equipment, enabling full traceability to the past test article or analytical model configurations. In addition, Teamcenter provides complete instrumentation traceability: from measurement requirements defined by engineering in the test request; to the instrumentation plan; to the physical instrument installed on the test article and its calibration data through to the raw data and the reduced engineering unit data used for reporting compliance.

Full traceability enables the ability to demonstrate that the test article matches the current engineering definition as well as the original production design at every stage.

Integrating the verification management system

Moving from planning what to do, to actually doing requires task definitions, scheduling, and management. Teamcenter provides this functionality for all verification activities to link engineering, manufacturing, procurement, and test to support long lead planning, resource utilization and execution of the verification activities. Verification requirements are linked to supporting documentation for virtual and physical test configurations, test plans, test procedures and test results to enable complete status reporting of the process. This holistic approach ensures efficient usage of resources and provides visibility into the process to ensure that deadlines are met. Requirements can be linked to activities on the verification management schedule as well as to a Work Breakdown Structure for correlation to financial reporting





systems; integrating cost, schedule, and technical requirements in a single system.

Conclusion

The Verification Management solution in Teamcenter empowers A&D companies to successfully execute their programs on-schedule and on-budget by providing visibility and closed-loop requirement traceability into all activities of the verification process to confirm requirement compliance. With efficient planning, simulation, analysis and test execution in an integrated environment enabling confirmation of requirements achievement, Teamcenter supports program audits and reduces the time and cost of verification that ultimately improves program performance.

by David Riemer

www.siemens.com/plm

Features

- Requirements management
- Verification planning and execution
- System analysis and test
- Schedule management
- Change management
- Configuration management
- Test article and equipment definition and history

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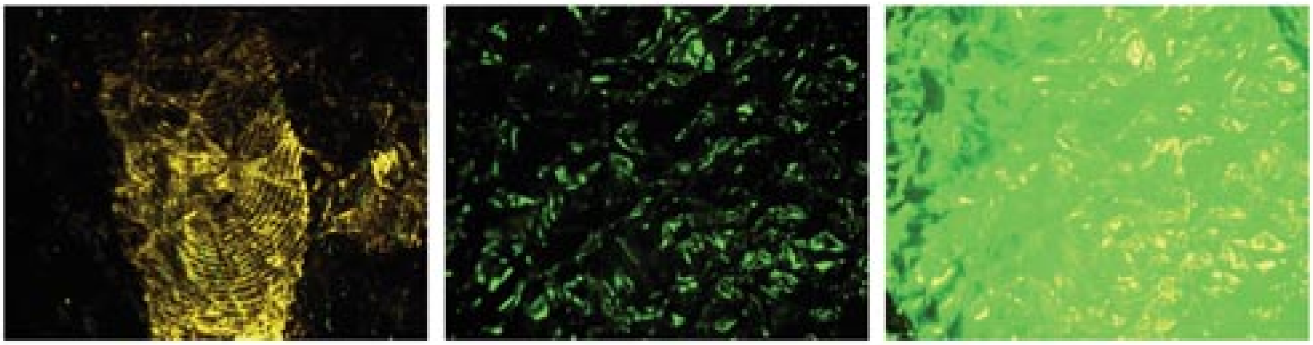
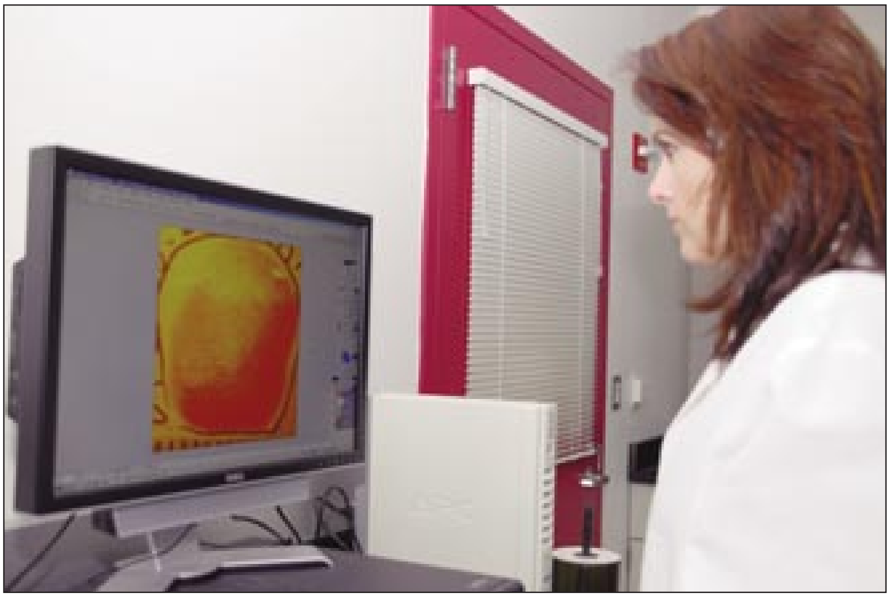


Figure 2. One of the advantages of green (532 nm) laser light is that it generates high fluorescence intensity. On this Rhodamine-dusted aluminum foil, this allows the camera aperture to be greatly reduced to obtain sufficient depth of focus for this highly contoured surface (left). This same dusted print could not be seen with an ALS (center), even with an extended exposure time with the ALS (right).



Forensic scientist Lisa Carson examines a fingerprint treated with Rhodamine and illuminated with a laser. The Rhodamine causes the print to fluoresce under the laser. (Photo Credit: Ms. Elizabeth Lorge (ARNEWS))

brightness) than an ALS. Second, it also has higher spatial brightness, making it easy to direct all of the laser's output into a small area, usually by means of a fiber optic connected handpiece. Together, these result in brighter fluorescence. Moreover, a laser also offers a time/speed advantage; it is ideal for single-sweep work, whereas optimum use of an ALS often requires multiple sweeps with different filter settings.

To deal with their high volume of work, the military now uses approximately twenty green lasers; these TracER laser systems are manufactured using Coherent's patented OPSL technology, and are supplied to the military by specialty US distributor Arrowhead Forensics. Some of these laser systems incorporate a rechargeable battery pack for field portability. The battery pack has the added advantage of making the laser immune to frequent power interruptions due to the lack of infrastructure in overseas power grids, such as in Afghanistan.

Rugged Reliability and Immunity to Vibrations

The semiconductor reliability of OPSLs has certainly been put to the test in this military work, particularly at the bases in Afghanistan. Reynolds explains that, "The mobile labs are pods based on standard 40 foot 'conex' transshipment containers, with bump-out sides. The outdoor temperature can vary from well below freezing to over 120°F. The lab heaters are hard to control, and the lab temperature could drop down below 40°F and then surge to the 80°F to 90°F range. And, because one of our labs was on a second story, the nearby landing and take-off of fighter jets caused major vibrational issues. Yet, we never had a laser head shift out of optimum alignment or fail in spite of all these very challenging operating conditions."

Summary

While lasers have certainly established their place in modern warfare, particularly in the areas of targeting, guidance, and countermeasures, they are also now quietly playing a key enabling role in a very different aspect of today's military conflicts. In particular, in an age when opposing forces often consist of irregulars and insurgents, rather than a clearly identified army, they can aid in positively identifying the enemy. Furthermore, as this work shows, these advanced lasers have proven the ability to perform this task under the most harsh and extreme conditions.

This article was written by Mark Keirstead, Coherent Inc. (Santa Clara, CA) and Brad Brown, Arrowhead Forensics (Lenexa, KS). For more information, visit ***http://info.hotims.com/49746-501.***

Open Generic Avionics Architectures and Distributed Processing Using Ethernet and VPX

The backplane and hardware module standards help to increase part commonality and the reuse of components in different system architectures and applications, but this is only one part of the system design challenge. While the specified footprint, backplane format, and electrical signal characteristics help the design of modular hardware and open architectures, they still tell very little about how modular (and unambiguous) the interfacing among functions and their interactions are. This aspect is covered at the system integration (network) layer.

VPX, as a switched fabric, supports the design of advanced integrated systems using technologies such as deterministic Ethernet, which can be used in backplane and backbone applications. In cases where functional interrelationships and Ethernet network bandwidth sharing is deterministic and all logical links among critical function have configurable quality of service with guaranteed timing, the complexity challenges in design of advanced integrated architectures can be much simpler to handle and mitigate. This enables design of truly open and flexible modular embedded systems, which can host hard real-time, real-time, and soft functions at lower system lifecycle costs. Incremental modernization is fully supported, and new functions can be added without influencing already integrated ones.

VME and the VPX Market

VME has been used for over 30 years in different industries, and its latest VME64 64-bit backplane can move 40MByte of data per second between plugged cards. Over the years, many extensions have been added to the VME interface (VME64x), providing "sideband" channels of communication in parallel to VME itself, to enhance bandwidth capabilities.

VPX (ANSI/VITA 46.0-2007) is positioned as a VME successor and backplane standard for design of rugged modular systems, designed by the VITA and its 100+ members. The VME embedded market today in aerospace and defense applications is estimated to be $600M (~20% is VPX). The difference in market numbers comes from the fact that VME boards are used for upgrades to existing systems, while VPX is used in new designs.

The VPX standard enables integration of high-speed serial switched fabric interconnects such as PCI Express, RapidIO, Infiniband, and 10 Gigabit Ethernet to satisfy high bandwidth requirements in a minimized footprint. Around this VITA (www.vita.com) standard, an ecosystem of COTS products has developed since 2008, with over 400 board products provided by major COTS board suppliers, such as Curtiss-Wright, GE IP, Kontron, Mercury, and over 30 other suppliers.

VITA 68 Bandwidth Extensions for VPX Backplane

As VPX was designed, the network bandwidth was significantly lower for many of the networking technologies used only 7-8 years ago. VITA 68 was introduced to support the integration of extended bandwidth and integrity guar-

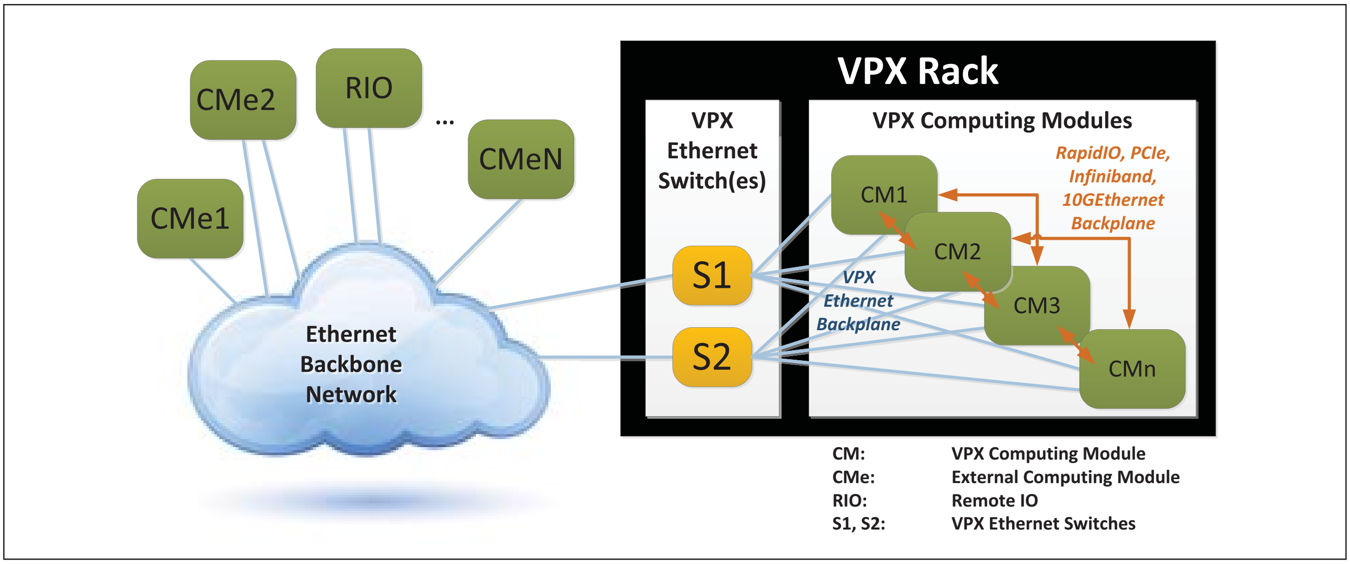


Figure 1. Logical View of VPX Backplane with external Ethernet backbone, computing modules, and remote IO.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	Bandwidth	Latency Control and Timing Guarantees	Jitter Control (hard RT)	Suppport for Fault-Tolerant Design
Infiniband	8GBps	No	No	No
RapidIO	6.25Gbps	No	No	No
PCIExpress	10GBps	No	Limited	No
Gigabit-Ethernet	100Mbps, 1Gbps, (10Gbps with 1000BASE-KX), expansion with VITA68 to 10Gbps (future 100Gbps)	No absolute guarantees, can be made "more deterministic" with VLANs and limited bandwidth use	No	No
Deterministic Gigabit Ethernet with ARINC664 and SAE AS6802 Layer 2 traffic classes	Typ. 1Gbps (1000BASE-KX), can be expanded with Ethernet bandwidth growth and FPGA component availability to 10Gbps (10GT-KX OR 10G-KR)	**ARINC664** (yes, max. latency defined, rate constrained with per stream policing and shaping) **SAE AS6802** (fixed latency, synchronous/TDMA communication service via Ethernet)	**ARINC664(AFDX)** – limited jitter control **SAE AS6802** (sub µs-jitter)	Yes, support for robust partitioning, redundancy services. Support for TTA-, L-TTA, and GALS architectures. **SAE AS6802** also supports masterless fault-tolerant synchronization.

* System architecture work around non-deterministic network technology to design a fault-tolerant and real-time embedded system. The architecture decisions are always shaped by the capabilities of system intergration technology.

Table 1. Real-Time and Bandwidth Performance of VPX Backplane.

antees for high-bandwidth networks into the VPX backplane format.

VITA 68 defines a VPX compliance channel, including common backplane performance criteria, required to support multiple fabric types across a range of defined baud rates and bit error rates (BER) for different fabric types. With this standard, the latest Ethernet physical layers (1000T-KX, 10GT-KX4), sRIO (6.25Gbps), Infiniband DDR (5Gbit/s) and QDR (10Gbit/s), and future technologies (100Gbps Ethernet 802.3bj) are and can be supported in VPX. The excess bandwidth does not assure deterministic operation, but new high-bandwidth Ethernet variants with 10+ Gbps and Layer 2 QoS extensions can enable the design of deterministic distributed functions and well-defined use of shared networking resources.

In the VPX standard, there is the difference between extension plane (PCIx, S-ATA, ...), control plane (Gigabit Ethernet), data plane (Inifiniband, serial RapidIO(sRIO), 10G Ethernet), and utility plane (clock sync, power ...). In Figure 1, a logical view of inter-module connectivity and integration with Ethernet VPX backplane and backbone is presented.

While InifiniBand and sRIO offer high bandwidth for distributed processing of large data volumes, they do not provide temporal guarantees for design of real-time systems. With Gigabit-Ethernet at a control plane, it is also not trivial to design hard RT systems and advanced integrated architectures. However, with Gigabit-Ethernet switches, which support deterministic QoS Layer 2 services, VPX plays the role of key platform technology for the design of advanced integrated systems with time-critical (hard RT), mission-critical, and safety-critical systems, which are simpler to design, integrate, maintain, verify, certify, and reuse. Essentially, the deterministic Gigabit-Ethernet switching devices for VPX backplane are not different from any standard Ethernet switch. Critical functions can take advantage of QoS services, while for all other less critical functions the network operates as any other switched Ethernet network.

VPX Ethernet Switches for Deterministic, Hard Real-Time Applications

While the electrical and mechanical aspects of the VPX backplane standard are known at the component level to many engineers, its capabilities and support for the design of advanced integrated architectures with deterministic and hard real-time applications have been rarely discussed in technical publications and press. It is believed, even among market analysts, that the older VME variant is more suitable for real-time applications than VPX. However, the fact is that VPX relies on serial switched fabrics, quality-of-services, (QoS) and its real-time performance. The system based on VPX is as (hard) real-time as the underlying backplane "databus" technology. VPX switches with ARINC664 and SAE AS6802 services enable deterministic integration of many critical functions hosted on common embedded computing and networking resources. The comparison is provided in Table 1.

Deterministic Ethernet and Layer 2 QoS Enhancements

Layer 2 QoS enhancements provide traffic classes that can handle Ethernet traffic with well-defined temporal properties (latency and jitter control). The determinism of communication can be defined as a maximum point-to-point latency. For demanding hard RT behavior and processes with >Nx1000Hz sampling cycles, the determinism can be defined as a fixed latency, jitter controlled with µs-precision, and known message order. Another reason why the jitter should be controlled in complex inte-


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solutions come faster.
At Pulse, our advanced technologies aren't only designed to make your components thinner, stronger, lighter (or whatever else you may need them to be). They're designed for quicker customization —which gets you in market faster. Because we know that being #1 is the most valuable feature we could ever add.
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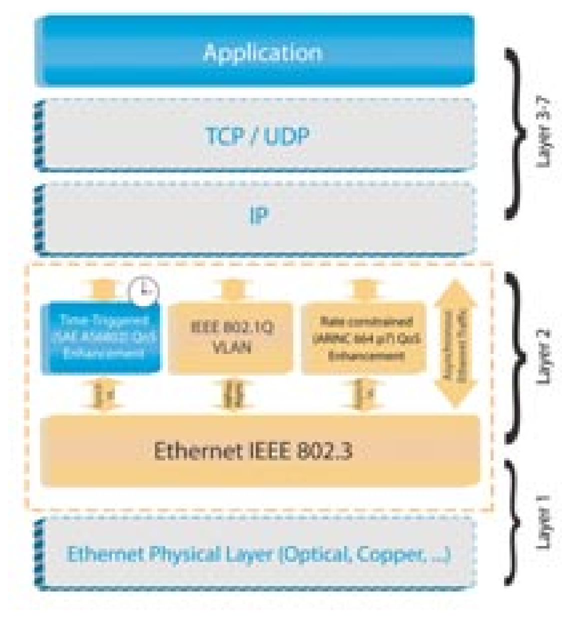


Figure 2. Gigabit-Ethernet switches with different Ethernet traffic classes (QoS Layer 2 services).

grated systems is the embedded virtualization.

In a distributed real-time computer with hosted hard RT functions, along with less critical functions for diagnosis, health management, and bulk data transfers (e.g. recording, A/V), the access to all resources shall be predefined in order to protect the performance for critical functions. The availability of fault-tolerant system time can simplify the virtualization.

ARINC664 is an Ethernet traffic class that provides defined maximum latencies for any periodic unicast/multicast data stream in the system. This is accomplished by per-stream traffic shaping and policing. The technology is used in integrated modular architectures for commercial aircraft and military transporters, such as the Boeing 787, Airbus A380, Airbus A350, Airbus A400M, and many others. All new aircraft use AFDX (ARINC664) networks to reduce SWaP.

SAE AS6802 is an Ethernet traffic class that provides fixed latencies for any periodic unicast/multicast data stream in the system, unaffected by other less critical traffic load. This service also provides a fault-tolerant distributed timebase used by different computing modules in the network, and/or Ethernet devices for scheduled forwarding of data.

With SAE AS6802, Ethernet gains strictly deterministic synchronous communication capability and can emulate circuit-switching communication in packet-switched Ethernet networks. Figure 2 shows the position of this service in the OSI layer model with relation to other Ethernet layers and applications. SAE AS6802 services do not depend on bandwidth or distance — they can operate at 0.1 to 10 Gbit/s or higher and can be used in large networks. Together with other QoS enhancements, Ethernet fully supports synchronous and asynchronous communication.

With SAE AS6802, system functions can be integrated on a common shared infrastructure and scheduled for all critical functions. All other bandwidth can be used for less critical applications.

Both ARINC664 and SAE AS6802 services do not modify operation of existing Ethernet services and are compliant with all standard Ethernet physical layers for backbone and backplane networks, including those described in VPX (VITA 46) and VITA 48. They are also compliant with higher OSI Layers 3-6.

Ethernet — As Deterministic as MIL-1553

With SAE AS6802 services, Ethernet networks can gain deterministic performance comparable to TDMA communication networks (e.g. MIL-1553 in synchronous communication mode, or Time-Triggered Protocol (TTP) – SAE AS6003), but at much higher communication speed, without bus controller and in complex switched architectures. It enables strictly deterministic communication, fixed latency, sub-µs-jitter, and predictable message order in redundant multi-hop networks. Layer 2 Quality of Service (QoS) enhancements, standardized as Time-Triggered Ethernet (SAE AS6802), guarantee deterministic computing and networking performance for advanced integrated systems. MIL-1553 operation can be emulated over an Ethernet network that implements SAE AS6802.

SAE AS6802 "Time-Triggered Ethernet" is used for human-rated space flight (NASA Orion), and evaluated for different aircraft and rotorcraft systems. It is used for the design of systems that utilize unified networking and support integration of hard real-time, real-time, and soft-time functions.

Advanced Integrated Architectures

Different variants of generic open architectures can be implemented by using VPX-based Ethernet backplane and backbone networks, assuming they provide absolute temporal guarantees and determinism for different critical functions (Figure 3).

Control-plane applications in VPX typically use single- or dual-star (redundant) topology with switched Gigabit Ethernet, which are also supported by VPX switches with SAE AS6802 QoS (TTEthernet switch). Depending on the application, TTEthernet switches can be used for control plane, data plane, and some utility plane applications (synchronization) in VPX-based systems. This means all functions and modules connected to backplane and backbone networks operate as if they are connected directly to a large, fault-tolerant Ethernet backbone. By allowing robust TDMA partitioning of networking resources, the system designer can determine the level of integration/interaction or isolation among different functions. This enables the design of innovative architectures and distributed platforms that can host many distributed functions using shared computing/networking resources for advanced integrated system architectures.

In deterministic Gigabit-Ethernet networks, it is possible to emulate reflective memory by using a periodic global data exchange with applications that are synchronized to the global timebase generated at the network level by SAE AS6802 services. From the logical perspective, different distributed functions

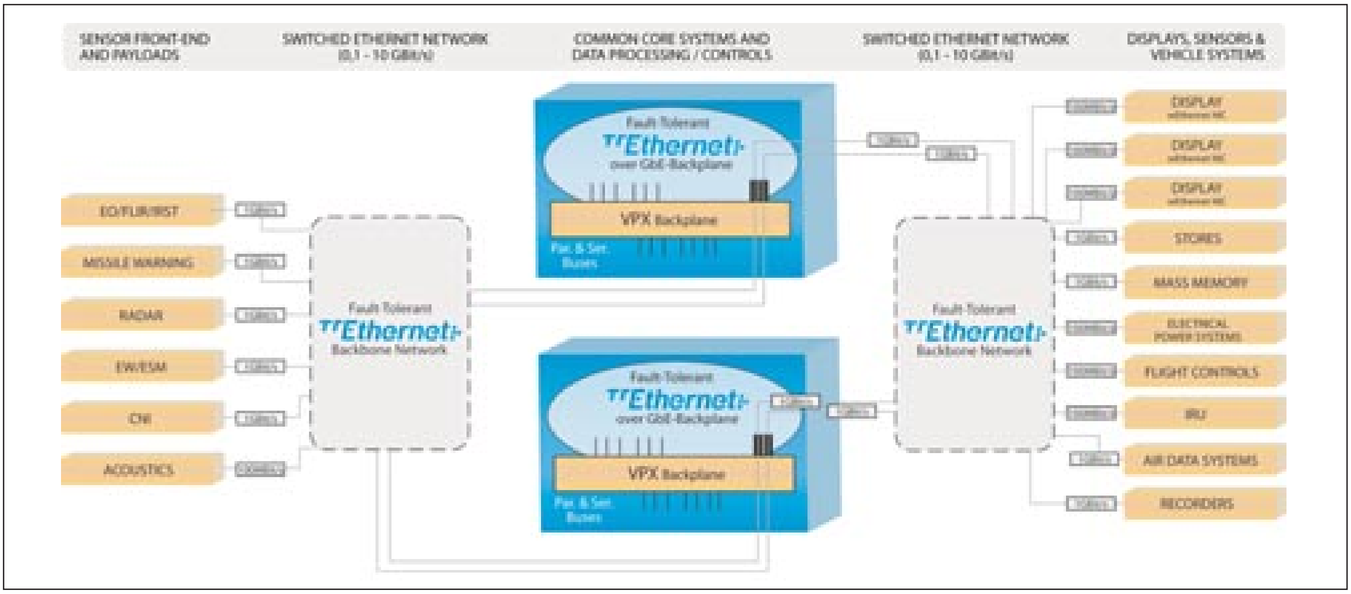


Figure 3. Advanced Integrated Architectures with deterministic Gigabit-Ethernet VPX switches.

gain a private, congestion-free shared memory. By using this approach, we can scale the level of functional integration without influencing other existing functions in the system. Also, distributed applications do not need to know about underlying architecture or topology.

Therefore, sensor fusion and distributed payload processing can be executed without fear of unintended interactions with other system functions. Voting on data from synchronous sources simplifies redundancy management and application software design. Obsolescence management, modernization, and upgrades with new DSP processors and applications are simplified, as the behavior of already integrated functions will not change and cause new system integration or timing issues. Critical, hard real-time functions will not be influenced by other less critical distributed functions. Sensor front-end data can be streamed to platform systems or common core computing systems, with exact latency and no jitter, independent of network load. This also means that processing functions do not require spatial proximity to a specific sensor, and can be placed anywhere in the system. This also simplifies reconfiguration, upgrades, and incremental modernization.

Summary

VPX modules and VPX-based Ethernet switches like those shown in Figure 4, which implement SAE AS6802 and ARINC664 and support Gigabit (or higher) bandwidth, support the design of open generic architectures in which the operation and interaction of all critical functions can be defined at design time, and new functions can be integrated with minimal impact on existing ones. This significantly reduces costs and effort in all phases of system lifecycle, and allows integration of robust hard RT functions in integrated embedded systems hosting safety-, time-, and mission-critical functions. Herewith, the design of integrated modular architectures, which follow key objectives of MOSA (Modular Open System Acquisition) and IMA DO-297 (Integrated Modular Architectures – Design Guidance and Certification Consideration), can be applied in complex Ethernet and VPX-based embedded systems.

This article was written by Mirko Jakovljevic, Senior Marketing Manager, and Perry Rucker, Director of Sales, TTTech North America Inc. (Andover, MA). For more information, visit ***http://info.hotims.com/49746-500****.*

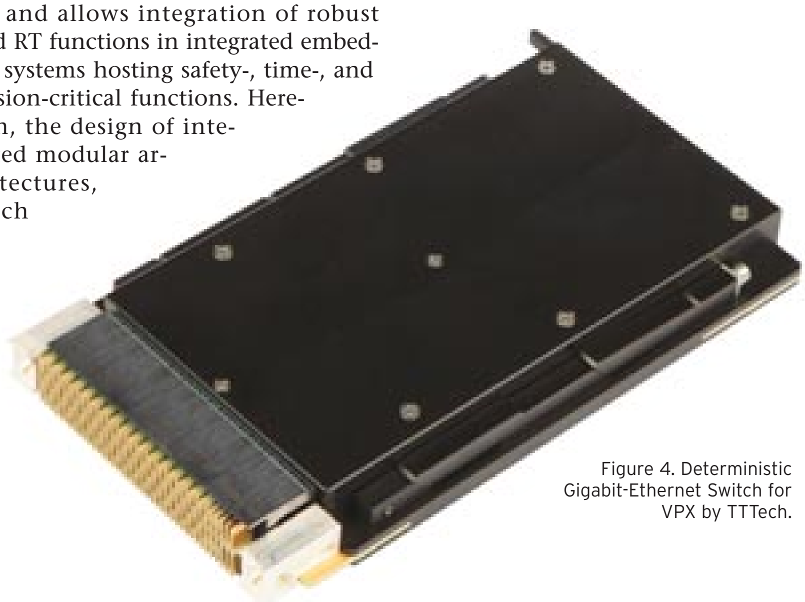


Figure 4. Deterministic Gigabit-Ethernet Switch for VPX by TTTech.

Comparing Blade-Element Momentum Modeling to 3-D CFD

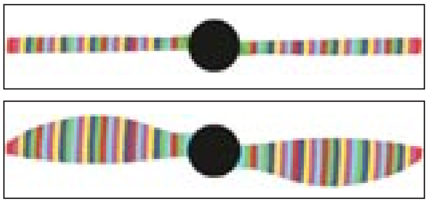
Many small unmanned aerial vehicles (SUAVs) are driven by small-scale fixed-blade propellers, and the flow produced by the propeller can have a significant impact on the aerodynamics of the SUAV itself.

Small unmanned aerial vehicles (SUAVs) are becoming increasingly popular for surveillance and numerous other applications. These SUAVs come in various sizes, and the smallest are referred to as micro aerial vehicles (MAVs). For purposes here, SUAV will be used to refer to all UAVs that are portable by a man.

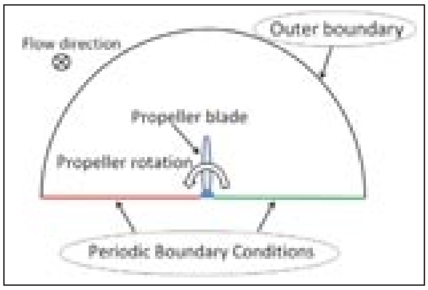
SUAVs commonly use small-scale fixed-blade propellers for propulsion. Fixed-blade propellers means the blade is rigidly fixed to the hub so that the blade pitch cannot be changed for various flight conditions. Propellers mounted in a tractor configuration often have significant effects on SUAV aerodynamics. Therefore, to perform Computational Fluid Dynamics (CFD) simulations of a SUAV-propeller system, the SUAV and the propeller must often be simulated in a coupled fashion as the SUAV-propeller interaction is strong.

In the design and analysis of a SUAV, hundreds of SUAV-propeller coupled CFD simulations are needed. Performing high-fidelity, time-dependent 3-D Reynolds-averaged Navier-Stokes (RANS) CFD simulations in which the propeller is rotated relative to the aircraft is very expensive computationally. For compactness, this method will be referred to here as the high-fidelity blade model (HFBM). HFBM is an unsteady problem, therefore steady-state convergence acceleration techniques cannot be used.

In addition, the fine grid needed to resolve the detailed flow around the propeller blades makes the overall grid size extremely large. HFBM is the most accurate and high-resolution method of propeller modeling as all the 3-D, compressibility, rotational, transitional, and turbulence effects are modeled. However, the high computational cost of HFBM makes it infeasible when numerous simulations are needed, as is the case for many SUAV-propeller problems.



To analyze the significance of 3-D effects on small scale propellers, two propellers were simulated using BEMT and HFBM. Both propellers were two bladed, had a 10-in diameter, and were made using a NACA 4412 airfoil for the blade sections. Propeller 1 (top) had a high aspect ratio of ~11 and no chord variation or sweep along the blade. Propeller 2 (bottom) had an aspect ratio of ~5 based on the largest chord in the blade, and it had significant chord variation like many small-scale propellers.



Periodic domain for the HFBM simulations.

For computational efficiency, steady-state models approximate the time-average flow produced by a propeller. These models embed momentum source terms into the propeller region of a mesh to induce thrust and swirl into the flow field. Many of these momentum source models are based on blade-element momentum theory (BEMT). BEMT determines the thrust and swirl from 2-D airfoil data. However, flow around small-scale propellers can be very complex and highly 3-D in nature, making it difficult for BEMT to accurately predict the propeller performance in many instances.

For this study, researchers from Mississippi State University compared HFBM simulations to a BEMT model for two small-scale propellers to determine the validity of using BEMT to model small-scale propellers in a wide range of flight conditions.

High-Fidelity Blade Modeling

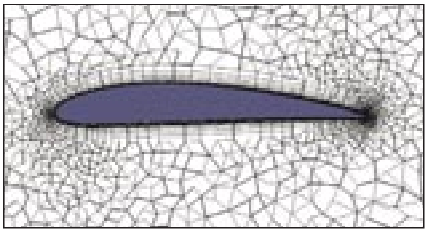
HFBM simulations were conducted with an in-house code at MSU called CHEM. CHEM is a second-order accurate, cell-centered finite volume CFD code and has been validated and applied to a wide range of problems. All HFBM simulations were compressible, viscous, and assumed to be turbulent using Menter's shear stress transport (SST) turbulence model. While the Reynold's number was low (<150,000), the SST turbulence model was used to achieve settled solutions since unsteady vortex shedding occurs.

The HFBM simulations consisted of modeling an isolated propeller with no other bodies in the flow. The flow was uniform and at 0° angle of attack relative to the axis of rotation. Therefore, the flow at each blade was periodic and steady-state when viewed in the fixed-blade reference frame. Only one blade was modeled, as the problem was periodic and thus periodic boundary conditions were applied to the axisymmetric planes.

AFLR (advancing–front, local–reconnection) was used to generate the unstructured mesh. The entire mesh was rotated for unsteady simulations in which one time-step corresponded to one degree of rotation. A time-step study was conducted to ensure the time-step used was small enough to accurately resolve the flow field. The grid was rotated for five revolutions so the force on the blade was settled without any start-up effects.

Computational efficiency could be gained by simulating the propeller as a steady-state computation in the fixed blade reference frame. However, unsteady computations were conducted for purposes of similarity to other CFD simulations in related research.

The surface of the blade was divided into sections so the CHEM code could



A cross section of the 3-D HFBM mesh around the blade at r/R = 0.4.

output the total force (viscous and inviscid) vector on each blade element. No wall functions were used, and so the grid near the viscous surface was refined to ensure the boundary layer is captured with a high resolution.

The top and bottom surfaces of the blade were each covered with 66 points. A far field size study was conducted to ensure the outer boundary of the computation domain was far enough away to not affect the propeller aerodynamics. The outer boundary was 12 blade lengths away from the propeller blade. The total grid size was 5.6 million elements, and the HFBM simulations were run in a few hours on the Talon super computer at the High Performance Computing Collaboratory of MSU.

Blade-Element Momentum Theory

To implement BEMT, a set of lift and drag curves were needed for the NACA 4412. The lift and drag on a 2-D airfoil are functions of angle of attack, Reynolds number, and Mach number. The tip Mach number for the propeller cases was small, <0.32, so compressibility effects were assumed to be negligible.

These low Mach numbers are typical for small-scale propellers due to the low flight speed and small propeller diameter. Some SUAVs have very high propeller rotation speeds causing the flow at the blade tip to be compressible despite the small propeller diameter. In these cases, Mach number can be considered in BEMT. However, for the test cases here it was unnecessary to include compressibility effects as the tip Mach number was low.

To conduct the CFD simulations to make the lift and drag curves, the Mach number was held constant at a moderate value of 0.15. Airfoil simulations covered the range of the Reynolds number experienced by each blade element (10,000-150,000). This range of Reynolds variation can have a significant effect on the airfoil's lift and drag, especially when a turbulence model is used.

A database of lift and drag data for the NACA 4412 airfoil was developed that covered the range of angle of attack and Reynolds number experienced by the blade elements for the propeller cases. For a direct comparison of BEMT to the HFBM simulations, similarity was maintained as much as possible between the 2-D airfoil CFD simulations and the HFBM simulations.

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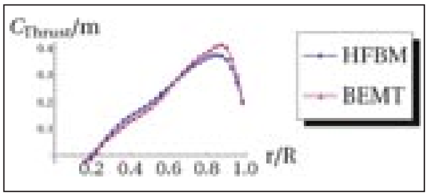
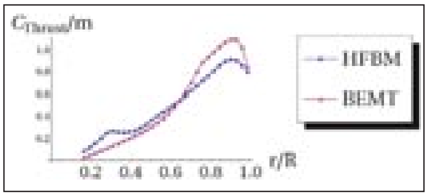


The spanwise thrust distribution (or thrust profile) for propeller 1 in cruise conditions. In this case, the BEMT model agrees very well with HFBM, with a 5.4% error. Most of the error is at r/R = 0.9 due to the tip loss effect.



The thrust profile for propeller 1 in low speed conditions. BEMT, in this case, has considerable differences from HFBM with an error of 14.7%. More error is seen in the inboard and tip region of the blade due to separation.

The CHEM code was also used to perform 2-D airfoils simulations with the SST turbulence model. For grid similarity, the same number and distribution of points used on a blade cross section for the HFBM grid was also used on the 2-D airfoil grid that was also made with AFLR. Therefore, the 2-D airfoil grid looked similar to the cross section of the 3-D grid generated for the HFBM mesh. In addition, the boundary layer was captured to a similar resolution as in the HFBM.

The BEMT model was programmed in Mathematica and only took a few minutes to run on a personal computer. Momentum theory was chosen as it is one of the most commonly used methods to calculate the induced velocities for blade-element theory (BET). BEMT is well documented in literature and is easily implemented with an iterative solution procedure. Prandtl's tip and hub loss correction factors were incorporated with the model, and no stall-delay model was used.

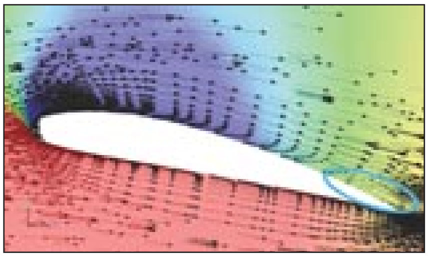
Analyzing Results

For propellers with high aspect ratio blades operating in conditions with little separation, BEMT was able to closely predict the distribution of thrust along the blade, as the 3-D effects were small. However, as the 3-D effects increased by way of blade geometry or operating conditions, BEMT lost accuracy and thus applicability.

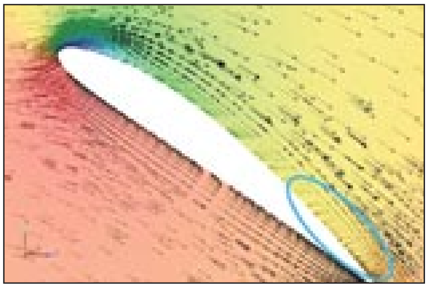
Correction models can be developed for and applied to specific tip geometries and propellers to achieve better agreement. However, these correction models for tip loss, hub loss, stall-delay, and rotational effects have difficulty in being generalized for a wide range of propeller geometries and operating conditions.

Despite these limitations in applicability, BET models are widely used when modeling propellers in CFD as they can be implemented as a computationally efficient steady-state model.

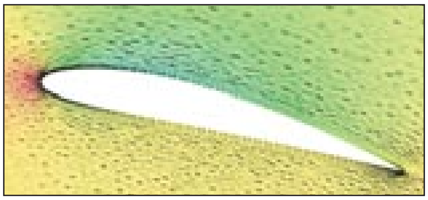
HFBM provided a time-accurate, high-resolution solution for the propeller that



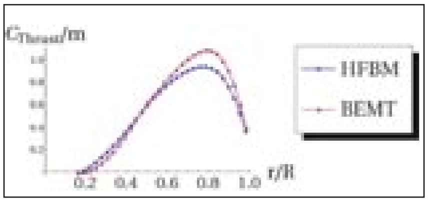
The velocity vectors of the HFBM simulations at blade cross sections of r/R = 0.9 for propeller 1 at low speed are shown to visualize separation, which is pinpointed by an oval. The separation occurs toward the trailing edge on the upper surface of the airfoil.



Velocity vectors at cross section at r/R = 0.3 for propeller 1 low speed conditions case showing separation. When separation occurs, the flow becomes highly 3D in nature with large spanwise components and BET loses accuracy.



Velocity vectors at cross section at r/R = 0.3 for propeller 2 in low speed conditions. Propeller 2 mainly differs from propeller 1 in that it has chord variation and sweep to the blade like many small-scale propellers. The velocity vectors in the first few cells off the wall point outward in the radial direction due to the centrifugal force from the rotation. However, the flow is not separated as the velocity vectors do not point back towards the leading edge.



The thrust profile comparisons between BEMT and HFBM for propeller 2. BEMT has an 11.9% error in thrust for this case. This error is not attributed to separation, and must be attributed to the low aspect ratio, chord variation and sweep of the propeller blade.

considered all 3-D effects. However, HFBM comes at a very high computational cost.

A fine resolution grid is needed to resolve the flow around the propeller. In addition, the problem is time-dependent and restricted to a small time-step to resolve the fast propeller rotation. This high computational cost of HFBM limits its use for many applications despite the high accuracy.

It is worth noting that the 3-D effects of separation and low aspect ratio that cause inaccuracies with BET are not specifically unique to small-scale propellers. Full-scale aircraft propellers, wind turbines, and other propeller or fan applications may also have strong 3-D effects, making BET insufficient. However, small-scale propellers on SUAVs are particularly prone to strong 3-D effects from blade geometry, non-variable pitch blades, and operation in a wide range of flight conditions.

The results presented here are intended to show situations in which the 2-D flow assumption of BET breaks down. Therefore, full 3-D CFD was compared directly to BEMT, whose aerodynamic database was developed as similar as possible to the HFBM simulations. This comparison allowed a detailed analysis of the flow field to examine why BEMT loses accuracy in certain flight conditions.

The physical accuracy of HFBM to experimental data is not guaranteed despite its consideration of 3-D effects. However, it is beyond the scope here to compare HFBM to experimental data, as HFBM is widely used and accepted in detailed propeller analysis. Other work has compared experimental results, rather than HFBM, to BEMT calculations. In such a case, global thrust quantities were compared rather than thrust distributions along the blade, and similar results were found showing how BEMT is inaccurate in cases with separated flow.

Propeller-Aircraft Coupling

The main objective of propeller modeling in this SUAV context was propeller-aircraft coupled CFD simulation. Often, the desired information from these coupled CFD simulations are the time-averaged loads on the aircraft that require numerous simulations. To save computation time, a steady-state, computationally efficient momentum source method is desired.

Currently, BET is the most accurate and common method on which to base a momentum source model in CFD. When implemented in 3-D CFD, BET does not necessarily need another model to calculate the induced velocities, as the 3-D CFD solution calculates the induction by satisfying the Navier-Stokes equations over the flow domain. Momentum source term models based on BET that are implemented into 3-D CFD are well documented and are currently the most popular way to implement a time-averaged propeller model.

For such models, the magnitude of the source terms are based on 2-D airfoil characteristics and are calculated from the inputs of angle of attack, Reynolds number, and Mach number taken locally in the flow field. Therefore, the source terms are locally coupled to the flow field and adapt as the solution progresses. Due to the local inputs, different flight conditions and interference effects from aircraft couplings are considered in the calculation of the source terms.

Nonetheless, the 2-D flow assumption of BET fails to account for many of the complex 3-D flow characteristics that can significantly affect propeller performance, limiting its accuracy and range of applicability. Fundamentally, the BET assumes the flow over each element to be 2-D in nature.

However, the work here has shown that propeller aerodynamics can be highly 3-D and thus not accurately predicted by 2-D airfoil data. To obtain accurate loads on an aircraft that is affected by the propeller flow, the magnitude of momentum sources must be correct.

So while the momentum source term implementations of BET are locally adaptive to different flow conditions and aircraft couplings, the magnitude of the source terms can have considerable errors when 3-D effects are significant on the propeller, as is often the case for small-scale fixed-blade propellers.

This article is based on SAE International technical paper 2013-01-2270 by Joseph Carroll and David Marcum, Mississippi State University.

The Airbus Helicopter Tiger attack helicopter.

Europe's Aerospace Industry Looking Confident

Apart from Airbus's highly visible presence in defense and commercial aircraft, Europe also has successful capabilities in helicopters, business jets, and aero engines, and in all these areas their global market share is growing.

by Richard Gardner

Talk of further consolidation within Europe's dynamic aerospace sector has been on the lips of industry watchers for several years, but although the major European-based global players have not progressed toward further mergers, the continent's biggest aerospace company, the former EADS, has achieved a very significant business restructuring, sweeping all its diverse companies into one giant, three-division entity, and adopting the new corporate identity of the Airbus Group.

At one stage it looked as if a proposed merger between EADS and BAE Systems might create the world's largest combined aerospace and defense company, but a German political veto put an end to this plan, largely because of sensitivity over the defense aspects of such a deal.

BAE Systems has a key role in the U.K.'s nuclear weapons program, and while Germans are enthusiastic on commercial aviation, the subject of nuclear defense is one that its politicians and public are happy to leave to the British, French, and U.S. The general reluctance of many NATO nations to maintain their defense budgets has caused a serious knock-on effect rippling through much of the European defense sector.

Legacy air defense programs, such as the Dassault Rafale, SAAB Gripen, and Eurofighter Typhoon, are today still providing plenty of production work, and upgraded versions are on the way, but beyond 2020 these programs are dependent on winning more export orders to avoid serious implications for existing assembly plants.

There are today relatively few new European military air programs, but one of

The French Rafale fighter represents the best in today's European military aviation portfolio with a powerful and flexible multi-role supersonic performance. (Dassault) the largest, the Airbus A400M transport, should generate new export sales and will extend production out well into the next decade, but other market sectors, such as jet trainers and surveillance aircraft, are proving very slow to mature into large-scale production.

The need to take a long-term strategic view on aerospace is recognized at the political and technical European Union level. Investment in highly innovative technologies and manufacturing methods is underway in an effort to retain a broad-based leadership role and to stay competitive with upcoming developments and production capacity in the BRIC countries (Brazil, Russia, India, and China). Heavy investment by European companies in overseas assembly plants has seen Airbus setting up factories in the U.S. (civil aircraft and helicopters) and Brazil (helicopters); Rolls-Royce expanding R&D facilities as well as production in the U.S. and Singapore; BAE Systems becoming well established in the U.S. and Australia; and Italy's Finmeccanica Group expanding in the U.S.

Snecma's M88 engines power the Rafale, and the core of the engine has been adopted for the A400M's turboprop engine that will be developed in a new open rotor prototype program.

A New Airbus Is Born

The restructuring of EADS into the new Airbus Group is far more than just a commercial re-branding operation. After decades of transatlantic criticism that Airbus is too political, and regarded by European leaders as a high-profile status symbol that must be subsidized—a claim always denied in Europe—the changes within the new Airbus finally create the accountable and transparent company structure that brings it into line with other global corporations.

Of course, financial assistance will still be willingly given by European governments to help invest in new programs and longer-term research and development, as is the case in the U.S. and elsewhere, but in business terms Airbus is now seen as a highly profitable independent enterprise that has broken free of its state controls.

In re-paying government loans through the generation of profits from its civil airliners, it has produced an extremely good deal for European taxpayers. For example, the best-selling A320 family was originally forecast to break even if 200 were sold. Today, the sales total for these single-aisle jetliners is a staggering 10,200, with a backlog of 4200 aircraft yet to be delivered. European governments that have supported Airbus financially collect a royalty on every one sold, so while it will be some time before they see a return from sales of the giant but slow-selling A380, the A320 has become a commercial success on a grand scale.


The Eurofighter Typhoon is evolving from an agile air defense fighter into a genuine multi-role fighter/bomber/reconnaissance aircraft.

A Gulf Air Airbus A320. This family of twin jetliners has achieved sales of over 10,200 aircraft and is being produced at a rate of more than 40 each month.

The new A350 is due to enter service before the end of this year, and full production is ramping up in a new factory.

Because the delivery timescales have now become so extended, Airbus has recently announced that it is raising the A320 production rate to 46 a month in 2016. Final assembly plants in Germany, France, and China will be joined by a new Airbus factory in Mobile, AL, next year. Just six years ago production was cut because of the financial crisis and falling demand, but since 2010 the demand has returned and monthly flow has gradually increased from 36 to the current rate of 42. By 2018 it could reach a monthly total output of 50 aircraft.

Since the decision to go ahead with the A320neo, with a potential 15% reduction in operating costs, sales have surged, and this has created a real challenge, as well as welcome news, for everyone across the global supply chain. Airbus Group CEO Tom Enders has played a key role in steering the new Airbus through a complex, multinational transition, and he has insisted on developing a close partnership with his supply chain in what he describes as an “extended enterprise.” He firmly believes that taking the suppliers into a closer, rather than confrontational, relationship is an important strategy if production costs are to be kept down.

The latest civil Airbus, the A350 family, is making rapid progress toward certification and first deliveries by the end of this year. Four aircraft are now in the test flight phase, with over 1100 hours achieved by the first two. One of the development aircraft is being fully fitted out with passenger seats and cabin systems and will soon embark on long endurance test and evaluation flying.

The A350 is being developed into a family of wide-body transports, seating from 276 in the A350-800 to 369 in the A350-1000, and with a non-stop range of up to 8250 mi. Nearly all A350 customers have selected the -900 and -1000 versions, and the -800 may be dropped. All variants are powered by two Rolls-Royce Trent XWB engines. The combination of advanced aerodynamics, a wide cross-section fuselage with over 50% made from composite materials, and lean burn engines will offer a 25% reduction in seat mile costs compared to equivalent size current jets.

Further cost reductions are expected from reduced training requirements due to a common flight deck design and flying qualities shared with all the other Airbus designs, the A320, A330, and A380. The latter remains the largest commercial airliner in production, with a passenger capacity from around 450 up to 700 in a high-density configuration. The A330 is still in great demand and is being offered with improved payload, and a version is optimized for high-density regional routes, aimed at China and the Asian market.

A military tanker/transport version of the A330 is proving to be a popular choice for many air forces seeking to update their air refueling and military transport fleets. This aircraft is large enough to be able to carry up to 265 troops and their equipment in the cabin, while at the same time it carries enough fuel to replenish receiver aircraft from two underwing refueling pods. A USAF-style refueling boom can also be carried on the rear fuselage centerline, or a third hose and drogue unit.

Business Jets

This sector has been well served by European designs over the years but is now one of the most hotly contested sectors in the whole commercial aerospace market, with major competitors including Gulfstream and Cessna in the U.S., Bombardier in Canada, and Embraer in Brazil.

Europe's leading supplier in this market is Dassault Aviation, with its family of twin and tri-jet Falcon aircraft. All feature very high-end specifications, in terms of performance, advanced flight systems, and passenger appeal, and this reflects the company's commitment to heavy investment in R&D and a strong technological heritage inherited from advanced combat jets.

The latest Falcon jet, the 5X, is all-new, and will emerge to join the Dassault bizjet family in 2015. It will feature a similar fly-by-wire flight control system to the tri-jet Falcon 7X but will have a larger cabin and "the most advanced flight deck in civil aviation," with numerous head-up and head-down displays, additional integrated enhanced vision sensors, and features to permit safe operation at night and in poor visibility when using runways in restricted locations, such as in mountain valleys.

Dassault has continued to upgrade all its family of jets to keep them highly competitive and has worked closely with other aerospace companies in the past on designs for a supersonic business jet, but the lack of a fuel-efficient and quiet engine that can cruise at a supersonic

Intro Cov ToC

The U.K. aerospace industry has a major share in the F-35 program, producing rear fuselage, fin assemblies, and the ejector seats, and providing the Rolls-Royce lift fan that gives the F-35B model its vertical takeoff and landing capability. (MOD)

The Dassault Falcon 2000S and 7X business jets.

speed over extended ranges has so far defeated all attempts at bringing a viable bizjet-size SST product to market.

European Helicopters

The reorganization of EADS saw the strong Eurocopter brand morphed into Airbus Helicopters. Apart from the name change, this rotary wing business has continued as before, with a world-leading market share in military and civilian markets. It has not developed any heavy-lift military products to challenge the Boeing CH-47 Chinook, but in all other size categories of helicopter the company has models that offer the latest standards in avionics and flight safety.

The NH-90 is the latest military helicopter and is in large-scale production for European and export customers. It is the most important of the new programs. Slightly larger than the Sikorsky S-60/70 Blackhawk and Seahawk, it has a fuselage that can accommodate a sophisticated anti-submarine/anti-surface naval equipment fit, and there is also a utility army version with a large rear cabin ramp.

Other medium helicopters in the Super Puma family are popular worldwide for search and rescue, combat SAR, special missions, and oil and exploration support operations. Smaller helicopters in the family provide paramedic support and police support capabilities, as well as general-purpose civil and military utility roles.

The main European rotary wing competitor to Airbus Helicopter is AgustaWestland, which has a very wide ranging portfolio from the AW101 Merlin and Lynx Wildcat military helicopters to a whole family of new-generation small and medium helicopters, including the AW139, AW169, and AW189. This latest family has high levels of commonality between the different types and also uses common tools and ground support equipment. A reduction of up to 40% in training time results. This family is aimed initially at oil-rig support, light transport, SAR, and coastal surveillance, but more protected, armed, military transport variants are emerging, offering high speed as well as a low profile for added survivability over the battlefield.

Powered Up

Europe's aero engine manufacturers include Snecma in France, MTU in Germany, and Rolls-Royce in the U.K. All are truly international with programs stretching to partners across the globe. MTU is closely involved in partnerships with both Pratt & Whitney and Rolls Royce on civil and military engines.

Rolls-Royce has around 50% share of the world's big fan market with its Trent series, which covers thrust ranges from over 50,000 lb up to 110,000 lb. Trents power all the largest current widebody jets apart from the Boeing 777-300ER, and the latest Trent XWB is due to enter service later this year on the A350.

Development work is underway on enhanced Trent derivatives that might have application on a revised A330 and possibly the A380. Snecma, through its CFM partnership with GE, has well over half the engine market on the A320 family and is sole powerplant on the Boeing 737 classic. The CFM Leap engine is destined for the 737 MAX and A320neo.

Although it has lost out powering the latest 737s and A320s, Rolls-Royce is determined to re-join this market at some time in the future, possibly via a new Boeing airliner sized between the 737 MAX and the 787.

In the meantime, CFM is moving forward with development of a prototype new-generation open rotor engine. If successful, a suitable powerplant can be matured in advance of the follow-on 150 seat civil programs that will eventually replace the 737 MAX and A320neo in the late 2020s.

Advances and Challenges in Developing Radar Applications

Significant advances in digital and RF/microwave technologies are leading to more diverse radar applications as well as greater commercialization. This article discusses some of the fundamental research and development challenges in both the digital and RF/millimeter-wave domains, as well as current and future directions in design, system integration, and test.

Radar is used to detect and/or track target objects and their attributes, such as range, speed, and other information obtained through signals at RF and microwave frequencies. The broad classes of radar systems are active and passive (Figure 1). Passive radar systems use non-cooperative source(s) of illumination, such as a target's emitted signals, broadcast signals, or cellular communication signals, to obtain information about the target. Since radar performance relies on the sensing capabilities of the receiver, significant innovations have been made in areas such as phased array antennas, digital beamforming, detection algorithms, and source separation algorithms. Active radar uses cooperative sources of illumination by generating its own signal(s) to illuminate the target. Within the class of active radar, there is monostatic radar, where the signal source is collocated with the receiver, and multistatic radar, where there are two or more receiver locations.

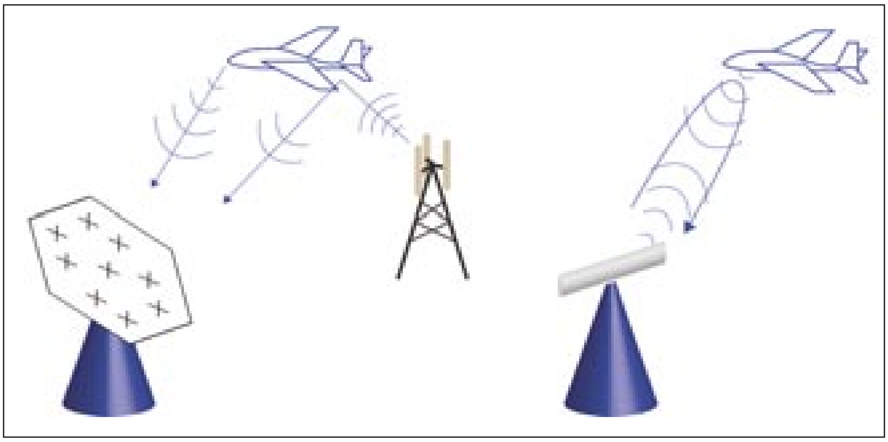


Figure 1. Passive radar (left) and active radar (right).

Among active radar systems, there are several common signal types. The most basic is continuous wave (CW) radar, where a constant frequency sinusoidal signal is transmitted. The CW signal allows the receiver to detect phase/frequency variations (Doppler shift) from the target reflection. Unless a special provision for absolute time marker is used, however, range detection is not possible. A modified CW signal using a stepped frequency modulated (SFM) signal obtains a better range estimate by hopping over multiple discrete frequencies. A further modification of the CW signal to linearly ramp up and down a range of frequencies is called linear frequency modulation (LFM) or frequency modulated CW (Figure 2). An LFM radar allows detection of Doppler as well as range by observing the frequency difference of the time-delayed received signal from the transmitted signal. If a stationary ob-

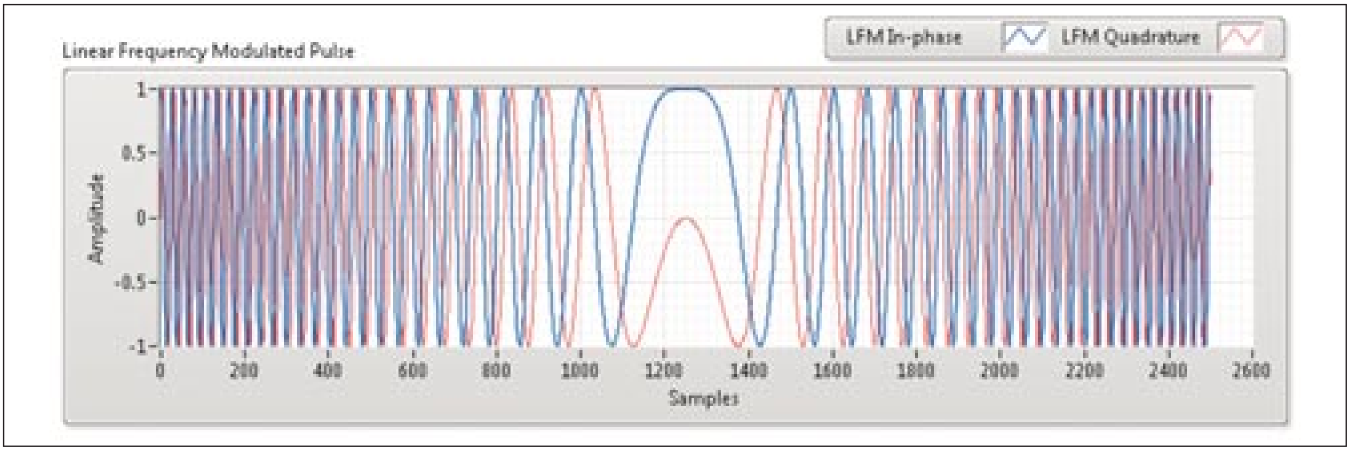


Figure 2. Example LFM waveform where a pulse ramps from high frequency to low, and back again.

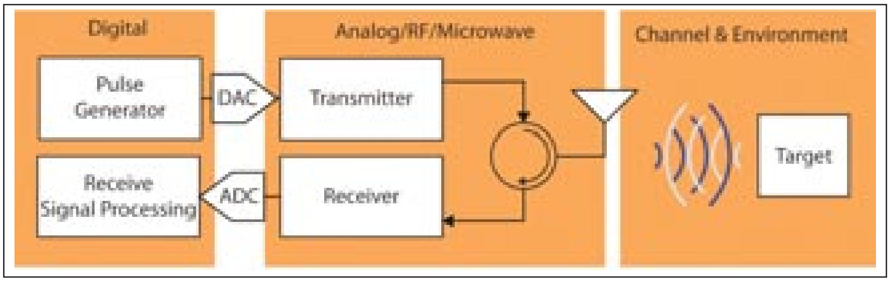


Figure 3. General radar block diagram.

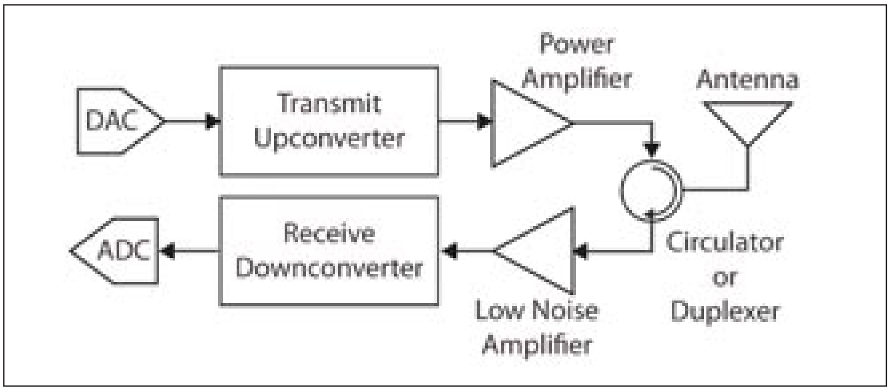


Figure 4. High-level block diagram of a radar front-end transmit and receive unit.

ject is detected, a constant beat frequency (transmit to receive frequency difference) is observed.

Without loss of generality, today's active radar system design can be broken into two major components: the baseband signal processing and the RF/microwave front end (including the antenna). Figure 3 shows a high-level block diagram of an active radar system.

Digital Signal Processing

Thanks to widely available commercial processors, embedded processors, field-programmable gate arrays (FPGA), digital signal processors (DSP), and, more recently, graphics processing units (GPU), radar signal processing engineers now have a breadth of platforms from which to choose. The choice largely depends on the type of signal processing that is needed and the cost of implementation. General-purpose, personal-computer-type hardware may be sufficient for radar systems with relatively low throughput and simple signal processing requirements. An FPGA or GPU-based processor might be needed if large parallel processing is needed. In this case, however, the cost of the hardware increases substantially. In most platforms, pulse generation and receiver algorithms can be implemented with appropriate software, bringing benefits such as programmability and reuse of intellectual property. At the same time, radar signal processing engineers are faced with the challenge of incorporating more and more sophisticated algorithms, consuming longer simulation times within the system and exhausting the available computational resources.

While each of the processing blocks has relatively simple functions, it becomes a complex task to integrate these algorithms, partition them onto appropriate platforms, coordinate and communicate with the RF/microwave front end, and compensate for its non-idealities. Does it make sense to implement all of the processing in the FPGA at the cost of hardware, development time, and less flexibility? Does it make sense to implement all of the processing on the CPU, perhaps at the cost of performance? Or does it make sense to partition the algorithms for the CPU and FPGA (and maybe DSP) such that each algorithm is run in some optimal way? If so, what are the throughput, latency, and synchronization requirements between these processing units? These are some of the challenges faced by radar signal processing engineers in developing the next generation of radar systems.

RF/Microwave Front End

The transmitter and receiver unit (Figure 4) plays a key role in acquiring the information for processing. Many radar systems today operate at S-Band (2 to 4 GHz), X-Band (8 to 12 GHz), and higher. Design choices for the transmitter upconverter and receiver downconverter depend on many factors, such as the target frequency range, available local oscillators, interfaces to the DAC and ADC, phase/amplitude control, and cost. Perhaps the most heavily researched areas are high power amplifier (HPA) and low noise amplifier (LNA) design.

The HPA performs the critical function of amplifying the illumination signal to the highest power permitted without adding distortion, while having high enough efficiency to maintain power consumption within specified limits. Depending on the application, transmit power levels can range from milliwatts to kilowatts. Linearity of the power amplifier is of great importance since nonlinearity can cause pulse degradation and introduce spurs that violate spectral mask requirements or corrupt the receive signal. In recent years, field plate technology has allowed GaAs HPAs to be operated at higher voltages. Field plate technology and air-bridges increase the breakdown voltages of high electron mobility transistors (HEMT). Increased power density, however, introduces heat dissipation issues. Field plate technology has been used with devices that already support higher voltages and power densities, such as gallium nitride (GaN) on silicon carbide (SiC) substrates. PA designers are faced with a multitude of problems in trading off devices, component count, thermal management, and miniaturization, all while satisfying the amplification and spurious emission requirements.

While LNA design is relatively mature, its performance is crucial to

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achieving front-end sensitivity and overall radar performance goals. Link budget and noise figure analyses have historically been performed with simple hand calculations or spreadsheets; however, use of a graphical tool like the NI AWR Visual System Simulator (VSS) or similar, greatly enhances the designer's ability to close in on the specification and spot problem areas (Figure 5).

Integration: Putting it All Together

The radar system architect has the enormous task of understanding various tradeoffs in the digital domain as well as in the RF/microwave domain, and putting it all together. Many years ago, radar systems might have been designed and integrated by a small team of hardware engineers, but today's radar systems are becoming increasingly com-

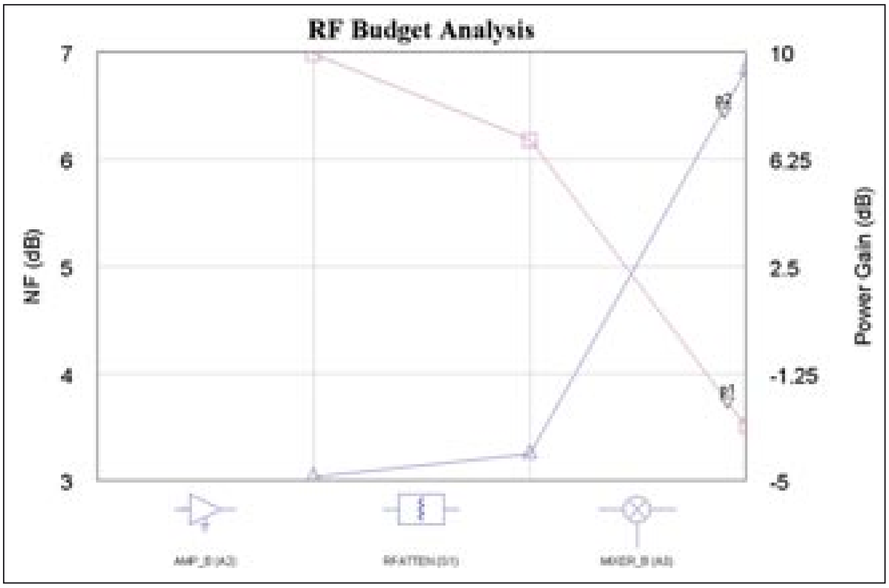


Figure 5. Link budget analysis using the National Instruments AWR Visual System Simulator.

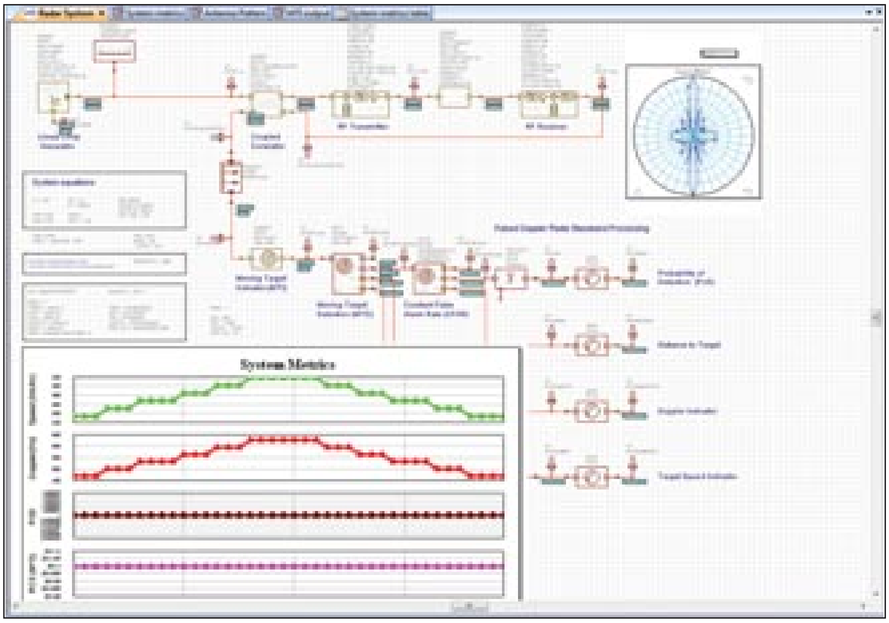


Figure 6. An example of an integrated tool chain by the National Instruments AWR Visual System Simulator.

plex with domain experts from several areas contributing to the development of one system. How can an algorithmic tradeoff be adequately balanced with microwave circuit requirements and cost? There is clearly a greater need for mixed digital and RF/microwave design, simulation, and a prototype framework so that the corresponding domain experts can communicate with each other to address this complex design problem. One approach is to consider a well-integrated tool chain that supports microwave design, digital signal processing, hardware-in-the-loop (either hardware-based processing such as on FPGAs or measurements), and the corresponding hardware capability to support rapid prototyping of designs (Figure 6). Various systems software packages allow multiple designers to easily create and evaluate subsystem architectures, bringing their designs from concept to simulation and, ultimately, to physical implementation in a single system within a single framework.

Conclusion

Today's radar systems are as complex as they are diverse. What is common, however, is that they each contain a digital signal processing section and RF/microwave front end. In this article, we looked at a few key elements in both of these areas with examples for pulse compression radar and discussed several technology challenges as well. While radar systems previously were developed by a few hardware engineers, today's systems often rely on the design contributions of multiple domain experts. Various software tools simplify the complexity of the design process and allow engineers to think across the traditional boundaries.

This article was written by Dr. Takao Inoue, Senior RF Platform Engineer, and Phyllis Cosentino, Senior Product Marketing Manager, at National Instruments in Austin, TX. For more information, visit ***http://info.hotims.com/49746-541***.

References

1) M. Grossi, A. Fiorello and S. Pagliai, "Advances in Radar Systems by SELEX Sistemi Integrati: Today and Towards the Future," European Radar Conference Proceedings, September-October 2009, pp. 310-317.

2) J. Hasch, E. Topak, R. Schnabel, T. Zwick, R. Weigel and C. Waldschmidt, "Millimeter-Wave Technology for Automotive Radar Sensors in the 77 GHz Frequency Band," IEEE Transactions on Microwave Theory and Techniques, Vol. 60, No. 3, March 2012, pp. 845, 860.

3) C. Li, J. Cummings, J. Lam, E. Graves and W. Wu, "Radar Remote Monitoring of Vital Signs," IEEE Microwave Magazine, Vol. 10, No. 1, February 2009, pp. 47-56. C. Gentner, E. Munoz, M. Khider, E. Staudinger, S. Sand and A. Dammann, "Particle Filter Based Positioning With 3GPP-LTE in Indoor Environments," IEEE/ION Position Location and Navigation Symposium Proceedings, April 2012, pp. 301, 308

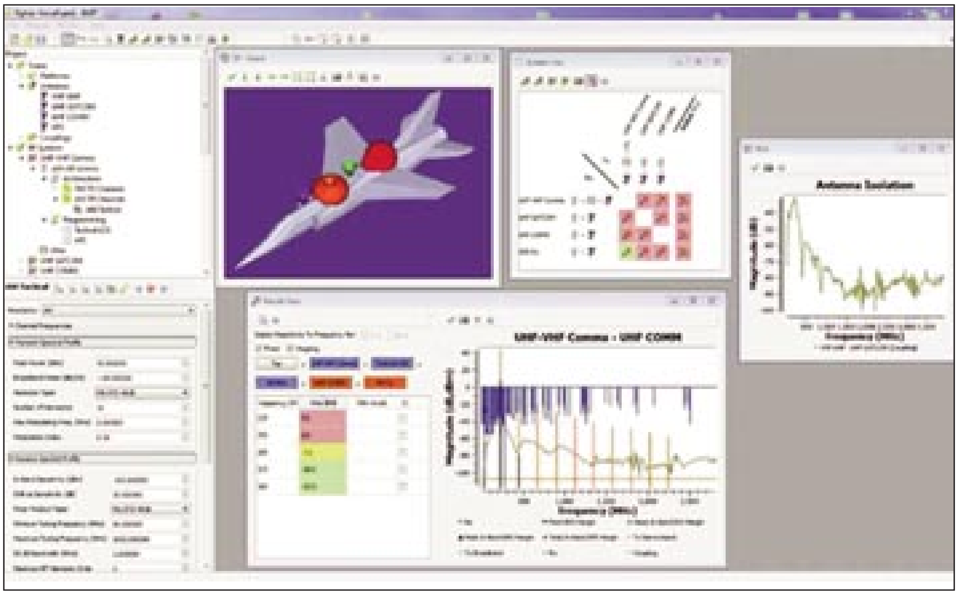
Intro Cov ToC

Simulation Tools Prevent Signal Interference on Spacecraft

Launching a satellite into space requires painstaking preparation, not only to make sure that a multitude of technologies are functioning, but also to ensure that critical components are working together in unison. One example is the communication systems onboard satellites and the rockets used to launch them.

A number of receivers and transmitters are installed into both satellites and rockets so that engineers on Earth can use radio signals to track and control their every movement, and function and troubleshoot problems that may arise during ascent. Once securely in orbit, satellites also send data back to Earth for telecommunications and scientific research.

But having multiple pieces of equipment sending and receiving



Delcross' EMIT interference simulation software analyzes for co-site interference between different RF systems.

radio signals within close proximity causes co-site interference: transmitters meddle with the signals being sent to receiving systems, preventing critical communications from reaching their desired targets. If the signal interference is severe enough, a launch could fail.

So before installing radio frequency (RF) systems, NASA engineers use simulation software to analyze and correct for any interference that would occur between a satellite and its launch rocket. They also analyze other RF systems near the launchpad, such as antenna towers and radar, which may also interfere with data transmission. If the simulator detects the potential for any interference, various measures can be implemented to correct for it. For example, technicians could move antennas to different areas of the spacecraft to reduce the inter-system coupling. Engineers can also engage in frequency planning, which means carefully coordinating when each system operates on specific channels, thereby lessening the chance of interference between devices.

Because there are many systems at play in any launch, and because they all need to be accounted for, staging a computer simulation can be tedious and time-consuming. In the past, it was even more painstaking because, in many cases, specifications for each RF system had to be manually inputted before running each individual analysis. That is, until engineers at the Launch Services Program at NASA's Kennedy Space Center (KSC) collaborated with the private sector to customize software that would streamline the work.

In March 2012, KSC entered into a Small Business Innovation Research (SBIR) contract with Delcross Technologies LLC (Champaign, IL) to enhance the company's EMIT interference simulation software by developing a more robust library of RF systems. The company had already created such a library for EMIT, which allows users to simply drag and drop whichever equipment is being considered for a rocket and satellite. Once all the prospective RF systems are in place, the software assesses whether there is any potential for interference between components. With the new contract, the goal was to increase the number of equipment items to choose from by adding a number of key systems of particular interest to NASA engineers, which would further lessen the amount of time needed to manually input specifications into the program.

Filling out the library was accomplished by tapping every publicly available source for all the data parameters needed, such as start and stop frequencies and channel spacing, to identify specific radios. By January 2013, Delcross completed the contract, having added hundreds of RF system specifications to the EMIT library. Having a more robust library will be an enormous help to KSC's Launch Services Program.

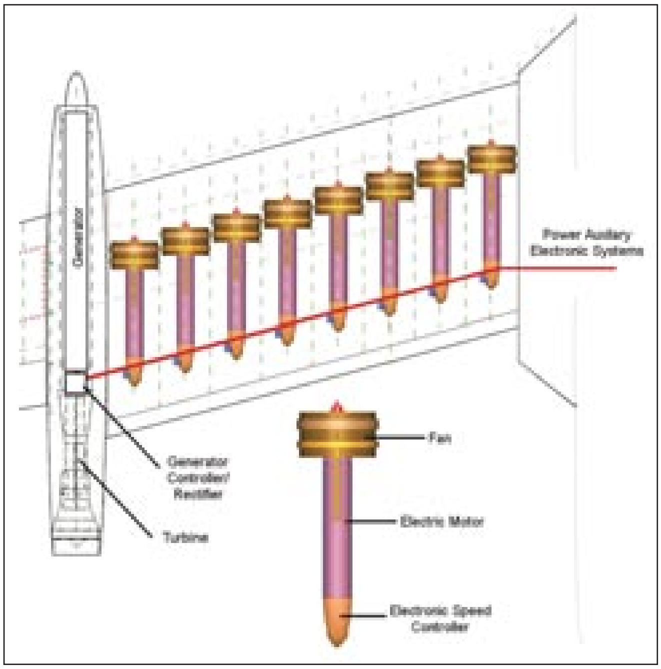
For Delcross Technologies, the collaboration has been a success. Since the new library was introduced, sales to the US military, telecommunications companies, and other organizations whose success depends on clear radio transmission signals, have increased. Creating the RF system models is one of the biggest bottlenecks in using a simulation program like EMIT. The database developed under the project goes a long way to removing that bottleneck by providing ready-to-go models, which can shave days off the analysis time.

For more information, visit www.delcross.com, or read the full story at ***http://spinoff.nasa.gov/Spinoff2013/it_3.html.***

Hybrid-electric distributed propulsion explored

A turboelectric distributed propulsion (TeDP) system is a powertrain consisting of a turboshaft engine used solely to provide electrical power through a generator to electric motors driving multiple propulsive fans that are distributed above, below, or inside a wing.

Empirical Systems Aerospace, Inc. (ESAero) has studied the application of TeDP in several forms to a wide variety of manned and unmanned air vehicles since its inception in 2003 with several approaches to distributed propulsion. In the studies, it developed a distributed propulsion system architecture and used it to estimate vehicle performance including details on the propulsion components, battery sizing and augmentation, and system performance using in-house design tools. It also identified tools that could be developed during future work.



A generic TeDP system architecture featuring eight fan/motor assemblies powered by one turboshaft engine/electrical generator combination located in each wing half. The turboshaft engine spins a generator to produce electrical power but is assumed to not provide propulsive thrust on its own. This electrical power is bussed through the wing to each motor/fan assembly and to the onboard subsystems, if necessary. A detailed electrical system layout was beyond the scope of this work; however, it did become apparent during this study that transformers would be too heavy for this type of vehicle.

Its most recent project (certain aspects of which are discussed here) was done under NASA's Environmentally Responsible Aviation Project, part of the Integrated Systems Research Program, to provide configuration alternatives to those being studied by the major airframe manufacturers and two universities.

Decoupled energy management

Participants in an FY11 NASA-sponsored TeDP workshop collectively agreed that TeDP might be more accurately considered decoupled energy management (DEM) as the overarching concept that enables hybrid-electric propulsion. The major benefit that DEM brings is an abundance of options pertaining to the aircraft's configuration and operation.

Decoupling the gas generator from the thrust producer allows for several unique advantages that could very well improve aircraft performance and efficiency. Turbofan engines are designed with a mechanical linkage between fan and gas generator that forces all components—fan, low- and high-pressure compressor, and turbine—to compromise on their individual peak operating points. Removing the mechanical linkage, or shaft, and replacing it with an electrical system allows components to be optimized with less concern for each other, especially in regards to rotational speed.

Not only does this yield the possibility for reduced component weight and fuel burn, but other advantages can be garnered, such as:

- Use of supplemental power (batteries, super capacitors, fuel cells) for failure modes or downsizing of gas generators
- Effective bypass ratio increases without excessively large-diameter fans
- Finer control over power distribution during any flight segment.

Introducing this method of DEM does bring with it high transmission losses and an overall increase in propulsion group weight. From an efficiency standpoint, propulsive efficiency can be increased. But until technology of conventional machines is improved, the increase cannot offset the weight penalty for regional missions. Savings in fuel burn must be much higher than the increase in propulsion system weight for a fixed takeoff gross weight if TeDP is to be economical.

Conventional electric component sizing

Electric components to power large commercial aircraft do not currently exist and thus it is difficult to estimate their performance and weight without a focused motor, generator, and controller design effort. With hybrid electric system research in full stride, it may require many years to establish a flight-worthy component database for use in modern conceptual and preliminary aircraft design.

In the meantime, off-the-shelf electric components must be used for scaling and performance curve extrapolation. Using this method has potential side effects since power requirements of airliner components is exceptionally larger than what current off-the-shelf components can provide.

ESAero maintains a database that now includes nearly 100 state-of-the-art machines, the most powerful of which delivers up to 885 hp and weighs roughly 7300 lb. Meanwhile, the commercial and military dual-use variants require 1500- to 2000-hp motors and 10,000- to 16,000-hp generators. Without an electric machine design effort with an emphasis on flight-ready components, extrapolating motor and generator size has a large potential for error.

Summary and conclusions

Aircraft integration, terminal-area operations, and climb and approach an-

Earlier studies hinted at the possibility that cryogenic cooling may not be necessary for certain classes of aircraft to achieve marked improvements in fuel burn and airport area noise. A more recent study, for NASA Ames Research Center under the Environmentally Responsible Aviation Project, applies non-cryogenically cooled electrical components suitable for the 2025 time frame to both a dual-use transport (left) and a regional airliner concept (right).

ESAero's ECO-150-16 is a cryogenically cooled TeDP airliner concept for the 2035 time frame.

gles are among the other aspects of the researchers' work, and are detailed in the technical paper on which this article is based (paper number at end).

Building off of earlier work involving cryogenically cooled, superconducting technology, more recent effort succeeded in preliminarily closing the ECO-150 and dual-use aircraft using conventional, state-of-the-art electric machines and components. While several benefits appear to show promise of improved mission performance and efficiency, concerns of integration, current state of high-performance electric machines, and the ever growing propulsion system weight of TeDP casts a dark shadow on future feasibility. As technology improves in the area of electric components, so will their use and application into regional aircraft. In the meantime, it may behoove the aerospace industry to invest time in research and development tools to aid in the analysis of hybrid transport aircraft.

The article is based on SAE International technical paper 2013-01-2306 by Benjamin Schiltgen, Andrew R. Gibson, Michael Green, and Jeffrey Freeman, Empirical Systems Aerospace Inc.

Enabling high-strength composites to reach their full potential

The use of composite materials for construction of aerospace components began in the early 1980s and is now the material of choice for commercial and military airframe designers. Composite material properties such as stiffness, weight, strength, and corrosion resistance have invigorated the transfer of composites within aerospace to include interior components such as seats and service carts. Interior parts and components account for as much as 40% of a commercial airliner's empty operating weight and represent a larger market (by volume) than airframe structures.

The same properties that attract aerospace designers to use composite material have also attracted other industries such as transportation, wind energy, and sporting goods equipment manufacturers to evaluate its use for their products. Composite materials offer a highly attractive alternative to metal, but the transfer of the material into high-rate production commercial products such as automobiles has been limited to high-priced luxury performance examples such as Lamborghini.

In their infancy, the performance attributes of composite materials for aerospace parts outweighed the complex manufacturing processes and material cost as parts slowly replaced metal. Once composite material, design criteria, engineering allowables, and manufacturing processes matured, the focus turned to cost.

Composite materials and processes

In their infancy, the performance attributes of composite materials for aerospace parts outweighed the complex manufacturing processes and material cost as parts slowly replaced metal. The focus was on qualifying composite parts and understanding the complexities of replacing well-understood performance and manufacturing processes of metal materials with parts made from the new composite material.

Once composite material, its design criteria, engineering allowables, and manufacturing processes matured and were better understood, the focus turned to cost. The two primary targets for cost reduction to produce parts made from composite materials are manufacturing processes and material cost. The two manufacturing processes where research focus has led to promising results is out-of-autoclave cure (OAC) and advanced analytics to control the inherent part variability of composite materials part fabrication process that complicates the assembly process.

The autoclave cure of composite material is complex and costly. Elimination of the autoclave to cure composites reduces cost and manufacturing complexity, improves throughput, and enables lean production initiatives. Progress has been made in the last decade, and OAC processes such as vacuum assisted resin transfer molded (VARTM) parts are replacing parts formerly requiring an autoclave. VARTM and similar resin transfer molding (RTM) processes are lowering cost and incentivizing the extensibility of composite parts to use in other industries such as wind energy for the manufacture of large wind turbine blades and towers. VARTM and other RTM processes use materials that have a per-pound cost that is a fraction of the prepreg composite materials they replace.

Four years ago, one of a B-2 bomber's four engines caught fire during what the Air Force called a "routine" engine start. The fire was one of three that the Air Force studied "to identify new tools and techniques that will allow firefighters to more efficiently cut, penetrate, and extinguish burning aircraft made of composite materials."

The evolution of computer-aided design has led to a digital tapestry that is beginning to be tapped to mitigate the inherent variability of composite parts. Composite parts vary in thickness and require secondary processing to insure outer mold line (OML) continuity between parts when they are delivered to the assembly floor. The digital tapestry of data derived from discrete manufacturing data at the point of part manufacture provides assembly with the necessary information to adjust the assembly for rapid fit-up and ease of assembly.

It is apparent that the attributes of composite materials have created a market pull for their use, and industry is on the cusp of developing manufacturing processes and lowering material costs that will facilitate composite transfer to a wide range of consumer and commercial products.

Future challenges

The continued use of composite materials in aerospace has revealed other challenges that need to be addressed while the solutions to material and manufacturing cost are reduced. Before the widespread use of the material in transportation vehicles can be realized, safety challenges surrounding the material must be addressed.

Four years ago, one of a B-2 bomber's four engines caught fire during what the U.S. Air Force called a "routine" engine start. The fire was one of three that the Air Force studied "to identify new tools and techniques that will allow firefighters to more efficiently cut, penetrate, and extinguish burning aircraft made of composite materials."

Such fires are challenging because hidden interior fires are difficult to extinguish, composites smolder and reignite, and fuselage penetration is virtually impossible with an axe and difficult with a K-12 firefighting saw.

As a result, the past few years have seen the emergence of research directives to address the safety challenges of operating a vehicle made from composite material. They include developing a new flammability test method for composites; composite prepregs that display fire resistance; flame-retardant adhesive technology for interior applications; modified cyanate ester for air duct applications; and fire-resistant nano-coatings for foam and fabric using renewable and/or environmentally benign materials. In addition, emergency response teams must be trained and equipped with the tools to enable the rescue of individuals trapped in damaged vehicles.

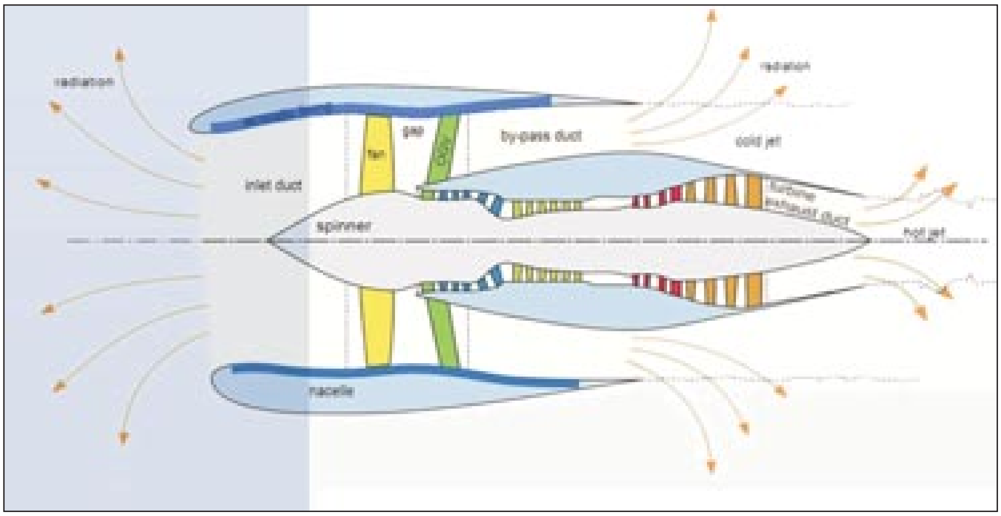
When these issues are resolved, the attributes of composite materials will be fully realized through their extensibility to other products beyond aerospace.

George N. Bullen, President and CEO of Smart Blades Inc., wrote this article for Aerospace & Defense Technology. He is author of the book "Automated/Mechanized Drilling and Countersinking of Airframes," recently published by SAE International, and is a member of the organizing committee for the SAE 2014 Design, Manufacturing and Economics of Composites Symposium, to be held June 10-11 in Madrid, Spain.

Designing quieter aircraft via acoustic simulation

Greater fuel efficiency and low emission requirements have grown into such an urgent imperative in aircraft design that it often overshadows an equally significant factor in air travel—noise.

Noise is as much a limiting factor on air travel as fuel efficiency and reduction of emissions. Airports around the world restrict takeoff and landing hours to protect surrounding areas from excessive jet aircraft noise. This is at the same time that air travel's popularity and the world economy's reliance on overnight air freight are increasing and driving demand for more flights, not fewer.



Acoustic simulation software can depict the sound profiles of key jet-engine assemblies such as the nacelles and turbine spinner.

The aerospace industry has responded to the noise challenge by designing quieter aircraft as governments all over the world have demonstrated they are willing to manage airport noise by restricting flight times in many different ways, such as curfews, surcharges, noise level limits, and quotas.

Before aerospace manufacturers can produce quieter aircraft, however, they must provide engineers with the necessary design processes and technology tools. The current development model in effect at most manufacturers does not fully consider acoustics until too late in the process to achieve significant noise reduction. To balance noise and fuel economy with all of the other considerations that go into designing aircraft, aerospace engineers must be able to weigh the effects of their design innovations from a new aircraft's inception.

The noise backlash

Concerns about excessive aircraft noise surfaced in the 1970s and have spurred increasingly stringent regulations ever since.

The supersonic Concorde jetliner is probably the most famous victim of the noise backlash. The British-French aircraft was restricted to relatively few landing sites by authorities in Europe and North America concerned about excessive noise. Though many factors influenced the aircraft's demise after almost 30 years in operation, those restrictions contributed to decisions not to develop a new version.

Homeowner complaints led the U.S. Congress to give the U.S. FAA authority in 1968 to set noise standards for new airplane designs. The FAA designated three generations (stages) of aircraft by noise level and laid out a schedule for phasing out the loudest.

In Europe, where the air travel safety agency Eurocontrol predicts a 16% increase in air travel by 2018, European Union nations have strict controls on Stage II aircrafts and are considering a proposal to phase the loudest Stage III aircraft out of fleets that service EU airports.

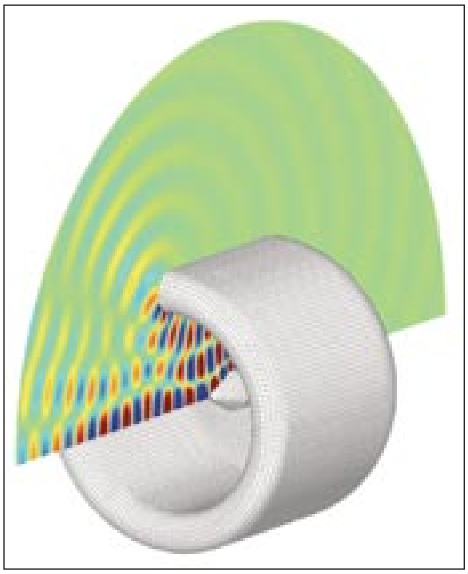
All this comes in spite of the fact that aircraft have become 75% quieter since the 1970s, according to the European Union.

The goal: quiet efficiency

Even as noise concerns were swirling around air travel, the seemingly endless increases in aviation fuel costs made more efficient aircraft an immediate necessity. This is significant to noise control because fuel-efficiency measures can conflict with efforts to make planes quieter.

Counter-rotating jet engines, for example, consume less fuel than conventional engines but they're also louder. Making parts and fuselages quieter has traditionally meant adding weight to reduce vibration. Today, however, aerospace companies are experimenting with composites and high-strength metals to reduce weight. Lightness can increase vibrations.

Nevertheless, it isn't impossible to balance noise and fuel efficiency. Engi-


The acoustic profile of a jet engine's fan intake and exhaust is shown.

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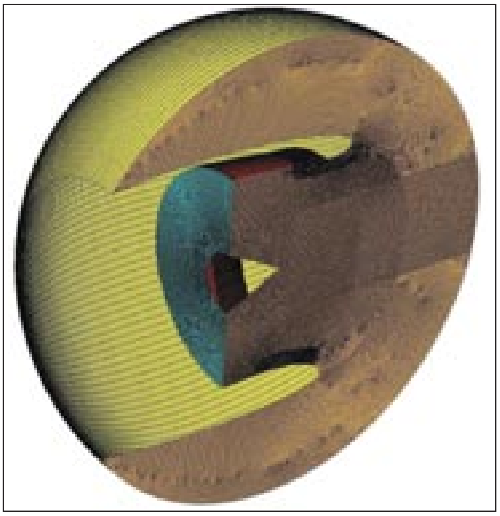

The analysis mesh of a jet engine provides the basis for acoustic analysis.

neers have surmounted higher obstacles. Even with new and lighter materials, there are opportunities to reduce noise through the shape of the fuselage, engine nacelle design, and insulation distribution, for example.

There's a proviso, however. Engineers must be able to determine how their noise-reduction adaptations will perform long before the design reaches the prototype stage. Late-stage changes are prohibitively expensive, so engineers have limited options for noise control if a design is even 50% finished.

By the same token, incorporating a noise-saving idea into a design without testing it runs the risk of finding out during prototyping that it affected the aircraft's performance, or didn't yield the results it was supposed to. To innovate early in the process while minimizing the risk of costly mistakes, engineers need tools that can simulate the noise profile of a single component, such as the nacelle, so they can see the immediate effect of their innovation, and the overall noise profile of the aircraft.

Acoustic simulation software tools have been in the aircraft industry for 20 years, though at all but a very few companies they have been poorly integrated into early stage design processes.

Airbus and Rolls-Royce are among the exceptions. They teamed up in 1999 with Free Field Technologies (now an MSC Software company) to develop Actran acoustic simulation software that can model entire systems and handle both engine noise and airframe noise (as induced by turbulent flows around the aircraft).

The earliest acoustic simulation software was too complex for every engineer in the process to learn, but Airbus has worked steadily over the past 15 years to "democratize" it. Today, acoustic simulation is fully integrated into its design processes.

Any engineer in Airbus' design process can initiate an acoustic simulation calculation. They change values for parameters such as speed, temperature, and altitude in a simulation model and submit it for calculation. Actran runs the simulation and reports the results to engineers. Airbus engineers can use Actran at the beginning of the process to get a broad idea of which design is the most promising.

As they get closer to a final design, they can adjust the parameters for optimal performance. This system eliminates guesswork and needless iteration. It avoids costly late-stage errors through constant simulation that reveals when an idea is going awry.

Whatever a company's sound management challenges, Airbus shows that it's possible to infuse acoustic simulation into design processes from beginning to end. This approach gives engineers the acoustic simulation intelligence they need to create quieter aircraft. The industry needs quieter aircraft so it can grow, which it won't be allowed to do if it reduces the quality of life around airports.

Dr. Jean-Louis Migeot and Dr. Jean-Pierre Coyette, co-founders of Free Field Technologies (FFT), an MSC Software company, wrote this article for Aerospace & Defense Technology.

Manufacturing Robotic Tools for Piping Inspection and Repair

A robotic inspection system enables preventative maintenance in space-constrained piping systems.

Office of Naval Research, Arlington, Virginia

Fleet piping systems are complex, space-constrained systems that are difficult to inspect using standard external inspection techniques. Pipe lagging, as well as limited space, makes external access prohibitively expensive and difficult. A robotic tool was developed that will deliver a sensor package capable of real-time corrosion/erosion and pipe wall measurements. Implementation of this system will allow for fleet preventative maintenance (PM), ensuring that possible failures are detected and replaced before they occur.

A mock piping test track was erected consisting of segments of schedule 40 PVC piping. Grippers were designed and fabricated integrating commercial off-the-shelf solenoid valves for airflow control.

The robot utilizes a flexible pneumatic cylinder that provides forward and backward motion while negotiating various bends in conjunction with the grippers (Figure 1). The prototype cylinder was tested to evaluate capability of operating in tight bends. This was accomplished by fixing each end to form a 90° bend and actuating the cylinder. Floating air manifolds deliver air to the entire robot and to each individual component. Additionally, air regulator bays control two set pressures of airflow through the entire robot. Pressure-regulated air is supplied to the various pneumatic actuating components on the robot.

Initial testing revealed the robot's ability to successfully navigate through a 3"-diameter pipe mockup horizontally and vertically. Skids were added to the robot's grippers, reducing the total cycle time of forward and backward linear motion. They allow the robot to move forward without causing any drag due to the bags being partially inflated. The robot successfully ran on autopilot through a straight section of pipe in both forward and reverse motions. The optimal travel speed was determined by adjusting the command cycle times. Flow rate usage vs. rate of speed was also obtained from this exercise.

Lab-grade borosilicate glass pipe was used for mock-piping 2.0 structures and testing. The glass aids in evaluating troublesome situations to clearly verify any problems in challenging pipe geometries. During testing, unrestricted expansion of the bladders decreased resultant axial force. A new X-wing design was developed to constrain bladder inflation and provide bearing surfaces during motion, and help center the module in the pipe. The X-shaped skid allows the silicone tubing of the grippers to inflate in a controlled geometry that decreases inflation/deflation times. A gripper snout was developed for both the front and rear of the robot to aid in smoother motion of the gripper around curves, tees, elbows, etc. The new design allowed for higher pressure, which allowed the gripper to achieve 30 pounds of axial force.

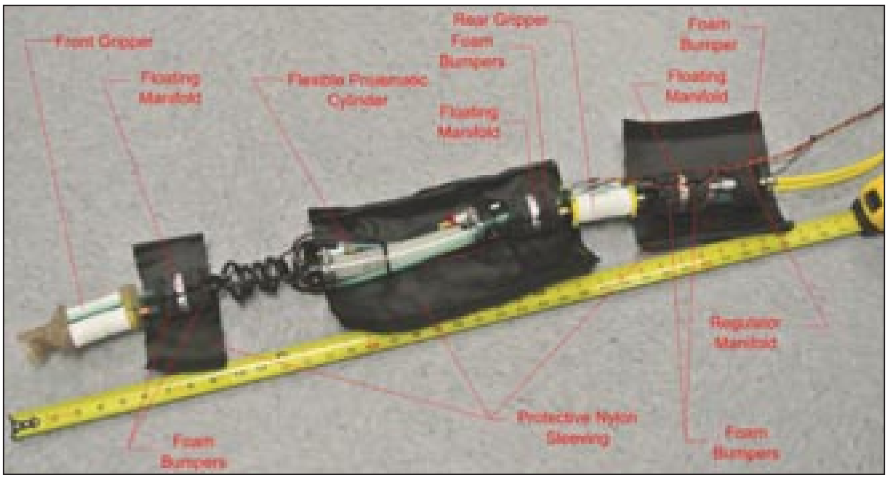

Figure 1. The piping inspection robot assembly.

Based on the success of the new X-wing design, a second set of parts was fabricated. A pod enclosure was designed to improve maneuvering capability and offers protection for the electronics against the pipe environment. The pod is attached to the aft end of the robot, which additionally serves as the connection point to the robot's tether. The tether serves as an umbilical between the operator control station and the robot.

A pilot cone was designed to improve maneuverability through the pipe. Prior to this design, the robot had a flat manifold that impeded movement during testing. During testing, it was observed that when one gripper was active and the second gripper activated, the first gripper bladder would slightly deflate while also loosing gripping force resulting from a transient decrease in pressure. Adding check valves minimized this effect by isolating each gripper.

Two steering heads comprised of the same components were developed, the only difference being the location of the pneumatic muscles on the head. The range of motion between the two was analyzed for optimal flex/travel. The steering head consists of a tail regulator manifold that reduces the high-pressure line down to 40 psi, a solenoid valve bank for controlling each muscle individually, and a pneumatic muscle assembly allowing eight possible directions. During the manual extraction, direction changes (bends), in particular, increase friction as they force more of the robot into contact with the inner wall of the pipe (Figure 2). This friction can cause excessive stress on the tube fitting connections and wiring, which may fail if excessive pull force is used

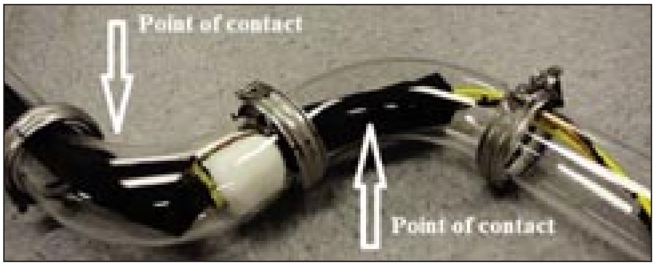

Figure 2. Bends increase friction as they force more of the robot into contact with the inner wall of the pipe.

when extracting the robot. Stainless steel rope linkages were attached between the manifolds to act as a strain relief.

Another pod enclosure was designed and fabricated using 6061-T6 aluminum. The new pod is machined out of a single piece of aluminum, which makes it much more robust than the previous acrylic iteration. The new version also allows for improved wire strain relief system than the previous design.

This work was done by Karl R. Edminster of Electromechanica for the Office of Naval Research. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Manufacturing & Prototyping category.*** *ONR-0031*

Fabricating Porous Systems for Super-Dense Memories and Sensors

Porous alumina systems fabricated via a "bootstrapping" method have applications in electronics and sensing.

Air Force Office of Scientific Research, Arlington, Virginia

This project was dedicated to solving basic scientific issues and developing the scientific basis that underlies the improvement of super-dense memories, towards the terabit-per-square-inch goal and the engineering of chemical and biological sensors. Both applications rely on porous materials. Among them, porous alumina has demonstrated to provide major improvements in these two diverse applications.

The following objectives were set: a) to improve the geometry (regularity, shape, decreased size) of the pores, b) to fabricate and study the properties of nanostructured magnets in a variety of configurations, and c) to apply this technology to chemical and biological sensing.

The size distribution of the porous alumina used for masks was improved significantly using a double anodization process. An unconventional "bootstrapping" method was developed, which uses self-supporting porous membranes. This new method enabled fabrication of very well ordered arrays of small magnetic nanodots on different substrates, which could not be done otherwise.

Although the two applications mentioned earlier are quite different, the basis for both of them is a common technology: self-assembled porous materials — in particular, self-assembled porous alumina on a substrate. Major improvements on the preparation and manipulation of porous alumina were made that have given rise to the understanding of nanostructured magnets, microcapillary condensation, and novel properties of confined organic materials.

Different approaches were investigated for the preparation of porous alumina samples to reach better pore regularity and to broaden the possible shapes that can be obtained. Three schemes were investigated: a) electron beam imprint lithography prior to the anodization to confer order and shape to the pores, b) two-stage anodization evaporation at an angle method to create noncircular nanodots, and c) unconventional bootstrapping to confer order to the pore array without the need of expensive nanoimprint masks. These methods permit the fabrication of complex nanostructures in macroscopic areas that can be used for sensing and confinement.

The original bootstrapping method makes use of iterative, anodization-nanoimprint mask preparation to improve the pore array distribution. High-quality, large, self-supported porous alumina was used as a mask, and by means of reactive ion etching, the ordered pattern was transferred to a supported aluminum thin film. A single, short anodization performed on the aluminum film after this process shows a considerable improvement in the ordering and size distribution of the pores. Unlike the original "bootstrapping" method, this one does not require iterations or the preparation of an imprint mask, which quite often breaks. It also presents a very competitive solution with respect to the electron beam imprint since larger anodization areas can be improved with much more inexpensive techniques.

The magnetism of one-dimensional Fe chains in metallo phthalocyanines organic thin films was investigated. Making use of the particular stacking of these molecules, one-dimensional magnetic chains of variable lengths were grown and studied. In this fashion, competition between intra-chain and inter-chain exchange interactions was determined. This one-dimensional magnetic material is an excellent model system to test and understand the limitations of storage in reduced dimensionality.

This work was done by Ivan K. Schuller of the University of California, San Diego 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 Materials & Coatings category.*** *AFOSR-0007*

Design and Fabrication of a Radio Frequency Grin Lens Using 3D Printing

Microwave lenses are used in a variety of applications such as electromagnetic wave collection and imaging.

Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio

Engineered electromagnetic materials and metamaterials have been researched to explore devices that enable access to electromagnetic properties that are not available in nature. This new class of devices can not only open the door to new functionality, but also be effectively utilized to improve the overall performance of existing systems with respect to electromagnetic performance, cost, size, weight, and repeatability.

This work focuses on the design, fabrication, and characterization of a 3D metamaterial implementation of a focusing GRadient INdex (GRIN) lens with an operational frequency of 12 GHz that is capable of focusing a uniform plane wave to a point outside the lens.

In the microwave bands, GRIN lenses are often made of polystyrene. Currently, focusing lenses with homogenous refractive index are curved. Their size and weight can make them prohibitive in applications such as airborne systems where these constraints are crucial to efficient operation. These issues can be addressed by designing a lens based on metamaterial structures and manufactured with 3D printing. The GRIN lens operates at radio frequency (RF) frequencies, and is not polarization constrained.

In contrast to lenses designed for operation in the optical regime, where lens size is many magnitudes larger than the wavelength, lenses that operate at RF wavelengths are physically only a few times larger than the wavelength.

A 3D rapid prototyping printer was used to fabricate the GRIN lens shown in the figure. 3D printers can be used to print a diverse set of materials, from dielectrics to metals. The materials can be used either individually or in combination (mixed during fabrication) to obtain anisotropic permittivity and permeability values with a range wider than the basic materials used in their neat form. This range of available material parameters can be further enhanced through careful design of geometric features in the unit cells. For example, to lower the limit on available refractive index range, holes/voids were included in this lens design. Since these voids can be defined in the computer-aided design (CAD) file, the printing is seamless and does not require an additional milling step used in conventional processes.

The lens was measured on a modified microwave Gaussian beam system that is used to fully illuminate the lens with a wave and measure the performance of the manufactured lens. The measurement system emits a Gaussian-like wave that does not have uniform amplitude or phase. This has to be accounted for because it has a large effect on the output of the lens. The electric field is measured down the centerline of the lens from 10 cm to 40 cm from the back face of the lens in a similar fashion to the data obtained in simulations.

Microwave lenses such as GRIN lenses are used in a variety of applications such as electromagnetic wave collection and imaging. These lenses are major contributors to system size, weight, and cost, which forces tradeoffs between system parameters such as focal length, field of view, resolution, bandwidth, reflectivity, and range.

The 3D printing approach was chosen to show how such methods can be used to efficiently and accurately fabricate such devices and electromagnetic materials. This allows for building truly 3D electromagnetic structures, as opposed to stacked layer approaches. This provides the freedom to leverage geometrical anisotropy as well as 3D material variation in designs, which in turn increases the degrees of freedom available to optimize the unit cells for a given application.

This work was done by Jeffrey W. Allen and Bae-Ian Wu of the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Manufacturing & Prototyping category.*** *AFRL-0229*

Preparing Carbon-Coated Current Collectors for High-Power Lithium-Ion Secondary Batteries

Coating the current collectors improves the overall power performance of Li-ion batteries.

Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio

Achieving high-power capability of a battery requires minimizing the overall resistance of the electrochemical system. For lithium-ion batteries, much effort has been devoted to minimize the ionic diffusion resistances and electronic resistance associated with the electrode active materials. In the typical electrode configuration, the layer containing the active material is supported on a metallic current collector. The interface between the current collector and active layer imposes additional resistance to charge transfer within the electrode. The advancement in material synthesis technologies has reduced the ionic and electronic resistances associated with the active materials to the point that they become competitive to the other resistance sources. Thus, the significance of the electronic resistance at the active layer/current collector (AL/CC) interface is worthy of re-examination.

Carbon-coated Al current collectors were prepared by two different coating processes: high-temperature thermal chemical vapor deposition (HT-CVD) and low-temperature chemical vapor deposition (PA-CVD). At least two beneficial effects are anticipated to result from the C-coating: 1) the C-coating removes the native surface oxide layer on the metal current

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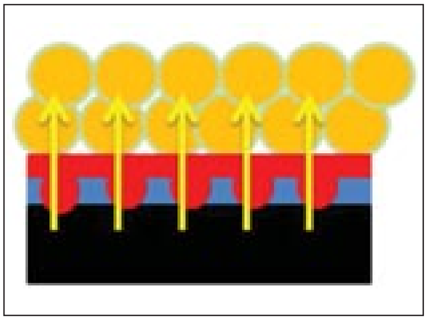
collectors, and 2) the C-layer is hydrophobic in nature and helps to improve the interfacial bonding. Both effects are expected to reduce the AL/CC interfacial resistance. The ultimate goal is to develop a viable C-coating process of the current collector in order to improve the overall power performance and/or cycle life of the electrode of Li-ion batteries.



Schematic diagram of the modified Al foil (PT-Al) as a current collector.

The strategy for manufacturing a large area of C-coated Al foil consisted of two parts. For the first part, due to the designed plasma coating system, the plasma process was easily scaled up under high vacuum. With the same operation parameter as the one to produce PB-Al, the length of the product was increased to more than 1.5 m. The second part is to scale up the thermal treatment, which is more difficult because of its large space occupation and the need of extra-low oxygen content in the furnace. To overcome this problem, a roll-calcination process was created. By winding plasma carbon-coated Al foil (PB-Al) tightly on a metal roll, not only was the occupied space compressed dramatically, but the interfaces protected each other from the surroundings and inhibited the oxide layer formation in high temperature.

The presence of insulating oxide layers at the pristine Al current collectors would impose significant resistance to current flow across the interface. Surface modification by the plasma process is set up along with suitable thermal treatment. The schematic diagram of the C-coated Al is shown in the figure. There are some high conductive regions penetrating through the native alumina oxide layer, and a high conductive carbon coating on the surface makes the surface hydrophobic. When used as current collector, a hydrophobic surface can increase the contact of the surface of active material and the current collector, and the electron transfer can simultaneously be enhanced. This low resistance successfully results in better rate capacity, low polarization, and better cycle life.

The relation of the thickness of the carbon coating to performance was studied. With the same treatment but different carbon amount, the one with the thin carbon layer gets worse performance of the electrode. However, increasing the thickness of carbon to get a visible color change, a high-conductive channel will be formed on the surface and provide a positive effect on the performance of the electrode. The scaling up of this surface modification process proved to be feasible by overcoming the oxidation problem after high-temperature treatment.

This work was done by Nae-Lih Wu of National Taiwan University for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Manufacturing & Prototyping category.*** *AFRL-0230*

Transparent Display Technology

Edgewood Chemical Biological Center
Aberdeen, MD
410-436-7118
www.ecbc.army.mil

The U.S. Army Edgewood Chemical Biological Center (ECBC) has partnered with the Massachusetts Institute of Technology's Institute for Soldier Nanotechnologies (MIT-ISN) and the Harvard University Department of Physics to develop a transparent display technology. Through ECBC's In-House Laboratory Independent Research program, the teams have explored how particles scatter and absorb light efficiently.

As the team researched the use of nanoparticles in obscurants, which block a warfighter's visibility over several bands of light, Marin Soljacic, a physics professor at MIT and leader of the team, had the idea of putting the technology to use in a different setting.

"The work on nanoparticles in the obscurants project is closely related to the development of this transparent display technology," said Brendan DeLacy, an ECBC researcher in the Toxicology and Obscurants Division. "In our obscurants project, MIT provides computational models that predict the optimum size and shape of nanoparticles that are required to absorb and scatter light. ECBC is responsible for creating the particles that are predicted by those models."

Typically, when an image is projected onto a transparent material such as glass, it simply goes through the glass and the image cannot be viewed. By coating the glass with a polymer containing silver nanoparticles with the appropriate size, however, an image can be reflected back and viewed as it if were on a screen. Additionally, the transparency of the glass is still retained. Advantages of this technology also include a wide viewing angle and the ability to scale the materials onto large display areas.

Each of the silver nanoparticles used in the technology is designed to scatter or reflect one color while rejecting the rest. Currently, a silver particle is used for imaging blue light. In order to simultaneously scatter red, green, and blue light, DeLacy said, researchers have one of two options: They can use three different nanoparticles, or they can create a clever particle with the correct properties that can display all three of the colors.

"The best part about this technology is how inexpensive it is. It costs much less than the other transparent display technologies, and it can be coated onto virtually any material that is transparent," DeLacy said.

For Free Info Visit ***http://info.hotims.com/49746-507***

Spatial Disorientation Flight Simulator

Environmental Tectonics Corporation (ETC)
Southampton, PA
215-355-9100
www.etcusa.com

Aircrew Training Systems (ATS), a division of Environmental Tectonics Corporation, has been selected by the U.S. Army Contracting Command to provide the Colombian Air Force (FAC) with a spatial disorientation flight simulator. The GYRO IPT II will help FAC pilots to recognize in-flight conditions that contribute to spatial disorientation. The new system will be installed at the FAC Aerospace Medicine Center (CEMAE) in Bogotá, Colombia next spring.

ETC's GYRO IPT II provides pilots with a hands-on, realistic, full-motion flight training experience. While in control

of a simulated flight, the pilot can be exposed to a variety of selected disorienting illusions. Unlike simple disorientation demonstrators, a pilot in the GYRO IPT II has full closed loop control of the simulation before, during, and after the illusion. The capability creates a fully interactive flight training environment where the training pilot must maintain control of the simulator and fly through the illusion to a successful resolution.

The new GYRO IPT II will complement the suite of training devices already operating at CEMAE, including an Altitude Chamber, Night Vision Training System, and Vestibular Illusion Demonstrator, all previously provided by ETC.

For Free Info Visit ***http://info.hotims.com/49746-508***

Multi-Role Close Air Support Weapon

MBDA
Arlington, VA
703-387-7136
www.mbda-systems.com

MBDA recently demonstrated its Dual Mode Brimstone (DMB) missile on an MQ-9 Reaper Remotely Piloted Aircraft (RPA), scoring nine direct hits against a range of targets, including very-high-speed and maneuvering vehicles. Dual Mode Brimstone is a combat-proven weapon designed for the engagement of moving and maneuvering targets, and targets in high collateral risk / urban environments. Brimstone can now provide Reaper crews with a weapon that reduces collateral damage risk and demonstrates first-pass, single-shot lethality against high-speed maneuvering targets on land and at sea, and in complex environments.

Conducted in December 2013 and January 2014 at US Naval Air Weapons Station China Lake, the trials were undertaken on behalf of the UK Ministry of Defence by the Royal Air Force's (RAF) Air Warfare Centre Unmanned Air Systems Test and Evaluation Squadron, Defence Equipment & Support Weapons Operating Centre, United States Air Force's BIG SAFARI Organization, General Atomics Aeronautical Systems Incorporated, and MBDA.

The trials began with captive carry of avionics and environmental data-gathering missiles, proving the successful integra-

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tion of the two systems and gathering additional evidence to support future clearance activities. These were quickly followed by a series of live operational missile and inert telemetry missile firings. The firings were taken from realistic "middle of the envelope" profiles; typically 20,000 ft release altitude and 7km - 12km plan range, with the platform being remotely piloted in operationally representative beyond line of sight (SATCOM) conditions, with tracking and designation of targets being conducted in a mixture of manual-track and auto-track modes.

Brimstone scored nine direct hits in a range of very challenging scenarios, including static, accelerating, weaving, fast, and very fast remotely controlled targets. Two of the more challenging scenarios were against trucks travelling at 70 mph in a crossing target scenario. At times, the targets were manually tracked by the Reaper crews, showing how the integrated semi-active laser and active MMW radar seeker works in tandem to ensure direct hits, even while tracking and designating targets manually over SATCOM. It was reported that every operational and telemetry missile performed as designed.

The Brimstone weapon system has already been fully integrated into the UK Tornado GR4 fighter aircraft, where it can be operated in either of two cockpit selectable modes. Mode 1 features Semi-Active Laser (SAL)-only guidance, while Mode 2 offers SAL initially with end-game Millimeter Wave Radar (MMW) guidance for fast-moving and maneuvering targets. In October 2013, a Brimstone-equipped Tornado GR4 demonstrated the ability to engage from a high off-boresight, targets travelling at up to 70 mph, from longer ranges and without the need to revert to straight and level flight, whilst operating from a Close Air Support (CAS) wheel.

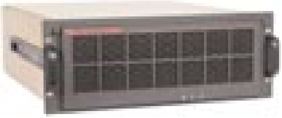
The most recent tests at China Lake demonstrate that the Brimstone's dual mode seeker and robust guidance capability can enable beyond line of sight Remotely Piloted Aircraft to deliver the same low collateral damage effects with the same precision as that demonstrated by Brimstone-equipped RAF Tornado GR4 fast jets on operations in Afghanistan and Libya. Combined with ongoing and contracted RAF trials against maritime Fast Inshore Attack Craft, these trials further demonstrate the unique capability to deploy a single, truly multi-role missile family for land and maritime attack from fast jets, remotely piloted aircraft, multi-mission and maritime patrol aircraft, rotary wing platforms, and surface platforms.

For Free Info Visit ***http://info.hotims.com/49746-509***


Brimstone substantially increases persistence through single-shot precision, 3-missile-per-pylon aerodynamic fit, and fast-jet qualified levels of environmental robustness.

Rackmount Computer

The Trenton TMS4703 4U rackmount MIL-STD military computer from Trenton Systems (Gainesville, GA) is designed for mounting in a 19" component rack or a transit case. The TMS4703 has flexible MIL-DTL-38999 and MIL-STD-1553 rear I/O connector configurations designed for customer-defined applications. The sealed connectors, plus front- and rear-panel air filters, enable TMS4703 certification to various MIL-STD-810G and MIL-STD-461F standards and test methods. A rugged, lightweight aluminum chassis is used in the TMS4703, and a corrosion-resistant coating is applied to the chassis and fastening hardware.



Other features of the TMS4703 MIL-STD military computer include: configurations available that support single or dual-processor SBCs; backplane options available to support multiple PCI Express, PCI-X and, PCI option cards; and life cycle with 7+ year SBC and backplane availability.

The TMS4703 supports up to ten 2.5" HDDs or SSDs mounted in front-access drive carriers and internal drive bays. System options include one or two 115/230VAC or 18-36VDC power supplies for single or two-in-one system configurations.

For Free Info Visit http://info.hotims.com/49746-511

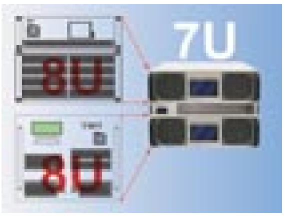
Laser Encoders

HS10/HS20 laser encoders from Renishaw (Hoffman Estates, IL) allow Flow International Corporation's Composite Machining Center (CMC) to machine 40-meter-long composite parts. With the precision of a laser interferometer, the encoder and its RCU10 real-time compensation unit deliver part-per-million positioning accuracy on the CMC's X-axis.

Flow's CMC can be configured as a mid-rail gantry or dual travelling column machine. The gantry design carries two rams on a single gantry, with a 5-axis wrist on each ram — one for ultra-high-pressure waterjet cutting and one for conventional high-speed routing. The modular CMC is available in standard X-axis lengths of 6 to 50 m, as well as custom sizes.

With a rack and pinion drive on each side of its gantry, the CMC uses split X-axis feedback with a laser on each side, working as a master and slave for positioning. The CMC also uses a Renishaw RMP60 touch probe for locating the part during setup and confirming finished dimensions after machining.

For Free Info Visit http://info.hotims.com/49746-512

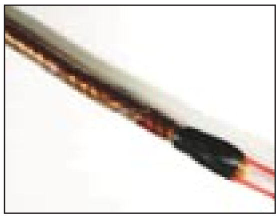


Power Amplifiers

The Airborne Pulse HPA from Empower RF Systems (Inglewood, CA) features UHF and L-Band pulse amplifiers tied to a shared power supply and delivering 1 kW and 3 kW pulse power, respectively. Each amplifier is housed in a 3U chassis, and the shared power supply is housed in a 1U chassis. The technology replaces older products which totaled 16U in size. The UHF pulse amplifier is designed with LDMOS, and the L-Band pulse amplifier is designed with GaN.

For Free Info Visit http://info.hotims.com/49746-514

Tube Heaters



Birk Manufacturing (East Lyme, CT) has announced RAPT°R (Rigid and Pliable Tube of Resistance), a heated delivery system that ensures that any liquids or gases transported will remain at the same temperature or arrive at an elevated temperature, despite thermal losses derived from flow, turbulence, conduction, convection, or time.

RAPT°R heats a desired liquid or gas up to 125 °C. Additional benefits include sensor integration, UL recognition, and the ability to add connectors. Standard tubing is available with widths from 0.063" and 0.750". Lengths range from 6-24", and each heated tube type is available with a silicone or Kapton heater.

For Free Info Visit http://info.hotims.com/49746-516

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Avionics Digital Panel Meter

Specifically designed to replace "needle" meters in military aircraft, the new APM model from OTEK Corp. (Tucson, AZ) conforms to military and commercial 1"-diameter standards, as well as a variety of Mil-Standards, including 461, 704, 130, 810, and 889. The APM accepts 4-20mA or VDC signals (others upon request), 0-5VRMS/VDC for intensity (dimming) control, and 5-48VDC power input. The 4-digit (9.9.9.9) display is standard or NVG3-compliant. For new applications (not yet military-approved), the APM can be loop powered, eliminating the need for external power supply and wiring. The < 100mW loop power adds a burden under 5 VDC max to the loop, and has an operating range of 3-36mADC.

For Free Info Visit http://info.hotims.com/49746-510

Integrated Circuits Support

Rochester Electronics (Newburyport, MA) has expanded manufacturing and support services of obsolete and active MIL-STD-883 and MIL-PRF-38535 integrated circuits. Through its Extension-of-Life® products, Rochester manufactures National Semiconductor's 54AC00/QCA (5962-8754901CA), Intel's 87C51, and Texas Instruments' UA733M/BIA (8418501IA) to MIL-STD-883 and MIL-PRF-38535 specifications. In addition,

the company has expanded its environmental test lab, which replicates conditions and elements experienced by military and aerospace applications. Rochester Electronics complies with MIL-STD-883 and MIL-PRF-38535 requirements through mechanical and electrical testing, as well as training procedures.

For Free Info Visit http://info.hotims.com/49746-518

TRANSPARENT, NASA LOW OUTGASSING EPOXY

Ideal for a wide variety of applications in the aerospace industry, Master Bond EP30HT-LO passes NASA low outgassing testing per ASTM E595 specifications. This two component system combines high temperature resistance up to 400°F with excellent optical clarity. EP30HT-LO cures rigid at room temperature with exceptional dimensional stability and superb physical strength properties. www.masterbond.com/tds/ep30ht-lo

Master Bond, Inc.

Free Info at http://info.hotims.com/49746-813

SHX1 LONG-RANGE MULTI-CHANNEL TRANSCEIVER

Lemos International offers the SHX1 Long-Range Multi-Channel Transceiver that provides:

- Unlicensed operation on MURS band frequencies (under FCC Part 95)
- Data rates up to 5 kbps for standard module
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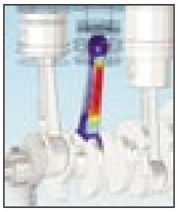

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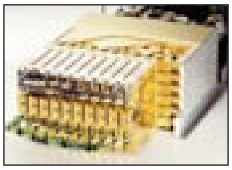

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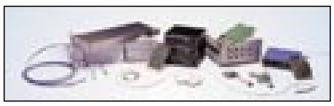

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