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August 2015

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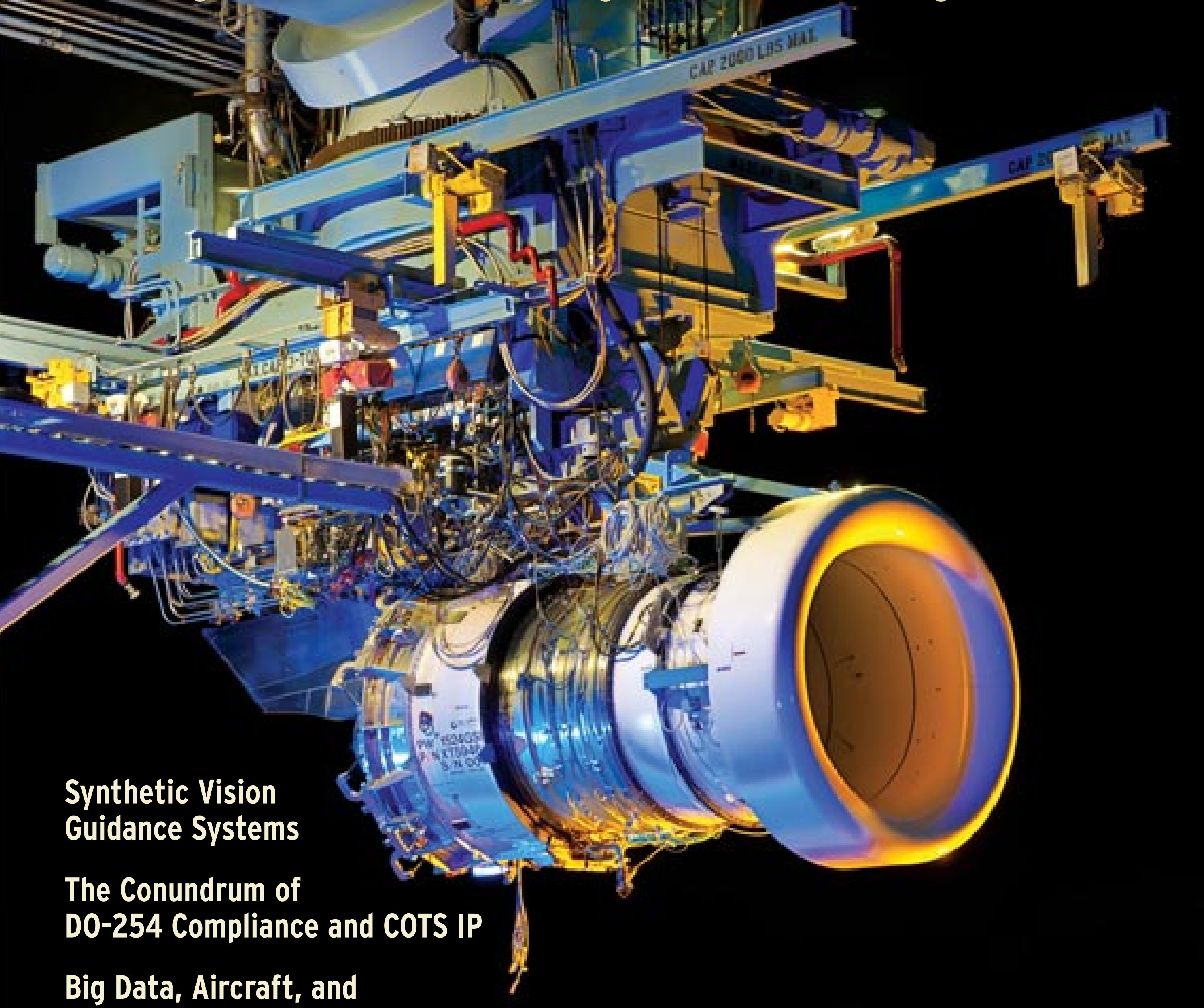

Synthetic Vision Guidance Systems

The Conundrum of DO-254 Compliance and COTS IP

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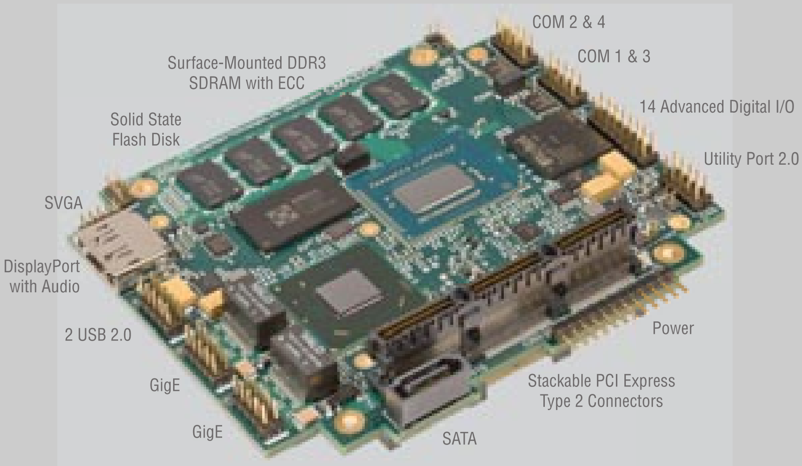

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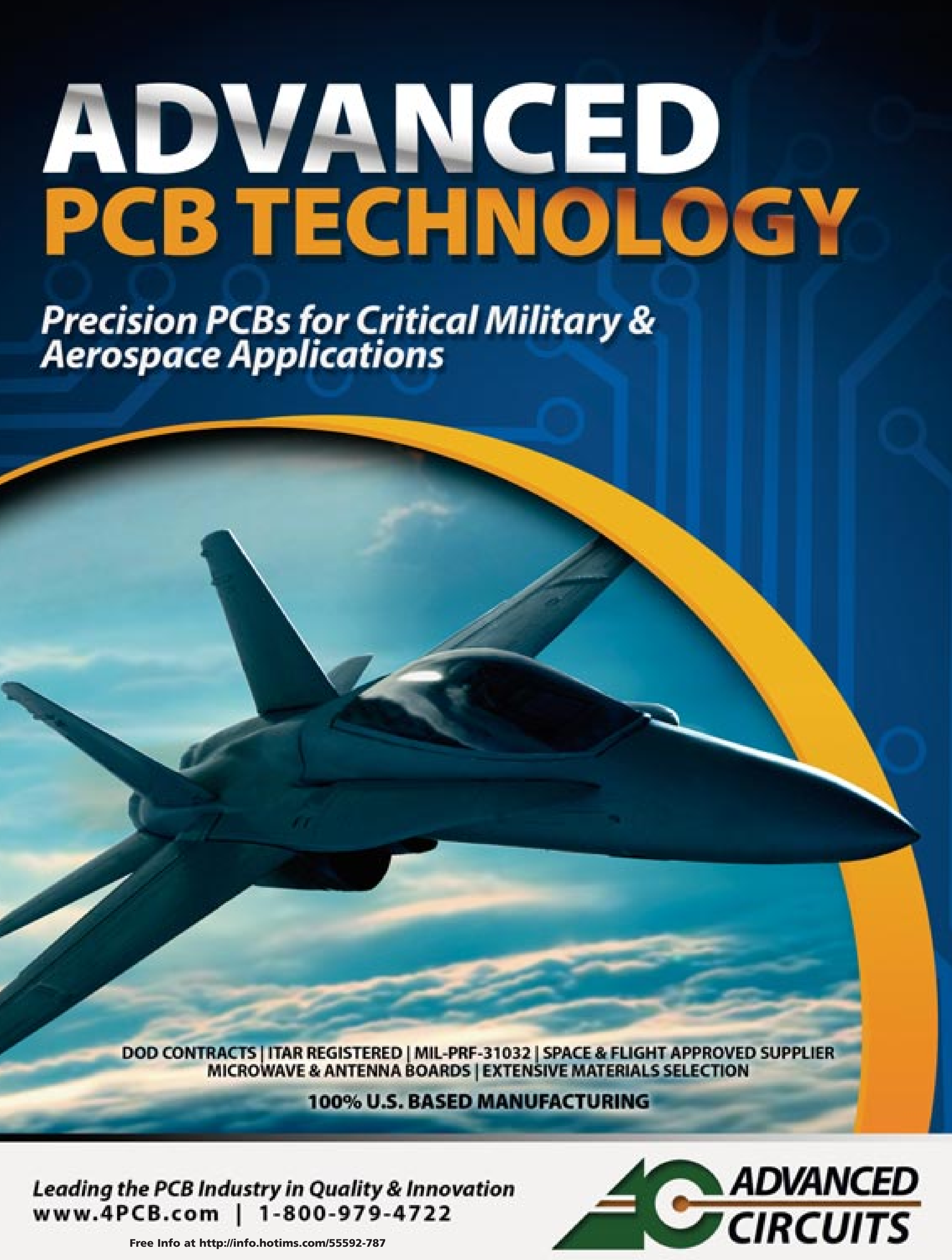
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ON THE COVER

Data collection on Pratt & Whitney's PW1524G engine started before it began ground testing, and will continue long after. The massive amounts of data collected are analyzed using statistical models and used to predict unplanned engine events that could cause a delay or flight interruption. To learn more, read the feature article on page 23.

(Photo courtesy of Pratt & Whitney)

Synthetic Vision Guidance Systems
Giving 2D data a 3D perspective

Photo courtesy of Honeywell

Synthetic Vision (SV) displays replace the pilot's traditional 2D primary flight display (PFD) with a 3D perspective view display. The 3D SV perspective display is rendered from an onboard terrain database, e.g., one derived from the Enhanced Ground Proximity Warning System (EGPWS) to create a virtual reality-like image. A comparison of a traditional 2D PFD with a 3D SV PFD is shown in Figure 1.

The first OEM large aircraft SV display was certified on the Honeywell Primus Epic® system by Gulfstream in January 2008. The natural perspective colorized 3D terrain offers an unmatched safety enhancement in that it always presents the pilot with a clear and natural view out the window even in degraded visibility conditions such as at night or during operations in inclement weather.

In addition to the 3D perspective terrain, obstacles, and runway environment, some certified SV displays include advanced Head-Up Display (HUD) symbology, like the flight path vector, to improve control precision and energy management. An SV display, with enhanced symbology, permits any typically trained pilot to fly a more tightly coupled approach easily and routinely, capable of achieving an enhanced level of performance. However, despite the improved all-weather terrain and energy awareness, and enhanced pilot performance provided by some of the new SV displays, certification of the SV systems to date has afforded no operational credit to incentivize operators outside the business and general aviation community to equip with the new technology.

NextGen and SESAR

Under the FAA's NextGen and European SESAR programs, the aviation authorities in the US and Europe are redesigning their airspace regulations, usage and rules to increase accessibility to airports and increase landing frequencies under any weather conditions. However the ability to provide a consistent level of accessibility and safety is not possible with the conventional airborne avionics and limitations of some airport infrastructures.

For GPS Localizer Performance with Vertical guidance (LPV) operations, specifically wide area augmentation system (WAAS) guidance, monitoring is provided by an entire system for North America, and is limited to a time to alert (TTA) of false or misleading information to 6.2 seconds limiting the decision altitude (DA) of a CAT I stan-

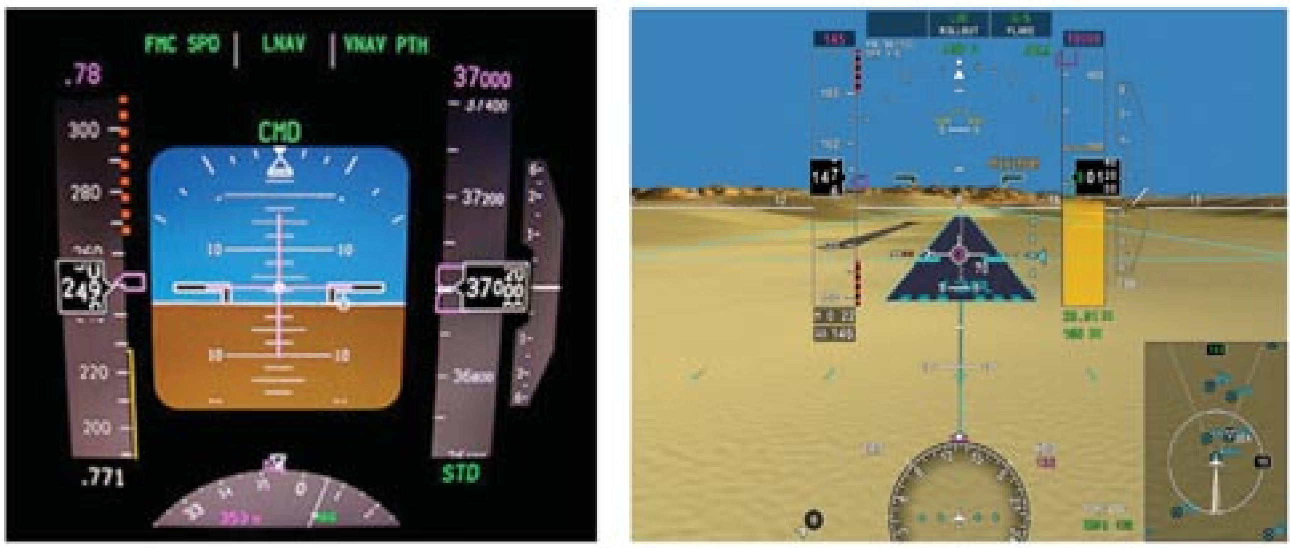

Figure 1. A traditional PFD is shown on the left-hand side of the above figure. On the right, an updated high resolution large format display with million+ colors provides the pilot with enhanced situation awareness of the topography and runway environment along with improved energy management cues.

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Figure 2. The integration between the Honeywell SVLM with FPV and runway approach symbology created in 2011 (left) based on Honeywell HUD2020 (right) created in 1996 providing the same functionality is shown above. LEFT: This screen capture is of an SVLM prototype installed in the company's Gulfstream 450. The approach shown was an ILS to runway 01 at Albany International Airport New York (KALB). RIGHT: This photograph was taken through the HUD combiner of the prototype HUD2020 installed in a Cessna Citation III. This approach was an ILS to runway 30C at Williams Gateway Airport, Phoenix Arizona (KIWA).

dard operation to 200 ft. DA is the altitude at which a pilot must see outside visual references in order to continue the approach to landing. If the DA on an approach is lowered, and aircraft and crew are appropriately equipped, airport accessibility and landing frequency is increased.

There is a proposal for a new SV Guidance System (SVGS) that will enable aircraft to get lower than standard on the ILS and LPV approaches by solving the existing integrity and accuracy problems that are limiting operations. This SVGS system will change the performance of the airplane and it is believed that it will incentivize regional and air transport aircraft operators and OEMs to equip with SV technology.

SVGS — A New Generation Display and Guidance System

SVGS is a flight path vector (FPV) based SV PFD with additional pilot in the loop control display elements and system monitors that is intended to enable operations to lower than standard CAT I and LPV approach minimums at reduced infrastructure airfields (e.g., reduced lighting). SVGS is based upon previously certified Primus Epic® avionics architecture with a software update to an existing Primus Epic SmartView certified display.

Honeywell's SVGS system is called SmartView Lower Minimums (SVLM). SVLM capabilities are based upon the design of the intuitive flight instrument elements that address previously complex training issues by pilot task reduction and increased pilot in the loop control in combination with a new airborne system monitoring for continuity of signal in space, CAT II level (or better) flight technical error, and new level of position assurance by nature of the flight display design elements.

HUD Symbology Concepts and Next Gen PFDs

The symbology design on SVLM intentionally adopts that of a HUD, and takes advantage of a high resolution, large format, color display. The SVLM display is a PFD that incorporates flight instrument, flight guidance and a terrain based attitude indicator using data approved in accordance with FAA DO-200A standards (Figure 2, left).

The HUD-like advanced flight instrument design symbology elements on the SVLM display include an expanded pitch ladder, which is conformal with the outside view; conformal FPV; and, conformal runway and airport symbols.

The FPV group symbology integrates many previously separate control and performance parameter elements that the pilot directly manipulates. Because the pilot is directly controlling path, the flying task becomes much easier. Because this is done on a much expanded pitch ladder scale, precision is improved. The FPV and the associated acceleration cue provide the crew with an intuitive way to fly the aircraft and greatly increase energy cues. They provide direct control of the aircraft's path through space and a direct indication of the effects of altitude and thrust on aircraft speed. The SVLM FPV group is registered with the (virtual) outside view.

The use of conformal symbology provides continuous knowledge of ob-

jects in the real world. The runway symbol cue is a good example; it allows continual knowledge of the runway location even in low visibility conditions. The transition from instrument flight to visual flight with a HUD or with SVLM requires context switching by the pilot, e.g., the pilot changes from the HUD symbology presented on the combiner glass, and must look beyond the symbology to visual cues in the natural world (note: sometimes it is a great challenge for the pilot to look through cluttered HUD formats to the far domain real world) or transitions from a head down SVLM PFD to a head out frame of reference. However, SVLM along with most HUDS, provide an aid in the form of conformal symbology that assist the pilots to prepare to visually acquire the runway when transitioning from the instrument to visual segment.

SVLM enhances existing SV features and ads features derived from HUD symbology (but now with color!). SVLM is a flight path centered and FPV based PFD flight instrument that provides a geographically correct terrain depiction attitude indicator with position assurance. In addition, it provides supplementary flight guidance during the final phase of the instrument approach segment via runway approach indicator. In addition to the runway approach indicator, a geometric Precision Approach Path Indicator (G-PAPI), flight path referenced vertical deviation and conformal lateral deviation with crab symbol have been added to the SV display (Figure 3). SVLM symbology also includes approach deviation arrowheads to alert the pilot during excessive lateral or vertical deviation (not shown in Figure 3). These new features and symbology are added to the PFD for the purpose of enhanced topographic and energy awareness and to obtain operational credit for SmartView to fly to lower than standard CAT I minima.

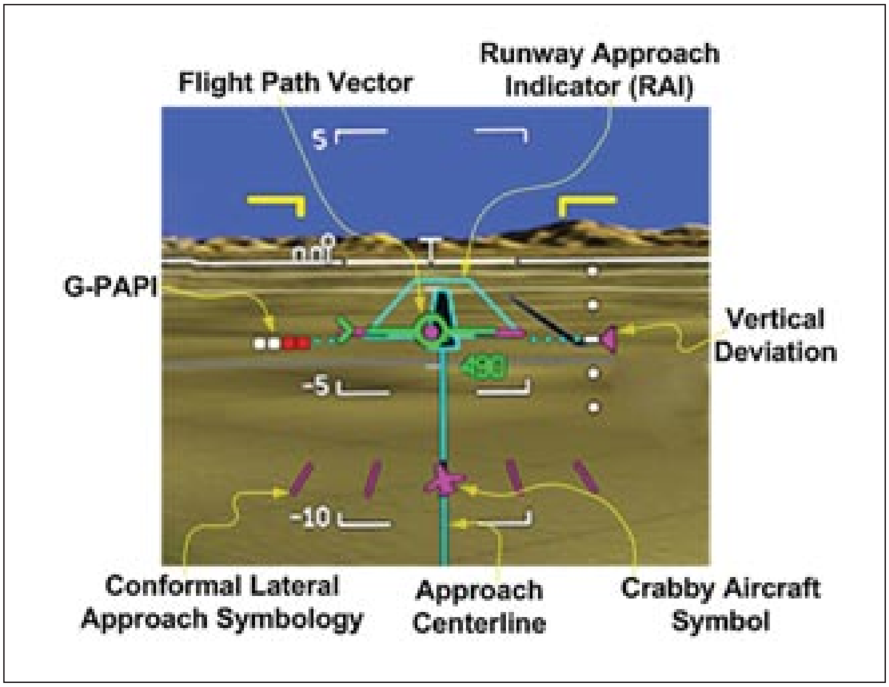

Figure 3. Synthetic Vision display showing runway approach indicator, geometric Precision Approach Path Indicator, and flight path referenced vertical deviation and conformal lateral deviation.

New Approach Monitors

In addition to the symbology enhancements previously described and reduced SBAS lateral and vertical integrity limits, the heart of the SVLM system resides with the new monitors. The new monitors had to be developed and added to the no operational credit version of the SmartView PFD to afford the integrity required for a lower than standard minimums operation and to meet time to alert requirements that are not currently supported by today's CAT I or LPV approaches. The SVLM concept contains five new monitors which are designed to alert the flight crew when airplane position solutions and database values are out of a predefined tolerance. The monitors are introduced as a result of a functional hazard assessment (FHA) that considered effects of functional failures when moving from a "no operational credit" SV Primus Epic certification to a lower than standard CAT I ILS and LPV200 approach. The five new monitors of SVLM are:

- Runway Data Integrity
- Delta Position
- Altitude
- Virtual Inner Marker
- Flight Technical Error

The runway data integrity monitor compares two independent sources of runway information to enhance integrity of the displayed runway.

The delta position monitor is a real-time position monitor that becomes active when the aircraft is stabilized on approach, about 1000 ft above the runway elevation, and it continues through the instrument segment to the approach minimum. The design of this new monitor is based on CAT II time-to-alert requirements. It continuously compares the approach deviations from the instrument approach being flown with a "reference approach". The reference approach is an idealized approach based on the approach geometry and navigation database values and its position is updated by an inertial reference system coasting algorithm.

The altitude monitor function protects against GPS altitude errors and associated LPV vertical deviations along with mis-set altimeters (pilot error or rapidly changing barometric pressure). It looks at the tracking of three independent altitude sources: GPS altitude, corrected barometric altitude, and radio altitude plus the terrain database.

The virtual inner marker utilizes a concept of an artificial inner marker as a decision altitude monitor that enables the use of a barometric decision altitude (DA)

for approaches with minimums below standard CAT 1 where radio altitude decision height (DH) is normally used.

Flight technical error monitor will alert the crew when an excessive lateral or vertical deviation is present. This monitor activates when the system has determined that the current position on ILS or LPV approach is offset such that a safe landing cannot be made without exceptional piloting skill and without full visual references available.

SVLM Testing

Flight technical, system performance, and human factors evaluations of SVLM were conducted with FAA and EASA in 2013. Eighteen participant pilots from FAA, EASA and OEMs flew the SVLM functional system prototype. Flight tests were conducted using Honeywell's Falcon 900EX EASy II test aircraft for system performance development and verification. Simulator testing to evaluate low visibility transition to landing verification was conducted in Boeing's M-Cab 777 simulator.

The test data demonstrated pilot performance well within CAT II approach criteria and reduced pilot workload that enables either a manually flown or monitored approach to lower than standard minimums with a level of system alerting and monitoring that meets and exceeds CAT II level of safety. In addition, the flight tests and simulator evaluations demonstrated that operations with an SVLM guidance PFD (head down display) facilitated a successful transition from instrument to visual segment and landing at both 150ft DA with 1400ft RVR and 100ft DA with 1000ft RVR. The flight tests demonstrated that the SVLM system provides independent position fixing and new monitoring systems to the required level of integrity, time to alert, and performance for a lower than standard CAT I operation with minimal crew training.

Next Steps Towards SVGS Approval

RTCA SC213 federal advisory committee is in the final stages of completing minimum aviation performance standards for an SVGS system. Upon completion, it is predicted that FAA will in turn update airworthiness and certification guidance and issue updated approach plates to permit lower than standard minimums on approved approaches with approved SVGS equipment and crew. It is hoped that the approval process and publication of approach plates will, in turn, provide the desired incentive of operators and specifically the airline industry to equip with the natural view 3D SV PFDs.

This article was written by Thea Feyereisen, Engineer Fellow, Advanced Technology, Honeywell Aerospace (Phoenix, AZ). For more information, visit ***http://info.hotims.com/55592-500.***

The Conundrum of DO-254 Compliance and COTS IP

A tornado is blowing through a specific area of the semiconductor market. The market for Intellectual Property (or IP, also known as IP cores or IP blocks) is roughly $2.5B and growing at twice the rate of the overall semiconductor market. As semiconductor platforms offer a continually increasing silicon playing field, designers are struggling to fully utilize the design real estate now available to them. Traditional design techniques simply can't keep pace. This is where IP fits in. IP provides pre-designed building blocks that can be connected relatively quickly and easily to create complex, custom semiconductor designs. Thus, IP is a critical bridge between designers' creative productivity and the markets' ever increasing demands for cheaper, smaller, lighter, lower-power, more reliable, full-featured designs.

These winds of change are heading now for the Aerospace and Defense (A&D) markets. All electronics market segments have been increasingly adopting the use of IP as standard practice. Some segments, such as A&D, however, have been slower to do so. Safety concern is the key reason. As the trend towards IP usage has been accelerating, aerospace regulators have been raising concerns that have put the brakes on its use in avionics. Understanding why this is so requires some knowledge of the airborne electronics design standard, DO-254.

IP used in avionics systems is growing.

The RTCA/DO-254 document "Design Assurance Guidance for Airborne Electronic Hardware" was developed throughout the 1990's by a committee of industry experts working under the guidance of the RTCA. The intent of the document is to ensure design safety by imposing a structured and rigorous development process to ensure that the resulting product will perform its intended function. This is what is meant by development assurance. The DO-254 development assurance process applies to airborne electronics. With IP use surging in other domains, more and more avionics designers either are—or would like to be—using IP to simplify, accelerate, and lower the cost of the avionics development process. Unfortunately, the typical commercial IP development process and business model do not easily lend themselves to DO-254 compliance specifically, or design assurance in general.

So does IP really need to be compliant? After all, DO-254 itself says noth-

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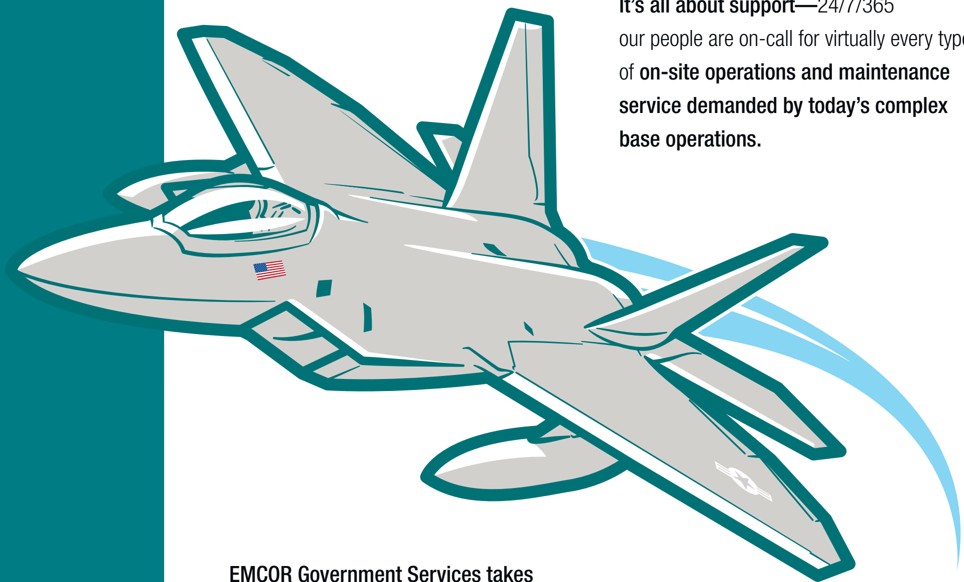

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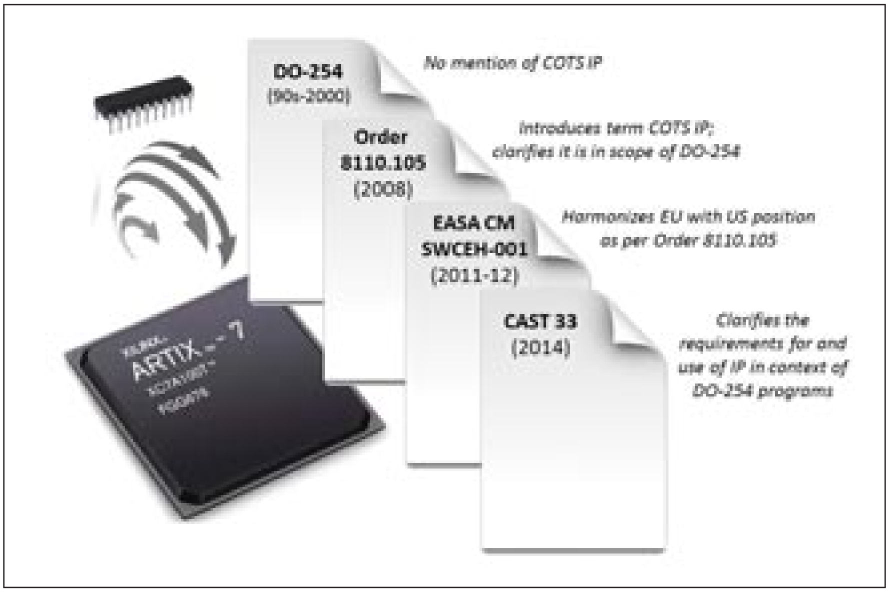

Policy evolution has led to IP compliance requirements.

ing about the use of IP. In fact, it barely references FPGA and ASIC designs, which are the focus of how the policy is applied today. This is not surprising given that DO-254 was developed in the 1990's, when these types of devices were in their infancy and not yet commonplace in the cautious aerospace market. But this highlights one of the key challenges that regulators face – how to keep policy up to speed with technology advances. The case of IP highlights this challenge.

In regulation and certification realms, IP is referred to as COTS IP. COTS, or "commercial off the shelf," is added presumably to emphasize that the IP is developed outside of the scope or control of the company developing the avionics design, which is subject to DO-254 compliance. The DO-254 compliance challenges arise primarily from the assumed lack of development assurance during the IP design process. These concerns with COTS IP are first mentioned in Order 8110.105 (2008), an FAA policy document that shapes how DO-254 is applied to FPGAs. Order 8110.105 emphasizes that COTS IP is indeed within the realm of DO-254 compliance. Order 8110.105 does not however explain how to apply DO-254 to these functions. Similarly, in 2011, the European Aviation Safety Agency (EASA) released certification memo SWCEH-001 which corroborated the FAA position, and still did not provide any specific guidance.

It wasn't until October 2014 that the CAST organization (the certification authority software team, which is a group of worldwide regulators who coordinate positions on certification issues for software and hardware) published the first real position and guide for the use of IP in DO-254 programs in CAST 33. This paper, entitled "Compliance to RTCA DO-254/ EUROCAE ED-80, 'Design Assurance Guidance for Airborne Electronic Hardware', for COTS Intellectual Property Used in Programmable Logic Devices and Application Specific Integrated Circuits," makes it clear that DO-254 compliance is necessary for IP and also describes how that may be achieved. While hard IP (that which is targeted for or implemented within a specific silicon package) has to abide by the latest guidance for COTS, soft IP (that which is available in source form and incorporated with custom code during the development process) must demonstrate the appropriate development assurance. In essence this means the IP has to be developed to be DO-254 compliant or reverse-engineered to become so.

On the surface, this sounds simple enough. An avionics engineer must buy compliant soft IP or get the source and reverse engineer it with an appropriate DO-254 process. In reality, it isn't so simple. Let's explore these options one at a time.

"Safe IP" is a library of DO-254 compliant IP

First, very few commercial IP vendors have developed DO-254 compliant IP. The investment is too high (due to the expertise and process required) and the return too low (due to the small size of the avionics market). Second, even if a commercial IP vendor provides the source code (which is somewhat unusual since it violates the traditional IP business model), the cost of obtaining the source is typically high and reverse engineering it for DO-254 compliance without support from the vendor can be nearly as difficult as just re-creating the IP function from scratch.

What then are the options? A market void will always be filled by some creative companies, and the beginnings of this are evident in the avionics IP market. A handful of avionics companies are reselling some of their own internal IP, which presumably they've taken through DO-254 compliance for their own programs. A few DO-254 compliant IP companies are emerging, developing new IP following a DO-254 process. An interesting hybrid business model is also emerging, involving the partnership of commercial IP providers and DO-254 consulting companies. In this situation, DO-254 experts take commercial IP with a proven track record and re-engineer it (with support from the original engineers as needed) to be in compliance with the standard. This latter model offers the benefits of starting with a proven baseline of industry use for the IP, and leveraging the expertise of a company well versed in DO-254 to work with that IP as needed to bring it up to full compliance for use in even the most safety-critical designs.

So how can an avionics engineer find and leverage this IP? Finding it is easy. A

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simple online search will yield sources for DO-254 compliant IP. However, not all IP has the same process and credentials, and DO-254 compliance at the block level does not equate to DO-254 compliance at the device level (where it is expected and audited).

In order to leverage the use of DO-254 compliant IP, the avionics engineer should familiarize themselves with CAST 33, which is geared primarily for the IP user. This document guides the IP user through a series of steps to ensure that the DO-254 compliance of the IP is adequate for its use in the design. The easiest IP to incorporate is that in which the IP provider established a methodology for reuse of the compliance effort. It's one thing to say that an IP is compliant. It's another to actually incorporate all the data and artifacts that demonstrate this into a DO-254 compliance package at the device level that can stand up to stringent DO-254 audits.

IP compliance data package requirements

Inherent trust is not a notion in DO-254. Compliant IP should come with a data package demonstrating that it has been developed or reverse engineered in compliance with the standard. This package provides evidence that the IP function itself meets DO-254 objectives. But that function is a small piece of a larger design. So reuse of that compliance effort and filling in any compliance gaps at the device level is also a necessity. Vendors of compliant IP should additionally offer support to help their IP users close this very vital gap in compliance.

IP use is here to stay and its use in avionics designs is certain to increase. But safety is paramount in airborne applications, and this includes the functions provided by IP. The policy makers have made this clear in the evolution of policy. Solutions are emerging to offer even this niche market IP solutions that provide the productivity gains designers are seeking and the design assurance certification authorities are seeking. The IP market tornado is yielding sunnier days ahead for avionics.

This article was written by Michelle Lange, Director of Sales and Marketing, Logicircuit, Inc. (Alpharetta, GA). For more information, visit ***http://info.hotims.com/55592-501***.

Let the Good Times Continue to Roll

The booming international commercial aviation sector continues to be a bright light leading the future of the aerospace industry.

by Richard Gardner

The Airbus 330-900neo (new engine option) will incorporate the latest-generation Rolls-Royce Trent 7000 engines with a 112-in diameter fan for a 10:1 bypass ratio, more seats, and new cabin features, along with new Sharklet wingtip devices.

It is hard to imagine just how radical the change in fortunes for the world's major commercial aerospace manufacturers has been in the last few years. Just ten years ago the smart money in aerospace pointed to the defense sector as the best source of future profitability. But just as this was reaching a peak, the full impact of a near meltdown in global financial markets brought home to Western governments that defense budgets couldn't just keep on expanding and a new era of military program cuts began.

In contrast, in spite of the grim economic backdrop, global demand for air travel just kept on growing. The steady year-on-year expansion of civil aviation in the Asia Pacific and Latin American regions, as well as in the Arabian Gulf, more than compensated for a slowdown in the ability of established Western airlines to replace elderly jetliner fleets with more fuel-efficient aircraft designs.

The turning point came as this decade opened with a whole new generation of commercial aircraft programs, powered by new, even more fuel-efficient engines. The 15-20% improvements in fuel efficiency, combined with other cost reductions relating to higher reliability, meant that the bottom-line benefit for airlines was too great to ignore.

Another major factor in airline growth has been the rapid expansion of low-cost airlines where new operators could start up business offering passengers cut-price fares and the latest aircraft. It was a winning combination that was to shake up the civil air transport industry. The outcome has been a surge in new orders on a scale that has never been seen before, with sales backlogs and deliveries stretching ahead for seven or eight years.

That 70s Show Up

When Airbus was created in the early 1970s it had one product, the wide-body A300B. In 1974 just one A300B was delivered to an airline. After a very slow start, the aircraft was improved and sales started to grow. A new long-range model, the A310, opened up new markets and pioneered twin-engine extended range operations that are now the biggest sector of the long-haul market sector.

By introducing advanced features, such as fly-by-wire flight controls, sidestick controllers, automatic flight envelope protection, two-crew operation, and glass cockpits, Airbus's fortunes finally took off in the 1980s and the

An Airbus A350XWB for Singapore Airlines is shown under manufacture.

Intro Cov ToC

1000th delivery was achieved in 1993. By 2007, deliveries had risen to 5000. In March 2015, the 9000th Airbus was delivered. In the meantime the sales backlog had risen to 6300 aircraft and the company was increasing production of its best-selling A320 family toward a monthly output of 50 aircraft.

Continuous product improvement has been the key to Airbus's market success. The A300 and A310 established a modular wide-body product line that featured a common fuselage width and cockpit and grew to include the more technically advanced A330 and A340. This pair offered a near-identical airframe and wing but with the option of either two or four engines. The enormous increase in engine reliability and added fuel economy saw the four-engine A340 dropped in favor of improved versions of the A330.

Today the A330-200 and -300 are still in great demand and now increased weight versions are available, to be joined in two years by the upgraded A330neo (new engine option) powered by two new Rolls-Royce Trent 7000s, which feature improvements adopted from the Trents developed for the Boeing 787 and Airbus A350XWB. The resulting A330-900 is aimed directly at challenging the Boeing 787-8, and will be in production alongside the all-new, bigger A350XWB, which will also challenge the Boeing 787-9 and 777 family of wide-body jets.

It was originally planned that the A350XWB, with its advanced wing and featuring a higher content of composite materials, would replace the A330, but demand from existing customers with large A330 fleets encouraged Airbus to revamp the design, and with the new Trent


An Airbus A380 for Asiana Airlines is shown taking off.

engines the A330neo is proving to be very popular as its performance will keep it highly competitive well into the next decade. That does not seem to have had any significant negative impact on A350XWB sales, however, and this latest Airbus entered airline service late in 2014.

Production of the A350XWB is ramping up toward 10 each month to help reduce the backlog of over 800 aircraft yet to be delivered. Using five development aircraft, the A350XWB program has been a smooth one for Airbus, with only minor delays regarding entry into services. The schedule called for this to take place in 2014 and it was achieved.

The popularity of the narrow body A320 family also shows no sign of slackening and new models continue to emerge. The earliest A320s are now 27 years old and many long-time operators are replacing these models with the latest versions. Total sales of the standard A320 family have reached 7679 as of the end of April 2015. Improvements to cabin arrangements have seen maximum passenger capacity on the A320 rise to 188 in a high-density configuration, designed for low-cost and charter operations, and this is being adopted by EasyJet, which has recently taken delivery of its 250th A320 family member.

The smaller A319 and larger A321 cater to varying customer range and payload requirements, allowing an optimized solution for their service route needs with high operational commonality across the family.

The new A320neo models feature a choice of the latest generation CFM LEAP 1A or P&W Pure Power engines and numerous other changes and improvements. Compared to the earlier A320s, the neo models offer a 20% saving in fuel burn per seat, lower noise and emissions levels, double the payload and an additional 500-nmi range improvement. Wingtip-mounted composite "sharklets" improve fuel consumption per passenger by up to 4%, and can be retrofitted to existing A320s as well as featured on new deliveries and neo models.

Shown is the budget economy class interior of an Airbus A380 (top), and the premium economy class interior (bottom).

In January 2015 Airbus announced the launch of a long-range A321, which would offer 4000-nmi non-stop transatlantic range capability, opening up new markets for the narrow-body jetliner and a possible replacement for current Boeing 757s.

The first PW1100G-powered development A320neo aircraft flew in September 2014 and the first LEAP-1A-powered A320neo just had its first flight this past May, yet already total sales have reached over 3620 from 60 customers and first deliveries are expected before the end of this year. Airbus has said it will raise monthly production to 50 by 2017 and may even take this up to 60 if demand continues at present levels.

Sales Go Up, Up, and Away

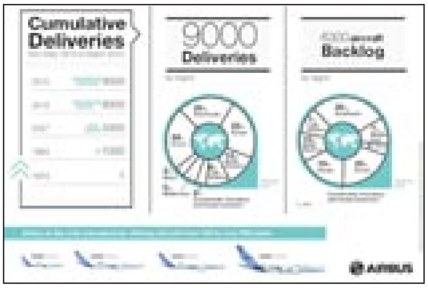
The A380, the largest commercial jetliner in production, has been in the air for ten years and to date 317 aircraft have been ordered and 159 delivered. The hoped-for one-for-one replacement of the world's jumbo-jet fleets hasn't happened, as most long-haul operators have chosen to replace the four-jet 747 with the twinjet 777, the extended capacity 777-300ER being particularly successful. However, on main-line routes that combine the need for high capacity and long range, the Airbus A380 is in a class of its own. The aircraft remains the only commercial jet with two full-length widebody passenger cabins offering a huge range of optional seat and class layouts.

Typically the A380 can carry 544 passengers in a four-class layout (first, business, premium economy, and economy) but in an all-economy high-density layout it can carry up to 853 passengers. The ultra-spacious cabin interior allows airlines to offer passengers more internal volume than any other commercial jet and this can include lounge and bar areas, wider economy seats, and specialized first-class luxury facilities, including individual cabins and even bedroom suites.

With a range of up to 8200 nmi, for long-haul passengers the comfort of the A380 has created a loyal following. The large capacity has also brought down the operating costs per seat-mile so that where traffic levels can justify such a big aircraft, the A380 can be a generous profit-maker for its operators. With built-in provision for a future capacity stretch, the A380 is well placed for the day when global air traffic will demand more ultra-large jets to avoid saturation of airport facilities and air corridors. In this respect it is still ahead of its time.

Boeing, the other giant of the commercial aviation sector, has also been clocking up record orders for its family of jets. Last year it brought home 1432 new sales, most contracts (1104 net) being for the legendary Boeing 737 family, now into its fourth-generation upgrade. Monthly production is running in the high 40s and is planned to rise even further as the company gears up for the new re-engined 737 Max family, powered by CFM LEAP-1B powerplants.

The Max brings a 20% reduction in fuel cost per seat and 40% noise footprint reduction. Revised aerodynamics,



Airbus's 9000th delivery cumulative orders chart.

The new 777X will build on the 777 and will include new engines, an all-new composite wing and will leverage technologies from the 787 Dreamliner.

Pictured here inside a paint hangar at Boeing Field in Seattle is the 7500th 737, which was manufactured for Malaysia-based Malindo Air.

Artist's rendering of the 737 MAX flight deck with four new large-format displays.

Boeing and Ryanair have finalized orders for 175 Next-Generation 737s.

with an extended tail cone and thickened rear fuselage plus new winglets, have reduced drag and together with the new engines and cockpit (which still retains much commonality with Next Gen 737s) offer yet another worthwhile upgrade to an aircraft that first emerged from the Boeing works in the 1960s. The rebirth success of this aircraft is astonishing. The latest 737 Max seems set to take production well into the second 50 years of its history, making it the best-selling commercial jet ever.

Boeing's second most popular model is the wide-body 777, which is being assembled at a rate of around eight each month. Net orders for 283 were received during 2014. The company needs to keep new orders coming in for the next two-three years to bridge the production gap until the 777-X enters flight development.

The 777-X will be powered by new GE9X engines and will feature an all-new longer wing design with greatly enhanced aerodynamics and raked outer sections that can be folded on the ground to allow compatibility with existing airport stand facilities. It will be the largest twin engine jetliner in service and Emirates Airlines showed its confidence in the new aircraft with an order for 150.

Many of the attractive cabin design features of the Boeing 787 will be incorporated including bigger windows and revised useable cabin width offering more passenger space and seat layout options. With the 787 well established in service and production flows increasing, the 737 Max coming forward as a priority program and a new 777-X entering the development phase, Boeing will have a competitive and balanced family lineup to face Airbus in the coming decade.

The one unknown issue is whether the company will decide to add another new model in the 200-250 seat category to replace outgoing 757s and 767s. The global market and business case for an all-new program is far from clear, though the company will be watching Airbus closely to see if significant airline interest emerges for the long-range A321, which might become a default 757 replacement if there is no rival Boeing product.

Big Data, Aircraft, and a Better Future

Aircraft manufacturers are exploiting the opportunities that come with collecting the vast amount of data available, from customer reports to engine exhaust temperatures. Why is it potentially so useful? What are some of the best ways to use it?

by Bruce Morey

The hype phrase today is "Big Data." It is a phrase Mark Bünger, Research Director for Lux Research, believes can have a number of definitions depending on who is doing the defining. Bünger was the lead analyst on a report that Lux published in April 2015 that surveyed both the technology as it is today and how various industries are adapting to the opportunities—and perils—in trying to exploit it.

Avoiding a precise definition in an interview with Aerospace & Defense Technology, Bünger explained Big Data is about raw data, databases, and speed. Companies now have access to a growing number of sensors attached to infrastructure and assets, from oil derricks to aircraft engines. These sensors provide vast volumes of data in high velocity. The data is variable—think spreadsheets to Twitter tweets. A major finding of its study is that, while information industries like banking and media know how to derive benefit from vast data sets, there is risk for industries that Lux terms "material-centric."

There is one material-centric industry that is gaining advantage in collecting, storing, and using data vast enough to qualify as Big Data. "The aircraft industry is pretty far along and other industries should follow its lead," he said.

This is especially true for engines over airframes, according to Bünger. "The [operating] conditions in engines are dynamic, with thousands of parameters, sometimes every millisecond. With airframes, the data rate is lower because data is only interesting during takeoff, some during flight, and then landing."

Mark Bunger from Lux Research notes that while the Velocity, Volume, and Variety definition of Big Data works for companies in IT, finance, and media, a better practical concept for industries like aircraft manufacturing and maintenance is around operational realities.

He also noted that it's not just the data for engines during flight that is worth tracking. Tools and parts in support of maintenance and repair operations are also useful. These require more advanced data capturing techniques, since the information is less structured even while using them efficiently is important. All of it becomes useful to the right company that knows how to use it.

"Big Data is a technology that is going to be very impactful for us," said Larry Volz, Chief Information Officer and Vice President for Pratt & Whitney. He too was wary about putting a precise definition on the term. "It is more about using the information we already have from our products and processes in a different way, moving from a descriptive analytical look at current information into being more predictive."

Predictive analytics—predicting future behavior and actions—is really what it is all about, according to Volz.

Moving From Reacting to Predicting

The key to predictive analytics is modeling all of that data statistically to gain new insights. The challenge and opportunity is in the nature of the data. The data store available to Pratt & Whitney today is indeed both vast and varied.

"We take data during manufacturing from our ERP/SAP system, we collect data during the build and overhaul operations, from customer service, our global field representatives, and warranty reporting system. We combine that with data from our on-wing engine health monitoring system, the Advanced Diagnostics & Engine Management, or ADEM," Volz said.

He also stressed that the company has all along been working with large data sets, such as simulation data used by design engineers to predict engine power output, NVH, and fuel burn. Now, by applying statistical models, they extend predictive capabilities to in-service use. He relates that they accurately predict unplanned engine events that could cause a delay or interruption in a flight.

Pratt & Whitney plans to capture 50 times more data on its newest engines, such as the geared turbofan PurePower PW1100G-JM engine shown here, compared to previous models.

On May 12, 2015, Pratt & Whitney announced it was delivering its eFAST to facilitate remote troubleshooting on all of Bombardier's CSeries aircraft systems.

According to Larry Volz, CIO and VP for Pratt & Whitney, predictive analytics is what big data is all about.

Although there were pockets of usage, as Volz described it, in 2014 the company decided to invest heavily with a company-wide initiative, working with IBM. He believes that incorporating outside expertise was important. "You need that expertise in areas such as statistical data modeling that a company like ours does not necessarily possess," he explained. "We now have 90-95% confidence in the statistical models, based on our legacy fleet of engines."

What does he view as the enabling technologies to make this true in 2015? "There is a convergence of three major factors," he answered.

First is P&W's prior investment in a global enterprise system that captures all of the product and process data needed. "That foundation is critical," he said. Second is the vast increase in the industry's high-speed computing infrastructure that can store and process these huge data sets at what Volz describes as a reasonable cost. Third is the ability today to merge both synchronous and asynchronous data and use them in predictive models—not just tables of numbers (synchronous), but word documents from customers and comments from field service representatives (asynchronous). "We can take sentiment data from customers and roll that into our statistical models," he said.

P&W is expanding this predictive analytic capability beyond engines. It will deliver its eFAST on all of Bombardier's CSeries aircraft systems to provide real-time monitoring of all critical aircraft systems, not just engines. The eFAST system will be the infrastructure unit used to perform data transmissions from the CSeries aircraft's onboard Health Management Unit to the ground.

Aircraft Industry on the Cusp

IBM, Pratt & Whitney's partner in expanding its monitoring and predictive analytic capabilities, certainly sees a future in the field. IBM has invested more than $30 billion to build its capabilities in using data better. The investments include R&D, more than 30 acquisitions, and new business units for Analytics, Watson, and Internet of Things (IOT). But a focus on the data itself, however "big" it might be, is not the primary focus of its efforts, according to Jerry Kurtz, North America Leader, Big Data & Analytics at IBM Global Business Services.

"The focus of our energy is making use of all available data, internal or external, structured or unstructured, to provide insights not available before," he explained. "It is all about moving beyond the past and present by predicting the future. We want to help companies like Pratt & Whitney predict problems before they happen."

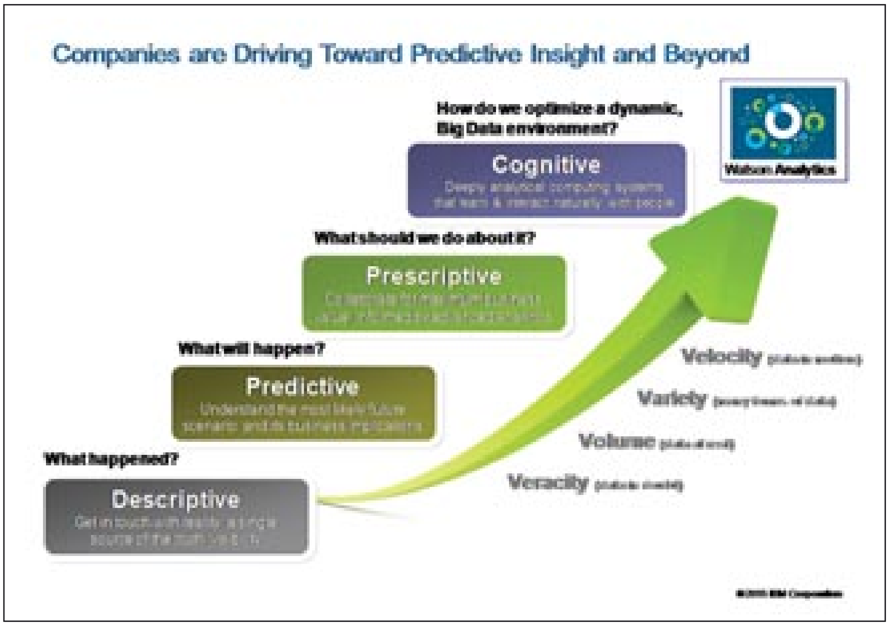
His experience with companies like Pratt & Whitney among many others led him to stress three important fundamentals that companies need to address in getting value from predictive analytics: business capability, information foundation, and organizational governance. "Business capability is about identifying specific use cases that provide specific value, such as the case with Pratt & Whitney predicting future engine events" through modeling, he explained.

Information foundation is the investment needed to make the right data accessible to provide useful predictions. "This is more expensive and actually provides less actual value than developing a specific use case, but it is required," he remarked.

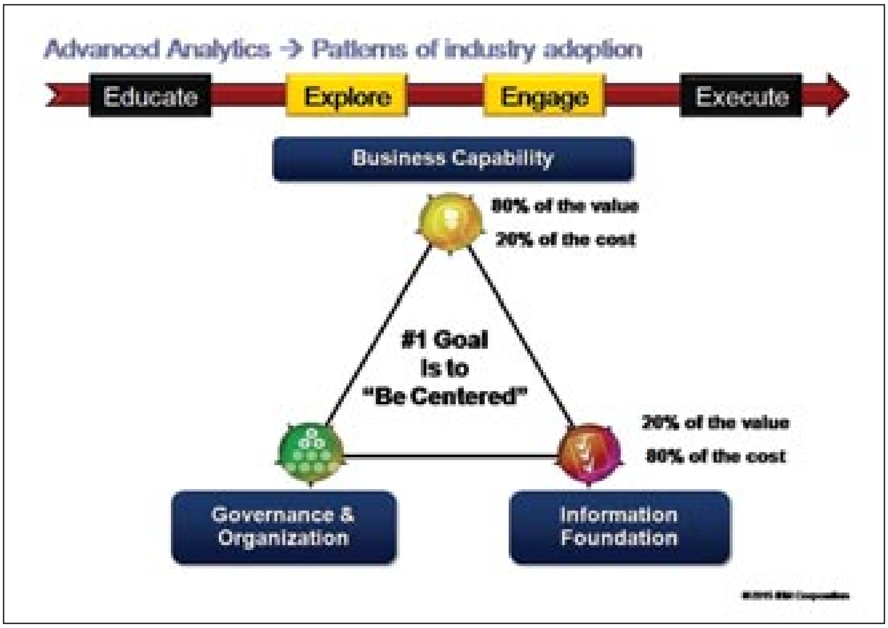
Finally, he also stressed the third factor—an organization ready to move into a new world of predictive, prescriptive, and cognitive use of data. Questions around positions and roles need to be answered. "What is the role of the CIO or Chief Data Officer? Does the organization need new skills? Do you insource, outsource, or co-source these capabilities?" he asked rhetorically.

He also believes that the aircraft industry, more than some, is ready to significantly expand its capabilities quickly. If industries like finance, insurance, and banking have significantly moved up a capability curve in taking advantage of analytics, aircraft will follow quickly. Why?

"They have spent the last few decades getting their house in order in basic transactions," he explained. This means installing the latest generation of ERP as well as getting structured processes and data in place. "This is re-



IBM's view of the ultimate evolution of predictive analytics is using the data stores available today in a cognitive manner.



The three pillars of developing a predictive analytical capability are equally important, according to IBM.

ally hard to do, but most companies [in aircraft manufacturing] are beyond that now," he said, making them ready to exploit data effectively for predicting and anticipating future events rather than reacting to events as they occur. The future will include tying this knowledge back into future designs, making a closed-loop system.

"I have seen fads in my 25-year career, and this is no fad," said Kurtz. "Everybody in aerospace is dipping their toes in the water. Everyone in aerospace manufacturing is working with us (or others) on some number of projects."

He thinks that in just a few years companies will have scalable, on-demand, cloud-based solutions with hundreds of models running in production, with predictive dashboards helping managers not only understand how engines or aircraft are currently operating, but how to intervene best to keep them that way for the future.

Unmanned Ground Vehicle Communications Relays

Figure 1. First-generation ADCR system on an iRobot® PackBot®.

The need for a high-bandwidth communication link to carry multiple video channels from a mobile robot (unmanned ground vehicle, or UGV) back to a control station requires using high-frequency RF communication links. These links are mostly line-of-sight, often limiting the flexibility of the robot's movement. The Autonomous Mobile Communication Relays project demonstrated the capability of autonomous slave robots to provide communication-relaying capability for a lead robot exploring an unknown environment.

Several generations of Automatically Deployed Communication Relay (ADCR) systems led to a robot-mountable Deployer module that deploys static relay nodes when and where needed. To meet specific in-theater requirements, the Manually Deployed Communication Relay (MDCR) system was developed. A fourth-generation ADCR system was developed in 2013 to automate the deployment of these fielded and proven MDCR relay nodes.

Radio Frequency Principles

One of the common weaknesses in other relay systems that causes them to fail in field tests is the use of high-gain antennas. While high-gain antennas may seem desirable for range extension, without the use of an electronic amplifier, this gain can only be achieved by focusing the radiation pattern.

For a relay system to be versatile and work well in various environments, low-gain antennas are generally best. Low-gain omnidirectional antennas should be used for a relay system to be versatile and able to work in a wide variety of environments with no a-priori terrain and placement information.

The height of the relay-node antenna when placed on the ground must be equal to or greater than the height of the antenna on the robot. Otherwise, the deployed relay node with a lower antenna would encounter lower received signal strength than the robot, and might be unable to join the network. When two nodes are in close proximity, the receiver front end of one node tends to get saturated by the strong signal emitted by the nearby node's transmitter. This may lead to mutual jamming so that neither can enter the network. This often means that only one node should be on at a time while being transported by the robot.

MDCR relays and end-point radios use standard half-wave dipoles with 2.1-dBi gain. Active MDCR nodes (operating at 4.9 GHz) must be kept at least approximately 1 m (40") from each other to ensure no mutual jamming. For this reason, in the first- and second-generation ADCR systems, only one stowed node inside the Deployer module was active at any given time. The system ensured that the active node had successfully joined the network before deploying it and activating the next node in the Deployer module. In the MDCR design, both relay nodes had to be active while being carried by the robot. Placing the two nodes on a level tabletop at the same distance apart prevented them from entering the network.

Input filtering is the best defense against unintentional radio frequency (RF) jamming to preserve the link between the operator control unit (OCU) and the robot. A commercial bandpass filter was used on the OCU-side MDCR end-point radio to mitigate jamming issues. The center frequency and bandwidth of the bandpass filter were chosen to match the relay network's frequency characteristics. The bandpass filter helps to attenuate the noise out-

Intro Cov ToC

side the frequency band of interest, improving the overall signal-to-noise ratio of the received signal.

Wireless Networking

The high throughput required to transfer multiple streams of video data from a remotely controlled vehicle (often outfitted with multiple cameras) limits the practical number of relay nodes in the data route. This limit is about three for 802.11g wireless networks. Techniques for increasing this limit include reducing the video resolution, eliminating the color component, or using multi-frequency radios.

Due to the delay incurred in establishing a new route, the constant switching between two routes could bring the network to a halt. One way to prevent this is to use some measure of hysteresis and “good enough” metrics so that a new route is not selected as long as the current route can still carry the required network traffic.

The required throughput, type of data, mesh topology, and the data usage determine the maximum number of relay nodes that can be used in a data-traffic route. Problems with remotely controlling the vehicle in real time begin to appear after three relays are present in a linear route. This can be mitigated by reducing video resolution, number of cameras, and/or dropping color information from the video stream. Another solution is to use dual-frequency radios to allow si-

Figure 2. Second-generation ADCR system on an iRobot® PackBot®.

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multaneous transmission and reception of data at each node, increasing the overall throughput capacity of the mesh network.

Antenna Deployment

Several key attributes are desired in a relay-node antenna mast deployed from a UGV. Appropriate antenna height is considered critical. Additionally, resistance to impact loads and durability are also very important. Deployment of the relay node may be while the UGV is in motion and may include a freefall to the ground. For this reason, the relay node and antenna must be constructed to mitigate the destructive effects of ground impact. An antenna mast can be constructed to withstand the impacts or stowed within an outer shell that protects it until after the node has been placed. The antenna can then be deployed.

Deployable antenna masts are usually more complex because they need to transform from a compact shape inside the relay node enclosure into a long, straight, vertically oriented mast. Many different concepts of deployable antenna were examined to understand their utility. Nine types of antenna masts were analyzed, and of these designs, the spring-hinge and spring-steel foldable masts are most suitable for relay nodes to be deployed from moving unmanned ground vehicles.

A spring-hinge antenna mast is made of three aluminum links, a radiating element, and four spring hinges. The mast is folded and stored in a cavity in the relay node for protection until the relay node has come to rest on the ground surface. This type of antenna mast proved effective for deployment from vehicles the size of an iBot® Packbot® UGV. The antenna mast was approximately 18" tall and could be folded into a relay node less than 8" long. This design could be scaled to larger systems. The relay enclosure protected the antenna effectively before mast deployment. However, the complexity of the mast reduced its durability.

A spring-loaded linear telescoping mast with stacked links was developed as a conceptual prototype. It was very com-

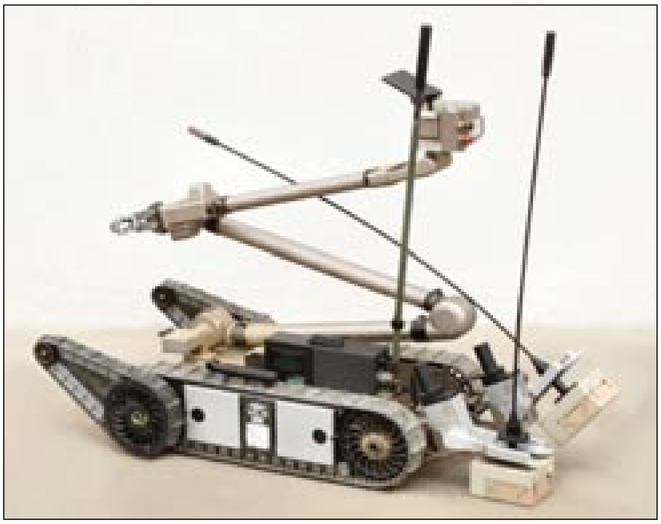


Figure 3. Fourth-generation ADCR system on an iRobot® PackBot®.

pact, but also very complex and prone to jamming. A spring-steel foldable antenna was used with the MDCR system. The antenna mast is rugged and flexible; it can be bent 180° at one point and still return to its original position. It is constructed from two long strips of spring steel, each with a parenthesis-shaped cross section (similar to a tape measure). The two pieces of spring steel are held together with an outer sheath, and the coaxial cable for the antenna runs between the pieces of spring steel. This type of antenna mast, designed for use with UGVs, is rugged, reliable, and can be configured to reach a beneficial height.

Relay Node Deployment

A relay-node enclosure contains the radio, battery, and electronics, and provides for antenna deployment. It must also be designed to meet the shock, vibration, ultraviolet, thermal, and ingress protection requirements of the application. Interface requirements may also need to be considered, such as recharging, power switch, battery level, relay retrieval, remote power toggling, and channel selection.

The robot carries a Deployer module that contains the relay nodes to be deployed. Since a relay node takes a finite amount of time to fully boot and enter the network, it is of utmost importance to have a relay node that is fully booted and in the network before deployment is needed. This prevents any network interruptions because of deployment.

All deployment systems require a method for placing the relay node on the ground. The first-generation ADCR system (Figure 1) used a compression spring-loaded mechanism. The second-generation ADCR system (Figure 2) used a constant-force spring-loaded mechanism. MDCR used a fork with magnets to hold the relay node securely, with the node placement accomplished by the robot flippers. Finally, the fourth-generation ADCR (Figure 3) used a motorized forked carrier with magnets to place the relays. Many other methods are conceivable, such as dropping the relays out of the bottom of a Deployer using gravity. The spring-loaded designs had the benefit of allowing relays to be closely packed into a small space on top of the robot. Shock isolation is an important consideration when designing a relay node that will be dropped from a fast-moving UGV or from a considerable height. For this reason, internal electronics may need to be mounted on shock and vibration isolators.

An Ethernet link is normally used to communicate between the robot and the relay-deployment module it carries; however, Ethernet is not a strict requirement. If the robot is one of the older analog systems, then a video/audio codec board can be used to convert the analog signals to Internet Protocol (IP) Ethernet data.

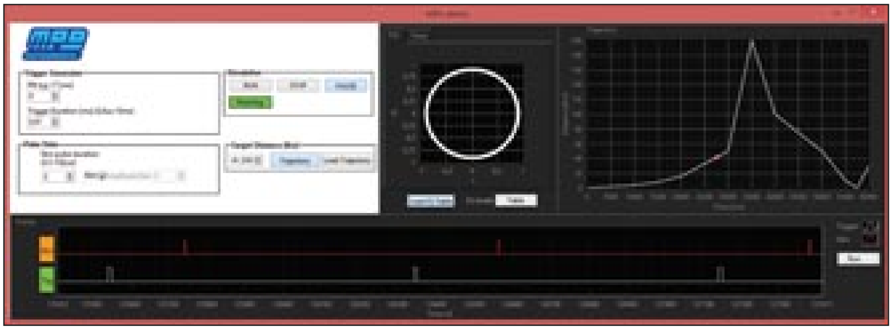
One of the common issues with initial prototype systems was that the robot and OCU needed to be reconfigured for every test. This was an unfriendly, unreliable, and time-consuming process. Additionally, this is unacceptable for a system to be fielded. The systems had to be plug-and-playable, with no configuration needed on the target robot or OCU. This started a search of various technologies to make connecting the robot and OCU over a mesh simpler, and resulted in the use of VPN technology, specifically, OpenVPN. This technology provides a wrapper around the network messages, providing a plug-and-play solution. The radios do not need to know which robot or OCU generates or receives the traffic data; hence, no robot or OCU configuration is needed. The drawback, however, is that data generated by one radio can only be received by the other in the pair, while the intermediate relay nodes can be any compatible mesh node.

This article was written by Hoa Nguyen, Narek Pezeshkian, Aaron Burmeister, and Abraham Hart of Space and Naval Warfare Systems Center Pacific (SSC Pacific), San Diego, CA. For more information, visit ***http://info.hotims.com/55592-541*.**

System Generates and Simulates Skin-Echo Pulses for Radar Testing

One of the methods for radar testing is the simulation of an environment where there are dynamic or static objects that are scanned by the radar under test. In particular, simulation implemented by MPG Instruments (Rome, Italy) generates skin-echo pulses coming from radar that transmits a defined pattern stream. The system simulates an object in the scanning area of the radar and is hit by a pulse pattern stream. The X-band radar must be tested at a frequency from 7 GHz to 12.5 GHz, and K-band between 12 GHz and 40 GHz.

Since the pulse pattern streams of radar can be extremely different from each other in terms of pulse width, PRI, modulation on the pulse, and frequency of transmission, the simulation system must generate a scenario and transmit skin-echo pulses that are customizable by operators.



The LabVIEW interface for configuration, setup, and management of the simulation.

Hardware used to implement the Radar Target Simulator.

The system simulates the presence of an object within the coverage area of the radar under test. It can simulate either a static object or a dynamic object. If a static object is selected, the operator can set the distance of the object from the radar. The system hangs up the synchronization of the radar under test through the radar trigger output, which indicates the time when the pulses stream is transmitted, calculates the flight time of pulses, and transmits the skin-echo pulse back at the correct time to simulate the presence of an object at the distance specified by the operator. If a moving object has to be simulated, the operator can insert a completely customized trajectory of the object. The system can accept a trajectory pattern composed by the distance from the radar and time of the simulation. That means the system will be able to simulate objects either at constant or variable speed, with accelerations and decelerations during the simulated trajectory. Once hooked on the trigger of the radar under test, the system will calculate the flight time, apply the appropriate manipulation, and transmit the skin-echo pulse back.

In developing this test system, critical points were encountered. Performance of radar under analysis is characterized by high operating frequencies, combined with considerable bandwidths, and highly reduced frequency switching time. To cover a wide range of applications, the testing system can operate at a frequency between 10 MHz and 15 GHz, and transmit pulses of 500 ns to 10 µs, inside which the carrier can be further modulated in accordance to a defined pattern, with a repetition frequency of 10 Hz to 1 kHz.

To achieve this target, the system uses an NI PXIe-5646R vector signal transceiver (VST) from National Instruments (Austin, TX) to generate and process signals in the intermediate frequency (IF) band. The modulated signals are then sent to a range extender that executes up-conversion of the IF signal at higher frequencies, manages the frequency agility, and controls the phase coherency if required (for example, in beam forming applications). The range extender also has the task of generating a reference frequency at 1200 MHz characterized by extremely low phase noise. The VST modulates it and sends it back to the range extender.

The system features a LabVIEW interface that manages the simulation and can configure the pulse stream (pulse width and PRI – Pulse Repetition Interval) and the configuration of the trigger generator (if there is no way to access the radar trigger). The pulse is fully characterized by loading an I/Q data table that is then processed by the I/Q modulator; the software interface will also show the modulation in the time domain. The operator can choose between a static or dynamic object, and can load a customizable trajectory to run.

During simulation, the trigger and the skin-echo pulses are depicted on the lower graph of the interface that moves according to time. If a dynamic object has been selected, a graph of the distance against time will show the trajectory loaded by the user, and a red pin on the trajectory will indicate the precise position of the object and its behavior (distance from radar and time from the beginning of the simulation). The user will then be able to pause the simulation to stop a moving object in real time while the simulation is still in progress.

The result is a system capable of generating radio pulses with a resolution of 8 ns, based on the sampling of the I/Q modulator. It can then accurately characterize the flight time with a sampling rate of 125 MS/s that results in a spatial resolution of 2.4 meters. The system can simulate a maximum radar coverage area of 400 km.

This article was written by Mauro Cortese of MPG Instruments. For more information on NI equipment used in this application, visit ***http://info.hotims.com/55592-542.***

High-Strength Aluminum Powder Developed for Additive Manufacturing in Aerospace, Automotive

Metal laser melting has made a successful leap from rapid prototyping to an approved manufacturing technology, and the method is increasingly becoming an option for companies in high-tech industries, according to Toolcraft. And now the German manufacturer has teamed with Airbus APWorks to offer another option for additive manufacturing—the Airbus subsidiary's Scalmalloy high-performance aluminum powder.

Scalmalloy from Airbus APWorks is a corrosion-resistant material with the specific strength of titanium at a simultaneously high ductility. It is more than twice as strong as the aluminum-silicon powder currently in use.

"The cooperation between Toolcraft and Airbus APWorks has existed since the beginning of this year and as of now we process Scalmalloy," Christoph Hauck, Managing Director at Toolcraft, shared with Aerospace Engineering. Regarding challenges using the material, Hauck noted that Scalmalloy is a completely new alloy, so "the components need a fully new development of parameters."

Toolcraft also uses nickel and titanium alloys, stainless and tool steels, as well as aluminum-silicon alloys in its metal laser melting process. Any material that is weldable can be processed.

Scalmalloy is described as a corrosion-resistant material with the specific strength of titanium at a simultaneously high ductility. It is more than twice as strong as the aluminum-silicon powder currently in use, according to Toolcraft. These properties make the new alloy ideally suited for high-performance applications in the aerospace, aviation, and automotive industries, as well as for special machinery manufacturing: "For example, highly durable parts with extraordinary high-strength properties," Hauck added.

Toolcraft continuously seeks to improve its procedures and to expand its material base, Hauck noted, so materials-procurement partners are essential. "The Airbus Group has produced a type of powder that not only exhibits the positive properties of aluminum, but also very high strength with good elongation at break. Scalmalloy is therefore unique in the market," he said.

Scalmalloy is more expensive than standard aluminum alloys, according to Hauck: "There is no serial production of the material yet. The costs can be compared with titanium powder."

In the field of metal laser melting, Toolcraft provides a range of processes from engineering to additive manufacturing and heat treatment to finishing by turning or milling, as well as final tactical or optical measuring. It also uses a system for nondestructive surface testing and meets the requirements of the EN 9100 certificate for aerospace applications.

The cooperation with Airbus APWorks—the technical consulting firm and production operation for additive

The new alloy's properties make it ideally suited for high-performance applications in the aerospace, aviation, and automotive industries.

Toolcraft uses laser melting machines from Concept Laser that offer a workspace of 250 x 250 x 280 mm in the x, y, and z directions.

metal components at the Airbus Group—strengthens the process chain through enhanced topology optimization of the design data. Components can be evaluated in advance, taking advantage of the possibilities provided by additive manufacturing for potential redesigns, parts consolidation, and weight reduction.

"The additive manufacturing process builds up a workpiece layer by layer, as the laser melts the material concerned in powdered form," Hauck explained. "The material is checked for different properties by different analytic tools. The design data for the manufacture of the piece is divided into cross sections and then formed on top of one another during the melting process. The piece is thus literally built up in a '3D' way."

Four laser melting machines from Concept Laser are in use. The machines offer a workspace of 250 × 250 × 280 mm in the x, y, and z directions. They melt down layers measuring 20-80 µm in thickness at a speed of 2-20 cm^3/h depending on the material. The laser has an output of 400 W.

The new Scalmalloy material is now ready for production applications, Hauck said.

Ryan Gehm

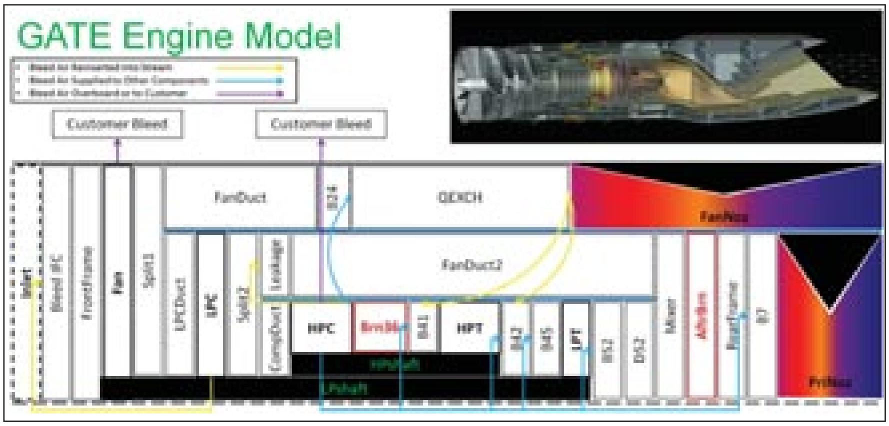
Propulsion Performance Model for Efficient Supersonic Aircraft

For the design process of the class of aircraft known as an efficient supersonic air vehicle (ESAV), particular attention must be paid to the propulsion system design as a whole including installation effects integrated into a vehicle performance model. The propulsion system assumed for an ESAV considered in a recent study done by Optimal Flight Sciences LLC and the Air Force Research Laboratory was a three-stream variable cycle engine (VCE).

The importance of engine performance on overall aircraft performance, even when using traditional performance methods, is hard to overstate. The ability to capture airframe-propulsion system interactions during air vehicle performance analysis promises great insights into the air vehicle design process.

Prevailing airframe-propulsion design methods involve high-fidelity, single-discipline propulsion modeling translated to a low-fidelity table format for an airframer's use in traditional performance modeling. The airframer may be required to add installation effects to this reduced engine model that are not coupled to the propulsion model that originally generated the table. This approach is not sufficient for the integrated nature of propulsion systems envisioned for future aircraft, including an ESAV class.

When information is passed from the airframer to the engine manufacturer in the early design stages, it is generally limited to net thrust and thrust specific fuel consumption (TSFC) requirements at some few points in a mission envelope. If an engine or engine core that already exists will be used to power the aircraft program, the data passed to the engine manufacturer are scale factors of the above parameters.



NPSS is a component-based object-oriented engine cycle simulator that is designed to perform many common tasks related to a propulsion system. Shown is a three-stream variable cycle engine.

It can be argued that a better aircraft system could be produced if a high-fidelity interface between the engine manufacturer and the airframer existed during conceptual design stages. Without this coupling, real physical interactions that are key to the eventual design that might otherwise possibly be capitalized on through design work will be missed, and will of necessity be dealt with later on costing money and usually aircraft system performance.

In this study, a computational model was built with the Numerical Propulsion System Simulation (NPSS) software to analyze the engine. This engine model was based on the generic adaptive turbine engine model developed at the turbine engines division of the AFRL. Along with this variable cycle NPSS model, a three-ramp external compression inlet model meant for conceptual design was developed. This model was used to capture inlet installation effects, including those attributable to angle of attack changes at supersonic Mach numbers.

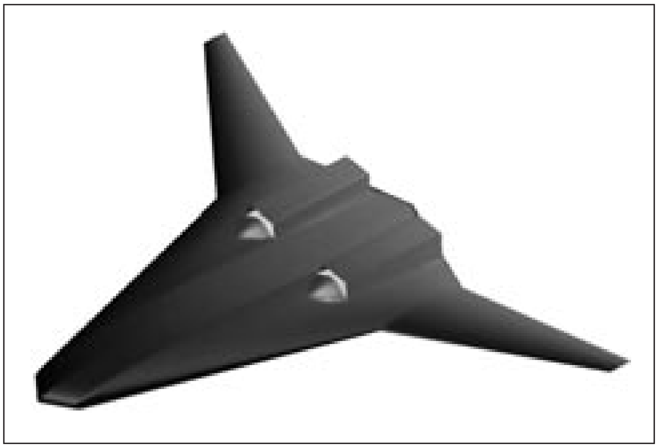
Those models were integrated into the Service ORiented Computing EnviRonment (SORCER), which enables parallel execution of the installed NPSS model to rapidly evaluate a full flight envelope. The SORCER-enabled NPSS model was used to produce an engine deck with an expanded selection of variable-state parameters compared to a standard conceptual level engine deck. These parameters were the inlet angle of attack, inlet flow bleed percentage, and flow holding percentage. This multiparameter engine data was used to evaluate the performance of an ESAV system model. The results of the evaluation showed that the additional nontraditional variable parameters included in the engine deck are significant and are worthwhile to consider in aircraft design work.

A conceptual design level, three ramp, external compression inlet model was constructed and integrated with the Generic Adaptive Turbine Engine (GATE) NPSS model. The inlet model was built using two-dimensional compressible flow equations, and it was verified in that it agreed well with flow results using the higher fidelity Euler code, CART3D. This inlet model and the parameterization and wrapping of GATE to be used in a multidisciplinary design and analysis optimization (MDAO) context is collectively called the MSTC-GATE installed propulsion model. (MSTC is the Multidisciplinary Science & Technology Center with AFRL.)

The inlet code was integrated with the GATE model in NPSS for the purpose of being able to calculate the installed propulsion multiparameter performance at the conceptual design level. The inlet model enabled the calculation of spillage drag using a physics-based approach. In addition, further effects and parameters were exposed to the aircraft design space including angle of attack effects and variable engine component settings.

The MSTC-GATE model was incorporated into the SORCER environment to facilitate the coupling of physics between different aircraft disciplines and to make the MSTC-GATE model computationally tractable for MDAO applications. Therefore, changes in one discipline can propagate into the whole aircraft system so that all affected disciplinary analyses can be properly updated. In this way, the complex physical effects that occur between different aircraft subsystems can also be accounted for, and possibly exploited, during the conceptual design phase, such as coupling propulsion and aerodynamics disciplines.

This effort utilized SORCER to exercise MSTC-GATE so as to study the effect of aircraft angle of attack and varying the engine diffuser bleed percentage and the flow holding value on aircraft system performance. To understand the impact of these parameters, the engine was coupled to a supersonic-capable lambda wing planform aircraft. Different performance methods that either utilize or fix various features of the MSTC-GATE engine model were evaluated. It was found that the impact of the features explored in the study such as angle of attack linking, supersonic spillage drag, flow mismatch spillage drag, and VCE



For the purposes of this study, an ESAV was defined as a lambda wing concept with two identical engines. The inlets on this ESAV concept are not two-dimensional external compression inlets, but are representative only of the ESAV configuration.

features with objective functions of TSFC minimization, spillage drag minimization, and SEP maximization all have a measureable effect.

These extra parameters, beyond the traditional Mach number and altitude mission envelopes, permit deeper insights into high-performance aircraft design by bringing more realism and physical effects earlier into the design process through multiparameter performance analysis. Conceptual design traditionally sets the majority of the eventual aircraft cost with the least amount of knowledge during the design process. This work has improved the situation by increasing the level of knowledge available at this stage of the design process, thus ideally reducing the eventual cost of the final aircraft and/or increasing the final system performance.

This investigation found that determining the optimal use of a VCE is a multiobjective optimization problem that is more complicated than the single objective problem envisioned.

Additionally, the potential to improve overall airframe-propulsion system level performance was demonstrated by showing that increasing drag improved the engine operational efficiency. This emphasized the importance of designing the propulsion system and airframe simultaneously for best performance.

Finally, researchers showed how a VCE could be used to operate the same air vehicle for either maximum specific excess power (SEP) or minimum mismatch spillage drag (only two of the many possible objectives). A standard aircraft performance analysis produces one SEP plot per air vehicle, whereas the multiparameter performance method offers designers an expanded view of many different flight envelopes based on different objectives for a complete picture of aircraft capability. These two objectives and their effect on the flight envelope were quantified as an example.

This article is based on SAE International technical paper 2014-01-2133 by Darcy Allison, Optimal Flight Sciences LLC, and Edward Alyanak, Air Force Research Laboratory.

Testing Multijunction Solar Cell Efficiency

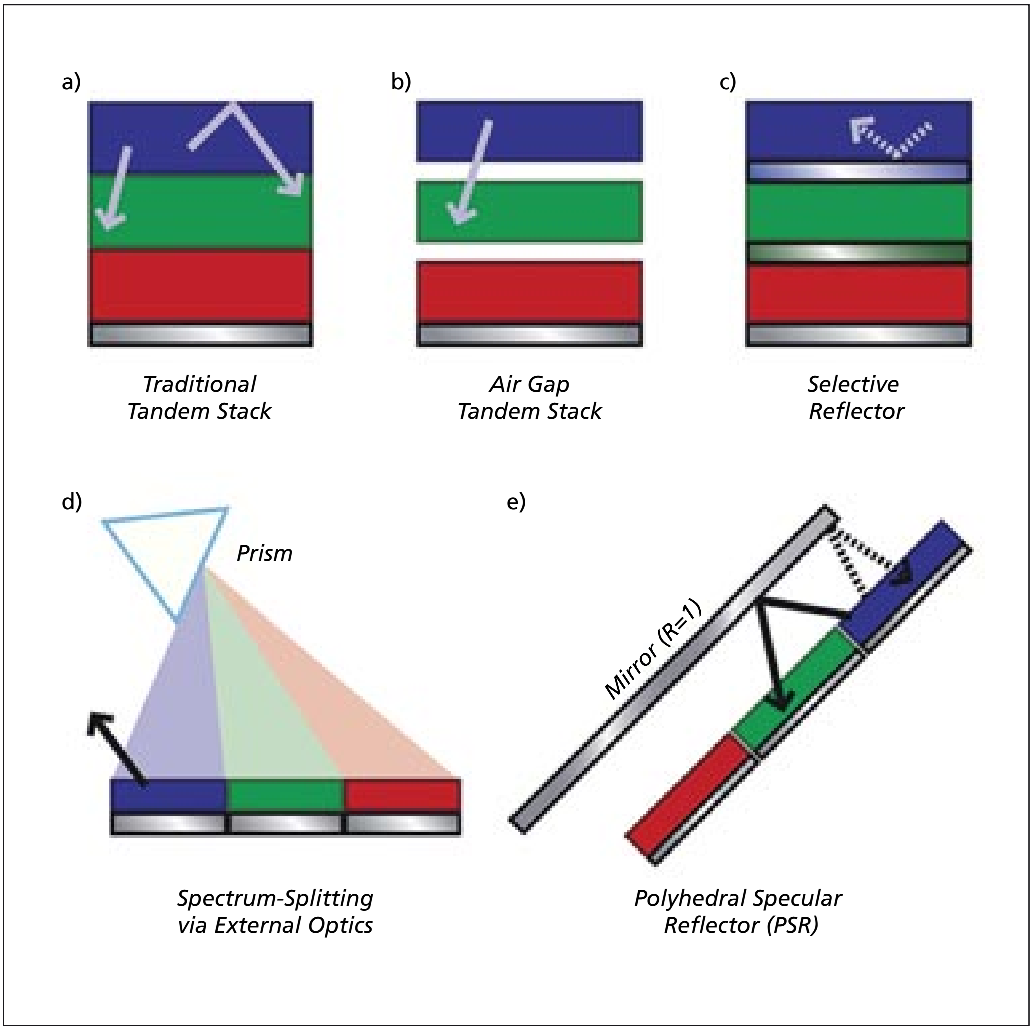
Different architectures were tested to provide insight on how their optical environments affect overall efficiencies.

U.S. Department of Energy, Washington, DC

The photovoltaic community is closer than ever to achieving ultra-high multijunction solar cell efficiencies (>50%). Subcells from III–V compound semiconductors are approaching ideal Shockley–Queisser behavior and emit significant radiation of photons with energies equal to or above the optical bandgap because non-radiative recombination has been minimized with advanced growth processes. The optical environment of a solar cell controls where the radiated photons from a subcell are directed, and this greatly affects its efficiency. Thus the optical design of multijunction architectures is crucial for maximizing performance. To date, light trapping and radiative coupling have been investigated as promising optical design strategies. Light trapping inhibits the radiative emission of a subcell in order to reduce the dark current and increase voltage.

This work investigated different multijunction architectures to provide insight on how their optical environments affect overall efficiencies. A simple model was employed to understand how radiative coupling between subcells with back reflectors can improve multijunction performance. This was compared to the previously assumed maximum efficiency case. For cells that do not utilize radiative coupling, decreases in subcell voltages and efficiencies for architectures that incorporate back reflectors on all subcells were analytically derived and experimentally verified. Increasing the radiative coupling between subcells enables these incurred losses to be minimized. Finally, the effect of radiative coupling between subcells with back reflectors for spectrum-splitting architectures was determined, as well as the overall efficiencies for these devices.

Previous time-symmetric multijunction architectures include the traditional tandem stack, the air-gap tandem stack, and the selective reflector structure. In all of these structures, subcells are stacked in order of decreasing bandgap such that the incident spectrum is divided by above-bandgap absorption of the subcells. Both the traditional and airgap tan-



Schematics of various multijunction cell architectures. Solid arrows denote photons that are radiatively coupled from the blue subcell to the green subcell; dotted arrows denote radiatively emitted photons that are trapped in the same subcell. Structures (a) - (c) represent traditional multijunction architectures that have been studied previously. The selective reflector structure (c) is the most efficient and has no radiative coupling. Structures (d) and (e) represent more novel spectrum-splitting architectures in which subcells are spatially separated from one another.

dem stack structures can radiatively couple between subcells, but the air-gap tandem stack can trap some of the radiative emission in the same subcell due to the refractive index contrast at the air–semiconductor interface on both sides of each subcell. By contrast, the selective reflector structure does not have any radiative coupling.

The selective reflector has the same benefit as a back reflector for a given subcell, but it can also restrict radiative emission for the next subcell if the difference between bandgaps, or spectral window, is small enough to reflect the radiative emission of the next lowest subcell. The selective reflector structure is more efficient than the tandem stack structures for finite numbers of subcells because the strong light trapping benefit from the selective reflector greatly outweighs the benefits from radiative coupling in the other structures.

In the architectures studied here, light is split and distributed onto a set of independently grown subcells either by an external optical element or by manipulating the packing of the subcells in the structure. This work only considers time-symmetric structures to provide the best comparison to the other geometries. However, spectrum-splitting structures can exceed the efficiencies of a selective reflector structure if radiatively emitted light can be coupled between subcells that have back reflectors. Because this geometry can recycle radiatively emitted photons between subcells that have back reflectors, a higher conversion efficiency beyond that in previously studied geometries was derived.

Analysis and experimental results show the important role of radiative coupling, and how spectral window and optical environment dictate the performance of subcells in a multijunction cell. As the number of subcells increases, the photon each subcell receives will decrease, reducing the power it converts, and this dependence is exacerbated when there is a lack of photon recycling between subcells. However, if subcells can radiatively couple into other subcells, this reduction is less significant.

This work was done by Carissa N. Eisler, Matthew T. Sheldon, and Harry A. Atwater of the California Institute of Technology; and Ze'ev R. Abrams and Xiang Zhang of Lawrence Berkeley National Laboratory for the U.S. Department of Energy. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Instrumentation category.***
DOE-0001

Thermal Response of Ultra-High Molecular Weight Polyethylene (UHMWPE) Materials in a Flash Flame Test

UHMWPE fabric and composite material, protected by a flame-resistant fabric outer layer, were tested in a flash flame environment to determine melting point.

Army Natick Soldier Research, Development and Engineering Center, Natick, Massachusetts

Testing was performed on Ultra-High Molecular Weight Polyethylene (UHMWPE) fabric and composite material in a flash flame environment when protected by a flame-resistant (FR) fabric outer layer. UHMWPE material has excellent ballistic protection properties, but has generally not been considered for ballistic protection garments due to its low melting point. This research was conducted to determine if UHMWPE materials could be considered for use in the recently developed protective undergarment (PUG) if worn beneath an FR uniform.

UHMWPE fibers are manufactured from solvent-based spinning processes, and have very high tensile strength and stiffness. They also have low density and are flexible. These properties have made UHMWPE fibers beneficial in ballistic protection applications. UHMWPE fibers have a low

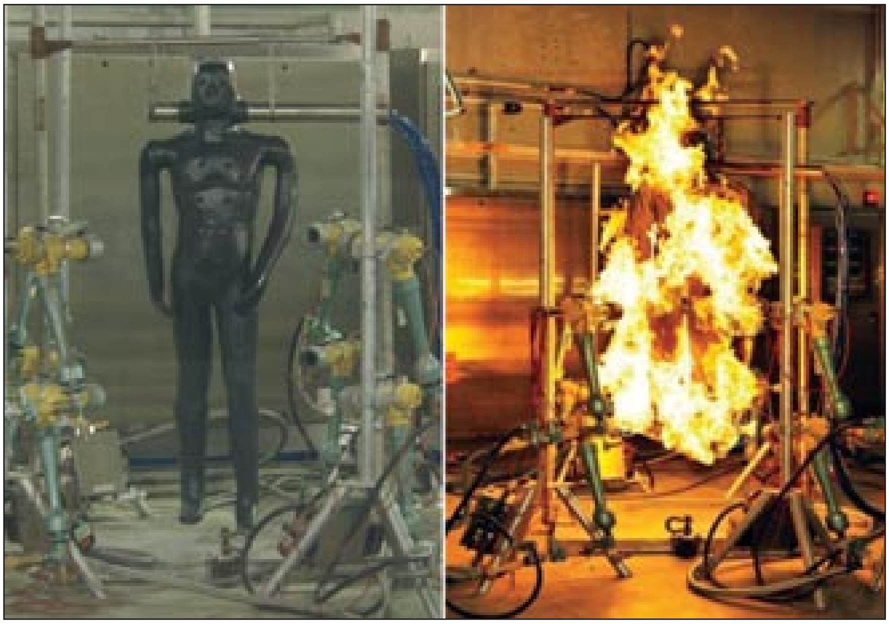


Figure 1. The flash flame test conducted on the thermal test manikin.

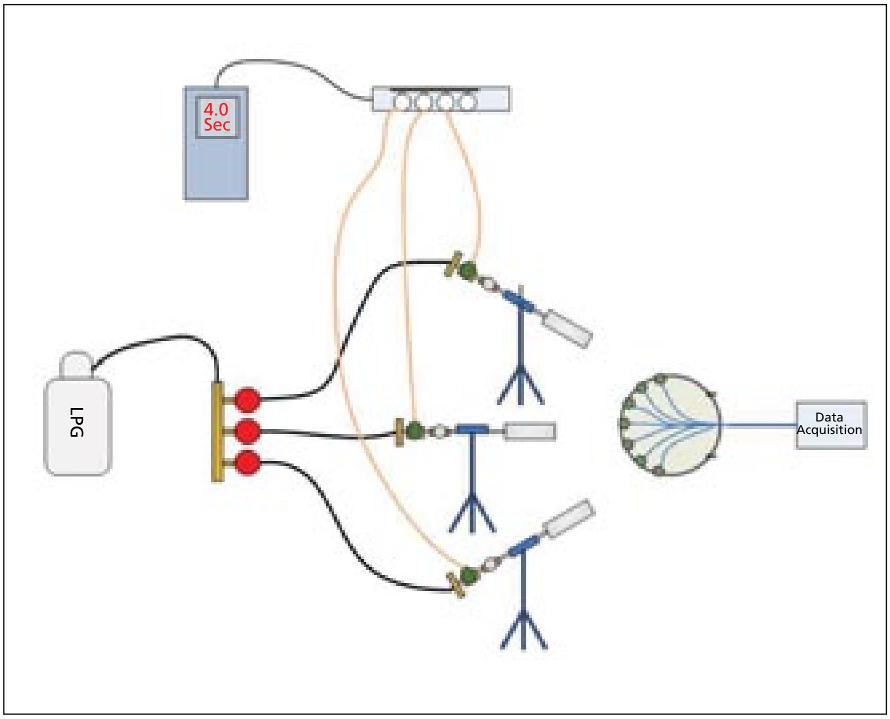


Figure 2. The midscale test setup.

melting point at approximately 135 to 150 °C. A concern with any thermoplastic that has the potential for exposure to high heat or flame is the melting of the polymer into a liquid phase, which could allow the hot material and flames to spread by dripping or flowing. In the case of thermoplastic materials in garments, there is concern that melted material may cause even more severe burn injuries by melting and re-solidifying over areas of burnt skin.

Midscale and manikin flash flame tests were conducted. Special garments were constructed for testing on the thermal manikin (Figure 1). The UHMWPE materials were fabricated into undergarments consisting of shorts and a vest. An outer layer of FR material was fabricated into a coverall worn over the UHMWPE undergarments. The midscale flash flame tests were used for preliminary testing during design and fabrication of prototype garments with UHMWPE materials and FR fabrics. These tests helped guide the choice of materials and fabrics by showing the response of the material configurations as they were exposed to increasing durations of flash flame.

An instrumented manikin that measures heat flux through 123 insulated copper slug calorimeters was used. The Army specifies a 4-s flame duration for testing combat uniforms, and heat flux data are collected for a total of 120 seconds. The heat flux data are input into a skin burn injury model, which outputs a predicted burn injury level (severity and area).

The midscale test is a more efficient means than the manikin test to develop an understanding between the relationship of heat input and material response (Figure 2). The UHMWPE fabrics tested on the manikin were chosen based on results of several initial rounds of midscale testing. The midscale test is conducted with the same basic test setup as the instrumented manikin test, using a cylinder or flat panel test apparatus. All of the flash flame test apparatuses used (for both midscale tests and the manikin testing) were instrumented with copper slug calorimeters.

The midscale test results showed that any direct flame on the UHMWPE materials will cause rapid disintegration of the material. These materials must be shielded by an FR material to prevent direct exposure to flames or high heat flux. The cylindrical midscale test showed that one of the UHMWPE materials was shielded from the flame, but it became evident that the hot gasses were able to flow behind the material, causing increased damage to the UHMWPE layer underneath. In the flat panel midscale test, this effect was prevented by clamping the material around all edges of the flat panel. The flat panel provided the most control, and was used to test all of the layered material combinations.

A major difference between testing materials on the thermal manikin and the midscale flat panel is the amount of variability in the heat flux over the testing surface, measured by different sensors at different locations in the same test. The standard deviation in heat flux calibration tests on the manikin was at least twice the standard deviation from the same test on the midscale flat panel. For the tests on the thermal manikin, this means the materials were exposed to heat flux in some areas that was significantly higher than the average, while significantly lower in others.

Undergarments of any kind reduced transmitted heat flux and predicted burn injury. The heavier UHMWPE undergarments showed a greater reduction in transmitted heat flux, as would be expected with any material.

In each of the six tests with the UHMWPE fabric undergarments on the thermal test manikin, some damage was observed in the undergarments. This damage was a localized deformation of the fabric, where some of the material had solidified into a hardened plastic area.

As was expected, preliminary testing with the vertical flame and midscale flash flame testing showed that the UHMWPE fabric must be shielded from direct flames, or it will be rapidly destroyed and consumed. It may be possible to incorporate UHMWPE materials in a protective garment (such as the PUG) and still provide the FR performance required to pass flash flame manikin tests.

This work was done by John Fitek, Margaret Auerbach, Thomas Godfrey, Mike Grady, and Gary Proulx of the Army Natick Soldier RD&E Center. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Materials & Coatings category.*** *ARL-0180*

Thermal Conductivity Measurement Setup for Low-Temperature Characterization of Laser Materials

Cryogenic lasers substantially increase the efficiency and power of existing room-temperature lasers.

Army Research Laboratory, Adelphi, Maryland

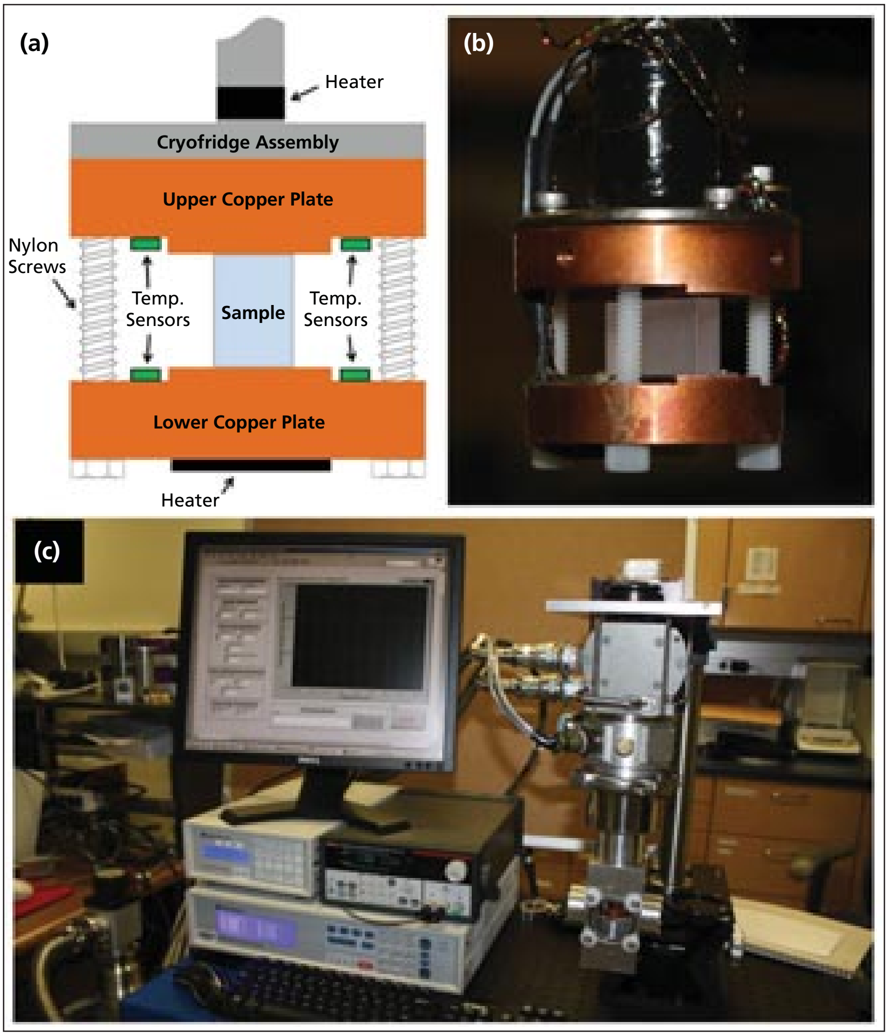
Operating lasers at cryogenic temperatures gained maturity only in the mid-90s due mostly to the progress in transparent, laser-grade ceramics and semiconductor pump sources. The main limiting factors for power scaling of room-temperature solid-state lasers are thermal effects such as thermal lensing, induced polarization losses, and fracture.

These detrimental thermal effects can be substantially suppressed by cryogenic cooling. The cryogenic temperatures modify the spectroscopic characteristics of the laser media. A possible concern is that the bandwidth of both the emission and absorption of the cryogenic laser host may be reduced down to less than 1 nm, introducing more stringent requirements on line width and emission peak stability of pumps. Fortunately, the recent progress in semiconductor pump sources, such as development by industry of high-power spectrally narrowed diode lasers, allows for the building of kW level cryogenic solid-state lasers.

Although the cryogenic concept is mostly applicable to so-called low quantum defect lasers where the heat deposition is kept at the very minimum, this approach was used to develop a diode-pumped, cryogenically cooled 2.7-µm erbium (Er^{3+}):yttria (Y_2O_3) ceramic laser, operating on quasi-three-level transitions. The approach demonstrated 14W of continuous wave (CW) optical power, and nearly diffraction-limited output; this output was strictly pump-power-limited. Nearly quantum defect (QD)-limited 27.5% optical-to-optical slope efficiency was largely achieved due to implementation of a sufficiently narrowband high-power pump source — a surface-emitting distributed feedback (SE-DFB) laser.

All of the above justifies the necessity of accurate thermal characterization of laser host materials at a wide temperature range from liquid helium to room temperatures.

The figure shows the overall schematic of the thermal conductivity measuring setup, which was designed around two copper plate fixtures that can be attached to the superstructure of a CTI Cryodyne cryogenic refrigerator. The upper copper plate attaches directly to the cryofridge assembly, while the lower plate connects via four 6-32 nylon screws attached from the bottom. The sample to be measured gets sandwiched between the two copper plates, with thin indium layers (~0.2 mm thick) ensuring good thermal contact between the sample and the copper. Accurate temperature readings are obtained using silicon diode sensors that have been indium-soldered to the upper and lower copper plates near the sample contact area. The lower copper plate has a thick-film chip resistor soldered to the bottom, which can generate up to 100W of heating power. A programmable power supply was used as the electrical source for the lower heater. Not shown in the figure is an aluminum



(a) A schematic of the thermal conductivity measuring setup attached to the cryofridge assembly. Wires have been omitted for clarity. (b) A picture of the finished setup fixtures with a sample in place. (c) The entire thermal conductivity measuring station.

intermediate heat shield that attaches to the upper copper plate and enshrouds the entire setup. This shield is necessary to mitigate any radiative heat transfer that might occur between the sample and the dewar tail of the cryofridge.

Thermal conductivity value is not acquired until the temperature at each point of the sample is constant. A LabVIEW front panel was created for the thermal conductivity measuring program, which includes an example data set further illustrating the flow of an experiment. First, the cryofridge is driven to the temperature at which the measurement will be made using an independent controller, and the temperature sensor readings above and below the sample are allowed to reach steady-state. Then, a power value is selected for the lower heater in order to achieve a small (5-6 K) temperature gradient across the sample. The sample dimensions are then input into the LabVIEW program in order to properly calculate thermal conductivity.

The measured temperature range was extended lower in these measurements because of the overall reduced thermal conductivity (lower heat flux) intrinsic to these samples compared to YAG. Immediately apparent in the results for this series of samples is the trend that increasing the doping content leads to lower thermal conductivity. This phenomenon is attributed to an increase in phonon scattering, which inherently follows from decreasing purity in the higher-doped samples. While there are no direct comparisons for this series of samples, the values are comparable to similar rare-earth doped ceramics.

This work was done by Zachary D. Fleischman and Tigran Sanamyan of the Army Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Instrumentation category.*** *ARL-0179*

Non-Destructive Damping Measurement for MEMS Acceleration Switches

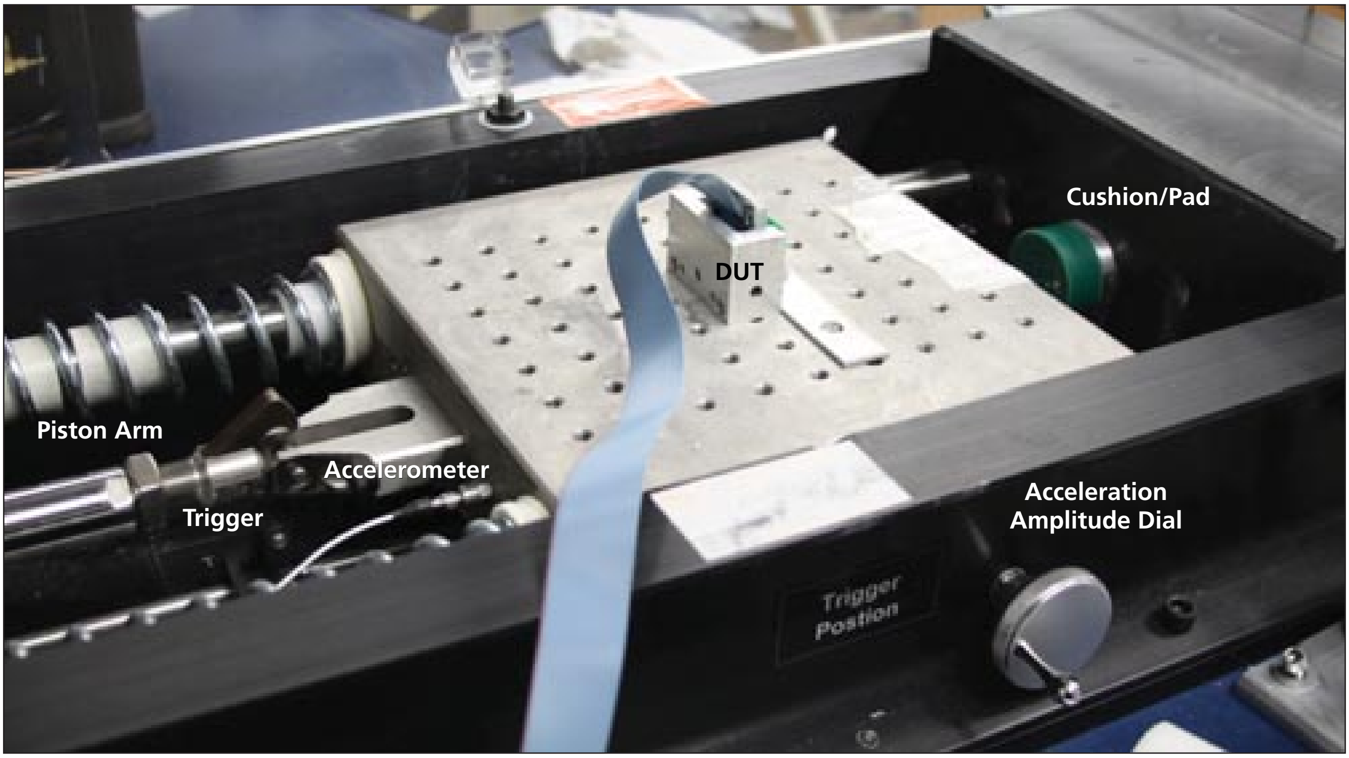
Determining damping coefficients is important for categorizing how each sensor or switch operates.

Army Research Laboratory, Adelphi, Maryland

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

Mechanical switches are single-output devices that distinguish whether closure occurs or not, and lack a transduction mechanism to turn acceleration into a readable displacement signal. A more inventive technique to analyze a closed switch has been devised. A shock table and vibration testing produces a deterministic acceleration input to close an acceleration switch, which has a defined switch gap distance, and mathematical fitting using these deterministic values allows one to determine damping coefficients. By using both an analytical equation fit method and a numerical optimization program, the damping coefficients for MEMS three-axis threshold acceleration sensors were calculated from the results of the tests and design dimensions of the switches.

The two damping measurement techniques presented cover all damping ratio values: underdamped and overdamped systems. Damping characteri-



The linear shock machine. Four channels were used to measure each sensor, one at a time. Six JFTP sensors were attached to the mounting plate and moved at high speeds into a cushion.

zation will benefit end users by allowing a framework for modeling acceleration switch response in their application, and help them correctly choose a closure-acceleration value for the MEMS switch.

A linear shock table was used to test the sensors, allowing the data acquisition device to plot acceleration and voltage change over time. An open switch indicated little or no voltage drop, but at switch closure, the short circuit caused a change in voltage. The voltage was measured against time, and the change in voltage corresponded to the g-force at the time of switch closure. The acceleration and voltage change was analyzed with the system modeled as a mass with a spring and damper in a second-order differential equation.

Two methods were developed that characterize the damping ratio for packaged MEMS acceleration switches. MEMS acceleration switches only provide a single point of information in an applied acceleration field — when switch closure occurs. The two methods discussed here are ways to measure damping when switch closure is all that is known.

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

There were many different parts to the experimental system setup used to test the sensors, and two MATLAB programs were written to analyze the data. A linear shock table was used to produce a high-impact shock (see figure). Four channels were used to measure each sensor, one at a time. Six JFTP sensors were attached to the mounting plate and moved at high speeds into a cushion.

The harmonic excitation method used an inductive shaker with accelerometer feedback control to hold a constant acceleration value through the sine sweeps. Data acquisition records the time versus switch voltage data and correlates into frequency versus switch voltage. Switch closure is indicated by a non-zero voltage. MATLAB post-processing programs were developed to sort through each data set and obtain the relevant information needed to solve for damping and natural frequency.

The analytical method for calculating damping was too sensitive to input variations; the acceleration, closure time, and frequency produced impractical damping values when applied to the equation. The numerical method proved to be a better way of determining damping because the analytical method used many assumptions when solving the characteristic equation.

There is a general decreasing acceleration pattern over increasing closure time for both contacts. There are data points that show constant peak acceleration over different closure times. Similar patterns occur with damping as with acceleration.

This work was done by Ryan Knight and Evan Cheng of the Army Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Mechanical & Fluid Systems category.*** *ARL-0181*

Intro Cov ToC

Tourniquet Training System

Charles River Analytics
Cambridge, MA
617-491-3474
www.cra.com

The Department of Defense recently awarded Charles River Analytics, a developer of intelligent systems and robotic platforms, a follow-on contract for Tourniquet Master Training (TMT). The TMT course helps warfighters provide immediate aid by halting the bleeding of soldiers' battlefield wounds.

Battlefield medical treatments have progressed significantly in recent years and quick and proper use of tourniquets has saved many lives. Unfortunately, traditional tourniquets or gauzes cannot treat some injuries, such as those in the abdomen or pelvic areas. New types of junctional tourniquets have been developed to treat injuries to those areas. The improved systems, however, require trained personnel who know how to apply the technology. The Tourniquet Master Training developed by Charles River Analytics teaches, assesses, and provides refresher lessons on the new devices, including the Combat Ready Clamp™ (CRoC), the Abdominal Aortic Junctional Tourniquet™ (AAJT), the Junctional Emergency Treatment Tool (JETT™), and the SAM® Junctional Tourniquet.

The scenario-based trainer includes a sensor-based system linked to a software-based virtual mentor. The software provides initial assessment and feedback during training, as well as a mobile instructor that provides refresher lessons. The TNT is usable with multiple manikins and configurable for future tourniquet technologies.

As the use of advanced tourniquets spread to non-military organizations, the training may also be valuable to Tactical Emergency Medical Support providers, such as the FBI, SWAT teams, and the Department of Homeland Security.

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Hybrid-Electric Military Motorcycle

Logos Technologies
Fairfax, VA
703-584-5725
www.logostech.net

In partnership with the San Francisco, CA-based motorcycle maker Alta Motors, Logos Technologies has received a Phase II Small Business Innovation Research (SBIR) award from the Defense Advanced Research Projects Agency (DARPA) to continue development of the SilentHawk military motorcycle.

When completed, the SilentHawk will allow small, distributed military teams to move long distances quickly and stealthily across harsh enemy terrain. The prototype combines Alta's existing RedShift MX electric motocross bike with the quiet, multi-fueled hybrid-electric power system developed by Logos Technologies.

The lightweight, single-track SilentHawk provides quiet, all-wheel drive capability at extended range. A field-swappable power system concept will allow the bike to be easily customized to satisfy various mission requirements.

During Phase I of the development, which began in February 2014, Logos and Alta conducted extensive performance testing on the RedShift MX in multiple terrains and riding conditions. Using the data, Logos demonstrated the hybrid-electric system's ability to meet a military motorcycle's off-road power requirements.

The result of Phase I was a preliminary design, supported by testing and modeling. With most critical requirements of the system already demonstrated, the Logos-Alta team will proceed with a Phase II program plan, with the goal of developing and testing the first operational prototype in 18 months.

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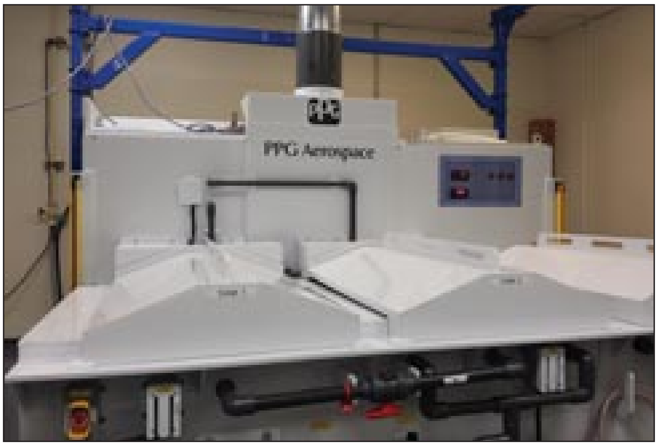
Electrocoat Primer System

PPG Industries
Pittsburgh, PA
412-434-3131
www.ppgaerospace.com

PPG Industries' aerospace coatings group has installed an electrocoat primer system at the US Coast Guard Aviation Logistics Center in Elizabeth City, North Carolina. The technology, custom-designed to protect the facility's aerospace parts, has reduced the time needed for primer application, processing, and full-cure.

Primers provide corrosion resistance to metal parts and enhance topcoat adhesion. Electrocoating, also called electrodeposition coating and commonly referred to as e-coat, uses electrical current to apply a coating to a conductive substrate submerged in a water-based paint bath. The process can be fully automated.

Unlike traditional, spray-applied primers, which create overspray and nonuniform film thickness that result in lower application efficiencies and higher coating weight, the PPG electrocoating processes immerse components into a chrome-free primer, called Aerocron™. The water-based electrocoat primer is attracted to the charged part, resulting in uniform film thickness, even in recessed and hidden areas. Only the amount of primer needed is deposited onto the metal surface, minimizing the weight of the finished metal component. Parts are also rinsed and thermally cured to achieve final coating properties. The e-coat process produces minimal waste because rinses are returned back into the electrocoat bath.



PPG's resin and paste components are dispersed in water in a dip tank. The system also includes an immersion rinse tank, a spray rinse tank, a cure oven, and lab-related equipment.

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Game-Based Naval Training

Office of Naval Research
Arlington, VA
703-696-5031
www.onr.navy.mil

To improve the ability to detect and defeat adversary radars and anti-ship missiles, the Office of Naval Research (ONR) partnered with the MIT's Lincoln Laboratory and games experts Metateq and PipeWorks Studios to develop Strike Group Defender (SGD), a multiplayer training program.

The virtual environment tests and evaluates personnel in surface electronic warfare. The game exposes Navy planners, tacticians, and operators to different missiles and the best ways to counter them, either through electronic means (soft kill) or with traditional firepower (hard kill). SGD is cloud-deployable and accessed through an Internet browser. No special hardware is required.

The experience begins with a screen depicting incoming threats. In one example, a warning states a missile is 20 seconds from impact. The "missile matrix" gives users a rundown of several missiles, their locations, and how best to defeat them. The game then offers specific recommendations, such as using decoy flares to distract an infrared-tracking missile that is not susceptible to radar jamming. After a session, the game shows users the missiles that both hit and missed.

Operators can choose to play in a variety of modes including 1 vs. AI, 1 vs. 1 (asynchronous), 1 vs. 1 (live), and Force vs. Force (live multi-player). The highest scores are awarded to players that achieve the best results with the least amount of resources. Pre-built scenarios take new players through basic actions, and several "capstone" scenarios further test their skills. Additionally, all scenarios are recorded, making every new case available to the user community.

Threats are preprogrammed for the tutorials and test scenarios but include some randomization. Once players are in the free play mode, and particularly live play modes, the threats are determined by the opposing force, making them purely random and unpredictable.

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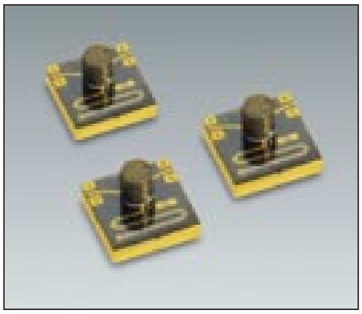
30 GHz and 35 GHz Microstrip Isolators

TRAK Microwave (Tampa, FL) has announced two new Microstrip Isolators covering popular mm-wave frequency bands. Models T001110 (29.6-30.6 GHz) and T001111 (34.5-35.5GHz) integrate ferrite circulator/isolator substrates on to printed circuit board (PCB) material providing for a high performance, yet economical, solution. Typical insertion loss is 0.8dB, return loss 20dB, and isolation of 20dB. These devices handle RF power levels consistent with T/R Module applications in phased array radar or SatCom tracking antenna systems.



TRAK's advanced in-house modeling and simulation capability was leveraged to improve circuit matching into an integrated termination. These devices are constructed to accommodate standard layouts, and scalable modeling techniques allow for customized variations to meet exacting customer specifications. Key features include smaller size, variable port locations, and optimized electrical performance.

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Compute Stick with Windows

Mouser Electronics, Inc. (Mansfield, TX) is now shipping the Intel® Compute Stick with Windows 8.1, a new generation of computer from Intel Corp. The Compute Stick is a revolutionary new device that enables any screen with an HDMI interface to become a fully functional personal computer. The Compute Stick comes preinstalled with the Microsoft® Windows® 8.1 operating system. The Intel Compute Stick is a fully-functional computer in a package similar to a large USB stick.

The new Intel Compute Stick with Windows 8.1, available from Mouser Electronics, is powered by a 64bit 1.83GHz Intel® Atom™ Z3735F Quad-Core processor with 2Mbytes cache, integrated Intel HD graphics, and multichannel digital audio. The Compute Stick plugs into any display that has an HDMI 1.4a interface. Networking is achieved with onboard IEEE 802.11 b/g/n WiFi, and peripheral connectivity is available through the Bluetooth 4.0 and USB 2.0 interfaces. Comes with 32GBytes of eMMC Flash for user file storage, 2GBytes of RAM, and a free six month subscription to McAfee Antivirus Plus. Flash user storage is expandable for both versions through a microSDXC slot on the side of the device.

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ARINC 429 XMC Interface

GE Intelligent Platforms (Huntsville, AL) recently announced the RAR-XMC ARINC 429 High Density XMC Interface for deployment on many single board computers. Designed for embedded, laboratory and simulator applications, the RAR-XMC supports maximum data throughput on all channels while providing onboard message scheduling, label filtering, multiple buffering options, receive message time-tagging and error detection, and IRIG-B receiver (AM or DC/TTL) and generator (DC/TTL).

Up to 16 transmit and 32 receive channels are available, with configurations supporting fixed and software-programmable transmit/receive channels. Configurations with support for ARINC 717 are optionally available. Dual-mode functionality supports either ARINC 717 HBP (Harvard Bi-Phase) or BPRZ (Bi-Polar Return to Zero) across a range of bit rate/subframe combinations. Included with the RAR-XMC is GE's flexible, high-level, API (Application Programming Interface) support for Windows® 7, Vista, XP, VxWorks® and Linux® Kernel Versions 2.6 and 3.x.

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Avionics Interface Computer

Data Device Corporation (Bohemia, NY) has introduced the Avionics Interface Computer (AIC), providing a scalable, programmable, and portable platform to develop and test MIL-STD-1553 and ARINC 429 system applications via an Ethernet network. The AIC features 2 PMC and 2 Mini-PCIe expansion sites, allowing users to select interface boards optimized for their specific application and connectivity needs. An onboard Intel® Atom™ E3845 Quad Core 1.91GHz processor provides programming flexibility and simplifies connectivity by automatically bridging messages in real-time between Ethernet, ARINC 429, and MIL-STD-1553. The BU-67121W AIC also lowers the complexity and cost of many long discrete cables by locating the 1553/429 interfaces close to onboard electronics, and using the Ethernet interface to provide network access and control from the test lab.

3 Modes of operation provide complete bridging capability. Remote Access allows easy access to 1553/429 connection via Ethernet network. Protocol Conversion allows users to create embedded software that seamlessly transfers data between 1553, 429 and Ethernet interfaces. Standalone allows the AIC to operate as a user programmable computer system.

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Adaptive IF Relay XMC

Pentek, Inc., (Upper Saddle River, NJ) has introduced the newest member of its Cobalt® line of XMCs (Switched Mezzanine Cards). The Model 71624 dual channel, 34 signal, adaptive IF (Intermediate Frequency) relay XMC with a Virtex-6 FPGA accepts two IF analog input channels, modifies up to 34 signals, and then delivers them to two analog IF outputs. Any signal within each IF band can be independently enabled or disabled, and changed in both frequency and amplitude as it passes through the module.

The Model 71624 features 34 digital down converters (DDCs), each independently tunable across a 100 MHz input IF range, handling signal bandwidths from 20 kHz up to 312 kHz. The DDCs deliver 34 baseband signals to the host computer, which determines how each signal is dropped, replaced, or changed in amplitude and frequency. The modified signals are then combined and delivered as an analog IF output.

The Cobalt Model 71624 XMC is designed for commercial, rugged or conduction cooled operating environments. It is also available in several form factors, including 3U and 6U VPX (52624/53624 & 57624/58624), 3U and 6U cPCI (72624/73624/74624), AMC (56624) and PCIe (78624).

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Two-Stroke Engines

Ewatt AeroSpace Company (Wuhan, China) has developed a new series of lightweight, powerful and reliable two-stroke engines for both UAV and light-manned aircraft. The engines are being designed and developed by aircraft engine designer Guido Polidoro in Ewatt's new European Engine Development Center in Piacenza Italy. The new Ewatt engine is designed to be modular, and expandable into multi-cylinder versions to produce more horsepower. Each cylinder has 188cc displacement, developing 22 horsepower at 7500 RPM, making the single-cylinder version, at 7 kilograms, a powerful alternative to other engines on the market.

The latest development involves two and four cylinder versions capable of producing over 40 and 65 horsepower. These engines all use the same cylinders, pistons, rods and parts of the crankshaft to keep the cost of the engine production more affordable. There will also be a six-cylinder version developed to produce over 80 horsepower and weighing only 34 kilograms.

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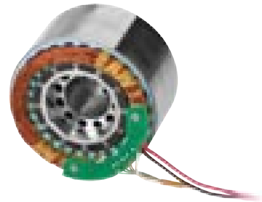
Brushless DC Motors



BEI Kimco Magnetics (Vista, CA) has developed new frameless brushless DC motors in multiple designs for a variety of applications including robots and remotely piloted military vehicles. These new motors provide operational efficiencies in excess of 90% by utilizing proprietary low magnetic circuit design techniques to extend battery life. Other important features include a frameless motor design composed of two pieces a rotor and stator. This design makes it easy to integrate into a customer's existing assembly, minimizing the need for extra components and reducing overall weight. Motors range up to 20" in O.D. with torques in excess of 50Nm and operational speeds beyond 70K rpm.

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