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AEROSPACE TESTING INTERNATIONAL

Bombardier CSeries

A complete roundup of the trans-Atlantic test program

Au revoir STS

One of the last astronauts, Dr Nicholas Patrick, discusses the past, present and future of manned space flight

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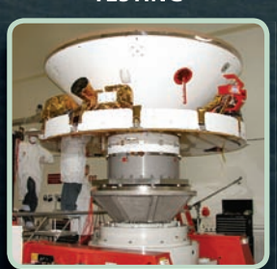

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WHAT MOVES YOUR WORLD

MOOG

In the previous edition I mentioned contrails and their impact on the world's weather. In this issue of *Aerospace Testing International* I ask astronaut Dr Nicholas Patrick, "What man-made things can you see from space?" It's not the most academic question, but his disturbing reply is, "Nothing. Not the Great Wall of China, or anything like it, but you can see deserts, forests and mountains – but also lots of airplane contrails, everywhere." Apparently, the ICAO are having a review of aviation emission-related greenhouse gas emissions, and are recognizing the need to present a credible mitigation plan for aviation bunker fuels. It's high time.

Eurocopter has hit the news with several rotor development milestones. I do remember being in a Lynx helicopter on many occasions as a soldier (at the time the fastest helicopter in the world) on operations with doors open, six of us, and me asking the pilot: "Can we close the doors? Every time we do a steep angle right, I am facing Earth, and held in by one strap."

Eurocopter and Advanced Technologies & Engineering (ATE), South Africa's aerospace systems integrator, have begun flight test firing a new Stand Alone Weapons System (SAWS) for light and medium helicopters.

Initial test flights with the SAWS-equipped Eurocopter EC635 have taken place at the Murray Hill Test Range, a South African weapons test facility near Pretoria.

The trials follow Eurocopter and ATE's decision to jointly design, develop, manufacture and support a modern SAWS that can be installed on any of Eurocopter's light and medium helicopter products.

Eurocopter and ATE described the firing trials as the successful completion of the initial phase of the system's flight test and development program. The EC635 participating in the flight test program is fitted with a Belgian FN Herstal HMP-400 12.7mm machine gun and a French Nexter NC-621 20mm cannon. The first phase of the trials involved firing the Herstal machine gun. This was followed closely by the firing of the Nexter cannon.

The first HAD support and attack version of Eurocopter's Tiger helicopter has also initiated its flight test program at the company's Albacete facility in Spain.

During the next 15 months, a full program of tests and development flights will be carried out to obtain the first qualification step (Block 1), which is scheduled for December 2011. These evaluations will include firing campaigns of the Mistral and Spike missiles, planned before the end of this year.

"This is the first time that Eurocopter Spain has taken on the responsibility for testing a helicopter prototype," said Liberto Negral, who is responsible for Eurocopter's governmental programs in Spain. "We are extremely proud to be performing the Tiger HAD's flight tests, which are proceeding very well and are on time. This represents a great technical achievement for Eurocopter in Spain."

The first production Tiger HAD helicopters are scheduled for delivery in early 2012. Two countries already have placed orders for this version of the Eurocopter Tiger combat helicopter family, 24 from Spain and 40 from France.

Lately, Eurocopter's Albacete facility has adapted the configuration of the aircraft for its HAD version, which is a derivative of the Tiger HAP support-and-escort helicopter variant. This activity included integration of the new MTR390 turboshaft engines, which have been specially designed for the HAD version.

For the different Tiger versions available, France has ordered 80 helicopters, Germany 80, Australia 22 and Spain 24. A total of 57 Tigers have entered service so far. The HAD version offers numerous improvements over the HAP version currently deployed in Afghanistan by the French army. Updates include a more powerful engine and increased payload-carrying weight, an improved optical sighting system, launchers for Hellfire and Spike air-to-ground missiles, an identification friend-or-foe (IFF) interrogator, optimized ballistic protection, and a new electronic warfare and countermeasures system.

Also, a helicopter, but very much smaller than your standard Eurocopter, Dragan Fly has developed a camera-carrying helicopter, which has been bought by the University of Worcester, UK, for its environmental and ecological research. It will be used to study rivers, archaeological sites, and landscapes. The Draganflyer X6 can take vertical and oblique aerial photographs.

Rotorcraft design, right now seems to be at the forefront of test and development.

Christopher Hounsfield, editor

TECHNOLOGY PROFILES

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NEWS FEATURES

REGULARS

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Raising the plane

A FOCUS ON THE COMPLETE INTEGRATED AIRCRAFT SYSTEMS TEST AREA (CIASTA) FOR THE BOMBARDIER CSERIES AIRCRAFT

BY SEBASTIEN MULLOT & CHRIS HOUNSFIELD

The Bombardier CSeries aircraft is often described by manufacturers as a 'game-changer' because it is an advanced technology jet specifically designed to meet the growing needs of the 100- to 149-seat mainline commercial aircraft market category. There has not been a new technology aircraft purpose-built for this segment in several decades. But that is only one of many differentiators for the CSeries in the marketplace; another is a planned 99% dispatch reliability at entry-in-service, earmarked for late 2013.

This is where advance testing and an overall risk mitigation strategy becomes an important focus of the CSeries product development program. One of a number of components in the plan is the Complete Integrated Aircraft Systems Test Area, fondly known by its acronym, CIASTA.

An important part of Bombardier delivering on its reliability commitment for the CSeries, the company broke ground for the CIASTA facility in September 2009. Nearly complete, the facility is just one of several buildings in the first phase of construction for the company's all-new CSeries aircraft assembly site in Mirabel, north of Montreal, Canada.

CIASTA is a testing and systems-proving facility that will house up to six different aircraft level test rigs. It will permit integrated systems and software testing across the entire CSeries aircraft program one year before we embark on flight tests for CSeries. We estimate that by CSeries' first flight, it will have performed 2,000 hours of testing on the ground, thanks to the capabilities of CIASTA.

This is a major initiative aimed at ensuring Bombardier will mitigate potential risks in employing leading-edge new technologies and

The CSeries aircraft contain 70% advanced materials comprising 46% composite materials and 24% aluminium-lithium

processes. CSeries is no ordinary aircraft. Available in the 110-seat CS100 and 130-seat CS300, CSeries will deliver up to 20% better fuel burn than any aircraft currently in production, and it will feature: increased use of composites and aluminum lithium in the structures; a next-generation engine – the PW1000G geared turbofan; the very latest in system technologies, such as fly-by-wire and fourth-generation aerodynamics; up to 20% less CO_2 and up to 50% less NoX; and up to 15% improved cash operating costs versus current in-production aircraft of similar size.

Prove dispatch reliability

With CIASTA, Bombardier's customer support engineers and field service representatives will, for the first time, be able to collect data to prove the aircraft's dispatch reliability, well before the actual aircraft flies. In fact, the first CSeries test article (a virtual aircraft) will be built in the CIASTA. This is significant because it will enable earlier product maturity. All the flight control systems, avionics, electrical, and environmental controls will be tested.

The CIASTA will include six ground test rigs that will address all aspects of aircraft level development and integration testing. The Reconfigurable Engineering Flight Simulator (REFS) is a flexible flight simulator which allows the user to have a real flight experience. It's built on representative physics and control laws, which can be adapted as the development and the pilots' feedback is received. This has been used since the early stages of the program to confirm assumptions with the different stakeholders, to perform control law development and handling quality assessments, and for cockpit ergonomic studies.

The environmental control system and cabin interiors rig will consist of a full CS100 fuselage, made with production representative parts, which will validate the passenger's environment. This test rig will enable development and testing of the air systems, cabin lighting, cabin management system, audio system, entertainment system, passenger oxygen system, and ordinance signs.

The Flight Controls Integration Lab (FCIL) is new a rig where fly-by-wire (FBW) architecture and software will be verified and validated with prototype hardware and actuation systems. As FBW is a key technology on this aircraft, this rig will be an important tool for the system level development to help mitigate risk. The Engineering Simulator (ESIM) is a full flight simulator, without cabin motion, including a fully representative cockpit with a visual system. The ESIM host computer will incorporate flight dynamics models, system simulation, and hardware interfaces. The ESIM will be used for pilot-in-the-loop aircraft testing, safety of flight assessment, system functional performance testing, failure simulation, stability and control testing, endurance testing, and flight test procedure validation.

The Integrated Systems Test Certification Rig (ISTCR) will combine production representative aircraft structure and system components and installations. The flight controls will be fully functional in the roll, pitch, and yaw axes. The ISTCR will primarily be used for systems integration. It will simulate aerodynamic loading conditions.

The Systems Integration Test Stand (SITS) will be focused on Avionics system development and will also validate electronic interfaces between all aircraft systems. It will contain representative aircraft hardware. It will be used as a tool to exercise and test aircraft software and hardware in an operational environment.

At the core of CIASTA is its ability to allow testing (at high cycles) for robustness of systems, such as hydraulics, avionics, electrical software, and flight controls. The plan is to take these systems to the limit on ground to ensure robust, mature, reliable systems, and software prior to the initial flight tests, and entry-into-service.

The CIASTA building itself is constructed as a LEED (Leadership in Energy and Environmental Design) structure; the first such building for Bombardier Aerospace. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development; water efficiency; energy efficiency; materials selection; and indoor environmental quality.

The buildings will be completed in phases. Eventually Bombardier will erect a complex of buildings near Montreal that will total 860,000ft^2 – the size of 15 North American football fields. ∎

Sebastien Mullot, director, CSeries Aircraft Program, Bombardier Commercial Aircraft, Canada

The advance of resin infusion

Against a backdrop of ever-increasing operating costs, environmental targets, and rising competition between carriers, Bombardier's CSeries aircraft is designed to address the market conditions and demanding customer requirements of the future. Bombardier is embracing new technologies to gain the competitive advantage and offer customers an aircraft with unmatched economics, operational flexibility, passenger comfort, and reduced environmental impact.

Taking up the challenge of developing and applying new technologies, Bombardier in Belfast, Northern Ireland, is producing the advanced composite wings for the CSeries aircraft, using an innovative Resin Transfer Infusion (RTI) technology to manufacture the large one-piece wing skins and structural spars for the wing torque box.

The composite demonstrator wing at Bombardier's Belfast facility, which has successfully undergone the ultimate load test – representing 150% – of the most severe forces the wing will undergo

"The CSeries aircraft wing program is progressing to schedule"

Resin transfer technology

"We are responsible for the design, manufacture, and integration of the complete wing for the CSeries aircraft, including all flight control surfaces and high lift systems. Our patented RTI composites technology is ideally suited to primary structures and offers significant cost and performance advantages over metallic and conventional composite manufacturing processes," says Colin Elliott, vice president of engineering and business development for Bombardier Belfast.

"The application of this particular RTI technology onto a new aircraft and on a scale and magnitude not before seen on a commercial airliner presents a significant challenge to us, but offers great production benefits, as well as benefits to the customer," he explains.

The Belfast operation's RTI process is different from the composite technologies used in most other aircraft programs, although the basic materials are very similar. Most of today's composite technology programs use material which is supplied pre-impregnated with resin, which basically binds the fibers together to create the hard durable structure when it is cured under high temperature and pressure, usually in an autoclave. However, with Bombardier's RTI process, 'dry' fabrics are used to create the structure and then the resin is injected after it is placed in the autoclave.

"This combination delivers a structure with better properties than competing processes utilizing dry fabrics, and has proven to be very reliable in producing defect-free components, making it particularly beneficial to primary structures such as wing skins and spars. It is taking the use of composites to even greater levels of complexity and structural performance" observes Elliot.

Production benefits include material savings and reduced cycle times, due to the ability to produce large parts in one single piece. The dry fabric used is also more easily recycled and does not have the shelf-life restrictions that pre-impregnated material has.

In addition to weight reduction, customers will see a benefit in reduced inspection and

The CSeries demonstator wing in the test rig (prior to loads being applied)

maintenance activities, due to the corrosion-free properties of the materials.

In order to develop and 'prove' out the design, manufacturing, and assembly technologies to be employed to produce the CSeries wing, Bombardier Belfast undertook a major research and development program.

So far, Bombardier has carried out tests on over 4,300 small specimens to understand the basic mechanical properties of the materials. More complex structural details, such as bolted joints and penetrations of spars, are being interrogated through the testing of almost 600 specifically designed specimens. And testing of the buckling and failure mechanisms of the large integrally stiffened wing panels is underway.

Part of the complex test and development program also included the designing, manufacturing, and assembling of a full scale, three-quarter span pre-production composite wing demonstrator, as fully representative as possible to the final CSeries configuration, to help develop and refine the RTI process for manufacture and assembly.

"Even before we started testing the demonstrator, the actual assembly of it has been a tremendous learning experience. Our manufacturing engineering team used new technologies so that we could ensure we meet the exacting aerodynamic tolerance requirements. For example, we learned how to drill very close tolerance holes through thick stacks of dissimilar materials. This learning will stand us in good stead when it comes to building the first production standard units," explains Elliot.

"For the demonstrator, our primary focus was on the complex structural interfaces such as the wing to fuselage joint and the installation of the main landing gear and engine pylon. Our objective was to ensure we had a good design for these areas before we committed to full production standard drawing release. The entire production standard wing will be fully tested as part of the full aircraft certification test program."

Once assembled, the composite demonstrator wing was mounted in a specifically designed test rig. A total of 2,100 strain gauges were connected to data acquisition systems by some 64km of wiring.

The completed CSeries demonstrator wing being lifted out of the assembly jig, prior to being installed in the test rig (left)

The first phase of Bombardier's new wing manufacturing and assembly facility in Belfast, N. Ireland

"We plan to test the unit to failure, but it is very much a case of continual re-evaluation"

Landing gear simulation

A simulated main landing gear leg and a simulated engine and engine pylon were attached to the demonstrator wing. Using 12 hydraulic jacks, various combinations of aerodynamic loading, together with appropriate engine and main landing gear loads, were applied. The severity of the loading was progressively increased to fully understand how the wing would behave, until the ultimate load test was successfully completed in June, representing 150% of the most severe forces the wing is ever likely to experience in service.

"After each test was completed, the data was reviewed and a thorough inspection of the wing was carried out, both visually and using various non-destructive inspection techniques," notes Elliot.

Bombardier is now carrying out a detailed analysis of the data from the various load distributions and strain levels, and determining where the critical points are. This will help to optimize the final production design for weight and performance, and ensure that the wing has the correct strength and stiffness to meet all possible loading conditions in service.

In addition, Bombardier engineers are carrying out further tests on the demonstrator to assess the wing's capability of sustaining various types and levels of damage. This will also allow them to ensure that repair systems are proven before the aircraft enters service.

"We are focusing on and testing various areas so we can be absolutely confident in the wing structure. This is another means by which we are building confidence among our customers and potential customers," says Elliot. "We plan to test the unit to failure, but it is very much a case of continual re-evaluation and progressively pushing the boundaries of our knowledge to maximize our learning. We want to gather as much data as possible to fully understand the structure's capability, maintainability, and reparability before we finalize the wing design and start production."

Type certification

Like most new aircraft development programs, two sets of wings will be built to be thoroughly tested on the ground, as part of the final Type Certification process. One unit will be used for 'static' testing where individual loads representative of specific flight conditions will be induced.

Many of the critical loading conditions will be applied even before the aircraft flies for the first time. The fatigue test unit will undergo many thousands of different loading configurations to represent a complete lifetime of flying. In addition to the ground test units, a number of aircraft wing sets will be built for evaluation in the flight test program, which will be completed before the aircraft enters service in 2013.

"The CSeries aircraft wing program is progressing to schedule, and we are absolutely delighted with the results we've obtained. All of our testing to date has demonstrated results as good as, and in many cases better, than our initial analytical predictions. This gives us huge confidence that we will meet the rigorous weight and performance targets, and confirms that our Resin Transfer Infusion process is an excellent means by which to manufacture the large primary structural elements of the composite wing torque box for the CSeries aircraft," Elliot adds.

Production of the CSeries aircraft wings is due to get under way early in 2011 in a new 600,000ft^2 purpose-built factory in Belfast, the first phase of which is nearing completion. ▮

Mighty Grizzly bears up on UK tour

Europe's new military airlifter, the Airbus Military A400M, made its debut in the UK in July 2010 with a visit to the Royal International Air Tattoo at RAF Fairford, to the aircraft's future home in Oxfordshire at RAF Brize Norton to allow RAF aircrews to see their next charge, and finally to the Farnborough International Airshow to participate in the static and flying display. *Aerospace testing International* had the chance to take a look inside the A400M during its visit to Farnborough as a guest of its manufacturer to see many of its unique features.

The first thing that is readily apparent about the A400M is the shape of its fuselage – it is wide and high. This means it provides a quantum leap in capacity above the veteran Lockheed Martin C-130 Hercules or Aerospatiale/MMB C-160 it is scheduled to replace later this decade. Crucially, it allows bulky outsized cargoes, such as helicopters and armored vehicles, to be loaded inside.

The aircraft Airbus brought to Farnborough, however, was packed with testing instruments as the aircraft was still participating in the flight test program, and even the display at Farnborough counted as part of this effort. This meant to get from the rear ramp to the cockpit required a very tight squeeze between the hull side and the racks of test instruments. Another interesting feature of the A400M is its three-crew operating concept and right next to the rear ramp is a large control console for the loadmaster to operate the various automated loading equipment. The cockpit of the A400M is far more spacious than that of a Hercules and it was relatively easy to get into the pilot's seat.

The cockpit is something of cross between a modern fighter and an airliner. The glass, drop down head up display provides the fighter pilot element, and the seven multifunction displays provided the feel of a 21st century airliner.

Again, the crewing concept is minimalist with only a two flight deck crew being the normal complement. There is a third crew station with a multifunction display positioned just behind the two pilots, which is where the load master, will work during transit flights. Exiting the aircraft,

Enhanced performance of aerial scout

Eurocopter is working to enhance the 'hot and high' performance of the UH-72 Lakota helicopter variant being offered for the US Army's Armed Aerial Scout (AAS) competition. This will be a crucial game changer in the US military helicopter market and if Eurocopter win it will result in the US Army buying its first foreign designed helicopter for frontline combat duty. The company is already flying enhancements to the helicopter's main and tail rotor systems on a unidentified test bed aircraft at its Donauworth site in Germany, according to Eurocopter chief executive Lutz Bertling.

Speaking at the company's media seminar in London on the eve of the Farnborough airshow, Lutz said the required hot and high performance of its offering, dubbed the AAS-72X, had already been proven. "We can do it," he told Aerotesting International. "We have shown we can meet the hot and high performance required with the mission package."

He said Eurocopter now planned to incorporate the enhancements on the three technical demonstrator aircrafts (TDA) it is modifying at its site in Fort Worth in Texas, and these will start flying in December this year.

One of the three TDAs will have a full mission package of weapons, sensors, and communications provided by Eurocopter's partner Lockheed Martin. The two other aircraft

MSN0-02 or EC-402, via the port fuselage door an interesting development in the designation of the A400M comes into view. A large logo of an aggressive looking bear signifies that the A400M has been named by its test crews as the Grizzly. This, however, has not received official sanction by the aircraft's seven customers yet and the RAF was reportedly less than impressed. So Airbus had to quickly make it clear that the name only referred to the three test aircraft, not the production examples that will be delivered to the RAF.

Airbus's head of flight tests, Fernando Alonso, told a media briefing at Farnborough that the development aircraft MSN003 will undergo preliminary work near Toulouse to assess the effects of manoeuvring on the ground with chalk pellets scattered on the runway. Later in the year he expects the A400M to make its first landing on an unpaved surface. The company also plans to install the aircraft's under-wing hose and drogue refuelling pods this year. "It is urgent to clear the configuration flying with the pods, and with the hoses extended," Alonso said. Later this year the A400M will undertake hot weather trials in the Middle East, cold work in Scandinavia, and start practicing carrying paratroops.

Airbus's current three A400Ms had logged 109 sorties and 415 flight hours before MSN002 arrived at the show. After getting rave reviews from its visit to the UK in July, the fate of the A400M seems a bit more secure, but the program to build Europe's next-generation airlifter will be decided in the autumn when the seven customer governments are expected to sign a new revised production contract.

have trials instrumentation fitted to prove different areas of the product.

Eurocopter was funding the development of its TDAs ahead of the formal launch of the AAS competition by the US Army. Bertling said this was expected late next year after it completes its current analysis of alternative activities and issues formal requirements. He expected the US Government to allocate development and procurement funding in the fiscal year 2012. Currently, Eurocopter is working against specifications set out in a request for information issued by the US Army last year.

Eurocopter is prime contracting the AAS-72X project and it plans to manufacture the helicopter at its site in Columbus in Mississippi, where it is already building the utility version of the UH-72 helicopter for the US Army and National Guard for non-combat roles within the Continental USA. "Some 123 UH-72 have so far been delivered by Eurocopter on or ahead of schedule, leading to the US Department of Defense to call it one of its top performing programs," said Bertling.

Bertling described Lockheed Martin as the "strongest partner you could have" but declined to provide details of its mission package being offered on the AAS-72X.

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Taranis seen as key to future RAF combat ISTAR

Combat intelligence, surveillance, targeting, and reconnaissance (ISTAR) missions in contest airspace are seen as being a key role of any future evolution of the BAE Systems Taranis combat unmanned air system (UCAS) advanced technology demonstrator, according to senior Royal Air Force officers.

Speaking at the Taranis 'first view show' at BAE Systems' Warton site on July 12, 2010, Air Chief Marshal, Sir Simon Bryant, Commander-in-Chief of RAF Air Command, said: "This program talks about contested air space."

Senior military officers, defence industrialists, and media representatives at the event got a limited view of the only Taranis air vehicle currently in existence. Many features of the air vehicles design are still classified as 'UK Secret', so visitors were not allowed to approach the Taranis and only front views of it were allowed. Nigel Whitehead, BAE Systems managing director for the Programs and Support Operations Group, described the Taranis as being a "super smooth aircraft" that was designed to be "appropriately immune to enemy air defences".

The level of low observability or stealth capability that is eventually incorporated in any production derivative of the Taranis will be determined by the upcoming UK Strategic Defence and Security Review, which is expected to endorse specific requirements for future UK unmanned air systems and ISTAR capabilities.

"High levels of low observability comes at a price," said Bryant. "It is far less expensive to conduct combat ISTAR in non-contested airspace, as we do in Afghanistan today."

Whitehead stressed that the continued development of Taranis and future unmanned systems were fundamental to the future of BAE Systems military aircraft business. "Unmanned technology is a prelude to the

An end to the comercial duopaly?

This year's Farnborough airshow featured the usual ritual verbal battles between the two giants of the civil aviation market, America's Boeing and Europe's Airbus.

The two contenders in the global airliner manufacturing duopoly both had a good week at the UK's premier airshow, announcing a combined total of more than 300 new orders for the aircraft, worth more than US$50 billion (£32 billion). Hundreds more orders are also expected later in the year, with industry executives predicting that the recession in air travel is well on the way out. Not surprisingly, Airbus and Boeing executives were bullish in public but behind the scenes the top players in the civil aviation industry seemed to recognize that the sand was shifting under their feet as globalization takes hold with a vengeance.

Farnborough this year was noted for the relative lack of rhetoric about the infamous World Trade Organisation investigation into alleged state subsidies for Airbus from European governments. Airbus is awaiting another WTO report into state subsidies for Boeing's airliner products that is expected out later this year. Although much media coverage of this issue has focused on US Department of Defense support for Boeing's technology development it now seems that the US company's global supply base of component and equipment suppliers will receive just as much attention from the WTO. Here it seems there has been a high level of government support for second and third level suppliers that could have had an impact on the ability of Boeing to build its new 787 Dreamliner. With Boeing

next generation of fighting capability," he said. "If we are not on top [of it] and part of it there will be no future for the UK military aircraft industry, it is as fundamental as that."

Whitehead said the Taranis was expected to fly next year and it would undergo a "substantive flight test program". The location of the flight test program was not revealed by BAE Systems or the Ministry of Defence, but it believed that the Woomera Test Range in Australia is the most likely choice.

Performance details and other specifications were not released at the 12 July event, however comments were made that the air vehicle was "about the size of a BAE Systems Hawk trainer jet, which is approximately 12m in length with a wingspan of 10m". *Aerospace testing International* understands the Taranis is powered by a Rolls-Royce Adour 951 engine, as used in the Hawk, which suggests the new air vehicle will not have a supersonic capability.

Whitehead said the design team, drawn from BAE Systems, Rolls-Royce, General Electric, and QinetiQ faced significant challenges in several areas during the development of Taranis. He identified stability control, power plant integration, low observability, and maintaining build standards as major issues. "Packing all the systems into a small space inside a super smooth aircraft was a significant engineering challenge," he said. Air Commodore Phil Osborn, head of deep target attack capability supported the view, saying that, "signature managed air vehicle that can do complex tasks are relatively new outside the USA". He added that the 'system of systems' element of was a key challenge.

outsourcing much of the cost and risk of developing the Dreamliner down its supply chain, this issue greatly muddies the water over the actual level of government support for the new airliner project.

EADS chief executive, Louis Gallois, suggested that a way out the WTO impasse would be global negotiations between Boeing, Airbus, and both company's suppliers. "The supply chain is now all over the world, not just in Europe and the USA." he told *Aerospace Testing International*.

Industry executives at Farnborough saw this development as the first stage in the break down in the Airbus-Boeing duopoly. Canada, Russia, and Brazil are already starting to build and market large regional airliners that could compete with the two giants lower end products, the A310 and 737 series aircraft. It would only be a matter of time before China enters this game as well.

"It took Airbus nearly 30 years to get to the point where it could challenge Boeing as an equal," said a senior aircraft industry executive at Farnborough. "It takes time to convince customers that your products are safe and efficient, but you can see the Brazilians and Chinese coming up fast in the rearview mirror. In ten years time, or maybe sooner, Airbus and Boeing will find themselves with real rivals."

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The Block III Apache Longbow is effectively a new helicopter with structural and avionics improvements to be verified by a Combined Test Team. Frank Colucci looks at the US Army/Boeing effort to deliver a more powerful, lethal, and affordable Apache

Let loose the Longbow

On the tarmac and in the cockpit, the Block III AH-64D Apache Longbow looks like the attack helicopters already coming off the Boeing production line in Mesa, Arizona. Block III is nevertheless a new Apache with more lift, lower operating costs, better battlefield connectivity, and control over Unmanned Air Vehicles. It introduces a powerful split-torque transmission, high-lift composite main rotor blades, and an open system avionics architecture with ample processing power and throughput.

The first System Development and Demonstration (SDD) aircraft with combined Block III structural and avionics changes took off in May 2010. By mid-July, a second aircraft was flying with the consolidated improvements, and the combined test team from Boeing and the US Army had logged about 850 flight hours on different Apaches with various pieces of Block III technology. Army Apache Block III product manager Lt Col. Dan Bailey explains, "The intent of the combined test team is to have one combined test plan so we don't have a Boeing test plan and an Army test plan. We reduce the total test cycle time and we synergize, so we don't repeat testing."

About 600 more flight hours and associated ground work will position the latest Apache for Block III Lot I Initial Operational Test and Evaluation in early 2012. IOT&E uses active duty Army pilots from the 'First Unit Equipped'. A full rate production decision later the same year requires Block III advances attain Technology Readiness Level 7 with most functions available for demonstration and test and new hardware and software integrated with ancillary systems. Under current plans, Boeing will deliver 634 Block III AH-64Ds to the US Army from 2011 to 2025. Taiwan has already signed up to be the first international Block III customer, and current Apache operators are expected to turn aircraft in for upgrade.

In mid-summer 2010, the Block III team was transitioning from developmental to verification testing. Boeing chief Apache engineer John Schibler summarizes, "This is all about meeting customer requirements. When all that sorts through the performance specification, there are 850 test points we have to demonstrate for verification." Around 450 points are met in aircraft with rotors turning; the rest are achieved in laboratories or through analysis. Lot I verification testing includes 13 basic test plans formulated by Boeing and approved by the Army. "They boil down to thousands of test cards," notes Schibler.

While Boeing engineers track specifications and contract requirements, Army testers take a different view, according to Bailey. "The Army piece looks at the test from the operator's perspective. What it does is tell me if this is good or bad for the pilot operationally and usable for an operational guy." The Block III attack helicopter crew, for example, is expected to exercise Level IV control over Unmanned Air Vehicles – changing UAV flight paths and steering sensors in dynamic combat situations. "The Army pilots look at it from a mission-relation perspective," says Bailey. "Is the interface for the pilot from a cognitive sense effective? Can the pilot in the Apache effectively execute Level IV UAS control without significantly increasing his workload?"

Apache Longbow Production Vehicle PVD027 was the first aircraft to fly with combined Block III structural and avionics enhancements

Block III flight testing is shared by Boeing and Army crews. The Redstone Test Center (RTC) at Redstone Arsenal, Alabama, has three Army Experimental Test Pilots (XPs) and three flight test engineers assigned to Boeing Mesa. The director of the RTC contingent is a retired senior Warrant Officer (WO 5) with combat experience in Desert Storm. The other XPs are active-duty W05s who flew combat in Iraq within the last four years. Bailey explains, "They execute the flight test but routinely, they receive augmentation. It's really a forward element leaning back on their support here at Redstone."

RTC merged the Aviation Technical Test Center previously at Fort Rucker, Alabama, with the Redstone Technical Test Center and operates under the Army Test and Evaluation Command (ATEC). The Mesa element can call in more people as needed. "Any of the pilots they lean on to augment their force from Redstone have recent combat experience," notes Bailey.

Boeing recently began consolidating rotorcraft developmental flight test operations for the Apache, Chinook, Hummingbird, and other aircraft at sunny Mesa. Scott Rudy, Apache Block

“Block III flight testing is shared by Boeing and army crews”

III program manager observes, "We're blessed here in Arizona. We get about 20 hours a week of test flying where a lot of folks get on the order of four or five."

Though Boeing Mesa is the center for Block III development, about half of the testing to date, including sensor and weapons testing, has been conducted at Yuma Proving Ground (YPG) in Arizona, about 200 miles away. Other specialized sites are used as needed. Colorado provides the high density altitudes to verify Block III performance high-and-hot. White Sands, New Mexico, has facilities to test Aircraft Survivability Equipment. RTC itself does electromagnetic compatibility testing. IOTE and Follow-On Operational Test and Evaluation will be done at sites to be determined.

The AH-64D Block III Ground Test Vehicle is an AH-64A incorporating the new split-torque transmission, -701D engines, and composite main rotor blades

Structures testing

The original AH-64A Apache with General Electric T700-GE-701 engines stayed in production from 1984 to 1994 and gave the US Army a heavily-armed, ballistically-tolerant attack helicopter that could fight at night. The remanufactured Block I AH-64D fielded in 1997 topped the Apache with a fire control radar accessed through integrated cockpits. It offset the 400 lb mast mounted radar and other heavy add-ons with more powerful -701C engines but still suffered a performance penalty in mountain elevations and desert heat. Block II aircraft today come off the line with still more powerful -701D engines, but the Block III Apache Longbow aims to restore AH-64A performance at high density altitudes with composite main rotor blades and a new main transmission.

Boeing received the Block III SDD contract in July 2006 and dedicated five aircraft to the test program. An AH-64A Ground Test Vehicle (GTV) continues to turn the Block III blades with the new transmission and engines. "We took a real, live Apache and bolted it to the ground and just tortured the heck out of those components," says Rudy. The very first production Block I AH-64D – PVD01 – still serves as the structures test vehicle for Block III flight strain surveys and handling qualities analysis. "It was instrumented like you would never believe. There's more orange wire on that aircraft than aircraft wire."

Block III composite main rotor blades were initially a cost-saving technology for longer blade life at higher operating weights. Today's aluminum-spar, steel-skin Apache blades were designed for gross weights to 14,500 lb but rarely attain their 2,000 hour design life. AH-64Ds already fly at up to 17,000 lb, and Block III grows gross weight to 17,500 lb. Composite blades are expected to mature from 4,000 hours to 10,000 hours to unlimited service life. Boeing engineers conducted fatigue tests at the root, mid-span, and tip of the graphite and glass blades. "You do a boat-load of tests in the laboratory on the ground," says Rudy. "You do that on coupons, sub-components, and components. That moves to the GTV in a pit." The Army Research Laboratory meanwhile showed the composite blades could match the ballistic tolerance of metal blades with a 23mm threat. The new blades also incorporated new airfoils for enhanced performance.

Transmission systems

Blade risk reduction flights were undertaken on a Block II Apache Longbow in Colorado before PVD01 received the new blades and transmission. The original Apache transmission cannot increase much beyond 2,800hp without shortening its 5,000-hour life. The Block III transmission from Northstar Aerospace uses split-torque face gear technology to pack more power in the identical footprint. It is rated 3,400hp for 10,000 hours and can grow even more powerful if needed. Transmission work started with slow-roll tests to develop gear patterns. "We did a lot of testing back at Northstar in Canada on smaller rigs," recalls Schibler. "Before you can put people in the aircraft and go fly it, there's like two years of developmental testing. It kind of works its way up to a full-scale rig that sees all the loads a real transmission will see including tail rotor shafts."

Rudy notes, "We use different transmissions for different tests... there are flightworthy ones and some for just bench testing... you go back and forth

between structural lab testing and flight testing to increase the hours between inspection intervals." The Block III transmission began flying on PVD 01 in November 2009. It was first removed after 50 hours for fiber optic inspection. Drive components on the Ground Test Vehicle meanwhile run two hours for every flight hour. The GTV transmission was torn down after 200 running hours – equivalent to 100 hours on flying aircraft. Successively longer inspection intervals clear the transmission for production.

PVD01 with Block III composite blades, split-torque transmission, -701D engines, weight-saving composite horizontal stabilator, and composite bottom panels remain covered with strain gauges. Engineers in the Boeing Mesa Green Room monitor stress data telemetered in real-time as pilots expand the Block III envelope. "There are key gauges that are monitored real-time and others recorded, so they can download tap into the computer system," says Rudy. "It's the key gauges that we watch that are telemetered so we can ensure the safe operation of the aircraft and the crew... We know what the dynamic limits are."

Block III remanufacture plans start with US Army Block 1 AH-64Ds and 'renew' existing airframes along with landing gear, canopies, Environmental Control Systems, and other structures and systems. Full Rate Production introduces all-new metal airframes. A composite tailboom, vertical fin and horizontal stabilizer are in test and cut into later production lots to shift the Block III center of gravity forward.

The Block III structural test aircraft accumulated about 750 hours before the first of the avionics test aircraft, PVD27, flew with both structural and avionics changes. PVD01 also performed summertime tethered hover tests aimed at one Block III Key Performance Parameter: 3,400 lb payload at 6,000ft at 95°F. Tethered results were combined with blade test data from Colorado to build high-fidelity performance models awaiting late-summer high-and-hot flights. "When you're doing these test programs

"The GTV transmission was torn down after 200 running hours"

Block III Avionics Test Aircraft PVD027and PVD023 were flown by active duty pilots in Limited User Tests

you're at the will of Mother Nature," says Rudy. "But our models are really very good now... We have good confidence that we're making the KPP."

Flight tests continue with blades instrumented through slip rings and rotating pulse control modulators. Schibler says, "Is it easy? No. Is it an art more than a science? Yes. Is it cause for frustration? You have no idea." He adds, "It's an art, but we're really confident in the data we got."

Systems testing

The added lethality and survivability of the Block III Apache Longbow relies as much on avionics improvements as flight performance. Wideband digital connectivity ties the attack helicopter to other air and ground units for greater situational awareness. Data fusion software merges on- and off-board sensor data for cognitive decision aids to route the helicopter crew around threats and accelerate tactical decisions. Level IV UAS control enables the Block III crew to send unmanned aircraft into high-threat areas and view and relay their imagery with the helicopter out of harm's way. For all its network power, the cockpit in the Block III Apache Longbow retains the same displays and controls to minimize the training burden on transitioning crews.

The open system architecture of the Block III Apache uses commercial off-the-shelf hardware and partitioned software to avoid obsolescence. Boeing built a systems hot bench at Mesa to integrate actual line replaceable units. "It runs on horsepower, but it's basically a full-up avionics laboratory," says Schibler. "There's also a simulator-simulator with the full-up dome. We do some semblance of validation/verification testing in it." The Block III test program used two avionics test aircraft – PVD027 and PVD203 – to fly the system. In addition, Block II PVD065 tested the longer-ranged Block III Radar Electronics Unit.

Level IV UAS control is a Block III Key Performance Parameter, and Boeing engineers performed risk-reducing ground simulations before demonstration flights. Rudy recalls, "The first thing we did was total bench testing where we connected one of our mission processors with the TRU, the main computer than runs the communications on the airplane. We ran an RF cable over to a UAV simulator just to test the interface and the metadata in the interface." Subsystem tests led to real aircraft.

The BlockIII Ground Test Vehicle running in test pit in specially designed test rig

With a safety pilot aboard to oversee autonomous flight controls, the MD530F Unmanned Little Bird gives Boeing a low-cost, low-risk UAS testbed. "We connected up a real Apache with an Unmanned Little Bird with both of them on the ground with a cable... we were trying to minimize the use of the Apache because that costs more money," explains Rudy.

Successful Boeing tests led to the Army Limited User Test (LUT) at Yuma, Arizona, with active duty pilots drawn from the 4/3 Cavalry at Fort Hood, Texas. Over 10 days and nights, government testers scored the LUT while Boeing maintained the two Block III avionics test aircraft. The LUT and other warfighting experiments at Fort Dix and elsewhere showed the Block III Apache Longbow could communicate with other battlefield resources.

Both avionics test aircraft were rebuilt with the new transmission, blades, and other Block III structural details. PVD 027, the first avionic aircraft with structural improvements – went to Yuma for gunfire vibration and body bending tests. PVD01 was itself grounded after its flight strain surveys for engine changes in preparation for handling qualities tests. IOT&E will be done with low rate initial production aircraft. However, even after Lot I testing concludes, Block III SDD continues to test technologies inserted in successive production Lots. Lot IV testing starts in 2012 to verify Apache Longbow diagnostics, a crashworthy external fuel system, and LINK XVI datalink capability. Lot VI testing focuses on software for cognitive decision aids, assisted target detection and classification, and data fusion. Boeing is proposing Extended Block III plans with fly-by-wire controls and a new cockpit with bigger displays, and more testing. Schibler observes, "PVD 01 is an old girl; she's about done. By the time this work is done and finished, she's going to be a great GTV. ▮

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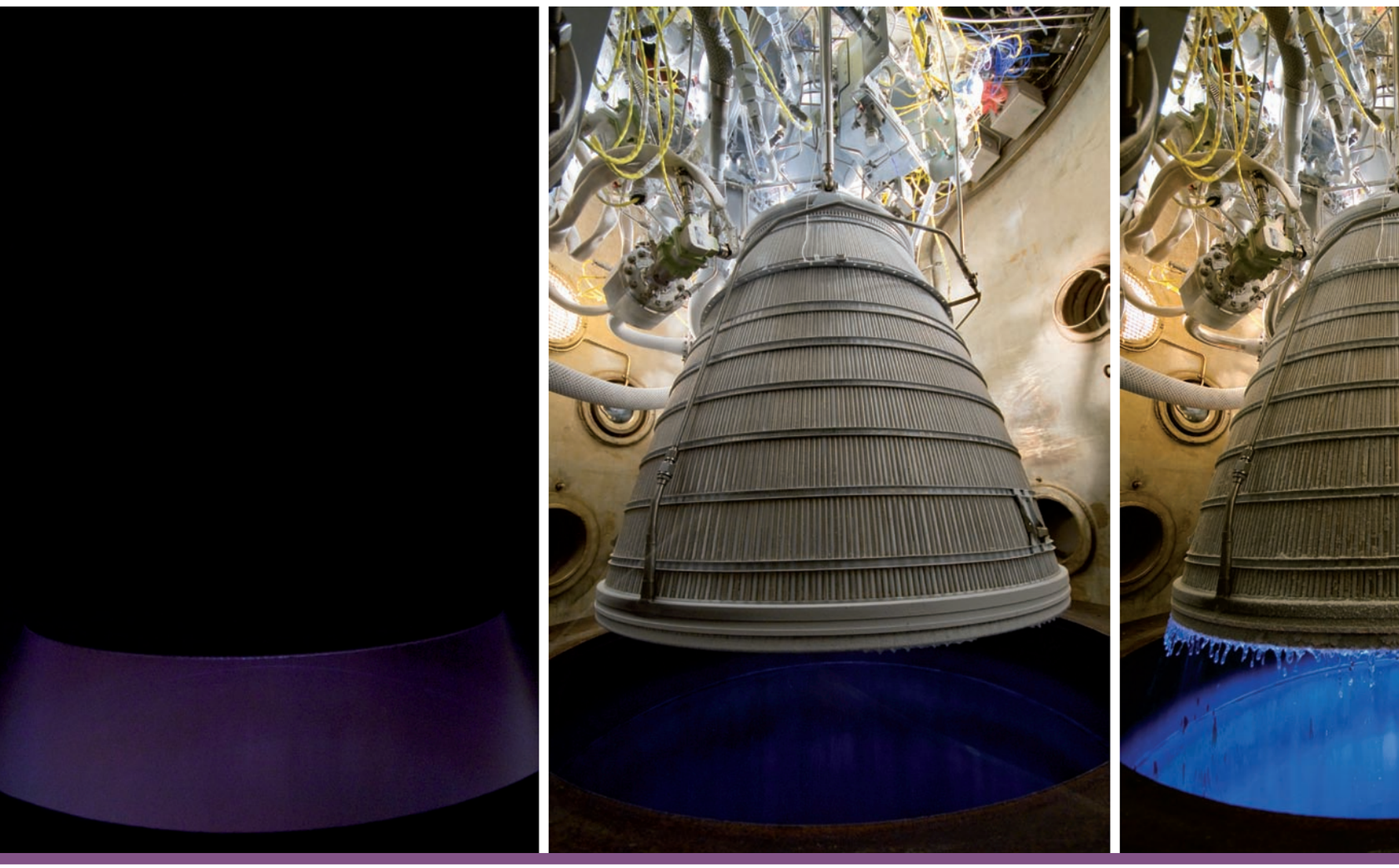


Not just fans, turbofans

THE NEXT BIG ENGINE DEVELOPMENTS ARE THE NEW GREEN ENGINE, SCRAMJET ENGINES, AND WORKING WITH SUPER-COOLED PROPELLANTS

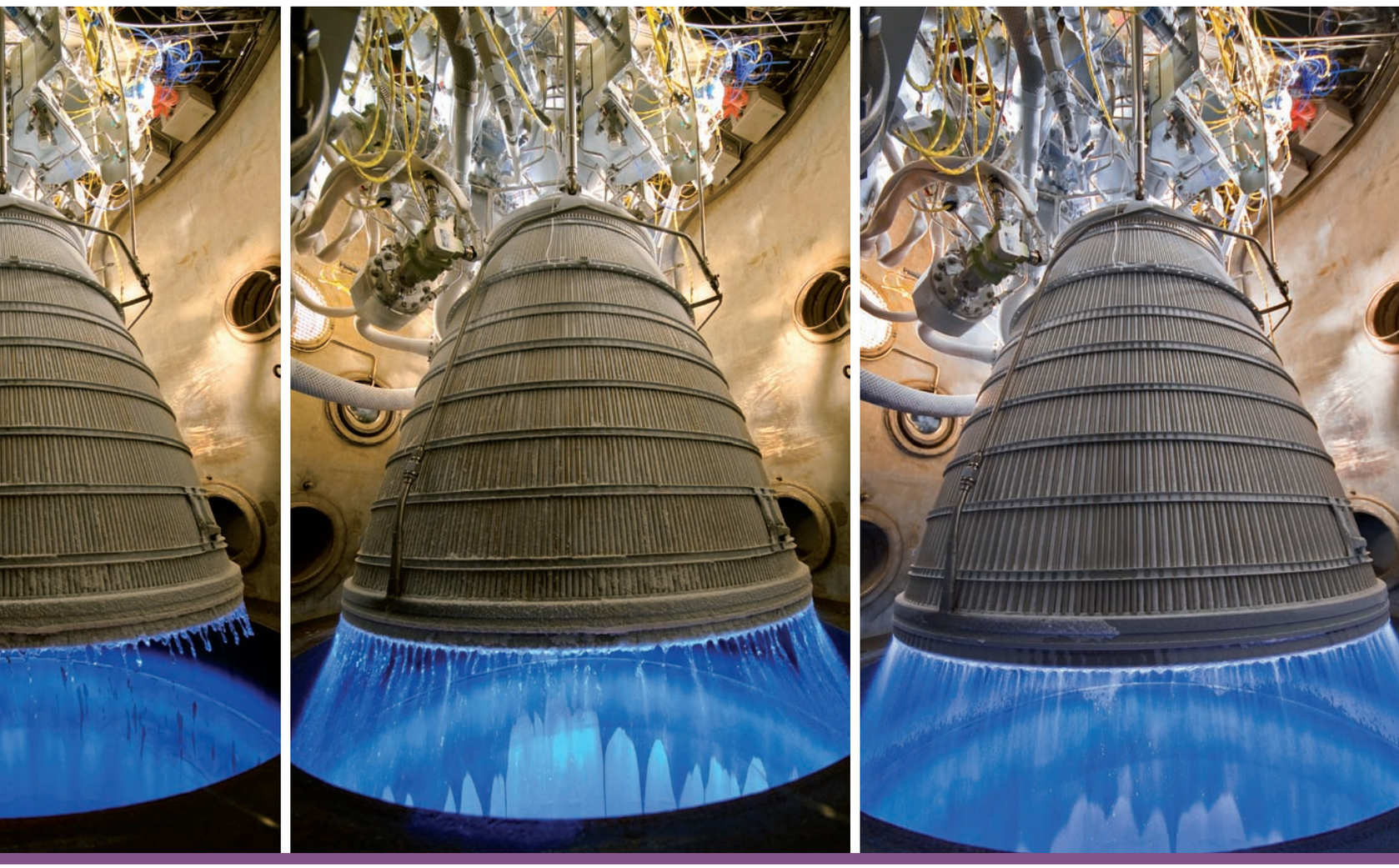
Firing sequence: A key CECE technology is 'deep throttling', a wide range of thrust that enables a spacecraft to maintain thrust for in-space travel, yet be able to power down for a gentle landing

BY CHRISTOPHER HOUNSFIELD

The first assembly of the Pratt & Whitney PurePower PW1524G engine for the Bombardier CSeries aircraft has been completed. Pratt & Whitney is scheduled to deliver the engine to the company's West Palm Beach, Florida, facility to initiate testing at the end of September 2010. This marks the beginning of an multi-engine validation and certification program.

The engine test program will run a total of eight test engines over the next 24 months with engine certification and aircraft first flight scheduled for 2012. Entry into service is scheduled for 2013. Bombardier has already sold the CSeries aircraft to German flag carrier, Lufthansa, Lease Corporation International and Republic Airways. More importantly, Pratt & Whitney recently concluded PurePower engine core testing with more than 260 accumulated test hours. In addition to the core testing, the company has performed critical module-level testing for the PurePower engine program, including fan drive gear-system testing with simulations of more than 60,000 take-offs and landings, and hundreds of hours of testing on the low and high-pressure compressor, with advanced designs meeting or exceeding efficiency and operability goals.

Paul R. Adams is the senior vice president engineering and technology, Pratt & Whitney



Division, with more than 20 years management and engineering experience. He joined Pratt & Whitney from Williams International, in 1999, as director of turbine engine projects and was subsequently, in 2002, made chief systems engineer, analytical. Adams wants to talk engines.

The Pratt & Whitney PW1000G is a high-bypass geared turbofan engine currently selected as the exclusive engine for the Bombardier CSeries, Mitsubishi Regional Jet (MRJ) airliners, and Irkut MS-21.

"We're looking at step performances that are 16% better in fuel burns in current engines, 20% better in maintenance cost, 50% reduction in emissions with a 50% decrease in noise level," says Adams. "We've tried to get a configuration and a product that balances all of the key metrics that our customers are concerned about.

"Our objective was to build a product that was best value and for what? If we had gone out to try and get more fuel efficiency, we could have – the potential exists easily to do that. But it wouldn't have the true, unique characteristic of the engine which is going to offer a uniquely improved value proposition to the end customer.

"Currently GE and Rolls Royce do not have anything like this. Both have invested heavily in the 787 products over the last few years, and while they've done that, we've taken the opportunity to really completely refresh our product portfolio. We've included the development and utilization of the gear system, which we have been working on for a very long time, to enable the class of PurePower.

"We've got 270 hours plus of test time on that and demonstrated all of the performance, efficiency, operability characteristics on the core"

"We had a extremely successful core test on the 1000G program from January through to the end of May 2010. We've got 270 hours plus of test time on that and demonstrated all of the performance, efficiency, operability characteristics on the core. That was an extremely important milestone for us and one that really positions us to start the full-scale development test program of the Bombardier and MRJ engines in the September 2010 time frame.

"We're very close to being able to run the entire engine and this would be the start of the full-scale development program for Bombardier," says Adams.

Adam's played a significant role in driving engineering productivity and performance which was reflected in the reduced surge rates, notably in the PW4000 ring case

PurePower

The Pratt & Whitney PW1000G was previously known as the Geared Turbofan (GTF) system, and before that the Advanced Technology Fan Integrator (ATFI).

"We built a full-scale gear terminal fan-demo engine that we flew with Airbus and we had an extremely successful full-flight program with Airbus to demonstrate the technology to bring the product to market," details Adams. "We completely upgraded our test capability and test facility and have been doing key endurance tests to strike out the durability and make sure that we've got a great product to market.

"We had over 400 hours of ground testing and 100 hours of flight testing with Airbus over 27 flights and it completely validated the overall system operation, oil system, heat rejection, aircraft integration of the technology on a real aircraft in flight. We did full power take-offs, projected take-offs, wind-up turns, on-power stalls, side-flip manoeuvres, acoustic testing, thermal-management testing, dwell testing at high altitude and cold temperature, and windmill testing. We really ran a full gamut of real systems-level testing, integrated on an aircraft, to shake that out.

"I think that was one of the key successes for us which enabled us to demonstrate, not only to Airbus but really to the industry, that from a systems level standpoint, we had the full systems engineering, and all of the technical issues associated with the introduction of technology, well understood and well documented."

Realistically, how unique is the system? "The gear system is an enabler, it allows us to decouple the speed of the turbine to the speed of the fan," says Adams.

"As you increase the by-pass ratio, the impact of the mismatch of speed gets exacerbated, but to really accomplish a very high propulsive efficiency, we had to combine the gear technology along with a very low-pressure ratio fan technology to operate the system very thermally efficiently.

"Pure power is the biggest kind of technology in product-development investment that we've got going right now, orientated toward a series of market opportunities that we saw developing broadly in all three of our key markets, the commercial, the business aviation and also the military markets.

"All three look like they had opportunities emerging in this 10,000-30,000 lb thrust class," Adams clarifies.

Geared turbofans

The second phase of flight testing for the PW1000G was conducted on an Airbus A340-600. The testbed aircraft, with the engine in the number two pylon position, flew for the first time in Toulouse, France on October 14, 2008. According to Adams, GTF technology is a landmark in engine development. How might this effect the marketplace? "I think this would be the equivalent of Rolls Royce's decision many years ago to switch to three-spool configurations. Now, we actually think that we'll get much bigger product differentiation than Rolls got with moving to three spools. I give them a tremendous amount of credit because they have grown their market share, but if you look at the competitiveness of their three-spool versus the two-spool product that either we or GE had historically put together, they're pretty damn close in terms of key-product characteristics.

"I think that GE or Rolls Royce will have to either introduce GTF technology, or some other technology innovation, to be able to keep pace with us.

"We have looked at other technology innovations and we are very convinced that the gear technology is the right place to be. They could potentially react differently, but we think that we've got the right technology and the market timing is now right for it," says Adams.

Engine upgrades

Pratt & Whitney do not just develop new engines. Much of the focus has been on existing engine upgrades, and the company feels it is an important aspect to the company profile.

"We do believe that it is important to maintain competitiveness in the market place with our existing engines, so we have moved to a process now where we look at our existing engines and we look where we can upgrade them with technology that provides value to the end customer," explains Adams. "A good example in the last few years is the two products to which we've introduced enhancement packages. "One was the V2500, which we did in partnership with IAE, where we added a package that allowed us to improve the fuel efficiency and also the time-on-wing of the V2500. It has been successfully deployed in the market place within the last eighteen months. "The second is, on the PW4000 our 100in engine, used on the A330. We introduced the Advantage-70 enhancement package, which increased the thrust level on that engine to 70,000 lb from 68,000 lb thrust, improving fuel efficiency by approximately 1-1.5% and also improved the time-on-wing by approximately 20%.

Hypersonic flight development

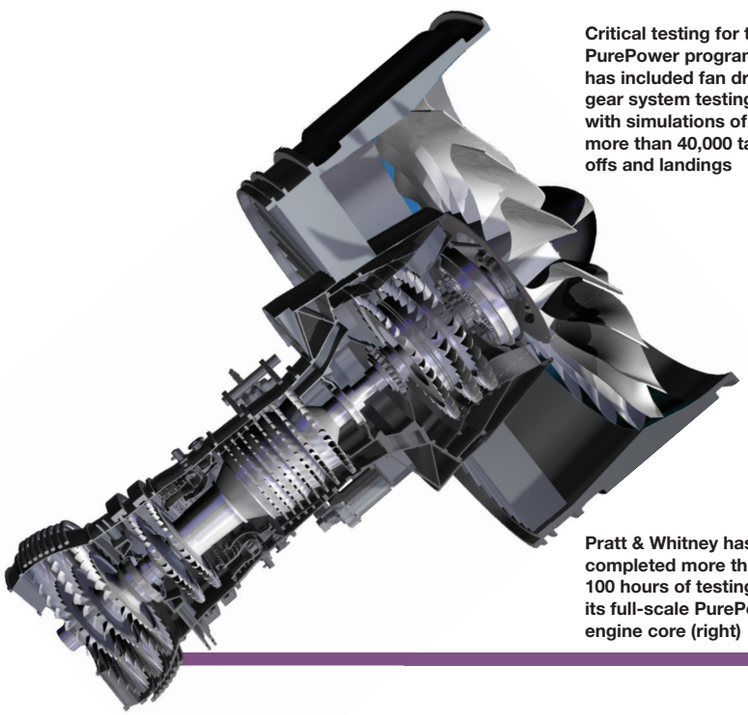
The X-51A WaveRider hypersonic vehicle, powered by Pratt & Whitney Rocketdyne's scramjet engine, achieved aviation history in May by making the longest-ever supersonic combustion ramjet-powered flight. A solid rocket booster fired and propelled the cruiser to greater than Mach 4.5, creating the supersonic environment necessary to operate the new wave engine.

The booster was then jettisoned and the Pratt & Whitney Rocketdyne SJY61 scramjet engine ignited, initially on gaseous ethylene fuel. Next the engine transitioned to JP-7 jet fuel. Pratt & Whitney have invested heavily into the X51 and hypersonic flight.

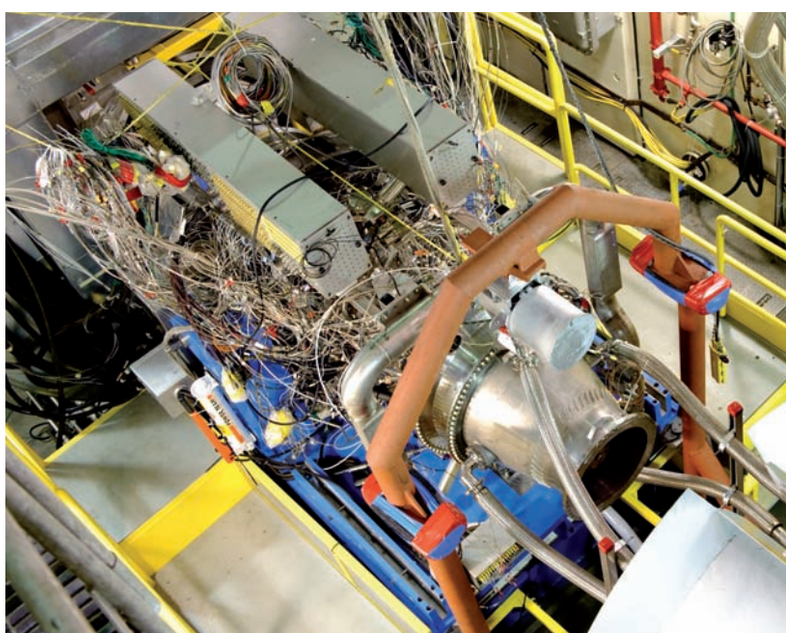
"We think long term, and this is a long-term technology for us," comments Adams. "We think there's a long-term business, probably initially in the military, both as an intelligence/surveillance, and also potentially, a weapons-delivery platform; making hypersonics a very interesting field.

"The key is the ability to achieve hypersonic flight using hydrocarbon-based fuels. Liquid hydrocarbon-based fuels are much easier and much safer to store than hydrogen, which has, historically, been the only successful fuel for scram jets. The ability to deploy larger numbers safely using liquid hydrocarbon, is a key milestone and a key enabler. It would allow us to open the market up to look at hypersonic delivery systems, either for missiles and/or for intelligence surveillance-type vehicles.

"My expectation would be a target to get a program launched in the next 12-36 months," asserts Adams.



Critical testing for the PurePower program, has included fan drive gear system testing with simulations of more than 40,000 take-offs and landings



Pratt & Whitney has completed more than 100 hours of testing on its full-scale PurePower engine core (right)

F135 JSF system

In August 2010 Pratt & Whitney concluded final ground tests on the short-take-off-and-vertical-landing (STOVL) version of its F135 engine for the F-35 Lightning II Joint Strike Fighter. However, the whole program has been criticized due to performance issues of the joint GE-Rolls-Royce engine system. Adams is confident that the F135 has achieved all goals.

"I think from our perspective, the program is going extremely well from an engine standpoint," he maintains. "We did get initial service release on the conventional take-off and landing version of the engine earlier this year. We are working to get the STOVL version released through initial service release this year.

"We have successfully completed a number of vertical landings," he says. "That has been really flawless. We have demonstrated the aeroplane, the STOVL version of the aeroplane has gone supersonic, and the ramp-up in terms of flight-test hours that was projected for this year is on target, if not a little higher than target.

"We think the progress that the aeroplane has made this year is on track and the engine has been extremely solid in the flight test program," says Adams. "We're pretty happy!"

Head of Engineering at P&W, Adams is confident about the future and puts the weight of his expectations on PurePower.

"On the commercial side of the house, we've concentrated on the narrow body and regional market and we've done that deploying our GTF technology. We also see potential for military versions that would use a military-style low spool." ▮

> "We've concentrated on the narrow body and regional market and we've done that deploying our GTF technology"

Stars in the eyes

In July 2010 Pratt & Whitney Rocketdyne's common extensible cryogenic engine (CECE) demonstrated a throttling range 35% greater than in the three previous tests, as well as several new technology breakthroughs to support space exploration. The CECE is a 15,000 lb thrust-class cryogenic-demonstrator rocket engine The liquid oxygen and liquid hydrogen-fueled CECE technology-development testbed evolved from the mature and flight-proven design of PWR's RL10 upper-stage engine.

Program manager, Victor Giuliano, speaks exclusively to *Aerospace Testing International*:

Tell me about the several test breakthroughs with CECE

This was the fourth in the series of engine tests that we've conducted. The program began in the summer of 2005. We are now concluding the program. We started out with demo 1 that we ran in 2006, demo 1.5 ran in 2007, demo 1.6 ran in 2008, and now this one running in 2010. Each of these has successively built upon the lessons learned about the prior tests, with the original goal given to us from NASA of a liquid-oxygen, liquid-hydrogen engine, and rocket engines. They are meant to be turned on and operated at 100% thrust and maybe a little variation in thrust for the mission; and then that's it. A throttling engine like this would be used for something like the lunar lander. NASA was specifically looking for a cryogenic engine and it became one of their most important contracts

What do cryogenic engines entail?

Cryogenic engine are powered by liquid, super-cold propellants, liquid-hydrogen and liquid-oxygen. Liquid hydrogen exists nominally at about -420°F and liquid oxygen runs out at about -320°F to 330°F. When you take two super-cold propellants like that, they have extremely high energy stakes. Put them together and combust them, and they release a lot of energy. When hydrogen and oxygen come together their by-product is water, as opposed to a lot of other rocket engine propellants. It's the type of thing that you'll carry with you on long-term missions.

So you can recycle?

You can recycle and you can find elements like hydrogen and oxygen in reasonable abundance at the various exploration destinations NASA wants to go to. So they're very interested in in-situ resource utilisation, frequently referred to as ISRU, which simply means wherever we go in the solar system, we'd like to be able to find the things we need to survive and work.

What makes the latest test so critical and important?

One thing that's not been done before is to successfully achieve what is referred to as 'a closed loop control', a CLC. This is important because it proves that we could develop the smart software that could follow throttling as it's rapidly going up and down from 100% down to 10%, and we could maintain the power level and the blend – the oxidizer to fuel ratio. So that's key, if you can successfully keep the ratio and power level tracking each other very accurately, you now have a system that can be extremely fuel efficient. You can choose to set any point you want for the length of the mission to burn the right combination of propellants to achieve the right performance, and it can all be done automatically. NASA wanted to see that done and we successfully accomplished that.

What has been special to this specific test scenario?

If you're running a wide range of thrust, you have to be prepared to measure all of your flows with much greater accuracy over a wider range than you might normally do. If you simply turn a rocket engine on and off, you have a extremely narrow band of thrust, and flow rates that you expect to have to measure accurately. If you're going to run a throttling engine, you've just increased the complexity to the test facility pretty substantially.

What do you feel has been the biggest technical success?

First, the overall throttling ratio of 17.6:1. We achieved this in the first four years of being able to go to test. We have also established a very good database, to figure out how to do this better for NASA in the future – it's their data now. Other firsts that are very substantial include: the close of control that is going to be very useful for other engine programs.

With cryogenic propellants, you've got to very carefully maintain the balance of pressure, temperature and flow rate. With cryogenics that's very hard to do, when you're trying to run about a low-power point. You're running at a fraction of the rate of these propellants when you're running at 100% and yet you're running very cold propellants. You've got to be able to control their state. That's what we did.

Have there been any major test problems, and how did you overcome them?

In a program like this, there are always challenges along the way. We had to learn about some of the various test set-ups. When we were running various conditions, again with super-cold propellants, we had to make sure that the right type of propellant conditioning was done. We had to learn lessons with regard to that. We had several challenges that had to be overcome, but nothing that prevented us from, ultimately, achieving the success of the four tests – and that's what's important.

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Guiding light

A NEW WEAPON SYSTEM HAS NOW ENTERED LOW-RATE INITIAL PRODUCTION. THE GUIDANCE AND CONTROL SECTION WAS TESTED AND DESIGNED BY BAE SYSTEMS

> **"APKWS provides aviators with a highly precise weapon that is effective against soft and lightly armored targets"**

BY KAREN SPILLER

The Advanced Precision Kill Weapon System (APKWS), a low-cost guidance kit that transforms standard unguided rockets into smart, highly precise laser-guided missiles, is one step closer to protecting men and women in combat.

BAE Systems, which designed the system's laser guidance and control section, recently entered Low-Rate Initial Production (LRIP) of the APKWS following the US Navy's declaration that the system is ready for production and deployment. That decision, known as 'Milestone C', was approved in March 2010 following a rigorous series of flight, component, and all up-round qualification tests. With the completion of the development program and the US Navy's Milestone C decision, APKWS has been established as the US Department of Defense's program of record to meet warfighter requirements for a laser-guided 2.75in rocket.

Developed by BAE Systems in partnership with the US government, APKWS provides aviators with a highly precise weapon that is effective against soft and lightly armored targets. It minimizes collateral damage, which is important in urban areas and other situations in which non combatants or friendly forces are near hostile targets.

The final APKWS flight tests, which culminated in a perfect '8-for-8' score in a series designed and conducted by marine test pilots, demonstrated that the system's accuracy exceeds government requirements. Throughout its eight-year history of flight tests, APKWS has hit an average distance from the center of the

The Advanced Precision Kill Weapon System (APKWS) in sequence

Artist impression: APKWS in action

Win the bid

The winning bidder for the APKWS II contract was the team of BAE Systems, Northrop Grumman, and General Dynamics, beating the offerings from Lockheed Martin and Raytheon Systems.

The APKWS II would have shared the Distributed Aperture Semi-Active Laser Seeker (DASALS) technology with the PGMM. This system allows a laser seeker to be located in the leading edge of each of the forward control canards, working in unison as if they were a single seeker. This configuration would have allowed existing warheads from the Hydra 70 system to be used without the need for a laser seeker in the missile nose.

laser spot of less than 0.75m against a government specification of 2m. In both developmental testing and operational assessment, APKWS was fired off US Marine Corps AH-1W Cobra helicopters.

"A 100% score in a weapon system test program is quite rare in the missile industry," said John Watkins, director of missile and munitions solutions for BAE Systems in Nashua, New Hampshire, where the guidance section is built. "These results show that APKWS will make a real difference in allowing aviators to complete their missions and return home safely."

APKWS brings three essential operational benefits to those in combat. First, the BAE Systems guidance section is designed to be compatible with current 2.75in rocket motors, warheads, and fuzes, enhancing the capability of the existing 100,000-unit inventory of unguided rockets. Second, the system provides the lowest collateral damage for precision engagement and gives the military greater flexibility to engage the enemy. Finally, the unit cost meets the Navy's objective against lower value targets.

Executive oversight

The Navy assumed executive oversight of the APKWS program in 2008 and has fully funded it for production. In addition to its planned use on rotary-wing platforms, the Navy has entered into a joint cooperative technology demonstration program with the US Air Force to evaluate the suitability of APKWS for fixed-wing platforms.

"There's a lot of excitement around this product," Watkins said. "Any time I have the opportunity to talk to our men and women in uniform, I hear about the pressing need for the capability afforded by APKWS."

APKWS can be fired from any helicopter that can launch 2.75in rockets. While the initial platform is the AH-1W Cobra, APKWS also has been successfully demonstrated from a US Army OH-58 Kiowa Warrior. Watkins says the Navy plans to run about 10,000 units, and, with growing international interest, the company expects surging demand for the capability.

The series of test shots completed from November 2009 through to January 2010, which culminated in the 8-for-8 record in operational assessment, tested the system through a tactically representative range of government specifications. APKWS was launched from minimum and maximum specified ranges (1.5km and 5km, respectively), as well as from intermediate distances; in a variety of flight profiles ranging from low-altitude hover to high speed, diving fire; and using representative laser designation methodologies, including self designation from the firing platform, buddy designation from a second, rotary or fixed-wing aircraft, and ground designation from a forward observer.

> **"APKWS requires no platform integration or aircraft modifications"**

As is typical during developmental test shots, the majority of the APKWS tests used surrogate warheads fitted with electronics to collect data in-flight, and the designated targets were painted target boards to allow precise measurement of the distance between the point of impact and the center of the laser spot. In the final eight shots completed in January of this year, however, Marine AH-1W Cobra helicopters flying a variety of scenarios fired laser-guided APKWS rockets at targets typical of those encountered in theater. Live warheads were fitted to the APKWS guidance section, and in day and night tests, the guided rockets struck their laser-designated targets and detonated on impact.

Rocket systems

The 2.75in rocket fitted with the mid-body APKWS guidance section is about 6ft long and can be fired from standard 4, 7, or 19 round launchers. At less than 35 lb, APKWS is well-suited for smaller aircraft, as well as for aircraft flying in high-altitude, low-air density environments in which weight must be minimized. By carrying multiple lightweight APKWS systems during a single mission, aviators can engage a greater number of targets than was previously possible, with increased accuracy. APKWS allows aviators to engage targets from a much greater range compared to conventional, unguided rockets or guns. This helps to provide enhanced safety to the aircrew through greater standoff.

The key to APKWS is its distributed aperture, semi-active laser seeker, DASALS-based guidance system. Rather than using a nose-mounted laser seeker, the APKWS guidance section is installed between the warhead and the rocket motor. The DASALS technology divides the seeker aperture into four elements, which are placed on each of four wings housed within the guidance section prior to launch. The mid-body design ensures that the optics and guidance system are protected prior to launch from harsh conditions, such as adjacent rocket fire, sand, dust, and salt.

"It's an easy weapon to use," said Watkins. "Because it uses standard launchers, APKWS requires no platform integration or aircraft modifications, and because it's loaded and fired just like a standard 2.75in rocket, very little additional aviator or ordnance crew training is required."

There are several advantages to using guided 2.75in rockets. "Unguided rockets are typically used for area suppression, and are not suitable for use in urban settings or areas in which friendly forces are close to a hostile target," Watkins said. Likewise, warfighters must be very careful when using today's larger, anti-armor precision guided weapons, since their larger warheads may result in unintended collateral damage.

"A guided 2.75in rocket, on the other hand, allows the aircrew to prosecute a specific target with a high degree of confidence," Watkins said. "The warhead fitted to APKWS, the 10 lb HE warhead, delivers a smaller blast than other precision-guided weapons in inventory, making APKWS the right-sized weapon for many engagements."

The guidance section for APKWS is being built in a modular BAE Systems factory in Nashua, New Hampshire. That factory, Watkins said, has the potential to be expanded if needed based on required volume. ▮

Karen Spiller is the manager of media relations with BAE Systems based in the USA

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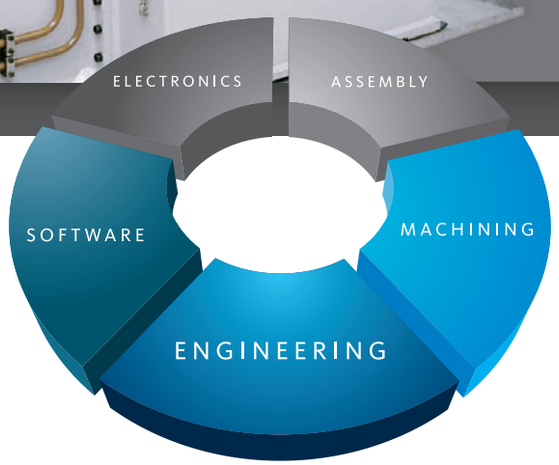

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NASA astronaut Nicholas Patrick, STS-130 mission specialist, participates in the mission's third and final session of EVA as construction continues on the International Space Station

Event horizon

AFTER NEARLY FOUR DECADES THERE ARE ONLY TWO MORE SPACE SHUTTLE MISSIONS. IN AN EXCLUSIVE INTERVIEW, *ATI* TALKS TO ASTRONAUT NICHOLAS PATRICK ON THE PAST, PRESENT, AND FUTURE OF MANNED SPACE TRAVEL

BY CHRISTOPHER HOUNSFIELD

In 2010 there will have been four space shuttle flights planned, with one planned for February 2011. After 130 missions, these are to be the last five. It is a huge upheaval for the NASA Space Shuttle program which started in the late 1960s and has dominated manned operations since the mid-1970s.

The shuttle's planned successor was to be Project Constellation with its Ares I and Ares V launch vehicles and the Orion Spacecraft. However, in early 2010 the Obama administration asked Congress to instead endorse a scaled-back plan with heavy reliance on the private sector. This may take time and has no guarantees.

In late 2008 NASA issued a statement announcing, 'Administration policy is to retire the space shuttle in 2010 and purchase crew transport from Russia until Ares and Orion are available'. A US$2.5 billion spending provision allowing NASA to fly the space shuttle beyond its then-scheduled retirement in 2010 passed the Congress in April 2009.

STS-130, Endeavour, was the first Shuttle to take-off in 2010. When it launched in the night of February 8, onboard was Englishman, Dr Nicholas Patrick, born in 1964 in Saltburn-by-the-Sea, North Yorkshire, and one of only seven Britons to fly in space, although he now has dual US-British nationality. This was his second flight into space (previously he had been with the crew on STS-116). He says of his two flights, "On STS-116, I was a member of the flight-deck crew and also the lead robotics operator on the Shuttle so there was that and a lot of training involved with inspecting the shuttle heat shield, which was an issue on STS-107.

Endeavour, carried aloft the International Space Station's final permanent modules: Tranquility and Cupola. Tranquility (or Node 3) is now the life-support hub of the ISS, containing exercise, water recycling, and environmental control systems. Cupola is the space station's conservatory, providing the largest set of windows ever to grace a spacecraft. There are seven, arranged in a hemisphere, giving a spectacular and panoramic view of Earth and enabling future crews a direct view of ISS robotic operations.

"STS-116 was only the fourth Shuttle launch after the Columbia disaster and only the second 'mission'. The heat shield was damaged on launch, and unfortunately, didn't hold up during the re-entry and so by now, we inspected the heat shield very carefully, both immediately after launch and the day before re-entry using the shuttles robot arm and the multisystems attached to it.

"That's a very big and complex job that I was in charge of on my second flight earlier this year, the STS-130, I also did some of the robotics, but I was also one of the two space walkers. And my colleague Bob Baker and I did three space walks from the space station airlock to help assemble and actually essentially finish assembling the space station."

"There are really two kinds of astronauts, two flavours, one is the pilot astronaut, they are exclusively graduates of the US Air Force or US Navy test pilot schools and they are all high performance jet pilots and they historically

> "You get to see the atmosphere edge, and appreciate how really thin it is. It makes you a bit more environmentally conscious"

Space, the final frontier?

Patrick is a very affable man, very English, very polite, very private school. Our interview is now more than 20 minutes over time; important in that he had to leave a critical meeting to speak to me. However, I cannot help myself asking the boyhood-dream question, "You spent a month up there so what is it like floating in space?

"The two things that really stand out about being in space are the ability to float which takes a lot of getting used to but is really magical. It makes trivial tasks impossible, but it makes the impossible easy, if that makes any sense?

"Making a sandwich, which is a trivial task on earth, becomes almost impossible in space, there are too many things to hold on to. But the impossible here on earth, floating through a module like superman without touching any walls, is easy with the littlest practise. The other amazing thing about being in space is the view, and that doesn't take any getting used to, it's immediately fantastic. You can enjoy it the minute you get to space and it's a view of the earth like no other, it's like looking down on a constantly moving map but with no political boundaries.

"When I look down on the planet I'm not thinking about the people so much because there isn't that much evidence of them. You can see at night all the cities and you can see contrails and smoke from forest fires and so on. You can't see the Great Wall of China, but you can see some of the effects of human life on the planet.

"By and large, what you see is the oceans, the clouds, the mountains and the deserts and just the natural scenery which is breath-taking and you spend time thinking about the natural planet. You get to see the atmosphere edge and appreciate how really thin it is. It makes you a bit more environmentally conscious.

What of the Space Shuttle? Mothballed? Broken up? Sold off?

"We hope that the shuttles will find their way to appropriate museums where members of the public can finally get really close to them and appreciate the fantastic technology that they represent. I think that the thing that we risk losing if we don't keep our operational tempo over the next decade is peoples' understanding of what it takes to operate a complex space craft like that and that's why we're all hopeful that a new spacecraft will come along soon and allow us to keep our expertise and our skills sharp."

The future of Orion?

"It depends how far into the future you look. I think, if you look decades in to the future, then we will hopefully be on commercial launch vehicles. We, at NASA, will be focused on doing the things that aren't commercially viable, long-distance exploration and so on.

"In the near future, it's hard to tell. We're in a transitional phase, we're still working on the Orion capsule, helping commercial spacecraft companies build in the systems that we think would be needed for us to use their vehicles safely. It's a an interesting and transitional time, and it remains to be seen what the direction is in the middle of this decade".

You feel the Orion and Constellation programme is something that will happen? "I think so. I'm hopeful; but these are transitional times."

have learnt to pilot and command the Space Shuttle; and then there are mission specialists.

"We come from a variety of backgrounds, some military aviators, some military non-aviators and lots of engineers and scientists and we come in and learn to do all the other jobs, flying as flight engineers on the Shuttle, flying as crew members on the space station, flying as robotics operators and space walkers. So there are lots of jobs available for mission specialists to match up the fairly broad variety of backgrounds."

Patrick has logged 638 hours in space as a mission specialist on STS-116 and STS-130. He has logged more than 18 hours of EVA (extra-vehicular activity) time during three space walks on STS-130.

Between flights

Currently Patrick is working in the astronaut office, and in the immediate future, on the design of the next generation of spacecraft. But in-between walking in space and training to walk in space, as well the myriad debriefings and presentations related to being an astronaut, Patrick has held down other day jobs.

"Between flight assignments, astronauts spend time working on technical issues. Now I'm working on the Orion Capsule user interface. But, at times, I've done other things and one of the really rewarding jobs I did was to act as a CapCom in mission control, that's a capsule communicator, a phrase left over from the original days of Mercury, Gemini and Apollo.

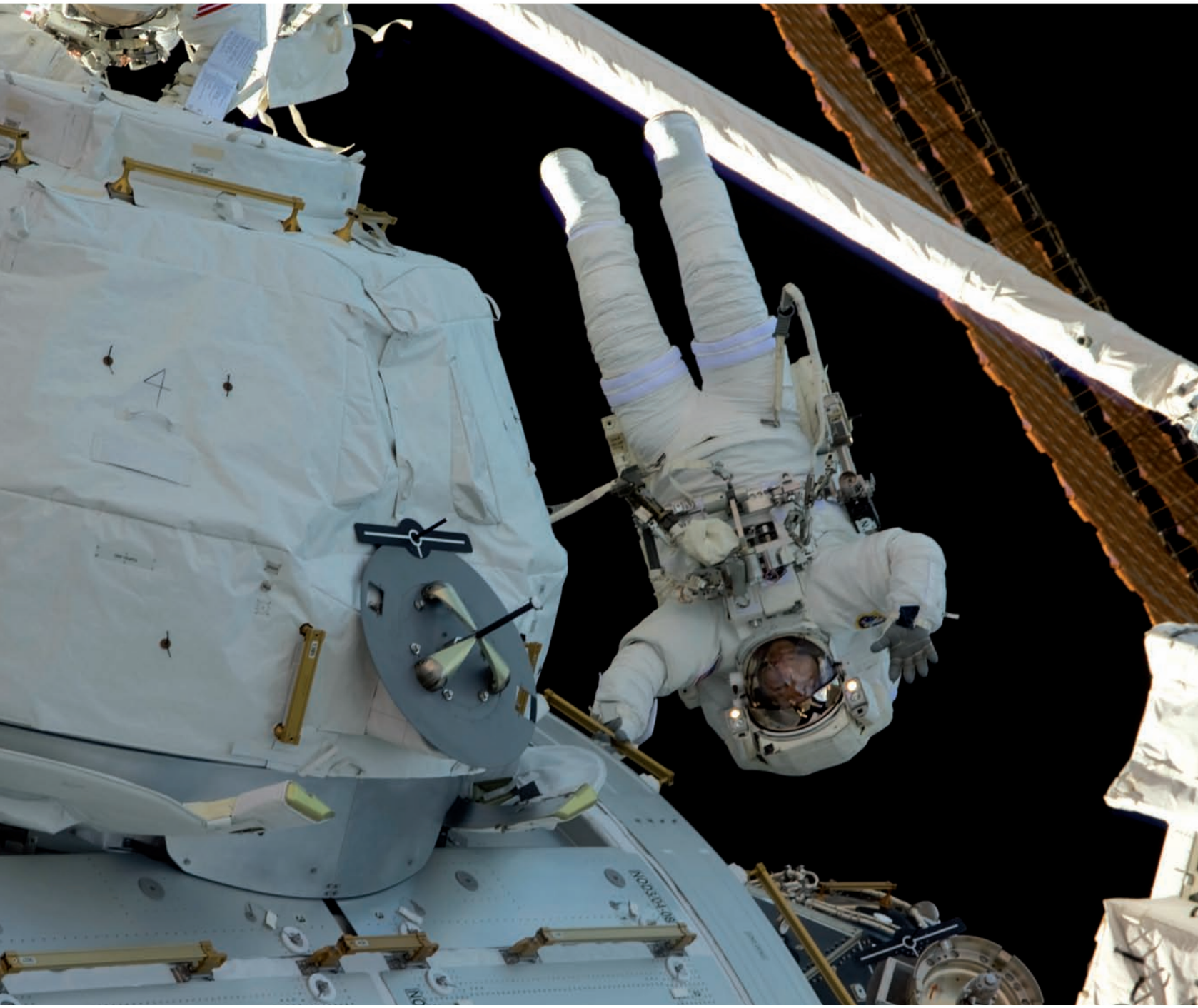
"The CapCom sits next to the boss in mission control who is the flight director and is the sole point of communication between the crew and mission control to make sure that the words that go out to the crew are words the crew will understand, phrased in a way, and in the right context, for the crew. To be a CapCom is similar to being an astronaut, and the CapCom has had the same training as the crew, unlike everybody else in mission control."

More recently, Patrick has worked on the Shuttle cockpit avionics upgrade development and test program, but this has since been ditched. "This was a great program we worked on about five years ago that unfortunately didn't quite make it all the way through to flight because they were coming to the end of the Shuttle program," he explains.

"The shuttle is a 1970s aircraft essentially, it's the first fly-by-wire aircraft but it is old and about twelve years ago, they replaced a lot of the mechanical instruments like the artificial horizon with a computer-generated replica to reduce maintenance time and cost.

"We had a fantastic project to go one step further, and to take all of the electronic displays in the cockpit and replace them with Smart displays, driven by a set of computers that would understand what failures were really happening in the vehicle and present them in an easy way to the crew, the same way as they'd be presented on a modern commercial airliner.

"It was a really interesting project. I was in charge for a while of the user-interface aspect, picking the colors and working on the layout and standardizing the displays. It was completely designed, but not installed in the Shuttle sadly."



Beginning of the Shuttle end

The Shuttle program's demise is already underway. The last two crews are preparing with STS-133 and 134. Other NASA astronauts are already working and training with the Russian Soyuz program – two astronauts have already been sent up onboard Soyuz spacecraft, to make emergency ISS repairs.

"We have had two redundant ammonia pumps and one of them failed and needed to be replaced because we're now only one pump failure away from not having station cooling which would be a very bad day in space, indeed," says Patrick. "So two of the astronauts up there, Doug Wheelock and Tracy Dyson have been conducting space walks to repair this.

Above: Dr Nicholas Patrick EVA.
Left: STS-130 crew members pose for a portrait in the Harmony node following a joint crew news conference with the Expedition 22 crew members while space shuttle Endeavour remains docked with the ISS

Extravehicular Mobility Unit (EMU) spacesuit fit check in the Space Station Airlock Test Article (SSATA)

Submerged in the waters of the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center

Avionic background

At university in England, Patrick spent his summer vacations as a civil engineer, inspecting bridges in New York and Connecticut. After graduating from Cambridge University, he moved to Boston, Massachusetts, where he worked as an engineer for GE's Aircraft Engines Division.

He then attended the Massachusetts Institute of Technology (MIT), and was a research assistant in the Human-Machine Systems Lab in the Department of Mechanical Engineering. His research interests included telerobotics, aviation psychology, decision theory, and optimization.

On completion of his doctorate, before joining NASA, Patrick worked in Flight Deck Engineering at Boeing's Commercial Airplane Group in Seattle, Washington. He was a systems and human-factors engineer on many of Boeing's commercial-aircraft models.

> **"Astronauts get to sit in design meetings and go through demonstrations of how to get out of the Orion capsule quickly"**

"They have had great difficulty doing it, but what's new about this is it's the first time a major space-station component has been replaced by crews who aren't flying up on a Shuttle, who haven't had time to train on the ground recently. They're using general space walking skills that they trained on the ground to do six months or a year ago.

"They're not doing this with the benefit of the support of a Shuttle that's docked, with fresh crews with recent training and people who are used to 1G and therefore have very well conditioned muscles and so on. This is the way of the future for us."

New international horizons

The Constellation program also has huge questions marks over its timeline and future. How does NASA technically collaborate with its old arch rivals in the East?

"We are helped enormously by the fact that we're all dealing with the same physics; we all have to get things up to the same speed, we all have to contain a pressurised atmosphere for astronauts to breath and so on," explains Patrick. "Necessarily our solutions all look, from fundamental principles, quite similar.

"There were some major differences early on in the designs. For example, American spacecraft have traditionally used low-pressure, all-oxygen atmospheres and we would ideally have designed a space station that used a lower pressure and a higher percentage of oxygen. The Russians have air-cooled avionics and therefore need 14.7psi and a sea level-like atmosphere for their architecture to work. The compromise was that we went with a double atmosphere which actually has some of the benefits for us as well.

"Some trade-offs had to be made early on and the design of the space station had to accommodate Russian modules that are essentially designed for the Mir space stations. They fit together with larger modules than we can carry up in the Space Shuttle. That's done through a mechanical and electrical interface that is carefully controlled and was agreed more than a decade ago.

"Now, when you get up to the space station, you float from one side of it to the other, one end to the other, from the Japanese and European modules, through the American modules into the Russian segment of the space station, and although the colors change and the shapes of the handholds change, the really fundamental things that you care about are the same. The atmosphere and the environment is the same. So it works very, very well."

With so many countries and initiatives, how do the technology and systems fit one Japanese part to one NASA? "We make sure it's integral," says Patrick. "Our contractors make sure that things fit by keeping test articles on the ground and moving bits of hardware around the world to try them out before they ever launch. The interface is also very well documented and well controlled. The success of this project is a testament to everybody's ability to design and interface and communicate internationally – it has really been a hugely successful international engineering project."

The next phase

The Constellation Program and the Orion project are still on the horizon, although maybe a more distant one. However, astronauts such as Patrick continue to work.

"Astronauts are playing a very important role bringing their space flight expertise to bear on the problems of things like emergency egress," says Patrick.

"When engineers sit down and design a way of getting out of a new spacecraft, it's really helpful if they can sit down with the people who have done the training for that, who through their training and space-flight experience understand what it's like to wear a space suit and be strapped into a capsule or a Shuttle, and then have to leave in a hurry. So, astronauts get to sit in design meetings and go through demonstrations of how to get out of the Orion capsule quickly; and then we get to advise the design and give our feedback.

"We did the same for display design, abort systems, and space-suit design. Orion needs a new space suit that's capable of doing some space walks and providing crash restraint. Those are jobs that the Space Shuttle suit called an ACES, an 'Advanced Crew Escape Suit' doesn't do. It doesn't have a conformed helmet to support your head during a crash, and it's not useful during a space walk. Because we don't have room on Orion to carry a second space suit, we have to make the launch suit do double duty.

"Some things evolved and for some things we went right back to the Apollo drawing board. We took the capsule shape from the Apollo, but some things are new. The heat shield technology is new, the computing technology is very up-to-date, even compared with the Shuttle; and certainly compared with Apollo which was at the dawn of the computer era. It's really the best of both worlds – a simple robust capsule combined with modern systems. ▮

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Taking a stand

NASA PREPARES FOR THE FUTURE OF ROCKET ENGINE TESTING

BY STENNIS PUBLIC AFFAIRS OFFICE

In the 1960s, NASA's John C. Stennis Space Center, all but hidden away in the woods of south Mississippi, built a reputation of excellence in testing the massive first and second stages of the Saturn rocket for the nation's Apollo Program.

Beginning in 1975, the center firmly positioned itself as the nation's premier rocket engine test facility with its testing of the highly-sophisticated space shuttle main engine. Testing continued until 2009, with none of the 132 space shuttle missions to date failing as a result of engine failure or malfunction.

With the space shuttle program drawing to a close, Stennis Space Center is focused on maintaining and extending its record of engine testing excellence. Efforts are under way to partner with commercial companies in their space flight projects, as well as provide testing for next-generation rocket engines that will power humans beyond low-Earth orbit once more.

Stennis Space Center is a commanding facility, encompassing a 13,800 acre facility area and about 125,000 surrounding acres of undeveloped sound-buffer terrain. It hosts NASA and over 30 federal, state, academic, and private organizations, and numerous technology-based companies.

However, it is the rocket engine testing that takes center stage, and that arena is one of high activity in the second half of 2010. Work is proceeding on test stands across the center, as well as on a new stand that will include capabilities found nowhere else in the country.

Construction of the A-3 Test Stand began in 2007. It is the first large test structure to be built at Stennis since the 1960s, with a target for activation in 2012. The open-frame stand was erected in 16 vertical stories with four million pounds of fabricated structural steel. It will stand 300ft tall when completed.

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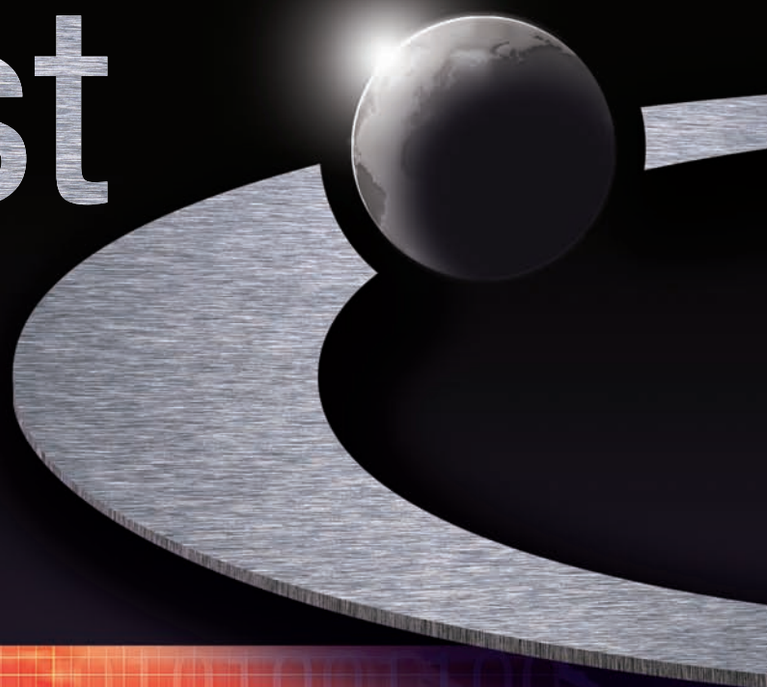

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Space shuttle main engine No. 0525 is lifted from the A-2 Test Stand at NASA's John C. Stennis Space Center against the backdrop of the new A-3 Test Stand under construction

The A-3 test stand – preparing for the future

Almost two decades after the last Apollo mission to the moon, there is general consensus that the time has come for the USA to travel beyond low-Earth orbit once more. Whatever forms those plans take, NASA's John C. Stennis Space Center is preparing to play a central role.

In anticipation of that role, NASA announced in May 2007 that it would build a new stand at Stennis for testing the next generation of rocket engines that will carry humans beyond low-Earth orbit. As the first major test structure constructed at Stennis since the 1960s, the new A-3 stand will allow operators to test engines at simulated altitudes of up to 100,000ft. Such testing is critical, since engines that carry humans beyond low-Earth orbit must be able to fire in space.

The simulated altitudes will be generated by using a network of chemical steam generators to reduce pressure within the stand's engine test cell, therefore simulating high-altitude vacuums. By the spring of 2008, the test stand site had been cleared and foundation work was complete. In April 2009, workers celebrated the erection of some four million pounds of open-frame structural steel to create the test stand tower. By year's end, general construction work was proceeding, and early work had begun for installation of the test cell diffuser. The 300ft tall stand, which is designed to withstand up to one million pounds of thrust, is scheduled to be completed and activated in 2012.

However, even before completion of that task, Stennis has been contributing to the future of American space exploration. Operators performed a series of power pack tests in 2008, providing critical information for development of a new generation of rocket engines. The power pack is the gas generator and turbopumps that perform a rocket engine's major pumping and combustion work. Stennis is now preparing its A-1 Test Stand for additional testing of next-generation rocket engines and related components.

In addition, engineers in the E Test Complex at Stennis have been conducting important early tests for the A-3 Test Stand project. The tests are designed to validate the design of the stand components and allow engineers to work out issues early in the process.

When the A-3 Test Stand is complete, Stennis will have unique capabilities. The new stand will allow operators to conduct full-duration tests (the amount of time the engines will have to fire during an actual flight) on full-scale engines and to gimbal the engines (rotate them in the same way they must move during flight to ensure proper trajectory), all at the simulated high altitudes produced by the chemical steam generators. No other stand in the country allows all of those aspects at such simulated altitudes at the same time.

During the Apollo Program in the 1960s, it was often said that however humans choose to go to the moon, they would have to go through south Mississippi, where the engines to power the missions were tested. Four decades later, that fact remains true. Whatever method the US chooses to travel beyond low-Earth orbit once more, wherever the mission may go, the journey will pass through south Mississippi and the John C. Stennis Space Center, the country's premier large rocket engine testing facility.

It will also feature a series of 27 chemical steam generators (CSGs) that will be used to create a vacuum to allow rocket engine testing at simulated high altitudes. The configuration has been used on test stands elsewhere with a skid of three CSGs, but the A-3 Test Stand will feature nine such skids. Configuring those skids presents the most-challenging aspect of A-3 Test Stand activation and operation.

The A-3 stand was designed for testing the J-2X rocket engine, a next-generation engine in development for the American space program. Since the engine could carry humans into deep space once more, it must be tested to those specifications. The A-3 Test Stand, with its CSG series generating 4,620 lb/sec of steam, will provide start and run vacuums as low as 0.16 lb/in^2 absolute, the equivalent of 100,000ft in altitude. The CSGs provide over four times the amount of steam as that produced by the J-2X engine.

The stand will enable full-duration tests on 300,000 lb thrust engines at simulated altitudes of up to 100,000ft with four degrees of gimballing. No other stand in the USA provides these capabilities.

A-1 Test Stand

However, that is not the only work under way at the NASA facility. The A-1 Test Stand is also being developed. Engineers are engaged in major maintenance and upgrading work on the 1960s-era stand, preparing it to test the power pack turbopump components for the J-2X engine. Since the J-2X is a new test article, a host of mechanical and technical aspects of the stand must be modified to meet test parameters. Work includes such things as replacement of liquid oxygen (LOX) and liquid hydrogen (LH) propellant run lines, installation of helium spin-start pressure vessels, reactivation of the gimbal hydraulic system, installation of new propellant flow meters, platform modifications, and installation of a new state-of-the-art thrust measurement system.

The 102,000 lb system is an advanced calibration system capable of measuring vertical and horizontal thrust loads accurate within 0.15% at 255,000 lb of thrust. That will allow test operators to measure thrust as they operate engines. Power-pack testing is scheduled to begin on the A-1 Test Stand in February 2011.

The last scheduled space shuttle main engine test was performed on the A-2 Test Stand in July 2009. The stand is now being readied for sea-level testing of the J-2X engine. The work includes many of the same modifications under way at the A-1 Test Stand, including installation of a new thrust-frame adapter, control system modifications, installation of new propellant flow meters, and replacement of LOX and LH transfer piping. The first J-2X test on the A-2 Test Stand is planned for January 2011.

B-1/B-2 Test Stands

The B Test Complex consists of a dual-position, vertical, static-firing test stand designated B-1/B-2, which was also built in the 1960s. First stages of the Apollo Saturn V rocket were static fired at the test stand from 1967 to 1970. For a number of years now, Stennis has leased the B-1 test position to Pratt and Whitney Rocketdyne for testing of its RS-68 engine. That ongoing partnership highlights NASA's new emphasis on working with commercial companies for space travel.

The future of space travel is on full display at the E-1 Test Stand at Stennis. The center's E Test Complex was built in the late 1980s and early 1990s. It features three small stands with seven separate test cells capable of testing that involves ultra high-pressure gases and cryogenic fluids.

In 2009, E-1 Test Stand engineers began modifications to test Aerojet's AJ26 engines for the Orbital Sciences Corporation. The work included construction of a 27ft-deep flame deflector trench at the stand. Flight engine installation and testing is scheduled for this fall. Two AJ26 engines will be used to power the first stage of Orbital's Taurus II space launch vehicle to provide commercial supply missions to the International Space Station. Orbital is under contract with NASA through the Commercial Resupply Services program to provide eight cargo missions to the ISS through 2015. The testing partnership between Stennis and the company is a prime example of the new NASA focus on working with commercial companies to provide space transportation.

E-2 Test Stand

Engineers at the E-2 Test Stand are preparing for delivery and installation of a CSG unit. Tests then will be run to achieve an optimal level of CSG performance to minimize use and water consumption. With the E-3 Test Stand, engineers have been actively involved in the construction. The team focused on subscale diffuser testing, providing critical data on design issues for the full-scale diffuser needed on the A-3 stand.

The A-3 Test Stand under construction at NASA's John C. Stennis Space Center is reflected in the water of the rocket engine testing facility's canal system

"The team focused on subscale diffuser testing, providing critical data on design issues for the full-scale diffuser"

Steam billows from the A-2 Test Stand at NASA's John C. Stennis Space Center during a July 29, 2009, space shuttle engine test

In addition to those efforts, Stennis continues to provide specialized testing capabilities to NASA and commercial customers.

For instance, it engaged in critical shuttle flow control valve testing in the early weeks of 2009, allowing NASA officials to clear space shuttle Discovery for launch on its STS-119 mission to the International Space Station. Stennis engineers were able to design a configuration and begin testing within a few days, demonstrating the adaptability and versatility of the facility and its personnel.

Earlier this year, engineers at the E-3 Test Stand also conducted acoustics launch testing, providing valuable data for future spacecraft launches. The engineers designed and built an adjustable launch platform simulator, allowing for quick variation of rocket drift and altitude. Subsequent testing allowed engineers within NASA to better define the acoustic environment associated with the first few seconds of lift-off. ▮

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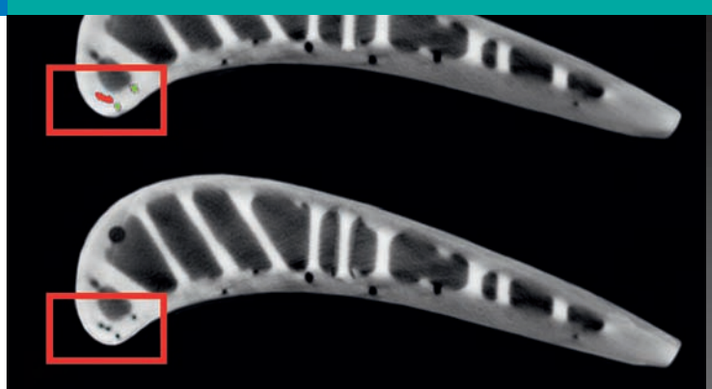

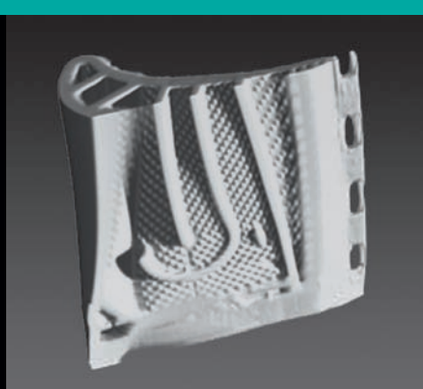

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Engineer the supply chain

THE WORLD'S LARGEST AEROSPACE COMMUNITY GETS THE ENGINEERING SHOW IT DESERVES

BY IAN STONE

Held at the Pasadena Conference Center, California, at the hub of America's largest aerospace industry cluster, Aero Engineering USA 2010 will attract visitors including OEMs, Tier 1s, suppliers, and subcontractors from across the entire North American aerospace engineering supply chain. Co-located with the Global Wind Tunnel Symposium and suppliers fair, it is the only 100% engineering-focused supply chain business networking and supplier event for the aircraft industry.

Based on the successful European edition, a unique combination of attributes will make Aero Engineering USA 2010 an important event. The show will include an integrated B2B online networking portal, which will enable hundreds of different attending groups to set-up B2B meetings prior to the event to discuss new business opportunities and strengthen contacts with existing and potential customers or suppliers.

Exhibitor highlights on the show floor will showcase leading suppliers, partners, and vendor organizations supporting the USA and North American aero engineering supply chains. This will cover design, through test and evaluation, production and assembly engineering, systems engineering, lifecycle support, and more.

An integrated two days of 'on the show floor' technology and strategic presentations – providing a program of high-level 'open' congress streams covering the latest certification, business, and technology issues from leading industry suppliers partners – will add valuable additional knowledge and insight for attending teams. Testing and evaluation will be under the spotlight at Aero Engineering USA 2010, with a dedicated test and evaluation session in the open technology forum, and a range of key exhibitors from R&D test and evaluation, production/quality testing, and MRO/fleet support test and inspection.

During the event there will be a focus on research and development testing and evaluation (RDT&E); ground testing; aerodynamic and wind tunnel testing; structural, fatigue and materials testing; engine/propulsion testing; environmental and lifecycle testing; acoustic and vibration testing; avionics/electronics/electrical testing; sensing and data acquisition/management; flight testing and analysis; non-destructive testing; metrology; quality testing, inspection and management; and automated test equipment (ATE).

Open conference program

The open conference will provide an integrated and complementary continuous program of presentations on the latest solutions and innovations from groups throughout the supply chain. Themes covered will include Six Sigma; NADCAP; lean manufacturing; training; aero composites; test and evaluation; advanced machining and tooling; quality engineering, and much more.

Following the success of the inaugural Global Wind Tunnel Symposium, the 2010 Symposium again brings together a global attendance of wind-tunnel facilities, government agencies, global customer groups, technology suppliers, and scientific organizations throughout subsonic, transonic, supersonic, and future hypersonic programs. For customer groups the forum will provide a vital feedback opportunity to define future demands and identify expectations to ensure future program needs are met. Presentations will be made by key OEMs to address future wind tunnel requirements against the backdrop of advanced program development. Finally, for supply chain infrastructure the forum will offer the inside track on wind tunnel facility requirements for future infrastructure investment for both new and upgraded facilities, and intelligence on future operational and technology requirements.

Composites – sessions

Hosted as part of the 2010 Aero Engineering USA Supply Chain Fair and Forum, the AERO Composites program provides design, manufacturing, and customer groups with two focused, half-day programs of presentations in the purpose-built auditoriums, integrated onto the show floor.

Specifically, the program will reflect developments specific to the aerospace sector, with a 'commercially focused' high-value, high-intensity program addressing the core issues affecting and influencing composites, current and future usage throughout the aerospace engineering sector, such as civil and military fixed and rotary wing aircraft, unmanned vehicles – UAV/UCAV, launch and space vehicles, as well as general aviation. ▮

More information at: www.aeroconfusa.com and www.windtunnelinternational.com/symposium. Email: info@leadingedgeem.com.▮

Tour de force

CRANFIELD UNIVERSITY IN THE UK OPENED ITS AEROSPACE DOORS TO INTERNATIONAL MEMBERS OF UK TRADE AND INDUSTRY TO SHOW OFF ITS FACILITIES. *AEROSPACE TESTING* TAGGED ALONG

> **"This was the first step in relationship development with client organizations"**

BY BUNNY RICHARDS

In July 2010, UK Trade and Investment (UKTI) representatives from five countries saw first-hand the impact Cranfield University has had on the aerospace sector during a high-profile tour. The visit from seven UKTI international investment officers was part of a fact-finding delegation to better understand and promote the UK's leadership in the aerospace sector.

The facilities showcased included the National Flight Laboratory Research Centre, the National High Temperature Research Centre, and the Safety and Accident Investigation Centre. The Technology Park, which is home to the Innovation Centre, and is serviced by Cranfield's development partners, St Modwen and the Incubation Centre (CUBIC), are both key aspects of the university's distinctive 'Innovation Habitat'. Currently, some 60 businesses reside in this habitat, ranging from pre-registered startups to global headquarters.

The tour highlighted the unique cabin evacuation research, which focuses on factors which influence survival in air accidents; the 'Blended Wing Body' (BWB) evaluation; the radical new aircraft design that results in enhanced fuel efficiency; and the Crash Impact Centre where F1 cars are tested to the maximum.

The delegates from Australia, Japan, the USA, and Canada, as well as the rapidly developing economies of China, also visited the Integrated Vehicle Health Management Centre (IVHM), which carries out essential research into the working condition (diagnosis and prognosis) of vehicles, from aircraft and ships, to high-speed trains and performance cars. This is done in collaboration with names including BAE Systems, Boeing, and Rolls-Royce.

During the tour, the delegation saw a wide range of facilities used to develop solutions to address complex technological issues within the aviation industry, including: methods of weaving carbon fiber structures and coatings for turbines to improve aircraft efficiency; a large cabin simulator for improving methods of aircraft navigation and evacuation; and laboratories specializing in jet propulsion and crash safety testing.

The delegation also visited Cranfield Health where they heard about how research into health and wellness measurement techniques will improve flight safety for pilots and passengers.

Step forward

Talking exclusively to ATI, Dr Paul Marshall, head of Cranfield University Aerospace, says: "This was the first step in relationship development with client organizations in nations represented by UKTI delegates. It was also an opportunity to showcase the unique facilities and activities of Cranfield related to the aerospace

The Cranfield advanced UAV design on display at Farnborough 2010

sector. These relationships could go on to include training or research. "The initiative's aim was to generate inward investment to the UK through international aerospace organizations, catalyzed by the opportunity to access the unique expertise, experience and facilities of Cranfield University.

"Cranfield has been at the forefront of aerospace technology for over half a century and has close commercial partnerships with many of the world's largest industry players. We're delighted to take a role in helping to attract overseas investment into a region which has so much to offer in the field of technology and advanced engineering," Marshall adds.

UKTI senior inward investment officer, Masamoto Shimizu, from the UK's embassy in Japan, says: "The visit has really opened my eyes to the wealth of expertise and world-class R&D facilities the UK has and Cranfield's leadership in so many fields in the aerospace sector. I was particularly impressed by the work at the IVHM center with the many industrial partners. My improved understanding will help significantly in promoting the UK as an excellent destination for businesses."

The Integrated Vehicle Health Management Centre (IVHM) carries out essential research into maintenance issues for aircraft, ships, high-speed trains, and performance cars. The work at the facility, which was partially funded by the East of England Development Agency (EEDA), is carried out with leading companies such as Boeing, BAE Systems, Rolls-Royce, Meggitt, and Thales.

EEDA is the driving force behind sustainable economic regeneration in the east of England and funds inward investment across the region.

Marshall says: "The aerospace industry is international and collaborative. Cranfield helps to retain value-added activity in the UK and encourage international aerospace organizations to work in the UK, utilizing Cranfield's impressive facilities. We hope the initiative has reinforced Cranfield's reputation as a world-leading university, and draws international aerospace organizations to use the specialist facilities and expertise of Cranfield University."

Cranfield specifically, among others elements, studies new concept designs and innovative test and development technologies. It brings together aeronautical engineering, materials, and manufacturing with expertise in aviation business processes and practices. It also plays a big part in the aerospace business sector with close commercial partnerships with Airbus, BAE Systems, Boeing, and Rolls-Royce. Cranfield worked with Boeing, for instance, to develop a cabin simulator at the university – a unique facility which focuses on factors that influence human survival in aircraft accidents.

Future development

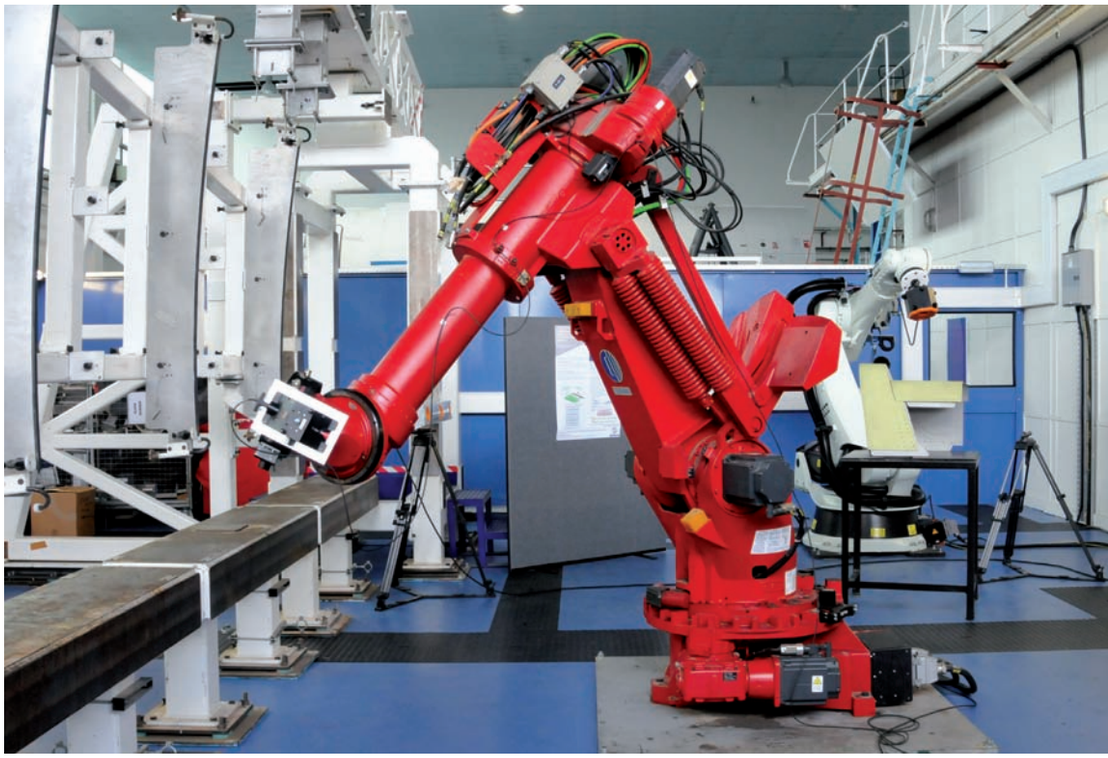
Cranfield has also partnered with key aerospace players, including BAE Systems in a £32 million (US$49.5 million) national program called ASTRAEA to develop technology and regulations to bring UAVs into routine, non-segregated operation in UK airspace.

Marshall continues: "We are playing a leading role in the Darwin Mission. This European Space Agency-funded mission is due to launch in 2015 and will look for earth-like planets in our galaxy. It will feature significant work by the university. We are also involved in efficient, environmentally friendly aircraft design. On top of this there are the UAVs: the Demon uses fluidic and thrust vectoring controls. It is the flying demonstrator of the ten-university FLAVIIR program launched by BAE Systems as their first 'grand challenge' to develop new technologies for UAVs.

"Cranfield is involved in the autonomous air-vehicles (National Flying Laboratory Centre – NFLC) Jetstream demonstration of sensors and autonomous flight control systems, as well as automated aero-structure manufacture, integrated vehicle health management, and safety and accident investigation."

It is a fact that 93% of Cranfield students are engaged in relevant work or research within six months of graduation, using applied research at industrial scale facilities, and this is something that Marshall considers the organization's greatest asset. So how does he forsee the future technologies progressing regarding aerospace development?

"I see increased fidelity and accuracy, and more efficient modeling and virtual testing. There will also be more composite and hybrid structures, more unmanned and autonomous operations, and reduced environmental impacts, Marshall concludes.▮



The facilities showcased included the Technology Park comprising an innovation center

Illustrious institute

Cranfield University grew out of The College of Aeronautics, established originally in 1946. Since that time the college has grown and developed into first an Institute of Technology and then into a university, with the original Aerospace College becoming one of the university's five schools. Further changes at Cranfield over the last decade saw the College of Aeronautics focus more fully on the needs of business through the Cranfield College of Aeronautics.

Dr Paul Marshall is head of Cranfield University Aerospace

Past the dark side of the Moon

THE ESTEC TEST FACILITY FOR THE EUROPEAN SPACE AGENCY WAS USED TO STUDY ENVIRONMENTAL PROGRAMS TO PROTECT THE HERSCHEL SPACE TELESCOPE'S JOURNEY INTO SPACE

A typical test, the Herschel is prepared for lateral sine vibration along its X-axis in the frequency range 4-100Hz. For this vibration test, the flight-model spacecraft was fastened on electrodynamic shakers in the ESTEC test center. Starting at 4Hz, the shaker frequency steadily increased to 100Hz over a period of about 80 seconds

BY JENNIFER SCHLEGEL

In May 2009, the largest space telescope of its kind, the Herschel telescope, was launched into space atop an Ariane 5 rocket from Europe's spaceport in Kourou, French Guiana, South America. Herschel's operational orbit will be around a point in space known as the second Lagrangian point – what astronomers refer to casually as L2. From this distant point in space, 1.5 million kilometers away from the Earth, Herschel will investigate the history of how stars and galaxies formed, and study how they continue to form in the Milky Way and other galaxies.

A project of this magnitude does not happen overnight. For years, the team of experts at ESA (the European Space Agency) and the European space industry diligently pieced together this precious piece of cargo and packaged it in its spacecraft: a tall tube measuring 7.5m high and 4m wide, with a launch mass of approximately 3.3 tons.

The Herschel's trip to L2 will be a demanding one. The telescope is scheduled to work for three years in an orbit far more distant than that of the Hubble telescope. Not only will it have to withstand very hard environmental conditions during its voyage to L2, it had to survive the launch itself, where it was violently shaken and subjected to extremely high noise levels caused by the rocket engine and aerodynamic effects on the launcher.

This is where the team of vibration and acoustic specialists from European Test Services (ETS) at the European Space Research And Space Technology Centre (ESTEC) test centre, in the Dutch coastal town of Noordwijk, stepped into the picture. Located between Amsterdam and The Hague, ESTEC is the largest ESA complex. A world-class test center and hub for European space projects, it is probably home to one of the highest concentrations of rocket scientists in Europe.

"The ESTEC test center is among the largest facilities in Europe and most likely one of the largest in the world," explains marketing and sales manager of test center-operator ETS, Alexander Kübler. "Mechanical test facilities include a series of electrodynamic shakers; HYDRA, the six degree of freedom hydraulic shaker; a state-of-the-art acoustic facility known as LEAF; and a number of physical-property measurement machines – all designed to verify the integrity and launch survivability of the structural design of spacecraft, their subsystems and other individual equipment."

"It is not such a big deal if you break a ton of cement but the HYDRA is special because, in the aerospace industry, controls need to be highly reliable and safe," adds head of the ESTEC test center, Gaetan Piret. "You have to be able to stop the shaker in an extremely smooth way, without risk of destroying the satellite.

"I believe there are not many sites in Europe that can handle this type of tonnage – and most of them are used for seismic testing."

Ensuring Herschel's safety

European Test Services (ETS), the operator of the ESTEC Test Center, was contracted to perform the environmental test campaign on the Herschel spacecraft. The spacecraft was delivered in several subassemblies and final integration was performed at the ESTEC test center by ASTRIUM (the prime contractor for the launch vehicle).

For mechanical testing purposes the spacecraft was equipped with accelerometers to measure acceleration and strain gauges to measure stress. In addition, the spacecraft was installed on load cells (ESTEC force-measurement device) to measure and control the forces the moment it is introduced at its base.

The LMS SCADA III system was used to acquire more than 300-acceleration, 72-load cell and 60-strain channels during the mechanical tests. ETS uses LMS mobile-acquisition rigs and patch panels. Five years ago, the ESTEC test center upgraded its in-house system to an LMS installation consisting of state-of-the-art LMS SCADAS III hardware and LMS

Herschel will have an unprecedented view of the cold universe, bridging the gap in the spectrum between what can be observed from ground and earlier space missions of this kind

vibration-control and data-reduction software in the form of the 'LMS Test. Lab Environmental Testing' software. In close collaboration with ESA staff, those standard items were fitted into a customized package for optimal deployment efficiency.

With over 500 channels, the system combines LMS Test. Lab Environmental software and LMS SCADAS III hardware. The 40-channel vibration control system accurately controls specific load-excitation schedules in real-time and in closed-loop mode. A master control station manages the overall data acquisition and four mobile stations process all measurement data. Each mobile station can manage signal conditioning, acquisition, raw time data storage and online processing for 128 channels.

The sensors are connected to the patch panels and the patch panels are connected to the acquisition rigs. This approach made it possible to leave all sensors connected when moving between facilities. Only the cable bundles needed to be connected to the acquisition rigs at the new facility. Notching sensors were connected to the spacecraft to measure acceleration levels so that excitation could be reduced if critical acceleration levels were in danger of being exceeded during testing.

With the mobile system, the operator moves physically with the rack and can easily interact with other operators on the floor.

"For vibroacoustic test, there is physically 100m between the two facilities"

"The days of walkie-talkies are long gone," quips Steffen Scharfenberg, in charge of mechanical testing at ESTEC. "During tests, you only need one operator with the master control panel. You don't need four operators – one in front of each rack talking with walkie-talkies.

The new mobility is an aspect that translates to improved flexibility as well. The previous system was one big and solid permanent system. Today, the data-acquisition system looks like four small refrigerators on wheels. The units can easily be split up or combined for 512-channel functionality.

Sine excitation sweeps

To ensure that the satellite structure was surviving the vibration test without damage, low level sine excitation sweeps were performed before and after applying large loads. The specimen acceleration responses and in particular their resonance frequencies were compared to see if any changes had occurred.

In addition to the base vibration, it was also verified that the spacecraft would survive the acoustic loads generated by the rocket. The noise generated by the rocket and airflow at the fairing of the rocket during launch was simulated in the frequency range from 25-2,500Hz. Then, the Herschel team simulated the performance of the spacecraft in the thermal and vacuum environment of space for more than two weeks. The environmental tests were completed with an electromagnetic compatibility (EMC) test performed in the large anechoic chamber of ESTEC. At various stages, the Herschel team also performed functional testing to ensure that environmental testing had not affected the spacecraft's operation or performance.

"For vibroacoustic test, there is physically 100m between the two facilities. In the past, this meant disconnecting 200 cables, reconnecting 200 cables on the other side, and double-checking them. In short, about two days of work for only 200 channels," says Piret.

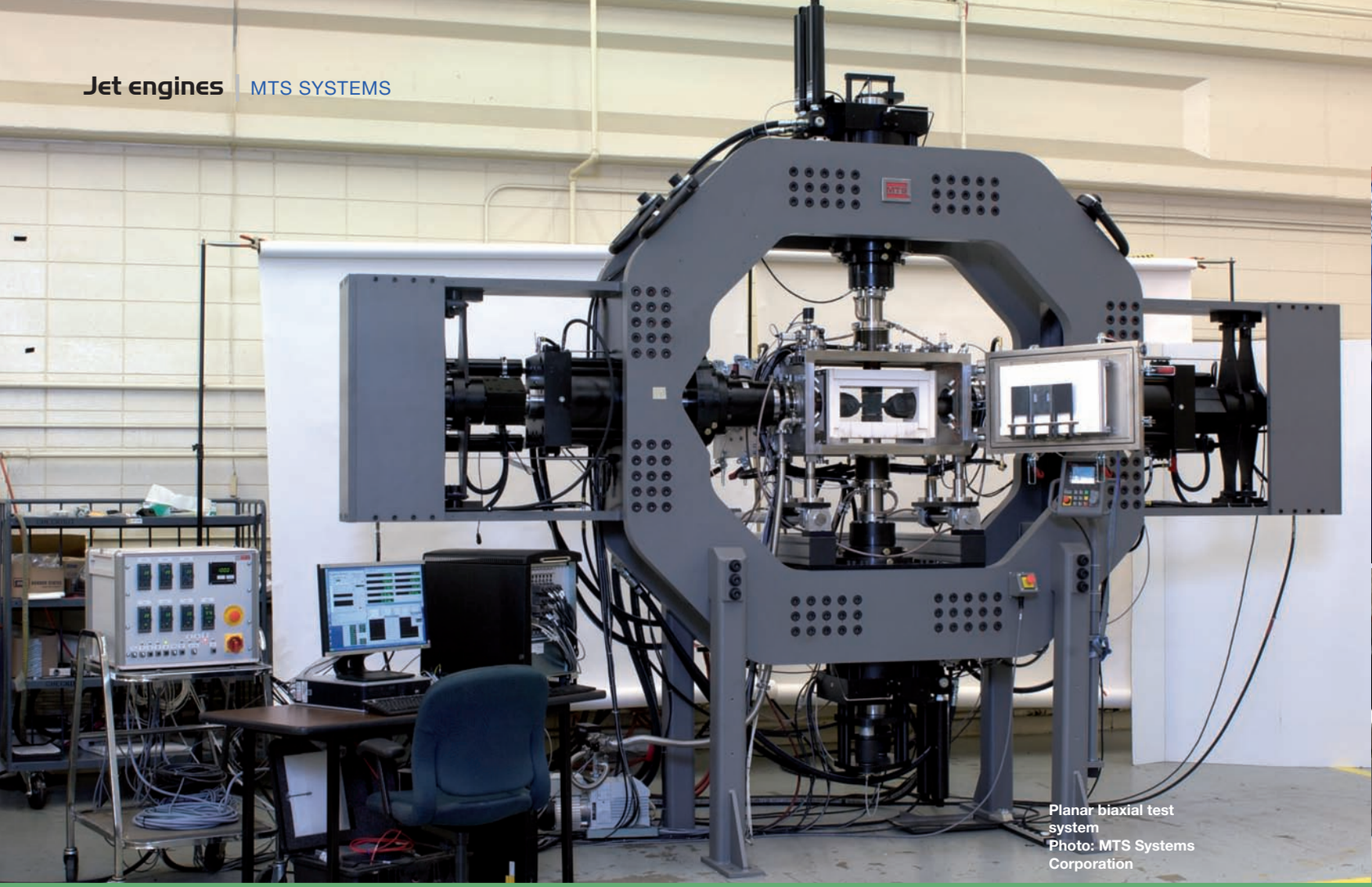
Now, due to the patch-panel concept, the team only does the connection job once, saving significant time in the tedious set-up process.

"With the new 500-channel system and patch panels, we only have 16 master cables to connect instead of 500 individual ones. To reconfigure now it takes a couple of hours instead of what would have been four days or more," adds Scharfenberg.

The entire test campaign took approximately one year. When the testing was completed, the spacecraft was installed in its transport container and started its journey to the launch site. It left the Netherlands in an Antonov cargo airplane which flew it from Amsterdam to Rochambeau Airport, French Guiana, arriving on February 12, 2009. It was then transported by road to the Guiana Space Centre in Kourou, where it was prepared for launch.

Herschel was carried into space on May 14, 2009 by an Ariane 5 ECA launcher in a combined launch with ESA's Planck spacecraft. The two spacecraft separated 30 minutes after launch and proceeded independently to different orbits around L2. ▮

Jennifer Schlegel, senior editor, LMS International, Leuven, Belgium



Planar biaxial test system
Photo: MTS Systems Corporation

> "These complex tests give us a sophisticated method of non-invasive measurement"

Feel the heat

HOW HIGH-TEMPERATURE TESTING IS UNLOCKING THE SECRETS OF ULTRA-EFFICIENT JET ENGINES

BY LARS OSTROM

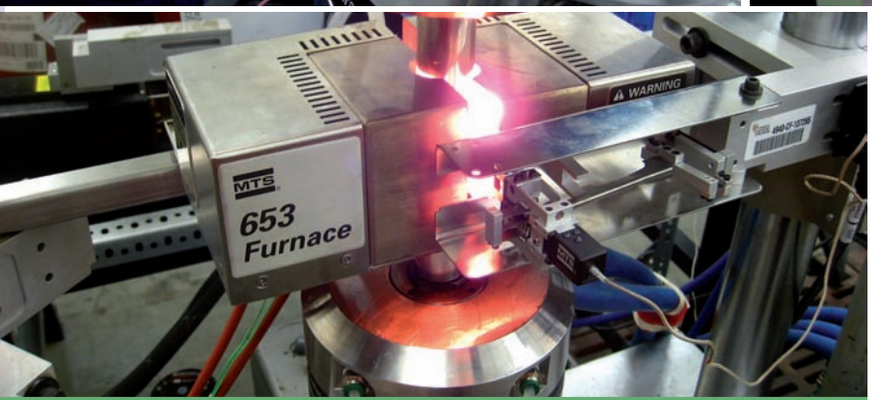
Imagine a future where fully loaded commercial jets make transatlantic flights carrying up to 15% less fuel than they do today. This time may be closer than is imagined, due to the work of aerospace researchers who are attacking the challenge of jet-engine fuel efficiency at multiple levels, from molecular structures of composites to complete engine designs.

Working near the limits of what is physically possible in the test lab, these research teams are devising complex tests that incorporate extreme high-temperature environments, precise multi-axial load schemes, and intricate real-time data acquisition. The ultimate promise of this groundbreaking work is nothing less than a complete transformation of the industry, driven by more durable engines that perform reliably at higher temperatures.

Thermal barrier coatings

At the molecular level, high-end aerospace testing concerns thermal barrier coatings (TBCs), thin layers of ceramic or composites that conduct very little heat and enable turbine blades to withstand higher temperatures. Some of the most advanced research in TBCs happens in the University of Central Florida's Department of Mechanical, Materials and Aerospace Engineering, where Dr Seetha Raghavan leads a team analyzing mechanical behavior of the oxide layer in TBCs under specific mechanical loads, using spectroscopy and high-energy x-rays for in situ materials testing. These innovative techniques allow the lab to observe exactly how high-strength ceramics and composites fail in real-time, but they come with a long list of challenges.

The first is space. Traditionally, these tests were limited to microscope-based setups with severe space constraints, and attempts to develop smaller loading equipment compromised control and accuracy. To overcome this, the team integrated a fiber-optic probe from the spectrometer in the setup, allowing laser excitation and data collection to occur outside the microscopy environment. This approach worked, but it created a new issue: data from the probe and the loading system must interact, and both data streams need to be stress-mapped in real-time during compression.



In situ mechanical testing of thermal barrier coatings (above). Elevated temperature low-cycle fatigue (LCF) testing (left). Photos courtesy: University of Central Florida

A third challenge is the nature of the coatings. Compression testing applies large loads on small cross-sectional specimens, yet the compression strength of these materials is over an order of magnitude higher than the tensile strength. To generate good data and avoid premature failure, tests must apply compression with perfect uniformity.

"To complete our work, we need precise, highly reliable loading with superior control, in a complex setup with several other instruments," Raghavan says.

To perform these tests, UCF uses the Insight 50 electromechanical test system from MTS Systems Corporation, based in Eden Prairie, Minnesota. In the lab, the twin-column, 50kN tabletop system provides high-resolution control during continuous loads, as well as load holding while the automatic stress maps are generated. Both capabilities are prerequisites for calibrating the behavior of spectral stress peaks for different materials.

"These complex tests give us a sophisticated method of non-invasive measurement that will move in situ mechanical characterization forward significantly," Raghavan explains. "This approach shows strong potential for real-time assessment of high-strength ceramics and carbon additive composites in the field, and will deliver high-impact results for aerospace."

High-temperature tests

Moving from coatings to materials creates a new set of high-temperature testing challenges. Also at UCF, in the same department as Dr Raghavan, a different team has forged alliances with local manufacturers Lockheed Martin, Pratt & Whitney, and Mitsubishi Power Systems, as well as the Kennedy Space Center to solve a long list of technical challenges related to engine efficiency. To address these problems, the lab needed to add high-temperature materials testing capabilities and expertise.

The expert turned out to be Dr Ali Gordon, who specializes in characterizing the behavior of turbine-blade materials at high temperatures. When he joined the school, Dr Gordon knew the biggest challenge would be integrating all the components required to perform high-temperature mechanical testing: load frames, controls, software, and accessories.

"Materials testing in extreme service conditions involves precise orchestration of force, motion, data acquisition, and environmental simulation, which can be difficult to achieve," he notes.

To ramp up these capabilities, Gordon collaborated, again with MTS, to integrate an existing mechanical test system (which comprised an MTS Model 810 servohydraulic load frame, controller and software) with new high-temperature environmental simulation components, such as a resistance heater, water-cooled hydraulic wedge grips, and an axial extensometer capable of maintaining high linearity and low hysteresis at temperatures up to 1,200°C.

Service environment simulation

Research into ultra-efficient jet engines also extends to engine designs and components. During product development, validating performance requires subjecting jet engine materials and components to the complex loads present during take-off, flight and landing, and also simulating the extreme sustained temperatures engines must withstand during operation to improve fuel performance. Here, Rolls-Royce is one of the manufacturers leading the way.

"Raising the standard for gas turbine engine performance requires equivalent advances in testing technology," says Materials Testing Team Leader for Rolls-Royce, Barry Ward. "To gain meaningful insight, we have to simulate extreme real-world jet-engine operating environments in our test lab, accompanied by advanced data correlation."

Rolls-Royce implemented these capabilities in September 2009, selecting a variety of hardware, software and accessories optimized for high-temperature material and component testing. Technology chosen included MTS Landmark servohydraulic test systems for uniaxial TMF, high-temperature low-cycle fatigue (LCF), fracture mechanics and tensile testing. The systems included grips, high-temperature extensometers, and environmental simulation systems. Rolls-Royce also added several MTS Planar biaxial test systems that enable advanced, highly precise multi-axial force, motion, and torque control of test specimens in high-stress, elevated-temperature vacuum environments that closely resemble actual jet-engine operating conditions.

All of these systems were deployed in the new Rolls-Royce Mechanical Test Operations Centre (MTOC) in Dahlewitz, Germany, opened in May 2010.

"We have achieved great strides in testing capability and productivity," Ward explains. "We do a lot of research that requires non-standard tests, and our testing equipment gives us the versatility and reconfigurability to support all of it. We are prepared to address near- and long-term needs in aerospace."

Major improvements in aircraft fuel-efficiency and durability are just over the horizon, due to the work of these forward-thinking researchers who continue to explore the possibilities of high-temperature testing, and continue to invent the coatings, materials and components that will undoubtedly be found in future generations of high-performance jet engines. ▮

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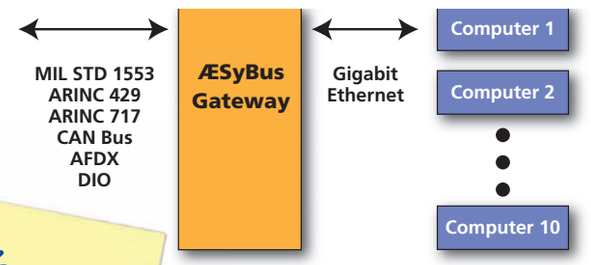

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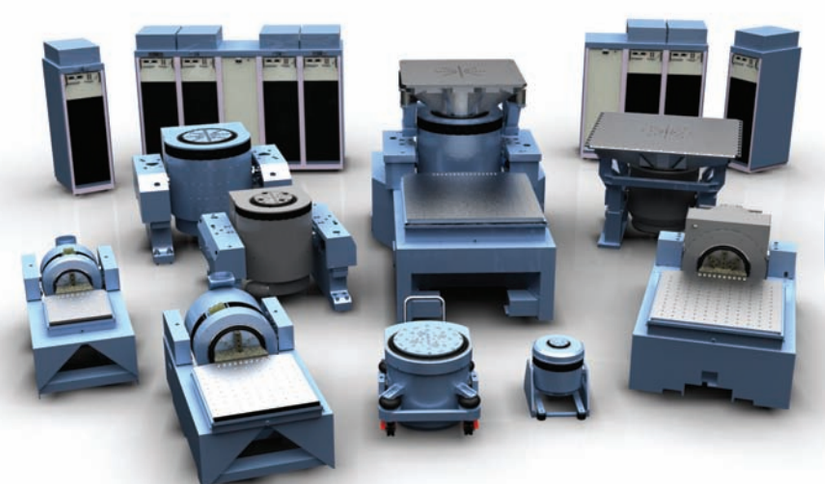

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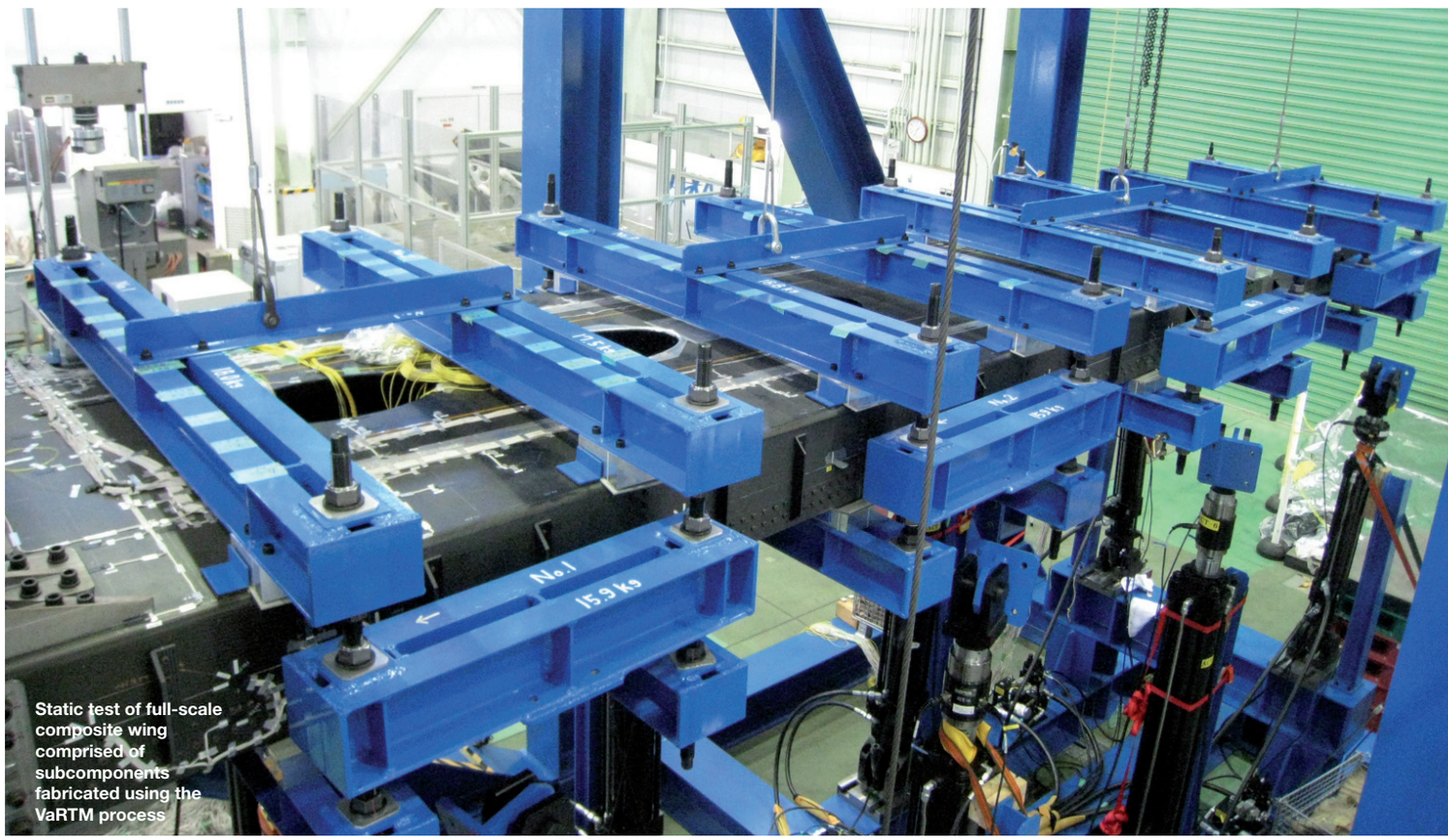


Static test of full-scale composite wing comprised of subcomponents fabricated using the VaRTM process

"VaRTM produced parts that weigh 20% less than comparable aluminum structures"

BY ROB REBISCHKE

Rising fuel costs and a global focus on energy conservation are increasing demand for aircraft that weigh less and consume less fuel. Historically, however, the composite components and structures employed to achieve this goal cost more to produce than their aluminum counterparts.

As part of its mission to advance aerospace research, the Japan Aerospace Exploration Agency (JAXA) set out to resolve this dilemma. Specifically, JAXA's Advanced Composite Group, led by Dr Yuichiri Aioki, sought to validate the quality of parts fabricated using an innovative composite-molding process known as vacuum-assisted resin transfer molding (VaRTM).

For aircraft, quality means safety. Aioki's team had to be absolutely certain that any production methods it introduced would not only reduce cost, but also deliver products that perform to the highest standards of durability, strength, and reliability.

The special benefits of composite parts are well-known. Although only 10% of passenger aircraft use composite materials, this trend is clearly changing. The Boeing B787 and Airbus A350, for example, use compound materials for more than half of their construction, including the main wings, rear wings, and body. If composite parts could be produced more cost-effectively, it would accelerate this trend, significantly changing fuel-efficiency calculations across the industry.

This is what led Aioki's team to perform some of the most thorough and rigorous mechanical testing of VaRTM-constructed components anywhere in the world. What the team discovered was astounding. VaRTM produced parts that weigh 20% less than comparable aluminum structures, and cost 20% less to manufacture than other composites.

Advantages of VaRTM

With VaRTM, a layered sheet of carbon fiber is placed in a mold, into which wet resin is then injected under vacuum pressure, forcing the resin into the cavity. This process allows precise tolerances and detailed shaping, as long as the resin fully saturates the fabric.

The primary challenge with VaRTM is ensuring the sheet is coated with resin in a single attempt, without generating air pockets between the carbon fiber and the resin. A second challenge is making sure the configuration

Left: Fatigue test of composite subcomponent fabricated using the VaRTM process

board achieves the exact same thickness as specified in the design, because the resin must be layered on top of the carbon fiber after the shape is formed.

The conventional process for composite manufacturing involves a carbon-fiber layered sheet that is pre-impregnated with resin ('prepreg'), and is placed in a pressurized furnace at 4-6psi to cure. There are several key differences between this approach and VaRTM.

First, VaRTM uses a more streamlined, single-sided molding that eliminates a considerable amount of material costs. It also requires lower pressure (one psi). Most important, it does not involve expensive autoclaves large enough to hold wingboxes up to 120ft long. Together, these differences significantly reduce manufacturing costs. Plus, VaRTM can form larger, more complex composite structures that incorporate fewer parts, so reducing weight.

Extensive, rigorous testing

Aioki and his team next had to prove that parts yielded by the VaRTM process could withstand the complex loading experienced by aircraft in flight. To do this, the team employed a variety of tests, starting with material characterization, then fatigue tests of subcomponents and structural elements, and finally static testing of a full-scale wing that involved complex multaxial simulation of actual flight conditions, including steep changes in altitude.

For the subcomponent fatigue tests (or, durability and damage tolerance testing), JAXA selected equipment from MTS Systems Corporation, based in Eden Prairie, Minnesota. Specifically, Aioki's team used a Model 311.41 servohydraulic load frame (2,500kN) outfitted with high-force hydraulic grips for wide panel specimens, along with a digital controller and multipurpose testing software.

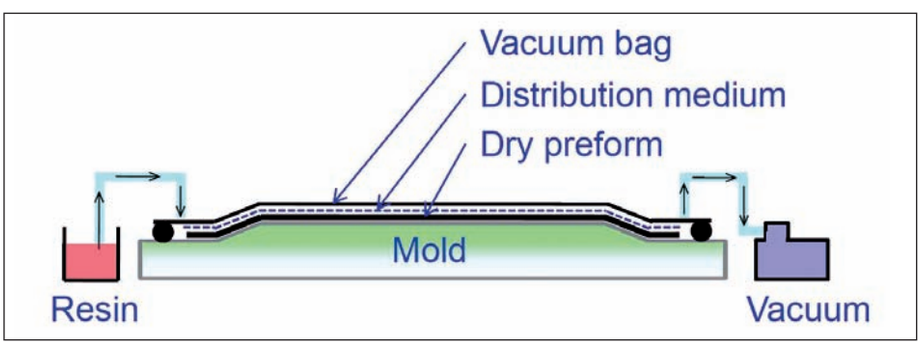
The test panel was a 2.1m x 0.9m subcomponent of a lower-wing panel. There were two critical areas for testing: the stringer run-outs and the maintenance hole. Steel fixtures were attached to both ends of the panel, which was then placed in the test system. The OML (outside mold line) side featured a random painted pattern that could be tracked using an optical 3D deformation-measurement system.

The multistage fatigue test plan was quite elaborate. It began with an initial strain survey and fatigue spectrum tests to evaluate disbonding of stringer run-outs. Next came 100% design limit load (DLL) verification, then a second strain survey to measure static behavior of VID (visible impact damage) and BVID (barely visible impact damage), and a second fatigue spectrum test to measure impact damage growth. Currently, the team is conducting two more rounds of strain surveys to evaluate the effects of part repairs, made after analyzing initial results. There will then be a final round of fatigue spectrum testing to measure the damage tolerance of repaired parts.

Equipment for the static testing of the full-scale wing, included compact servohydraulic actuators driven by a high-capacity digital controller and AeroPro Control & Data Acquisition software. The test rig measured 6.8m (height) x 4m (width) x 9.5m (length). Altogether, the setup involved 350 strain-gauge channels. Loading conditions were pure up-bend of the wingbox, which was tested up to 100% of DLL, and survived without detrimental permanent deformation.

Aioki's team also observed a tight correlation between their analysis of virtual component designs and the actual test results. This is absolutely critical for composite materials because they behave so differently from aluminum. Of course, composites do not scale up in a linear fashion as aluminum does, so it is important to understand exactly how specific forces affect different size components, as well as to determine where stress points and other vulnerabilities occur.

In addition, composites do not always show damage externally, whereas dents and cracks in aluminum are readily observable on the surface. Composites may look normal on the surface, even when serious structural damage is occurring internally. By aligning results of virtual and physical tests, Aioki's team can further refine the component designs and create more effective computer-driven methods for nondestructive component inspection.



Below: The new VaRTM process enables the fabrication of larger, more complex composite structures, incorporating fewer parts, reducing weight

Validating VaRTM

Although some final testing must still be completed, JAXA's test regime confirmed that composite parts produced using VaRTM can certainly withstand the real-world forces experienced by aircraft in flight. All test data can be traced back to a specific, properly calibrated device, essential during the development of a new aerospace manufacturing process.

"We can now prove that composite materials fabricated by VaRTM have been subjected to rigorous performance evaluations and have demonstrated their suitability for use in aircraft wings," says Aioki. "The world will soon have a new cost-effective means of manufacturing more lightweight and fuel-efficient commercial aircraft, without compromising passenger safety." ▮

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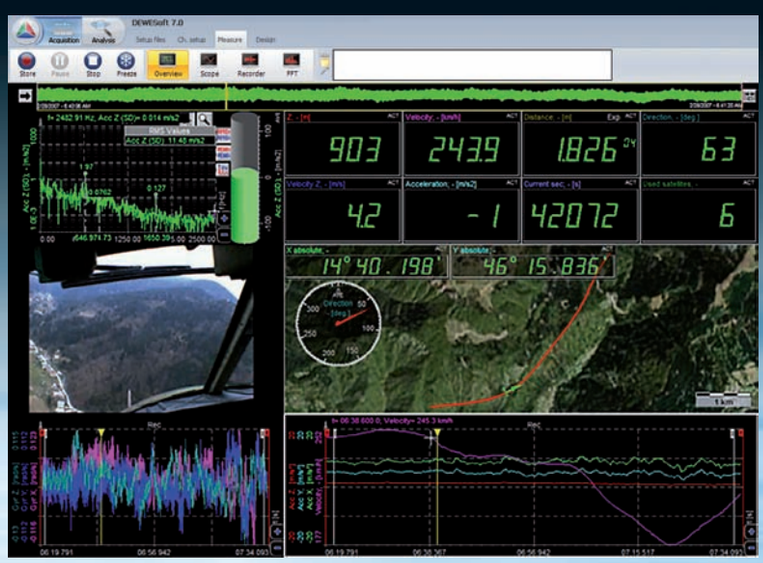

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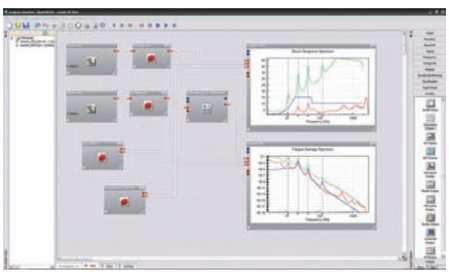
Case study one

New yaw control rods and mountings were required on a helicopter. The control rods run though the main fuselage and tail cone and are subjected to additional vibration from the tail rotor, and tail-rotor gearbox.

These components are critical to flight safety; a proposed swept sine and dwell test was considered unacceptably long and expensive (98 hours per axis), with an uncertain safety margin. By comparing with measured in-flight accelerometer data, a sine-on-random test was defined which runs in just 16 hours per axis. The tailored test offers a considerably enhanced safety margin over the entire frequency range.



Fight the fatigue

AGUSTAWESTLAND USES NEW METHODOLOGY FOR IMPROVED VIBRATION QUALIFICATION

BY JON ALDRED

The use of military helicopters in active war zones often requires the rapid deployment of new capabilities and configurations. But this cannot be achieved at the expense of safety. Each new development must be appropriately certified to ensure reliability in the tough vibrating environment of a rotorcraft.

AgustaWestland, the helicopter division of Finmeccanica, is successfully using a new 'test tailoring' methodology to assess these designs through more efficient testing. This approach is available in nCode GlyphWorks software from HBM, and is being used by AgustaWestland to ensure their helicopters meet the stringent durability targets.

All aircraft vibrate and components are designed, tested, and certified to survive these vibration levels over their entire service life. Helicopters are particularly challenging with regards to vibration and demonstrate clear benefits from the latest techniques for quantifying vibration-induced fatigue damage.

One important application of this technique is to derive tailored vibration tests directly from measured flight-load data. The objective of test tailoring is to obtain a qualification test that comprises at least the same fatigue-damage content as in a real aircraft environment, but in a much shorter test time.

Accelerometers record the vibration levels at a number of positions on the aircraft as it flies a prescribed sequence of maneuvers. The fatigue damage dosage for each maneuver is calculated using a fatigue damage spectrum (FDS), plotting damage versus frequency. The fatigue from each maneuver is calculated over the usage profile of the aircraft to determine the quantity of damage sustained during its entire lifecycle. From this analysis, a statistically representative vibration test can be determined.

A shock response spectra (SRS) is used to compare the worst amplitude seen in the test against the worst amplitude experienced in flight. The severest shock loads are very rarely encountered during in-flight conditions. Damaging fatigue loads are typically modest in amplitude but exist over very long periods. Test tailoring uses this effect to derive the optimum test duration so that the damage that occurs during the test is accumulated at the maximum rate without exceeding the worst loads seen in flight. Test tailoring is now supported by several design standards, including US military standard MIL-STD-810F Annex A, RTCA DO-160E, and French military standard GAM-EG-13.

The technique also offers a means of comparing damage severity across different vibration tests and different aircraft platforms. This enables test and service evidence, obtained on one aircraft platform, to qualify equipment on a new platform. This 'read-across' evidence has been successfully used to qualify equipment without the need for any additional vibration testing. It offers considerable cost savings and supports the rapid deployment of mission-critical equipment. ▮

Jon Aldred, product manager, nCode Software

Case study two

Equipment was urgently required for deployment on a military helicopter. No vibration qualification had been performed for this aircraft; however, previous clearance had been awarded for a different type of helicopter. The objective of this analysis was to compare the damage content of the original aircraft test with that required for the new helicopter and assess whether the existing qualification evidence is sufficient for flight approval on the new helicopter.

The original sine-on-random qualification test was performed in accordance with MIL-STD-810E for equipment mounted to the fuselage. The principal rotor dynamics are different and vibration levels are lower. The manufacturer's vibration requirements for the new helicopter are expressed in terms of a swept sine and dwell test. A direct comparison was performed using the shock response spectrum/fatigue damage spectrum approach. This showed that there was insufficient evidence to consider full type approval because of the difference in rotor harmonic frequencies.

By de-lifing the equipment to 100 hours, it was shown that the new helicopter was safely within the previous test qualification. In the first year of operation the equipment was re-tested and was eventually awarded full type approval. The read-across analysis enabled the immediate and safe deployment of the equipment to the field.

"We want everything to be better, faster, smaller, and lighter"

Grant M. Smith

President of Dewetron, USA

Dewetron is a maker of powerful data acquisition instruments that can record from analog sensors and from non-traditional sources, such as video cameras, GPS sensors, IRIG time signals, ARINC 429, and MIL-STD-1553 aircraft bus data.

What does Dewetron see as the latest prime development in data acquisition and your part in it?

From our point of view, the continual development of specific digital buses for every industry presents enormous opportunities for those willing and able to interface to them. There are important new buses in the automotive industry, and continually developing buses in aerospace, that can be tapped into, adding incredible value to data acquisition. The days when a data acquisition system could record analog signals and nothing else are ending. Our customers expect us to keep up with these interesting data sources that add value to the data that they record, and we are doing it. It's a big investment, but this is the future.

In addition, the possibility of connecting a good data acquisition instrument to any computer via USB and Ethernet is another good development that will push the market forward and create new solutions.

I understand the company won an award from NASA, can you explain?

NASA's official trade publication is called NASA Tech Briefs. It serves as a transfer of the high technology developed by and for NASA, to the private sector. They run a contest within each of their 12 annual issues for 'product of the month', chosen by the editors to represent the best new technology that they see on the market. Then at the end of the year, the 12 winners are put before the more than 200,000 readers, who vote on product of the year. The top three are elected by the readers, who are engineers and technical people in a wide range of industries – not just aerospace. Very few companies have won product of the year, and virtually none have won this award twice. I am happy to say that Dewetron has won product of the month three times and product of the year twice: first in 2006 for our battery powered system, and then again in 2009 for our DEWE-43-V.

You are also a test and measurement system provider. What have been your latest developments?

In recent years our systems have become more and more scaleable. In addition, we have developed the networking side of our data acquisition software, DEWESoft. We also have new hardware platforms which 'scale up' into thousands of channels in a very easy way. This combination of developments has opened the door for us to create test and measurement systems beyond the scale of a single instrument.

In recent memory we have provided solutions for interesting large scale systems in a wide range of industries and applications. A large NASA system has 700 isolated multi-function signal conditioning inputs, all of which can be sampled up to 100kS/s/ch, for example. We are working on another system now for an aircraft maker that has more than 1,000 analog input channels, plus dozens of bus inputs from ARINC and PCM.

Dewetron has systems for all aspects of 'trouble-shooting'. Can you qualify?

It would require ten of these magazines to describe it all. In short, can you imagine the breadth and scope of what goes into making an aircraft today? There are materials, components, subsystems, avionics, and finally airframes just to start, and each needs to be tested throughout the R&D process and then before delivery.

Makers of these elements have all manner of test systems and resources, from EMC and RFI to thermovac, shake and bake, environmental chambers, and more. From the analog input point of view, our products are in the business of making physical measurements, which is to say, the acquisition of physical sensor data. We humans have amazing sensors in our skin and other organs which can detect temperature, strain, stress, force, sound, and vibration, to name a few. The trouble is, these measurements are subjective, i.e. they cannot be quantified exactly.

So within this physical measurement realm, today's engineers use sensors that imitate our human senses, including accelerometers, microphones, cameras, load cells, thermocouples, and more. These sensors are interfaced to a data acquisition instrument, which is comprised of excellent signal conditioning and conversion into the digital domain, so that sensor outputs can be displayed and recorded within a computer. Then we can make objective, repeatable measurements, compare them over time, and analyze them deeply. This is what pushes development forward.

Can you give an example of a latest test case study/project?

NASA is at the forefront of research in many ways. Everyone knows about the Kennedy Space Center, where manned missions and others are launched from, and the Johnson Space Center in Houston, which takes over operational control once a manned spacecraft leaves the pad. But there are 10 NASA facilities around the USA, and they each play important roles in research, development, and testing of existing and upcoming technologies. NASA Glenn Research in Cleveland, for example, uses Dewetron data acquisition systems heavily this way. When ice was forming on the orbiter during lift-off and causing trouble, they did all kinds of tests to first duplicate this phenomenon, then figure out how to mitigate it.

What are the latest systems on the Dewetron drawing board?

It would not be particularly prudent to give away too much before we are ready to bring a new product to the market. However, it is safe to say that we are always working on something, and that it will push the envelope forward in more than one area. Like our customers, we want everything to be better, faster, smaller, and lighter. But at the same time we want to make them more reliable, more standards oriented, and even more scalable.

Mobile CT system

NON-DESTRUCTIVE TESTING: FRAUNHOFER OFFERS NEW AND RELIABLE TECHNOLOGIES

Non-destructive testing and evaluation (NDT&E) is becoming more and more of an important issue in aerospace production. This is in order to gain real-time information about the quality of manufactured aerospace components within the manufacturing environment. Methods like radioscopic imaging or computed tomography are still limited to laboratory applications and to support R&D for new product and material development.

The main target in the future is to advance these technologies for reliable and fast application on the production floor. This means providing mobile computed tomography systems (CT) capable of inspecting any component directly in and during the manufacturing process, independent of object size and structure. On the other hand, CT and radioscopy have to be speeded up in terms of data acquisition and subsequent automated data evaluation, especially for customized mass production modules, such as thermoplastic CFRP-clips.

The Fraunhofer Development Center for X-ray Technology EZRT, a joint research center of the Fraunhofer Institutes for Integrated Systems IIS and Non-destructive Testing IZFP, has developed a mobile CT System based on corresponding robots, one bearing the X-ray source and the other bearing a detector system.

Based on CAD data from the object under inspection, a CT simulator calculates the optimized positions for the robots to get the best radioscopic images for subsequent CT region of interest (ROI) reconstruction. Limited accuracy of the robots is compensated by proprietary algorithms, which are capable of calculating the exact position of the robots directly from the radioscopic images.

Therefore, the system is independent from the accuracy of the robots, because not the nominal, but actual positioning values are used for reconstruction of volume data. Moreover, for the inspection of large components, the development center is running a LINAC facility, equipped with a 9MeV linear accelerator and specific handling and detector systems in a 20x20m test hall with a height of 16m.

The CT reconstruction has also been improved for automated 100% inline inspection. This means that mass products can be inspected by computed tomography in less than 20 seconds per clip to find relevant deviations in density and structure, pores or blow holes. The big advantage of this new inline CT system is, compared to state-of-the-art methods, like two-dimensional radioscopic imaging. It offers a much more powerful image processing and defect characterization by three-dimensional CT data evaluation.

The consequence is this now enables NDT&E to not only check the object quality but also to classify the defects and consequently find a correlation between defect and correlated manufacturing process parameters. The future opportunities are evident; inline CT for the first time enables an inspection method to control and to enhance not only the product quality but also the production processes.

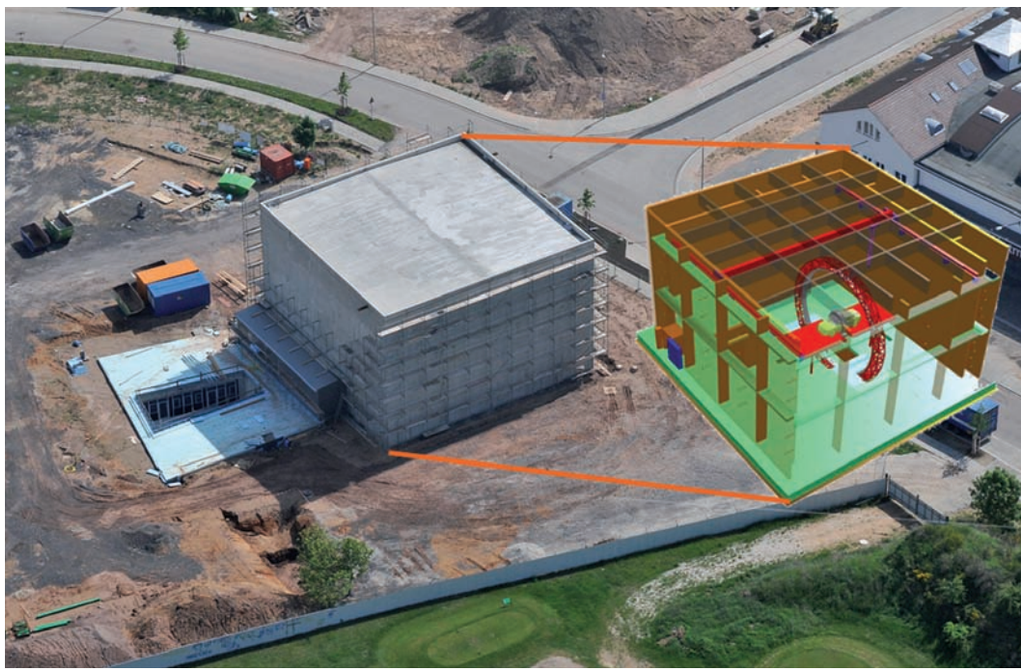
Effective mobile computed tomography system: Robo-CT

Non-destructive methods

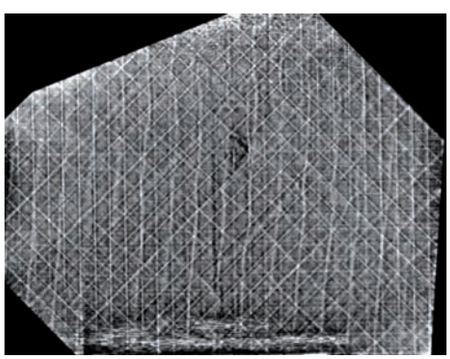
Additional NDT&E methods like ultrasonic, thermographic, electromagnetic, and laser-based imaging as complementary technologies are developed in the Fraunhofer Institute for Non-Destructive Testing IZFP. Sampling Phased Array ultrasound inspection is just one example of the many new and outstanding R&D results of this institute. Closely connected to NDT are new approaches for Structural Health Monitoring (SHM) to complement current methods for in-service inspection. Permanently attached sensors are used to generate a picture of a structure's state using methods like load monitoring and automated adaptions of NDT technologies.

As damage can be detected in a shorter range of time than in current inspection intervals, this technology offers advantages in different phases of the lifecycle, ranging from a potential for saving weight in future designs and reducing expenditures for scheduled and unscheduled maintenance, to monitoring repaired areas to a higher resale value if the individual load and damage history justifies this. Still, there are several open issues preventing the widespread introduction of this technology.

Far right: Mock-up of a 4m tall composite wing with over 40 embedded and surface applied sensors



Region of interest CT layer of a CFRP component



Fraunhofer is working in several institutes in critical segments for this upcoming technology. Aspects of research and development includes the development of new sensor systems, data fusion, estimation of the current condition based on sensor records, prognosis of the future structural performance, and reliability of sensorized structures. Those structures will be enabled in the future by the combination of different sensors. The combination of different sensors also improves the reliability if a method of repair for failed sensors is not available.

Manufacturing processes

Another very important module is manufacturing processes for sensorized structures. At the ILA Berlin Air Show 2010, Fraunhofer Institute for Structural Durability and System Reliability LBF presented a mock-up of a 4m tall composite wing with over 40 embedded and surface applied sensors. In the case of the wing mock-up, fiber-optic and metallic strain sensors were used for detecting loads. Impact sensitive piezoceramic sensors for Acoustic Emission and Acousto-Ultrasonic combined with pressure sensitive coatings create a picture of impact induced delaminations by foreign object damage.

In the future these sensors will help to detect all relevant loads and analyze the effect on the mechanical properties, e.g. with the methods of structural durability analysis enabling individual maintenance cycles based on the distinct wear and tear of a component.

At the ILA Berlin Air Show 2010, Fraunhofer researchers also presented their initial findings of the EU-Project JTI 'Clean Sky'. Air travel of the future is expected to be quieter, cleaner, and more environmentally friendly. To achieve this goal, new structural concepts and aerodynamic profiles have to be engineered, along with better drive concepts and adapted logistical designs.

In the newly formed Fraunhofer Lightweight Construction Alliance, 14 institutes working in the areas of design, new materials and composites, manufacturing, functional integration, and non-destructive and destructive testing offer all-in-one-solutions for complex R&D activities.

Important aspects of NDT in Aerospace will be discussed at the second International Symposium on NDT in Aerospace on November 22-24, 2010, Radisson Blu Hotel, Hamburg Airport, Germany. ▮

Martin Lehmann, Fraunhofer LBF, Darmstadt, Germany.

MeV-LINAC test facility for large objects like containers, aircraft wings, automobiles or jet engines. (All pictures Fraunhofer EZRT)

Look at advanced materials

SONATEST'S RAPIDSCAN AND WHEELPROBE PARTNERSHIP SAVES INSPECTION PERFORMANCE TIME IN THE AEROSPACE AND COMPOSITE SECTORS

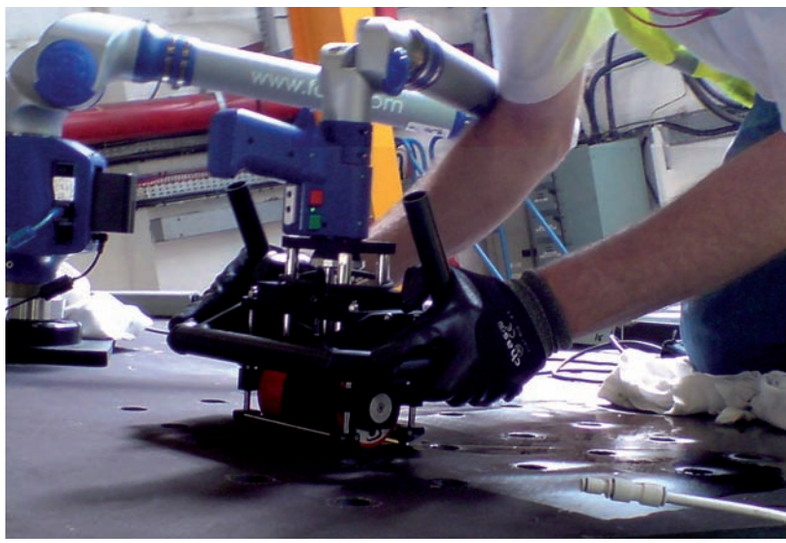
As the use of composite materials in the aerospace and aircraft manufacturing sector increases so does the need for inspection and testing of these more advanced materials. The nature of failure in composite structures is seen as being more complex to detect and interpret as a very small defect on the surface can conceal a much larger flaw beneath. The need to implement testing methods and systems for surface areas of composite materials, both in aircraft manufacture and MRO, has been growing over recent years, and is set to continue in the future. Sonatest's inspection solutions in this field using the Rapidscan systems and the patented WheelProbe has enabled end users to achieve fast and accurate results. The company's solutions are now being recognized as leading testing solutions within the aerospace sector.

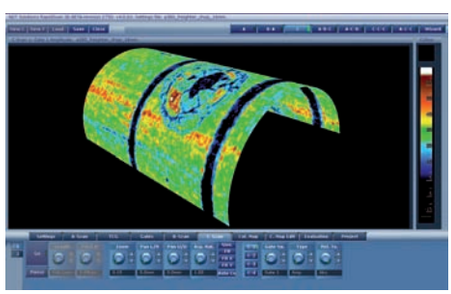
Sonatest's Rapidscan Series has come a long way since it's initial development in 2003 as a result of a partnership between Airbus UK and Sonatest. Now an established instrumentation series, the Rapidscan 2 and Rapidscan 3D both offer aerospace and composite testing fields unrivalled solutions – not only in terms of the time taken to complete inspection procedures, but also with regard to the quality and accuracy of the results that are achieved.

Frequent applications include: composite laminate inspection; bonded stringer inspection; bonded core inspection; delamination detection; and thickness mapping. The Rapidscan's partnership with the WheelProbe technology offers sound transmission into composite surfaces. The WheelProbe's polymer tire couples to the composite's surface with ease and only uses a mist of water as couplant. The conformable tire of the WheelProbe ensures that the coupling to these complex surfaces and shapes is far superior to that of using rigid delays. Additionally, a unique WheelProbe has recently been added to the range called the Radius WheelProbe, specifically designed for the Aerospace sector and curved surface mapping.

The Rapidscan 2 is a 2D ultrasonic array system that utilizes a 128-channel pulser-receiver to generate beams of up to 32 active channels. This system employs a custom high-speed data capture card, which controls the beamforming electronics and processes the raw ultrasound data to deliver high frame rate B-scan and rapid processing for C-scan data. Image frame rates between 100 to 300 times per second can readily be achieved permitting fast, high-resolution scanning of large components.

Building on the Rapidscan 2, the Rapidscan 3D has the capability to scan structures quickly and accurately in 3D using a coordinated measuring arm. The speed and ease of use of this system has changed traditional NDT scanning methods, removing the need for both expensive immersion baths and tooling, and reducing the time taken to locate and identify defects and anomalies. The system is ergonomically designed to follow complex 3D shapes, which greatly reduces inspection time. The inspection of even larger areas can now be achieved in a fraction of the time of traditional NDT methods. Accurate results are presented in the form of 3D images of the inspected part, which can be cross-referenced to traditional 2D C-Scans. These results can easily be shared and understood even by those without NDT experience.





Left: Computer 3D image showing cylinder impact

Aurora Flight Sciences in the USA has been using the Rapidscan System in recent applications on both commercial and military aircraft. Inspections of tail assembly bonds and rudder bonds are now taking only 15-20% of the time they used to, while producing precise and easily interpretable results.

A recent showcase of the Rapidscan 3D and WheelProbe Inspection system took place at the Virgin Engineering Excellence Day held in the UK, where it was recognized as being outstanding in inspection performance, as well as producing results that could be interpreted by the non-technical members of the team and the composite engineers and inspectors.

Sonatest's experience within the advanced composite testing and aerospace sectors is proving to be a valuable asset within product design and performance.

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DIGITAL HIGH-SPEED CAMERAS FOR FLIGHT CHASE AND OTHER HAND-HELD APPLICATIONS

As digital cameras, both for still photography, as well as for filming, get more compact, more powerful and add more functions every year, high-speed cameras develop equally rapidly.

A special type of application for 'airborne' applications is flight chasing. The camera operator in a chasing airplane records all types of flight maneuvers, extending and retracting landing gears, releasing loads, missiles, and flares.

As filming in a flight-chase scenario is a very specialized application, most standard cameras (still, video, and high-speed cameras) are not able to deal with the technical demands; and are therefore of only very limited benefit for aerospace applications. Only custom-designed cameras fulfil the special requirements.

The requirements for a hand-held digital high-speed camera for flight-chase applications include that they are compact and lightweight. The cramped space inside any airplane cockpit, as well as the high *g* forces during flying, make minimal size and weight of the hand-held cameras a top priority. The cameras must also be self-contained and self-powered. Indeed, all cameras for flight-chase applications have to be self-powered because any cable to the airplane could cause safety problems, such as emergency exit via the ejection seat. Ideally, the camera includes a high-capacity battery pack capable of providing the camera with power for two hours or longer. Of course, for safety reasons the battery has to be of a non-inflammable type, such as NiMH.

The camera must have a high recording capacity. The primary-image memory has a limited capacity to keep the cameras overall size and weight within limits. A built-in solid-state mass storage device, such as the conveniently available flash memory cards, enables an automatic 'dump' of image data once the primary-image memory is full, enabling a virtually unlimited number of sequences. When the flash memory card is full, it can be quickly replaced with an empty one for even more recordings.

The camera must also be easy to operate. Camera operators use flight gloves which prohibit the operation of normal-sized push buttons and other small operating elements. Hence a minimal number of reasonably-sized operating elements is a must. It is preferable to have a one-trigger button to start recording the next pre-configured sequence. All other operations, such as downloading image sequences to the built-in flash memory, can be automated or parameterized in the camera-setup menu to eliminate or minimize manual operation. Due to the lack of an electronic display the camera status cannot be indicated, as in an ordinary industrial application. However, the camera features extra-bright LED's which clearly show the most important status indicators, such as 'image data downloading' or 'mass-storage device full'.

The bright ambient light makes the use of conventional displays impossible, and similarly standard viewfinders often cannot be used, due to the crew wearing helmet-visors or sunglasses. A more basic sports-type optical viewfinder allows intuitive and quick aim at the target plane. The camera offers auto-exposure so the impossibility of displaying a live image to set the exposure is not critical. The high sensitivity of modern cameras enable a stopping down of the iris to an f-number which provides a depth-of-field from almost the front lens to infinity, making focusing practically unnecessary.

Hand-held S-CHASE high speed camera

Several cameras in one

Most flight tests which have to be recorded from a chase plane involve tests demanding various cameras. A high resolution still camera for overall (and possibly PR) images is often employed. Then, a video camera with standard frame rates is used for longer sequences with no fast events, and finally, the high-speed camera is employed to record those fast events, which otherwise

could not be recorded and analyzed. Due to the limited space in the cockpit, camera operators have to limit the number of cameras per mission. Ideally, one camera could be used in different operation modes.

State-of-the-art cameras like the S-CHASE allow a partitioning of its primary-image memory into so called sub-buffers. Each buffer can be used for one recorded sequence by pressing the trigger (release) button once. Now, each sub-buffer can be individually parameterized prior to the mission with the following settings: frame rate; from single shots via standard video rates to real high-speed framing rates of typically 500 or 1,000fps. Also, the image resolution can be from computer-friendly VGA (640 x 480) to the highly popular 800 x 600, from HDTV (WXGA, 1280 x 720) to full 1280 x 1024 pixels. Ideally, other image formats are possible too, such as 1280 x 500 or 800 x 240.

Trigger systems are integral, from pre- to center- and post-trigger in steps of 1%. Finally, the sequence length is such that it ensures the complete event is captured, without recording too much.

Typical digital high-speed cameras for flight-chase applications, such as the S-CHASE by AOS Technologies offer the above listed elements and an ergonomic handgrip, one push-button hand-trigger switch, and a collapsible sports-type viewfinder

High-speed for other systems

Beside the described 'standard' flight-chase application, there are some other applications which would benefit from a hand-held digital high-speed camera. One example is the critical take-off and landing operations of carrier-based aircraft. Take-off, as well as landing operations, can be recorded and played-back in slow motion to give aspiring pilots, as well as members of the ground staff, direct feedback on their performance. Seeing and understanding such critical operations are the basis of improving materials, procedures and individual performance.

The requirements for such an application differ from the flight-chase application, and the product features different specifications. It has the best ergonomics, ensuring that each component of the camera, from handgrip and the video viewfinder to the battery pack, can be individually positioned for the most convenient handling – and it can also be made suitable for left-handed users. The kit-based system is modular and expandable, enabling other components to be added or re-positioned at any time, without tools.

Flight-chase situation utilizing high-speed cameras

To achieve precise aim, an electronic eye-piece acts as a viewfinder during recording, in addition to a small monitor which enables immediate playback of the sequence. The electronic viewfinder shows the precise image, as seen by the cameras sensor, and enables the use of zoom lenses, and further precise focusing. A quick-release mount makes it possible to remove and re-install the camera in seconds

For uninterrupted operation for hours, a heavy-duty battery pack is installed on the rack. It can be replaced 'on the fly' with a fully charged one without it being necessary to shut down the camera system or stop recording.

Over the recent period, most film-based cameras have been replaced by digital cameras, which offer a range of benefits such as the immediate availability of the images. Even for very special applications such as flight chasing, suitable digital high-speed cameras have been designed and are available. Their operating costs are significantly lower than those of film-based cameras because there is no cost for films, development and scanning. They also offer extra value such as individual buffer settings or special, application-specific camera rigs. ▮

Below: The sub-buffer setting chart

Sub-Buffer No.	1	2	3	4	5	6
Frame rate	30	100	500	1250	500	30
Resolution	1280 x 720	640 x 480	640 x 480	800 x 600	800 x 600	1280 x 720
Trigger Setting	0%	75%	80%	25%	25%	0%
No. of frames	300	500	500	2500	2500	300
Sequence lenght	10 secs	5 secs	5 secs	5 secs	5 secs	10 secs

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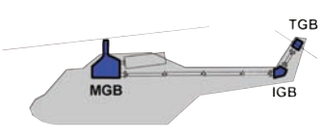

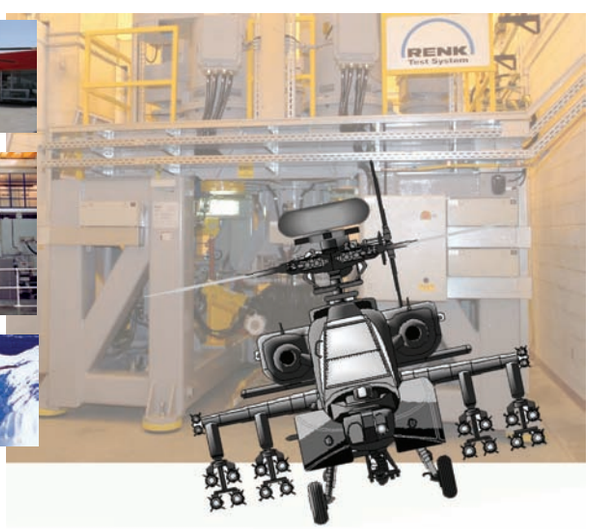

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Fighting fires

THE RUSSIAN KARNOVS ARE COMING. VARIANTS OF THE RUSSIAN HELICOPTER ARE NOW BEING FULLY INTEGRATED INTO THE WEST

BY DAVID OLIVER

The recent havoc caused by massive wildfires that destroyed some two million acres of forests in western Russia have once again highlighted the importance of fire-fighting aircraft, and helicopters in particular. One of the most efficient water-bombing helicopters used to fight the wildfires that raged across 17 regions of European Russia was Russia's own Kamov Ka-32. Developed from the multi-role Ka-27/28 naval helicopter, known in the west by its NATO codename 'Helix', the latest version of the Ka-32 has become the first Russian helicopter to be certified for commercial operations in EU countries.

The Kamov Design Bureau was formed in 1948 to develop ship-borne helicopters for the Soviet Navy. Under its chief designer, Nicolay Kamov, the bureau pioneered a family of helicopters using twin coaxial contra-rotating rotors that dispensed with the need for a tail rotor. The system enables the helicopter's dimensions to be kept to a minimum, with all the power to be used for main rotor lift without being bled off to a tail rotor. It also gives the helicopter exceptional maneuverability and ease of handling for a single pilot.

The latest in the long line of coaxial rotor helicopters produced by Kamov, now a 'joint-stock' company under the Russian Helicopters JSC umbrella, is the twin-engine Ka-32A11BC, originally built to Transport Canada certification in 1999. This variant is now the helicopter of choice for fighting fires in mountainous terrain and high-rise buildings. Its coaxial rotors ensure greater precision and control in hovering in highly turbulent conditions, allowing highly accurate dumping at lower altitudes.

The coaxial rotors of the Ka-32A11BC ensure greater precision and control and the power from its twin engines gives it a high rate of climb to take it away from the fire area. It can operate from restricted unprepared landing sites in remote regions with minimum ground support. An APU in the rear of the starboard engine fairing is used for engine start and to power the hydraulic and electrical systems on the ground to eliminate the need for a GPU. Kamov was the first Russian manufacturer to make extensive use of composites in the airframe and the foldable rotor blades, which have full profile electrothermal de-icing for operations in adverse weather conditions.

The Ka-32A11BC is fitted with two 2,400hp Klimov TV3-117VMA turboshaft engines with a 1,500-hour TBO, which gives it a top speed of 260km/h and an endurance of 4.5 hours.

"The coaxial rotors of the Ka-32A11BC ensure greater precision and control"

In its fire-fighting mode, it can be fitted with a 3,000-liter American Simplex belly tank and a water gun system, or carry a 4,000-liter underslung Russian VSU-5A bucket or a 5,000-liter Canadian Bambi-Bucket. For the transportation of firefighters and evacuation of casualties, the Kamov can carry up to 13 fully-equipped specialists, plus one or two crew members, or two stretchers and a paramedic. Other equipment includes Goodrich rescue hoists, PSAIR loudspeakers, and SX-16 searchlights.

More than 50 Ka-32As are flown by Russian commercial helicopter operators under domestic AP-29 certification, in addition to the Russian and Azerbaijan Ministries of Emergency Situations fleets that were heavily utilized during the summer firestorms. The type has been exported to a dozen countries worldwide, with more than 40 helicopters delivered to South Korea for its Forest Service, Coast Guard, and Air Force. The latter have been fitted with new avionics integrated by IAI/Lahav to provide enhanced day/night operating capability.

However, the issue of type certificate IM.R.133 by the European Aviation Safety Agency (EASA) in September 2009 boosted the Ka-32A11BC's potential sales in the fire-fighting role in Europe. Already in service in Portugal, Switzerland, and Turkey, a major operator of

The Kamov lifts 5,000 liters of water from a lake at Madroñallejo in a Bambi-Bucket (below and right)

The pilot begins a speedy engine start-up in the Ka-32A11BC's spacious and well equipped cockpit (far right)

A Ka-32A11BC operated by EMA for the Portuguese Ministry of Internal Affairs (opposite page)

(All photos courtesy David Oliver)

the type is one of Europe's largest commercial helicopter operators, Inaer.

The Spanish-based company recently acquired by a US private equity group, operates a large and diverse fleet of more than 200 helicopters in Spain, France, Italy, Portugal, and Chile. Almost 30% of its 2009 turnover of €300 million was derived from its aerial firefighting activities, which include fire surveillance, water-bombing, and the transport of firefighting personnel. Inaer has invested more than €279 million in acquisition and fleet renewal in the last four years, which includes the purchase of ten new Ka-32A11BC helicopters for firefighting operations.

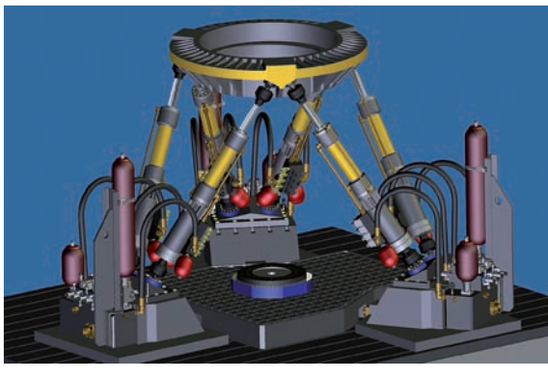
The Kamov fleet is maintained at Inaer's Mutxamel headquarters at Alicante during the Winter months prior to their deployment to forest defense centers, mainly in Andalusia, during the high-risk fire season that stretches from June to October. Inaer is certified as Type Rating Training Organization by the Spanish Civil Aviation Authority and conducts type rating courses and renewal certification for KA-32A pilots and co-pilots, who come from all over the globe - its chief pilot is Swiss. It also trains the technicians who oversee the Kamov operations when deployed away from Mutxamel and engineers who carry out deep maintenance at the base.

"Almost 30% of its 2009 turnover of €300 million was derived from its aerial firefighting"

Andalusia in southern Spain has more large-capacity helicopters dedicated to fire fighting operations than any other autonomous community in the country. In recent years, the Andalusian Public Administration has made great efforts to improve the effectiveness of the means and resources for fighting forest fires within the Plan of Prevention and Fire Fighting Forest in Andalusia (INFOCA). With a budget of over €100 million, INFOCA has four Ka-32A11BC helicopters stationed in the region during the fire-risk season while others are based in the Canary Islands, Castilla and Leon, Galicia and Valencia. Under the INFOCA plan, two of them are contracted by the Regional Environment Ministry and two by the central government's Ministry of Environment, Rural and Marine Affairs.

At the Madroñallejo Forestry Defense Center in Aználcollar on the outskirts of Seville, two helicopters are at readiness at the self contained fire-fighting brigades base, and when not on alert, the crews carry out training by filling the Bambi-Buckets with water from the adjacent lake and practice dropping the 5,000 liters on a target area with accuracy.

The capable Kamovs are playing an increasing role in checking the ever-increasing dangers of the forest fires that break out every summer throughout Europe.



Hexapod testbed, nose-gear testbed and automated test system for rims

Now, the hexapod

A COMPLEX TEST SYSTEM FOR REALISTIC LOADS

BY MARC ZURN

FGB has expanded its range of products for the aircraft industry. It has received a prestigious order from the Technische Universität Hamburg-Harburg to construct a complex hexapod testbed. The engineering for this highly sophisticated test device has completed the final production stage and the first components are scheduled for manufacture in September 2010.

The testbed is used to trial complex compound materials at realistic load conditions. The prototypes, sometimes weighing over a ton, are tested for any type of multiple-axis load conditions. At maximum rigidity the system allows for simultaneous movements in six degrees of freedom. The long-term experience of the company's engineers and technicians enables the testbed components' successful development and production.

The test system's modular design enables versatile test options. In the upper test bench (above the platform), both vibration tests (for airplane galleys, for example) and bracing tests (force-controlled even for strongly non-linear components) are implemented for large specimens. Below the platform, tests on smaller components (such as air springs) are carried out at maximum rigidity of the test system.

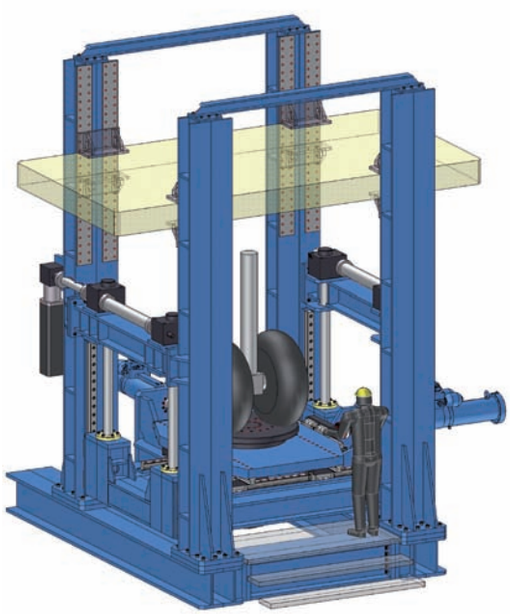
The mechanical parallel structure (hexapod) is operated dynamically in freely selectable force/distance control, and is also very demanding from the point of view of its control technology.

The FGB software used for the test programs contains all the required functions for operating the hexapod testbed. A de-coupled, hybrid force/distance control enables the user to specify distance or force data for movements in any spatial direction of the coordinate system.

The signals are implemented on the individual hydraulic cylinders from within the software, without the user having to do anything. Along with the control-mode pseudo-force control, an iterative real-time control (linear/non-linear) is also contained within the functional scope, and can be adapted individually by the user.

Providing customized test rigs to the aircraft industry is a major business of FGB. Other recent projects include, an airliner nose-gear test system, also a servohydraulic solution. It will be capable of stressing a complete nose-gear unit to the limit of its load conditions which occur during landing or take-off, mainly when the aircraft is on its taxiway.

In addition to its leading competence in servohydraulic solutions, FGB has confidence in its experience of developing and manufacturing non-destructive test systems, too. An example is the automated rim-inspection system. Weighing up to 150kg, the device inspects the rims for cracks and similar defects at the rate of 30 per hour. Be it life cycle testing or non-destructive methods, on or off aircraft, FGB covers the whole diversity of testing and inspection challenges in the aircraft industry. ▮



Performance data

Individual forces:	z axis up to 500kN, x/y axis up to 200kN
Individual torques:	40kNm

Distances and angles

Combined distances:	± 150mm
Combined angles:	± 5°

Dynamics

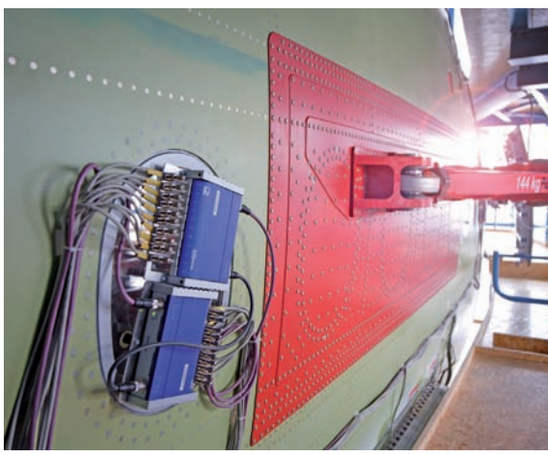
Speeds:	up to 1m/sec
Accelerations:	up to 6*g*
Operating frequency:	up to 30Hz

Hydraulics

Hydraulic oil supply:	1,000 liters/min
Operating pressure:	280 bar

Left: Installation comprising 400 CANHEAD modules for a 4,000-channel system

Below: CANHEAD modules can be installed close to the measuring points, minimizing interference



High-speed data

DISTRIBUTED AND SYNCHRONIZED MULTI-CHANNEL DAQ AT 100 MEASUREMENTS PER SECOND

BY MARC ZURN

During development and approval, aircraft have to meet some extremely strict requirements, especially in fatigue tests. In tests on large structures like wings, several thousand strain gauges are usually required. The challenge involved in these types of applications is to synchronously acquire interference-free signals from all strain gauges. Distributed data acquisition at a sampling rate of 100 measurements/sec offers great advantages.

Due to the physical size of an aircraft, the numerous measuring points are distributed relatively far away from each other across the airframe. The main advantage of HBM's CANHEAD amplifier is that it can be mounted in very close proximity to strain gauges to record their signals. A single CANHEAD module can acquire data from as many as ten different measuring points. With 90% less cables to lay, major benefits include massively reduced cable costs and time savings. A huge reduction in cable weight is an additional fact worthy of a mention. Approximately the size of a paperback book, CANHEAD modules are extremely lightweight and, consequently, do not influence the mechanical properties of the structure. Measuring cables are thus kept as short as possible, which almost completely eliminates interference, which can occur with longer cables.

Each CANHEAD module provides all requisite signal conditioning and 24-bit A/D conversion, with a separate A/D converter available on each channel. Individual strain gauges can be connected in regulated three- or four-wire circuitry. The 600Hz carrier frequency increases interference immunity. An amplifier unit can be easily and simply replaced in a matter of seconds by disconnecting (unclipping) it from its base (CANHEAD housing) to which all the strain gauges are connected. The system was specially designed to measure all kinds of strain gauges, e.g. linear types or rosettes, using the quarter-bridge modules. Force and pressure transducers can also be connected to full and half-bridge modules. Voltage can be measured within a range of ±10V. Other physical values can be synchronized by using an MGCplus amplifier and appropriate connection boards.

Digitized signals are transmitted via a standard CANbus, which interconnects individual CANHEAD modules. Cable lengths of up to 100m are possible with this rugged bus system. An ML74 communication module, from HBM's MGCplus data acquisition system, functions as the communication master. A maximum of five CANHEAD modules can be connected on one CANbus line, providing a sampling rate of 100 measurements/sec. As many as 10 CANbus lines can converge to a single 19in MGCplus chassis. It is particularly important that measurements are acquired synchronously on all channels. For this reason, individual CANHEAD modules can be synchronized via CANbus, MGCplus communication master, and various MGCplus devices, each via sync cable. Using this configuration it is possible to measure thousands of decentralized channels, synchronized at 100 measurements/sec.

The catman Enterprise software package, used for setting the parameters of the system and for data acquisition, is well known for its easy, user-friendly operation, even when the channel count is exceptionally high. The software is designed for measurement applications with mid-size to very high channel counts. Convenient and simultaneous acquisition of up to 20,000 channels is possible. The software enables the user to quickly and easily set up a measurement operation or sequence. It is now possible, for example, to automatically check the status of all the strain gauge measuring points. During measurement, data is acquired by a four-channel data server. The system's client/server architecture, permits different clients to simultaneously access data online, and visualize results in real time. Extensive trigger functions facilitate the activation of routines that were set up beforehand. These can be anything from the initiation of a fast measurement routine to sending an email. Special online calculations for experimental structural analysis are already implemented in the software. The open architecture allows users to integrate their own, additional functions. An integrated script language and an ActiveX interface are available for such purposes. ▮

Marc Zurn is: international product manager - HBM Test & Measurement

Acoustic measurement with latest microphone sets

G.R.A.S. Sound & Vibration has released a completely new family of microphone sets, designed to offer precision acoustic measurement capabilities with simplicity, reliability and robustness.

With unique designs developed from customer feedback, Type 46 Microphone Sets are available in quarter and half inch diameters and in free-field, pressure and random incidence types, with specifications developed to support common acoustic-measurement requirements. They are assembled in a dust-free environment to avoid interface contamination; are calibrated as a single unit; and are sealed with a removable label, for seamless integration into single- and multi-channel applications.

The sets are delivered with individual calibration charts, including sensitivity values and frequency response curves, allowing sensitivity values to be used directly within system setups. For frequent measurement-chain verifications, a 114 dB sound calibrator is supplied. The company's Type 46 Microphone Sets can be connected directly to all professional measurement systems, and are available to support constant current power (CCP) and seven-pin LEMO inputs. For larger channel count applications, the sets also incorporate TEDS, allowing for a plug-and-play solution and the ability to identify individual unit properties, types and calibration data. In addition, all sets are offered with a five-year comprehensive product warranty.

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Rugged capacitive MEMS accelerometers

Silicon Designs specializes in the manufacture of highly rugged industrial-grade capacitive MEMS accelerometer chips and modules with integrated amplification for zero-to-medium frequency applications. Sensors are ideal for a variety of aerospace testing applications, including flutter testing and flight test data recording; UAVs; passenger comfort studies; autopilot systems and controls; ejection seats; flight touchdown impact testing; and atmospheric re-entry monitoring.

Model 2220 single axis and model 2470 tri-axial analog accelerometer modules are particularly ideal for these applications, with frequency responses from DC to 2 kHz and operating temperature ranges from -55°C to +125°C. SDI accelerometer chips are also ideal for a variety of OEM applications, with full scale ranges from 2g to 20,000g. Ceramic & gold platforms, nitrogen damping and hermetically sealed designs provide high stability and measurement accuracy, with individual calibration and differential output.

Tightly controlled in-house manufacturing processes ensure that accelerometers are virtually identical for quick plug-and-play solutions with minimal setup changes. On-board voltage regulation and internal power reference minimize temperature and voltage changes and eliminate additional power requirements.

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or go to online enquiry card 101

USB Test Tool for AFDX/ARINC664

AIM has enhanced its range of USB based products for laboratory, field test and data-loading applications with the all new APU-FDX-2 USB module.

The new USB based APU-FDX-2 module is implemented in a shirt pocket-sized box that can easily connect to various types of computer systems via the USB port. The robust and low-power USB2.0 interface provides a high-speed connection between the APU-FDX-2 module and the host computer, feeding the supply voltage so that no external power adapter is required. A 'hot plug' capability is incorporated to maximize ease of use.

The APU-FDX-2 is AIM's new USB module offering full function test, simulation, monitoring and analyzer functions for AFDX/ ARINC664 (Avionics Full Duplex Switched Ethernet) networks. Its special onboard processing capability, memory resources, powerful and customized AFDX/ ARINC664 MACs gives AFDX/ ARINC664 users features for demanding AFDX/ ARINC664 applications.

The APU-FDX-2 is offered with two full duplex AFDX/ ARINC664 ports configurable to one dual-redundant AFDX/ ARINC664 port. Key features include error injection/detection, multilevel triggering for capturing and filtering, real time recording and synchronized bus replay. Ports can operate concurrently in Traffic Simulator and receiver/monitor modes with support for AFDX/ ARINC664 port-related frame statistics.

Full function driver software is delivered with the APU-FDX-2 cards for Windows XP/Vista/7 and Linux. The industry standard Databus Test & Analysis Tool PBA.proTM (for Windows & Linux) and fdXplorer/ParaView Data-Network Analyzer/Visualizer Software (for Windows) is available as an option to engineers to troubleshoot and de-bug aircraft data networks deploying AFDX/ ARINC664. Airline operators can use AIM's EasyLOAD-615A Data-Loader software package for Windows.

The APU-FDX-2 is software compatible with AIM's family of PMC, PCI, PC-Card, Compact-PCI, VME and VXI AFDX/ ARINC664 cards.

AIM has offices in the UK and the USA, with the main design and manufacturing facilities based in Freiburg, Germany. Our full-service technical website offers a powerful download area, providing online product updates and a full documentation service. AIM markets and supports its products through authorized representatives worldwide.

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No cold beer today

Imagine you are on a long distance flight for many hours and the flight attendants announces that no food will be served. In addition, and even worse, the beer is warm. Would you think that this disastrous situation is related to leak detection?

Modern long-distance aircraft are pretty big and accordingly there are two, three or even more galleys installed. During the flight (and, of course, on the ground) the storage cabinets for food and beverages are cooled to provide fresh food and cold drinks. The disastrous situation as described above comes up when the cooling fails.

Aircraft generate the cold in a central device. Through heat exchangers this cold is transported to the various galleys through long tubes and pipes. A special coolant is used for the transportation. An aircraft experiences many shocks and vibrations and the body is twisted a lot during flights, so there is a high likelihood that joints in the piping system start to leak and sooner or later the system is out of order.

The joints are not easy to get to. They are hidden behind panels or mounted in between decks. Also, there are so many joints that even a visual inspection of every joint is a major effort and the down time of the aircraft is very long. An effective method to find these leaks is using a modern sniffer leak detector (for instance Inficon's Ecotec E3000A), which is tuned to only react on the specific coolant used in the broken system. The instrument draws air into its sensors via a probe and as soon as the air is enriched with the specific coolant the instrument will detect it and release an alarm. It is not necessary to move the probe along the tubes and the joints. It is sufficient to stick the probe into cavities and box sections where the piping is installed. The instrument is sensitive enough to react without being in close contact with the joint or coolant. The concentration of coolants that builds up in these box sections is high enough to indicate that there is a leak close by.

Fuel tanks for instance have to be leak tight as well and many measurement devices such as gyroscopes and sensors have to be tight. In cases where the samples are filled with a gas, the gas can directly be used for testing. Otherwise tracer gases like Helium are pretty common. The Ecotec E3000A can be tuned to any gas that makes it a very suitable instrument for many applications.

For further information contact
Inficon GmbH, Bonner Strasse 498, 50968 Köln, Germany, Tel: +49 221 56788 612
www.inficon.com
or go to online enquiry card 103

High-temperature brochure

Dytran Instruments has released High Temperature Accelerometers for Dynamic Measurements, a brochure highlighting select models of the company's IEPE and charge mode accelerometers for high-temperature aerospace, automotive, defense, power-generation and test-and-measurement applications.

Accelerometers used for dynamic measurements within high-temperature environments require operation over a considerably higher temperature range of up to +482°C, as compared to standard laboratory accelerometers. This brochure highlights fifteen examples of Dytran accelerometers that can reliably perform within these environments, while providing the same durability and accuracy found within the company's standard product range.

For further information contact
High Temperature Accelerometers for Dynamic Measurements is available for download at www.dytran.com, or may be ordered in printed copy by emailing marketing@dytran.com
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The missing link - AFDX switch

An avionics full duplex switched Ethernet (AFDX) switch forms the central element of an AFDX network consisting of multiple, possibly redundant, switches and end systems. It supplies the infrastructure to physically interconnect all end systems and regulates the traffic to conform to the overall network configuration.

The switch consists of a filtering and policing engine that ensures that only valid incoming frames are forwarded to the correct physical ports, based on a user-provided configuration table. Its monitoring module provides operational, health, and error information to network-management systems.

TechSAT's AFDX Switch is available in two models: ERAS, a lab switch that is suited for use in a test and integration environment (1HU rack-mountable or desktop use) and RuERAS, a ruggedized package for flight-test instrumentation purposes (ARINC 600 2MCU tray mount, tested to a subset of RTCA DO-160F).

The switch is fully compliant to ARINC 664 Part 7, Chapter 4, including IEEE 802.3 and the ARINC 615A, TFTP, and SNMP protocols. Test-specific enhancements support BAGs not restricted to powers of two and resolutions of 20ns for BAG, jitter, and maximum skew.

Using the switch's echoing functionality, AFDX traffic can be captured non-intrusively from selected ports or VLs. Applications have full control over the switch through its discrete channels.

A multi-platform (Windows, Linux) configuration software allows users to create configurations for multiple switches, upload the configurations, and access the switch discretes for pin programming, fault/healthy and status monitoring. The software is also usable as a library.

For further information contact
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Email: contact@techsat.com
Web: www.techsat.com
or go to online enquiry card 105

German sales cooperation

Controllersolution GmbH test systems guarantees excellent command and feedback with simultaneous high test speeds. In comparison to conventional solutions available on the market, the test speed is clearly increased and dynamic test duration is reduced. This entails very high savings of costs of the entire test procedure.

Compared to other providers, the offered price-performance ratio of this system is convincing. Also time and resources for optimization are noticeably reduced during the test set-up and the system start-up.

"Beyond that, the high-control comfort, the multi-channel ability, as well as the hardware concept of the control system of Controllersolution testify to an innovative concept," says Prof Dr Thomas Fleischer, managing director of IMA Dresden GmbH.

On the basis of these attributes and the technical standard of the systems, IMA GmbH Dresden and WPM GmbH Leipzig include these products in their product range.

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A global approach in leak detection

Leak detection in the aerospace industry goes along a broad range of sensitivity requirements, all the way from 1.10-1stdcc/sec to 1.10-12stdcc/sec. This is why many different technologies are in use today, covering a wide variety of process requirements, from basic bubble or ultrasonic (for doors and windscreens), to helium mass-spectrometer testing, capable of measuring permeation leaks.

More sensitivity brings better quality control as the industry faces increasingly stringent quality requirements. There is no operator today who would accept a 1.10-5stdcc/sec fuel-system leak on a newly delivered airplane. This is why Boeing, and other manufacturers, look for this level of sensitivity during production final assembly, and why helium-leak detection is currently in use around the world during fuel system maintenance.

Although it is admitted that industry moves to increase leak detection sensitivity, it is less recognized that sensitivity only moves up with more sophisticated technology. This requires a deeper knowledge for the operator, and more training and engineering. For example, the working bubble test cannot compare with helium-tracer gas leak detection, for a permeation test of an organic vapor barrier. During the initial phase of a leak detection project, it is indeed crucial to perform some engineering and accurate calculations to provide the operator with a clear, easy and repetitive procedure. Once determined, of course, initial training needs to be followed by recurring training to maintain full-detection capacity, if the operator is not practicing daily. Handling the job any other way will leave the operator with false readings, application questions and, finally, heavy doubts about test accuracy. Understanding this crucial issue, some leak-detector providers are now involving themselves deeply in application support.

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2010 measurement product resource

Meggitt Sensing Systems has announced the global release of its new '2010 Measurement Product Resource', a 63-page full-color short form catalog highlighting select models of the company's high-reliability sensing technologies for aerospace applications, including avionics; flight and flutter testing; modal and structural analysis; aerodynamic studies; UAVs and flight control systems; HUMS; high-temperature engine monitoring; propulsion testing; combustor instability monitoring; cryogenics; nuclear testing; space program R&D; launch vehicles; high-g shock; and shock wave testing. Meggitt's Endevco, Sensorex, Vibro-Meter and Wilcoxon Research product lines are now offered under one umbrella, providing customers the opportunity to order a complete range of sensors and instrumentation via a single source.

Products include accelerometers, acoustic sensors (including hydrophones), structural excitation devices, pressure transducers, inclinometers, LVDT's, gyrometers, inertial measurement units, signal conditioners, cables and accessories. Each catalog section includes an introductory paragraph on the benefits and most common applications of featured sensing types, along with detailed technical product specifications, presented in a series of well-organized comparative charts.

The '2010 Measurement Product Resource' is available for download on the Meggitt Sensing Systems website at www.meggittsensingsystems.com, or may be ordered in printed copy by contacting the company on +1 949 493 8181.

For further information contact
Meggitt Systems
Web: www.meggittsensingsystems.com
or go to online enquiry card 108

Switch Matrix Systems

A Quantum Switch for the Better

Computer controlled analog signal switching replaces tedious manual patch panels

Precision Switch Matrix

- Non-blocking solid-state switch matrix
  - **4164:** 64 x 64 in compact 2U (3.5 inch) chassis
  - **464kB:** Configurable matrix sizes up to 256 x 256
- Store setups in the system or download setups from host computer
- Signal levels up to ±10 Vpk
- Frequency range: DC to 1 MHz
- System health monitoring and built-in self-test with reports
- Ethernet remote control or front panel operation

Switch GUI

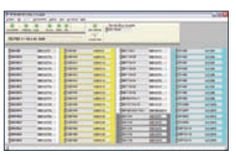
- Setup and save unlimited switch configurations offline, download configurations to the switch
- Label inputs and outputs
- Color-coded channel groups
- Run go/no-go tests to check current set up
- Initiate Factory Acceptance Tests for complete system check including I/O connections
- System health indicators

Precision Filters' computer-controlled analog signal switching systems replace tedious error-prone manual patch panels.

The Precision Switch Systems are reliable solid-state switch matrix systems providing computer-controlled connections between any input and any output. Program switch setups, store them, download them and verify them using a host computer.

The Precision 4164 is a 64 x 64 switch matrix provided in a compact 2U rack mountable or bench-top package.

The Precision 464kB is configurable up to a 256 x 256 switch matrix system. Larger systems can be built by bussing two or more systems together.



The Switch GUI makes it easy to manage system connections from the host computer.

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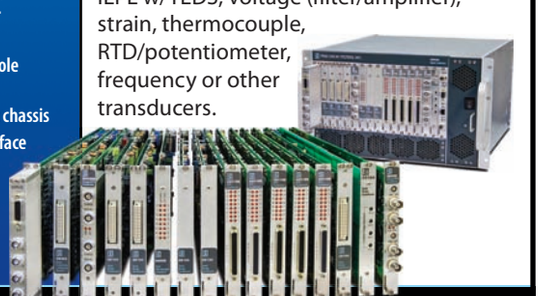
The 28000 System makes it easy to manage a test with up to 256 channels of fully programmable transducer conditioning. Choose a mix of bridge, charge, IEPE w/TEDS, voltage (filter/amplifier), strain, thermocouple, RTD/potentiometer, frequency or other transducers.



On the ***New Frontiers*** *of* ***Precision***

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Shock pulses using an electrodynamic shaker

Unholtz-Dickie now offers the Model S092-Series high-shock shaker rated up to 1,500g-pk for a wide array of test applications. Hardware items being tested on the S092-Series shaker include computer disk drives, weapon sights, missile-guidance system components, and a variety of shock/vibration sensors.

The computer disk-drive industry has been using the S092 shaker for many years to produce high g mechanical shock pulses up to 600g-pk. For higher g-level shocks, long-throw drop tower testers had to be used. At the request of several suppliers, UD developed the S092-UX Series shakers, capable of delivering half-sine pulses up to 1,500g-pk at 0.5m/sec duration, and up to 1,100g-pk at 2m/sec duration for test loads up to 2 lbs. This high g capability, and extended frequency range, make these systems ideal for aerospace/military applications that require testing small payloads to up to 5,000g SRS (5KHz BW) and 3,000g SRS.

This UD System consists of the Model S092-UX Series Shaker driven by a 240KVA Model 2XSAI-120 Power Amplifier. The actual waveforms are developed under closed-loop control with the Model Vwin II controller, using feedback from an accelerometer installed on the test fixture. Closed-loop control provides precise-level control and excellent repeatability between transient pulses.

For further information contact

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or go to online enquiry card 109

A quantum switch for the better

Precision Filters Inc has announced the launch of two computer-controlled analog signal switching systems that replace tedious manual patch panels. The Precision 4164 Switch Matrix and the Precision 464kB Switch Matrix systems are reliable solid-state switch matrix systems that provide computer-controlled connections between any input and any output. Switch configurations can be set up and stored on a host computer and then downloaded to the system over an Ethernet network, saving time and reducing errors. Connections of the current setup are verified by a built-in go/no-go test. An exhaustive self-test verifies all switch settings and input/output connectors.

The Precision 4164 is a 64 x 64 switch matrix provided in a compact 2U rack-mountable or bench-top package. The Precision 464kB is configurable up to 256 x 256.

For further information contact

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Generator test bench LMP300

The design and manufacture of generator test benches has been one of the core design skills of Test-Fuchs. The first generator test bench was delivered to the customer in 1960.

The latest test bench p/n LMP300 is in production and will be delivered to a well-known major MRO later this year. In partnership with this customer, we developed the LMP300 to become our flag ship aircraft-power generating test system for the future. This test bench is capable of testing all power generating components (IDG, AC generators, DC generators, DC starter generators, CSD, VSCF) that are installed on various aircraft types (from Embraer, Q400, CRJ, Airbus family, Boeing family up to A380 and B787-Dreamliner).

The newest technology for the drive and load unit causes a competitive advantage to the customers. Engine output up to 600kW and permanent loads up to 450kVA are possible.

To reduce investment costs for the customer a universal generator control unit (GCU) was developed. The major advantages of the universal GCU are full integration into the test equipment and a single investment for all test capabilities.

The LMP300 supports high automation and optimizes test times. Easy and fast adaptation of the unit under test was one of the key elements. Test-Fuchs now offers an easy fast coupling system that reduces the installation time of the units under test significantly. It is based on manual testing and is extendable to fully automated test runs.

For further information contact

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Unmanned phantoms

IN THE SPACE OF JUST TWO MONTHS BOEING HAS UNVEILED TWO NEW UNMANNED PHANTOM CRAFT

BY CHRIS HADDOX

In July, Boeing unveiled its hydrogen-powered 'Phantom Eye' unmanned airborne system during a ceremony in St Louis, Missouri. The demonstrator, which will stay aloft at 65,000ft for up to four days, is powered by two 2-liter, four-cylinder engines that provide 150hp each. It has a 150ft wingspan, will cruise at approximately 150kts and can carry up to a 450 lb payload.

"Phantom Eye is the first of its kind and could open up a whole new market in collecting data and communications," Darryl Davis, president of Boeing Phantom Works, said at the unveiling ceremony. "It is a perfect example of turning an idea into a reality. It defines our rapid prototyping efforts and will demonstrate the art-of-the-possible when it comes to persistent intelligence, surveillance and reconnaissance. The capabilities inherent in Phantom Eye's design will offer game-changing opportunities for our military, civil and commercial customers."

Later this summer, Phantom Eye will be shipped to NASA's Dryden Flight Research Center at Edwards Air Force Base, California, to begin a series of ground and taxi tests in preparation for its first flight in early 2011. That debut flight is expected to last between four and eight hours.

"The program is moving quickly, and it's exciting to be part of such a unique aircraft," said Drew Mallow, Phantom Eye program manager for Boeing. "The hydrogen propulsion system will be the key to Phantom Eye's success. It is very efficient and offers great fuel economy, and its only by-product is water, so it's also an environmentally responsible aircraft." ▮

Phantom Eye has 150ft wingspan, will cruise at approximately 150 kts and can carry up to a 450 lb payload

Humming test

The A160T has established a world record for a UAV in testing, according to Boeing, demonstrating 18.7 hours of endurance with a 3,000 lb/1,361kg payload. Total test time to date is more than 300 hours. The craft optimizes performance by varying rotor speed 60-100%.

Boeing began production in March 2010 and has committed to production of 21 aircraft. The company says this commitment has not changed, despite the crash of an A160T Hummingbird during testing earlier this year. Boeing is still investigating the accident.

Ray vision

Two months earlier Boeing unveiled the fighter-sized Phantom Ray unmanned airborne system, a testbed for advanced technologies.

"We are on a fast track, and first flight is in sight," explained Davis. "Phantom Ray is on schedule to fly in December 2010, about two years after this project began. This is a tremendous accomplishment for Boeing and the Phantom Ray team."

Phantom Ray has already been scheduled to complete taxi tests. The first flight in December will be followed by up to nine additional flights over approximately six months. Phantom Ray is designed to support potential missions that may include intelligence, surveillance and reconnaissance, suppression of enemy air defenses, electronic attack, strike, and autonomous aerial refueling.

"The initial flights will take Phantom Ray through its paces for the flight-test profile. Beyond that, the missions and systems tested will be determined by future warfighter needs," said Phantom Ray program manager for Boeing, Craig Brown.

Key Phantom Ray suppliers include General Electric-Aviation (propulsion and power distribution), Honeywell (brake system), Woodward-HRT (flight-control actuation system), Crane Hydro-Aire (brake controls) and Heroux-Devtek (landing gear).

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